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Economic Outlook on the APAC Semiconductor Industry

Global Markets Team – December 2022

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1. Introduction

Since the first quarter of 2021, severe semiconductor supply chain shortages have halted automotive production and are still causing various industries billions of dollars in lost revenues each month (Arora et al., 2022). Nevertheless, playing a pivotal role in many emerging economies, the global semiconductor market surpassed the 500 billion USD threshold last year after a 25.1% market revenue increase (Burman, 2022). This highlights not only the indispensability of the specialized components for critical products including all kinds of electronics, but also the divergence between supply and demand of integrated circuits worldwide.

Almost 75% of installed capacity for chip production is in Asia-Pacific, with the main market players being Taiwan, Japan, South Korea, and mainland China (Burman, 2022).

The Taiwanese semiconductor industry currently operates under market and technological leadership, with its core player TSMC being responsible for the vast majority of advanced semiconductor foundry. Nonetheless, challenges particularly with regards to technological progress and the geopolitical tensions with China could challenge the small island's ecosystem of microchip manufacturing. China's government has heavily subsidized the semiconductor sector with the goal to reach market leaders and eventually become self-sufficient, as it currently relies on its competitors for some parts of production. However, a possible invasion of Taiwan and export sanctions implemented by the US create uncertainty in the forecasts of this market. Furthermore, South Korea is currently facing uncertainty as the Chip 4 initiative develops, while the Japanese semiconductor industry is seeking independence in the market with subsidies from the government to reestablish itself as one of the main competitors.

Firstly, this report will cover the importance of the Taiwanese semiconductor market on the global supply chain. Then, China's role in the industry will be discussed and the implications that geopolitical tensions with the west and with Taiwan have on stock markets. Finally, other main competitors in the Asia-Pacific region, being South Korea and Japan, will be analyzed.

2. Economic Outlook for the Taiwanese Semiconductor Industry

Introduction

Taiwan is responsible for 92% of the world's most advanced semiconductor manufacturing of ten nanometers or below (Varas et. al, 2021). This small country has managed to become home to a whole ecosystem of companies contributing the fabrication of microchips, among which, most prominently, the Taiwan Semiconductor Manufacturing Company, short TSMC (Lee, 2021). To consider the impact of Taiwanese chip makers on not only its national economy but also for the global supply chain security of countless industries, an investigation into this ecosystem of companies and the challenges as well as the opportunities they face in the upcoming decades is paramount (Hille, 2022).

General Description

Taiwan dominates the global semiconductor market with 22% of overall market share, followed by South Korea and Japan with 21% and 15 %, respectively (Sevastopulo & Hille, 2022).

