Mitigating the Impact of COVID 19 and the Russian-Ukrainian War on the Semiconductor Industry: Strategy Analysis of Investing in Localizing the Semiconductor Supply Chain in Japan.

Siwar BELGACEM[1], Keiji MURAKAMI[2]

[1]Student, Graduate School of Management, Kyoto University
(Address 606-8397, Shogoin Kawaracho Sakyo ku, Kyoto, Japan)
E-mail: belgacem.siwar.73z@st.kyoto-u.ac.jp
[2]Member of SGB, Associate Professor, Graduate School of Management, Kyoto University
(Address 606-8501, Yoshidahonmachi Sakyo ku Kyoto, Japan)
E-mail: murakami.keiji.3c@kyoto-u.ac.jp

Semiconductors are important and indispensable products driving the technological and industrial growth. In fact, a single phone has around 169 semiconductors while a car has around 3500 semiconductors. Thus, the semiconductor industry is a strategic and a key industry.

However, a supply shortage has been witnessed during COVID 19. The semiconductor shortage resulted in operation suspension, revenue loss and supply instability.

The COVID 19 pandemic has revealed the vulnerability of supply chains caused by globalization. In addition, the Russian Ukrainian war can also impact the semiconductor industry mainly through Neon supply disruptions.

It is becoming increasingly important to change supply chain strategy trends and to understand the limits of globalization. Localization strategies have been the center of discussion lately with many countries investing greatly in it in hopes of mitigating these risks. For example, USA is extensively investing in its semiconductor supply chain.

This research aims to analyze the impact of COVID 19 and the war on the Japanese semiconductor supply chain. The research aims also to analyze the effectiveness of localization strategy in mitigating these impacts and in improving the competitive advantage of Japan.

The research methodology is to collect and analyze primary data from interviews with Japanese semiconductor companies and secondary data from available public sources.

Key Words : *Semiconductors, Supply Chain, Localization, Strategy, COVID 19, Russian- Ukrainian War.*

1. INTRODUCTION

Semiconductors are important and indispensable products driving the technological and industrial growth. In fact, a single phone has around 169 semiconductors while a car has around 3500 semiconductors. Thus, the semiconductor industry is a strategic and a key industry.

However, the COVID 19 pandemic has caused unprecedented global supply chain disruptions and an exponential demand of electronic products that resulted in a shortage of semiconductor products. Several industries were impacted by this shortage. For example, the automotive industry was hit hard, and many automotive manufacturers had to scale down production such as Toyota.

Amidst these issues, the war between Russia and Ukraine threatens the stability of Neon gas supply as they hold around 45%- 55% of global market share. Neon is a raw material used in the production of semiconductors.

Global events such as the COVID 19 pandemic and the war have revealed the vulnerability of supply chains caused by globalization. It is becoming increasingly important to change supply chain strategy trends and to understand the limits of globalization. Localization strategies have been the center of discussion lately with many countries investing greatly in it in hopes of mitigating these risks. For example, USA is extensively investing in its semiconductor supply chain.

Thus, this research questions are:

• What is the impact of the COVID 19 on the semiconductor industry in Japan?

• What is the possible impact of the Russian-Ukrainian war on the semiconductor supply chain in Japan?

• Can investing in localizing the semiconductor supply chain mitigate supply risks and improve the competitive advantage in Japan?

• What are the areas of growth that Japan should focus on?

The research methodology is to collect and analyze primary data from interviews with Japanese semiconductor companies and secondary data from available public sources.

2. GLOBAL SEMICONDUCTOR MARKET

(1) Market Growth

The global semiconductor market was growing steadily from 2015 to 2018 by 8.7% CAGR[1].

However, due to COVID 19 in 2019, the global market shrank by 12% compared to 2018 with all regions registering a growth drop. The market witnessed a slow recovery in 2020 by 6.8% but grew strongly by 26.2% in 2021.

The semiconductor market is forecasted to continue growing through 2022 by 16% due to high demand for semiconductor products and exceeding pre-COVID levels. The market is estimated to reach $679.65 billion in 2023[2].

China and the rest of Asia Pacific are the biggest markets for semiconductor products demand. In fact, they held 78% of global sales in 2020 with China accounting for over one-third of worldwide sales. 25% of sales revenue of major American semiconductor companies comes from China.