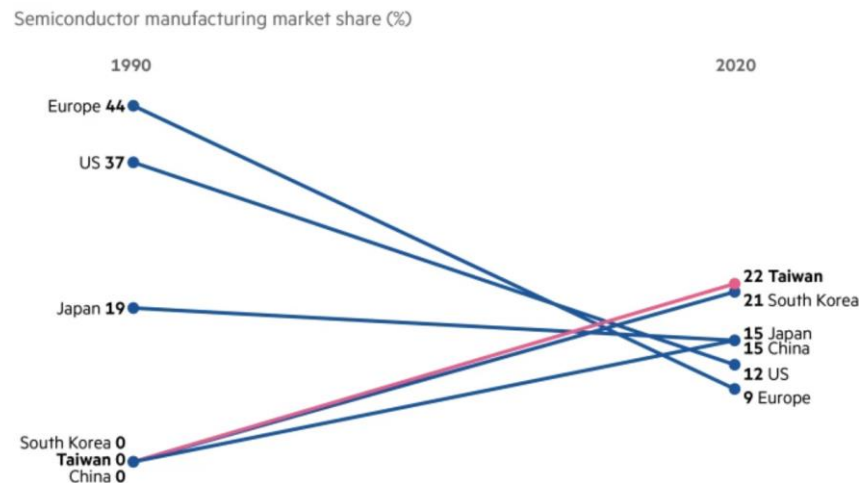


Figure 1: Taiwan developed into the leader of the semiconductor industry

Source: Sevastopulo and Hille, 2022

TSMC represents the heart of the Taiwanese microchip industry as it is worth more than 380 billion USD, currently being the most valuable company by market capitalization in the entirety of Asia (Sommer, 2022). The second major player is United Microelectronics Corporation (UMC), the first Taiwanese semiconductor company and competition to TSMC in semiconductor foundry (Sun, 2021). While TSMC attracts much more attention due to cutting-edge R&D and high-end positioning, UMC’s lower-end market focus enables stable growth and less capital, and, hence, less risky investment strategies (Sun, 2021). Other companies related to the industry are Foxconn, or Hon Hai Precision Industry, which is a multinational electronics contract manufacturer and the world’s largest (Hon Hai Technology Group, 2022). Furthermore, Global Wafers is the world’s third largest silicon wafer supplier and ASE Semiconductor Engineering is a provider in semiconductor services and tests (Global Wafers, 2022; ASE Semiconductor Engineering, 2021). Himax Technology and MediaTek are also relevant players in the Taiwanese market (Himax Technologies, 2022; MediaTec, 2022). In combination with a myriad of smaller suppliers, the aforementioned companies constitute the vast ecosystem of Taiwanese high quality chip manufacturing.

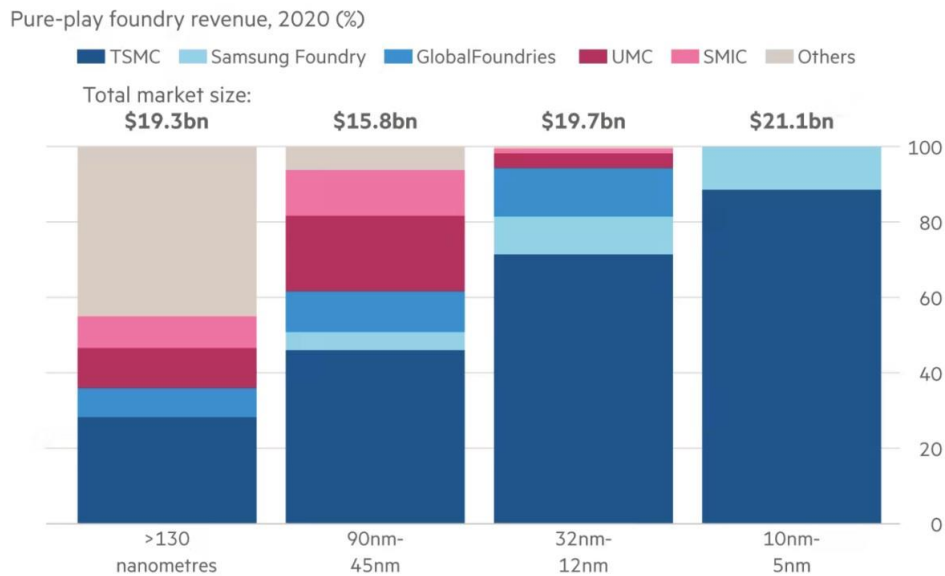


Figure 2: TSMC is dominating the advanced semiconductor technology foundry

Source: Hille, 2021

Taking a long-term perspective, TSMC’s future might not be as stable and secure as current popular opinion and valuation suggest (Hille et. al, 2022). Indeed, regardless of the Chinese threat, TSMC and the Taiwanese semiconductor industry face major challenges and could stumble as they are forced to develop new transistor technology (Hille et. al, 2022). In the past, making semiconductors faster and more efficient to allow for rapidly developing applications such as high-end gaming or climate change simulations was simply a matter of increasing the number of transistors packed on each chip (Shalf, 2020). Moore’s law, a techno-economic model and the principle that the number of transistors will double every two years, which in return enables explosive growth of processing power, is deteriorating (Shalf, 2020). In fact, MediaTek, a major smartphone chip design company, recently announced that the further miniaturization of chips to four nanometers (four billionths of a meter) led to an increase of a mere two percent in performance (Hille et. al, 2022).

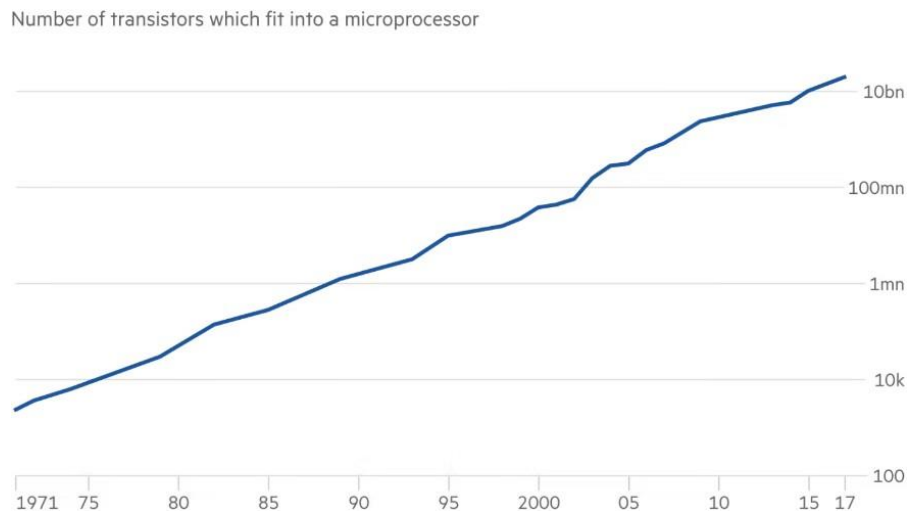


Figure 3: Moore’s Law and the Number of Transistors which Fit into a Microprocessor