Semiconductor products can be divided into Discrete, Optoelectronics, Sensors, and Integrated Circuit IC. If we analyze the market by semiconductor device type, we can observe that the IC is the dominant type with over 80% market share.

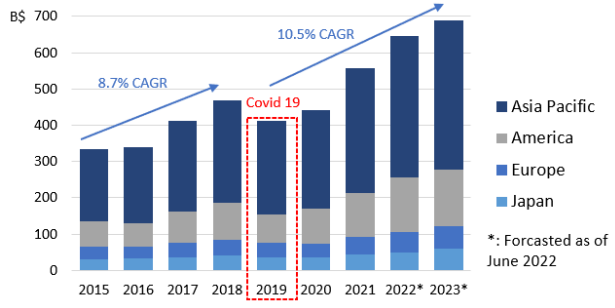

Fig.1 Semiconductor's Global Market Size.

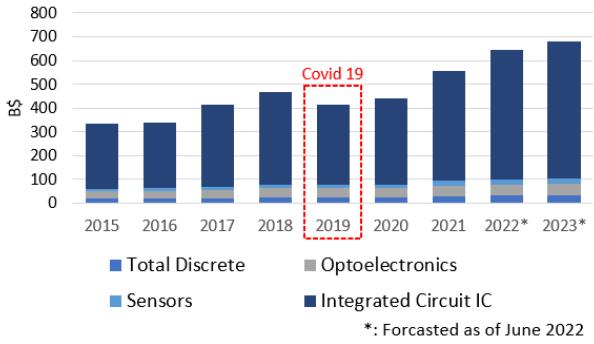

Fig.2 Market Size by Device Type.

(2) Growth Factors

Semiconductors are used in a multitude of devices across several domains: Networking & Communications, Data Processing, Industrial, Consumer Electronics, Automotive, and Government. Therefore, growth in any of these applications results in growth of the semiconductor market. The Networking & Communications and Data processing applications held the highest semiconductor market share in 2021 followed by Consumer Electronics, Automotive, Industrial and Government.

In fact, Networking & Communications segment is projected to grow as the demand for smartphones and smart devices keeps increasing.

The Data processing segment is forecasted to keep growing as the demand for memory storage and processing increases. For example, data generation is estimated to reach 463 exabytes per day as of 2025. Also, over 70% of GDPs worldwide is expected to undergo some form of digitalization by 2022.

The semiconductor market growth is also driven by the emergence of Artificial Intelligence AI and Internet of Things IoT. These technologies are used in wide applications such as Industrial Automation, Smart Cities and Autonomous Driving. For example, China had 3.17 billion IoT devices in 2020. APAC region is projected to be the biggest IoT spender by 2030. These technologies require advanced chips with powerful processors and memories. These requirements are driving chip design and performance. The emergence of Machine Learning ML is also accelerating growth as it is applied to improve the design process[3].

3. JAPAN'S SEMICONDUCTOR MARKET

(1) Japan's Semiconductor Industry History[4] [5]

Japan has a long history in the semiconductor industry. Since the 1950s Japan was a player in this market competing with USA. After dominating the transistor radio market in 1960s, USA overtook the market with the invention of Germanium transistors

and ICs. Japan's market share fell to 30% in the early 80s however it succeeded to increase it to 52% in the late 80s and exceeding the American market. By the 1990s, Japan's market declined again to never retake its leading position till now. While 6 Japanese companies were in the top 10 semiconductor companies in 1989, that number dropped to 2 in 2006 and to 0 as of 2021. Several factors contributed to Japan losing its competitive advantage in the semiconductor industry.

a) Semiconductor Technology and Demand Shift

While Japan was a leader in DRAM Memory, demand started to shift to microprocessors and Logic LSI fueled by the demand for PC. Thus, DRAM market shrank.

b) Lack of Investment in R&D

After the "VLSI Project" that ended in 1980, The Japanese government did not take any initiatives to grow the semiconductor industry and to invest in it. No research projects or actions were initiated until 1995. The 1980-1995 period was dubbed '15 years in blank' where Japan did not pursue any growth initiatives. Meanwhile, other countries were investing heavily in this industry and creating research centers and collaborations between universities and industry players.

c) Business Model Change

Semiconductor companies at the time followed a vertically integrated model (IDM model) where all business operations were conducted in house. However, in 1990 TSMC revolutionized the industry by adopting a horizontally integrated model focusing only on the manufacturing operations (Foundry model). American companies such as Qualcomm started to focus on the design process (Fabless companies) and outsourcing production to foundries. This allowed TSMC to produce chips for different customers and to expand their operations.

However, Japanese companies did not change their business model. While Japanese companies such as Toshiba and Hitachi were world leaders in the 1980s, they were only using their semiconductors in their own products. As a result, with the decline of the electronic market the semiconductor market also declined, and they could not compete with TSMC.

d) Capacity Expansion Plans

Japan had a bad timing with its expansion plans. While Japan expanded their 6-inch wafer capacity in 1991, Korea opened 8-inch lines in 1993 enabling it to be more cost efficient.

e) US-Japan Semiconductor Agreement in 1986

The agreement consisted of increasing foreign semiconductor products in Japan from less than 10% to 20%. This decreased the domestic market significantly and allowed the entry of Korean made DRAM memory. The agreement helped boost Korean's market share and Korea overthrew Japan as the DRAM leader in 1998 until this day.

In conclusion, Japan did not adapt to the industry changes, and it was passive in strengthening its industry since the 1990s. Japan's Industry Ministry described the 1990-2022 as the '3 lost decades' and is finally ready to invest in revitalizing the industry.

(2) Japan's Market Growth

Japan's global semiconductor market share in 2021 was $43.69 billion, a 7.9% share from which 6% was for Integrated Circuit IC. Compared to Asia Pacific APAC, America, and Europe, Japan constantly ranked last since 2015 slightly trailing behind Europe with 8% to 10% share. APAC successfully held to 60-62% of semiconductor market share. The second largest market share holder is America with 16-22%[6].

Before COVID 19, from 2015 to 2018, Japan's market grew by 6.5% CAGR. America, APAC, and Europe were growing at 10.6%, 9%, and 5.8% CAGR, respectively. This leaves Japan in the third place slightly in the lead of Europe[1].

The semiconductor market started to recover slowly after COVID 19. From 2019 to 2021, Japan grew by 10% CAGR same as Europe and ranking last behind America and APAC with 21.6% and 12.9% CAGR, respectively. In 2021, Japan showed a below-average growth rate at 19.8% while other regions were witnessing a growth more than 26%.

Japan's market is estimated to reach $47.93 billion in 2022, first time surpassing $45.4 billion since 2008[2].

In conclusion, Japan was always ranked in the bottom in terms of market share as well as growth whether before COVID 19 or after. Japan's position was remarkably close to Europe, but never really exceeding it. That said, Japan and Europe hold very low positions compared to America and APAC. In terms of growth, we can conclude that America has the highest growth rate, threatening APAC region share.

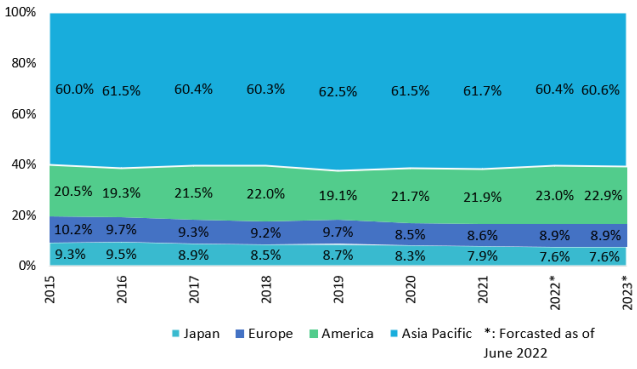

Fig.3 Semiconductor Market Share by Region 2015-2023.

4. SEMICONDUCTOR SUPPLY CHAIN OVERVIEW

The semiconductor value chain consists of 3 main activities: Design, Front End Manufacturing (Wafer Fabrication) and Back End Manufacturing (Assembly & Test). [7)]

In the Foundry business model, the production value chain is broken down between several players: Fabless, Foundry, OSAT (Outsourced Semiconductor Assembly & Test) and OEM (Original Equipment Manufacturers) companies.