Source: Hille et. al, 2022

To put it differently, as transistors reach atomic scale, chipmakers are increasingly coming closer to the laws of physics in terms of transistor density, and, hence, need to find technical alternatives. According to John Shalf (2020), head of Lawrence Berkeley National Laboratory, three different technology scaling paths exist, ranging from more efficient architectures and packaging, new materials and devices to new models of computation. The

grand challenge of identifying and developing efficient technological alternatives renders competition in the future semiconductor industry highly unpredictable and overall prone to volatility in market share and technology leadership (Hille et. al, 2022).

Additionally, considering the possibility of difficulty to move forward regarding technological advances, TSMC risks losing its leadership position. Hence, its current edge on competition from South Korea and the US could become less meaningful. It is vital for the Taiwanese semiconductor industry to stay ahead and safeguard their competitive technological advantage. Considering Chinese threats and geopolitical tensions in combination with the tendency of the west to decrease their supply chain dependence risks, selling an undifferentiated product will be lethal for TSMC and its suppliers. Although expansion strategies are considered and have been repeatedly emphasized, particularly by the US, TSMC produces the vast majority of microchips in Taiwan. Decreasing technological leadership would lead to a loss in sales and a shift of customers to competitors in South Korea and Japan to diversify away supply chain risks (Hille et al. 2022).

Considering the aforementioned need for internationalization of the Taiwanese microchip industry, it is worthwhile to take a closer look at the local banking system, which is a necessary component of resource intensive expansion strategies. In fact, Taiwan's financial sector lacks a global or regional bank that can support the industry in going global. This became evident just recently through another failed merger between a local financial holding company and a domestic bank in an overall environment lagging investment and particularly M&A activity. According to Chris Cottorone, president of a major Asia-based private investment company, this indicates the unwillingness of foreign investors to start entering the market. Even though efforts to consolidate the domestic banking system have occurred for more than 20 years, institutions controlled by governments still have majority power and fail to strengthen the financial system (Hille, 2022)

Financial Description

Looking at the stock performance of the main Taiwanese microchip producers and especially TSMC, it becomes obvious that the increasing demand of microchips through

changing technology landscape, combined with higher pricing power, are reflected in the development of share valuations. TSMC’s equity share’s value increased by a CAGR of 12.8% during the last five years. UMC’s share price CAGR in the same time period amounts to more than 23% while MediaTek exhibits a CAGR of 16.3%. Comparing this to the TWSE main index TAIEX (Taiwan Capitalization Weighted Stock Index) with a CAGR of 5.5% in the same time frame leads to the conclusion that the three main semiconductor companies in Taiwan have significantly outperformed their home country’s index. However, compared to an industry relevant ETF such as the iShares Semiconductor ETF tracking the investment results of an index composed of U.S. listed equities in the semiconductor sector, with a CAGR of 17%, reveals the average performance.



Figure 4: Relative performance (%) of TSMC (blue), UMC (green), iShares Semiconductor ETF (yellow) and the TAIEX (orange) over the last five years
 Source: TradingView (2022)

Outlook

Considering the above, TSMC and the overall Taiwanese microchip industry are rapidly growing and currently leading technologically and economically in the foundry for high-end microchips. However, it is crucial to keep the aforementioned limitations to Moore’s law in mind

and to expect future volatility and perhaps changing technological leadership. Additionally, there are two more factors to consider when evaluating TSMC's leading position in the future. Firstly, according to chipmakers, key tools and materials in use for the fabrication of semiconductors since decades will need to change significantly. Additionally, silicon, the base material of the industry will need to change. Hence, the outlook for the semiconductor industry is uncertain, with TSMC in the lead for now.

It is crucial to consider a potential invasion of Taiwan due to geopolitical tensions and the implications this may bring to its market. As this requires a new introduction into the conflict and the underlying presuppositions, this is done in the next section.