- Fabless semiconductor companies and electronics manufacturers (and independent design companies): create the design and specifications required for the chips using Electronic Design Automation & Intellectual Property (EDA & IP).
- Foundries also called Fab: manufacture the designed chips with several equipment and materials.
- OSAT companies: assemble, package, and test the chips.
- OEM and contracted EMS (Electronics Manufacturing Service) companies: integrate the packaged chip into final products such as smartphones and laptops.

In the IDM (Integrated Device Manufacturer) business model, one company designs, manufactures and sells their own chips without outsourcing the activities[8)].

The semiconductor value chain segments represent different added values to the final ready- to- use manufactured chip. The design segment creates the most value accounting for 50% of total industry in 2019. Followed by wafer fabrication and Equipment with 24% and 11% respectively. OSAT, materials and EDA & IP segments have similar added values with 6%, 5% and 4% respectively[7)].

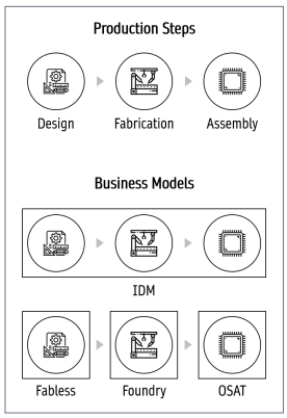

Fig.4 Semiconductor's Production Business Model.

5. JAPAN'S SEMICONDUCTOR VALUE CHAIN

(1) Design Segment

Japan has a weak global presence in the semiconductor design. In fact, Japan held a weak presence in the design of Memory. Also held a low share in Logic and faced competition from Taiwan, South Korea, and Europe. Japan better performed in DAO (Discrete, Analog and Other) design. The Design market is dominated by USA with around 70% Fabless market share[9)].

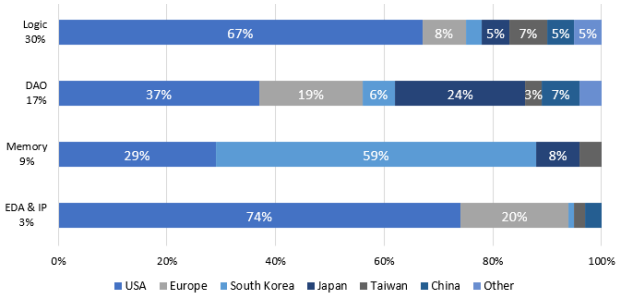

Fig.5 Design Market Share by Device in 2019.

(2) EDA & IP Segment

Japan does not have a presence in this value chain. In fact, USA dominates the EDA market with 3 companies: Cadence Design Systems, Synopsys, and Mentor. EDA vendors are concentrated in USA, controlling a 74% market share of EDA & IP in 2019 followed by Europe with 20%[10)].

Key IP players are from the UK (Arm, Imagination Technologies, Alphawave) and the US (Ceva, Silicon Storage Technology SST, Rambus)[7)].

(3) Front End Segment

Japan has a weak presence in the Front-End segment.

Asian countries dominate around 87% of the market in terms of semiconductor manufacturing (foundry market). Taiwan accounts for 63% of the foundry market. The Taiwanese company Taiwan Semiconductor Manufacturing Company TSMC is the largest chip manufacturer holding up to 54% global foundry market share and supplies to big companies such as Apple, Intel, and Nvidia. The second foundry market share holder is South Korea with 18% in which Samsung dominates by 17%.

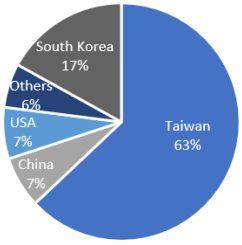

Fig.6 Foundry Market Share, 2021.

Japan has many semiconductor plants. The total number of major semiconductor plants in Japan in 2021 was 146. Japanese companies manufacture Sensors, Discrete and Optical Devices, Microprocessors, Memory, Logic, and Analog ICs. However, these plants are old and do not produce advanced semiconductors. In fact, of 146, 110 were built before the 1990s[11]. Currently, only TSMC and Samsung manufacture the most advanced 5-nanometer chips used in iPhones[12].

Japan's strongest areas are Discrete Power Semiconductors and NAND Flash Memory. In the 2nd quarter of 2021, Kioxia had an 18.3% NAND market share ranking second after Samsung (34%). However, in terms of regional market share Japan ranks 3rd with 23% after Korea (46.3%) and USA (32.4%).

Japan is among the leading Automotive IC suppliers (Digital and Analog ICs for Automotive Industry). In fact, 2 Japanese companies Renesas and Rohm ranked respectively 3rd and 10th in the top Automotive IC suppliers in 2019. However, this market is dominated by Europe[13].

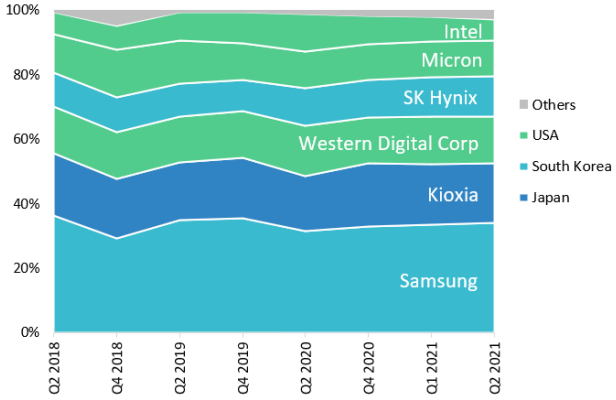

Fig.7 NAND Market Share 2018-2021.

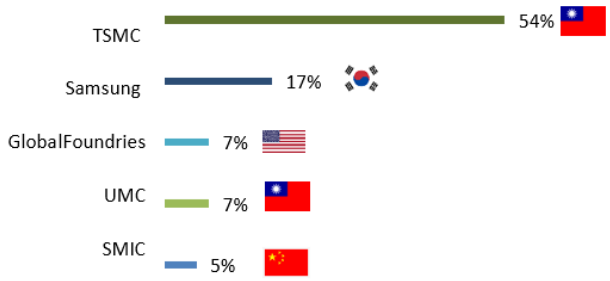

Fig.8 Top 5 Foundries, 2019.

(4) Back End Segment

Japan is weak in the OSAT (Packaging & Testing) segment. It had only 23 Assembly & Test facilities as of 2021 similarly to Europe (20 facilities) and South Korea (21 facilities). Thus, making it in the bottom rank of countries. Compared to Taiwan and China which had over 100 Assembly & Test facilities, Japan's presence is very low.

Taiwan dominated the OSAT market with a 20% global market share in 2021, ranking first in the world, followed by China[14].

(5) Equipment Segment

Japan is strong in this segment of the value chain. It ranked second with 23.2% equipment manufacturing market share in 2020 following USA (39%) and with Europe in 3rd position (18.3%).

The largest SME vendors are Applied Materials (USA), ASML (Netherlands), Tokyo Electron (Japan), Lam Research (USA) and KLA (USA) [15].

7 Japanese companies were in the top 15 SME. (Tech Insights, 2022) SMEs specialize in different segments of the value chain so each company has a different product portfolio. Tokyo Electron has a 100% share of the market for in-line coaters/ developers for extreme ultraviolet (EUV) lithography[11].

(6) Material Segment

Japan is strong as a Material supplier. The Material market is competitive but not as condensed as other markets. Several companies are players such as Kyocera Corporation (Japan) Showa Denko (Japan) Sumitomo Chemical Co. Ltd (Japan), BASF SE (Germany), Indium Corporation (USA) DuPont de Nemours Inc. (USA) etc.

For example, around 500 chemicals are used in the wafer fabrication process. Japanese companies are major suppliers. European companies are also important chemicals suppliers[8].

In terms of Silicon wafer, 5 companies control 90% of the market and Japanese companies dominate with over 50% market share.

6. INTERVIEW RESULTS

During this research period, interviews have been conducted with 3 Japanese Semiconductor Companies managers to assess the situation. The results offer insights on the Japanese companies' strategies and intake on the current semiconductor market difficulties and opportunities.

(1) Impact of COVID 19 on Japan's Semiconductor Supply Chain

According to the managers, there is no major effect of COVID 19 on domestic operations. This is thanks to the Japanese Government Anti-COVID measures that did not restrict mobility so much.