3. The Role of China in the Global Semiconductor Industry

Introduction

To further explore the impact of Asia-Pacific's semiconductor industry, the role of Taiwan's competitors will be analyzed. Due to increasing geopolitical tensions between Taiwan and China and the relevance this conflict imposes on global supply chains, the latter market will be explored. For this, firstly, China's semiconductor market will be introduced, followed by an explanation of how tensions with the United States and Taiwan come into play. Finally, an analysis of the effect this has on the Chinese financial market and the relevance this has for other Asian competitors will be conducted.

General description

China is the world's largest manufacturer of electronic devices, holding 36% of global production. For every one of these electronic devices, ranging from smartphones to cars and military systems, a semiconductor is needed. In 2020, China imported 378 billion USD worth of advanced chips, mostly from Taiwan, South Korea, Japan, and the United States. This is because demand significantly exceeds what it can produce domestically and China currently produces mostly low-end chips. However, this leads to a dependency on advanced chips made externally to their supply chains, which became increasingly noticeable with the semiconductor shortage that started during the COVID-19 pandemic. Therefore, to avoid such disruptions and keeping in mind the rising demand for chips, the fourteenth five-year plan issued by the Chinese Communist Party, covering 2021 to 2025, incentivizes technological autonomy. This includes semiconductor production (Wong, 2021).

Nevertheless, the semiconductor industry in China originated long before this. In the period from 2002 to 2014, the first Chinese-headquartered chip firms emerged. Goals for this sector were not formalized until 2014 when the government implemented the "Guidelines to Promote National Integrated Circuit Industry" and later in 2015 when the "Made in China 2025" plan was announced. After this, many subsidies have been given by regional and national funds to promote this industry and catch up with world leaders. These range from corporate income tax

exemptions for firms in this industry to the creation of funds dedicated to building over twenty chip manufacturing facilities (VerWey, 2019). In 2021, China still held less than half of Taiwan’s market share, with only 7.6% of global semiconductor sales. Yet, this is an increase from 5% sales in 2020 as seen in Figure 4. Of this percentage, the companies that contributed the most were HiSilicon and Semiconductor Manufacturing International Corporation (SMIC) generating 7.5 billion USD and 4.3 billion USD, respectively (Sukwanto, 2022).

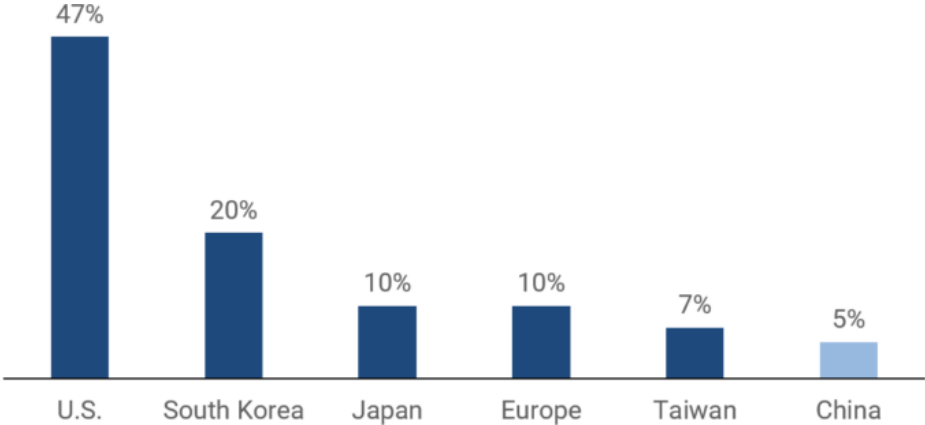


Figure 5: Market shares on global sales in the semiconductor industry in 2020

Source: Sukwanto, 2022

Even though China is currently behind its main competitors, according to a study by the Boston Consulting Group, the global semiconductor industry is expected to be more than doubled by 2030 with China accounting for around 60% of this growth (Williams, 2022). However, a politically and economically strained relationship with the United States serves as an impediment to this growth. In October 2022, the Department of Commerce’s Bureau of Industry and Security of the U.S. released a list of prohibitions on exports of semiconductors and other technologically advanced equipment to China. This list includes chip design software and equipment and extends to any firm that uses American semiconductor technology. Also, U.S. citizens and residents can no longer work at Chinese chip companies. With these sanctions, the Biden Administration intends to prevent China from acquiring the most advanced chips or machines necessary to make them (Bluhm, 2022).

Furthermore, an unsteady geopolitical context between China and Taiwan also contributes to the uncertainty of the future of the semiconductor industry. This ongoing conflict originates during the seventeenth century when the island was fully under Chinese control until 1895. The past two years, there has been a sharp increase in the fear of an invasion of Taiwan. In 2021, China sent military aircraft to Taiwan's Air Defence Zone, reaching 56 daily incursions. In August 2022, China declared six military exercise areas within a hundred mile range surrounding Taiwan (Brown, 2022).