However, there are minor disruptions in global operations such as production suspension, supply disruptions and price increase. For example, delivery

time of Silicon carbide Sic went up from 1 year to 4 years.

(2) Possible Impact of the Russian- Ukrainian War Japan's Semiconductor Supply Chain

According to the managers, there is no immediate disruptions. First, this is thanks to strategic Neon inventory. Second, Japanese companies diversified from Ukrainian suppliers after some Neon supply disruptions around 2016. Currently, Japanese Neon Supplier Portfolio consists mainly of USA and China.

However, if the war continues around more than a year, then the inventory will not be enough, and some issues might rise. Besides, despite not being too dependent on Ukraine, the war is affecting the Japanese companies indirectly through impacting their suppliers. For instance, the price increase due to the war.

(3) Semiconductor Supply Chain Localization Intentions

According to the managers, it is difficult to localize the supply chain due to several challenges such as cost. Localization would require a huge amount of investment. Another challenge is the unavailability of an adequate talent pool. The Semiconductor Industry requires specific technical knowledge and skill. More issues include the company's global strategy, government support, land availability etc.

(4) Growth Areas to focus on

According to the managers, Japan should focus on its strong presence as an Equipment Manufacturer, Material Supplier, and Classical Semiconductor Manufacturer (Power semiconductors, Memory, Discrete, Analog, Optoelectronics, Sensors). The managers believe that strengthening Japan's position in these areas is feasible compared to investing in advanced nodes and innovative technology.

7. CONCLUSION

The semiconductor market is forecasted to keep growing as demand increases making it an attractive market to invest in. It will be a key market levering future innovation. That is why countries are racing to be global leaders in this market. The value chain is mainly controlled by USA, Taiwan, South Korea, and China with each region specializing in at least one segment of the value chain.

While Japan is strong as an Equipment Manufacturer, Material Supplier, these segments do not contribute as much to the added value as of the rest. Japan is strong as Classical Semiconductor Manufacturer, but these products do not hold a large share of semiconductor demand.

Japan's market share and growth is insignificant compared to USA and APAC.

As a result, Japan will face several challenges in pursuit of revitalizing its semiconductor industry and in increasing its global presence.

First, Japan should build a more resilient supply chain by minimizing the vulnerabilities unveiled by COVID 19 disruptions. While localizing the supply chain would deem unfeasible, a partial localization can help strengthen it.

Second, Japan should set its ambitions and growth objectives. Based on that, Japan should consider what semiconductor technologies to invest in. Disregarding the advanced technologies will not allow Japan to gain any significant role in the global value chain.

The continuity of this research will delve into more details about the best course of action to be taken to improve the competitive advantage of Japan.

This research focuses on Japan's semiconductor market, its strengths, and weaknesses amidst global disruptions. It gives insights on Japanese Semiconductor companies' strategies as well as the strengths of Japanese semiconductor supply chains and how it can be improved.

APPENDIX A INTERVIEW QUESTIONS

- What is the business model of the company?
- What is the approximate percentage of local production in Japan and outsourced production?
- How did Covid 19 impact the production capacity of semiconductors?
- What are the reasons for the impact?
- What is the approximate (before Covid 19) production lead time?
- How did Covid 19 impact the production lead time of semiconductors?
- What is the loss incurred by the change in production capacity and lead time of semiconductors?
- Were there any disruptions in material/equipment supply because of Covid 19?
- If yes, what type of disruptions?
- If yes, how did these disruptions impact production?
- Were there any transportation disruptions because of Covid 19? If yes, how?
- Were there any disruptions in Neon supply caused by the Russian- Ukrainian war?
- How do you evaluate this supply risk?
- How do you position Ukrainian Neon suppliers in the Supplier Positioning Matrix?
- How would you evaluate Japanese Semiconductor Supply Chain vulnerability to global disruptions?

- What are the challenges for shifting the semiconductor supply chain activities to Japan?
- What area should Japan focus on to improve its competitive advantage?
- Does the company have any intentions to localize its supply chain/ part of it in Japan?
- If yes, what is the value chain segment that the company is considering?

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(Received April 1, 2020)
(Accepted July 1, 2020)