An invasion of the Taiwanese island by China would disrupt global supply chains especially due to implications on the semiconductor market. Beijing would gain some control over TSMC, one of the world's most important firms in the technological sector. The U.S. National Security Council predicted that the loss of TSMC in the case of Chinese invasion would result in one trillion USD loss to the global economy (Zheng and Wang, 2022). Some officials claim that destroying TSMC facilities would be better than allowing China to take over it, however, Taiwanese officials mention this is not the case (Hilliard, 2022).

In response to this, Mark Liu, TSMC's chairman, explained how even if China would be successful, TSMC would become "not operable". This is due to the real-time highly integrated production ecosystem with the outside world and therefore any disturbance to chip production in Taiwan would result in a drawback for China's technologies as well. This leaves no "winners" in the context of a possible invasion (Zheng and Wang, 2022).

Financial description

As a consequence of the sanctions implemented by the U.S, there was a loss of 8.6 billion USD in Chinese chip stocks. SMIC fell 4% in Hong Kong and other smaller companies had more significant drops such as Shanghai Fudan Microelectronics with 20.2%. The Hong Kong Hang Seng index fell 3% and repercussions are also expected to be reflected in the Japanese, South Korean, and Taiwan markets, but are delayed compared to that of China (Lockett, 2022). These were most evident for the stock valuations of Taiwan's market leader TSMC due to fears of China taking control over their manufacturing facilities if the ongoing geopolitical conflict worsens. As observed in Figure 5, TSMC shares fell 8.3%, the most in twenty-eight years, to

NT\$401.5 on October 11 on the Taipei stock market in response to the U.S.'s sanctions on China (Zheng and Wang, 2022).

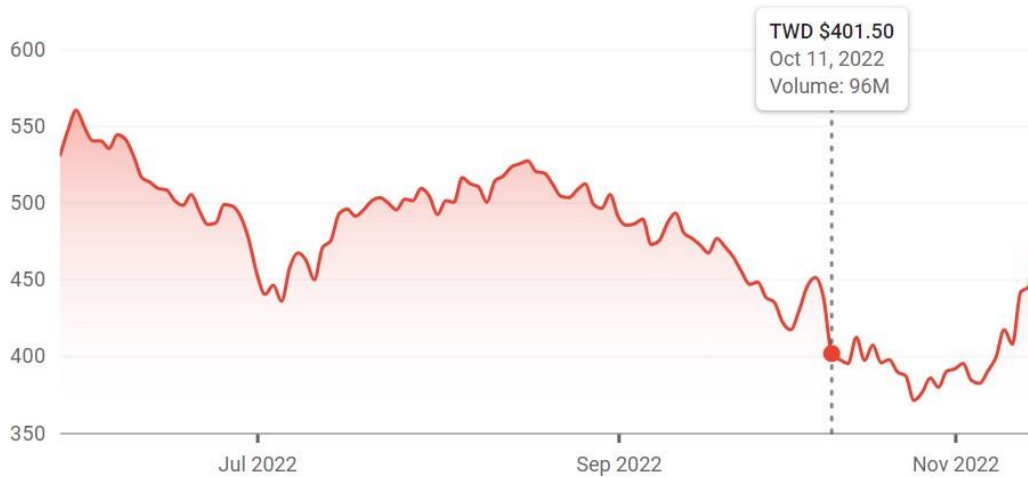


Figure 6: TSMC's stock market value from June 2022 to November 2022

Source: Google Finance, 2022

Outlook

Despite China's strong policies implemented to boost the semiconductor industry, including the National IC Guidelines, Made in China 2025, and the fourteenth five-year plan, there are significant threats to further augment this sector and catch-up with market leaders. With the recent U.S. exportation sanctions and the impossibility to benefit from a possible TSMC takeover, stocks have already fallen in both China and Taiwan. Developing a completely self-sufficient chip production will take years. China will lag behind even more as it is still unable to produce sufficient high-quality semiconductors and relies on what it imports. Global supply chains that rely on China may strongly underperform, resulting in possible distortions of the Chinese economy.

4. Other Main Players in Asia-Pacific's Semiconductor Market

Introduction

In addition to Taiwan's and China's relevance in the semiconductor industry, other competitors also take a pivotal role in the strength of Asia-Pacific's chip market. According to the International Trade Administration, Taiwan has a monthly capacity for producing semiconductors of 21.4%; however, two competitors are rising to this Asian giant as South Korea accounts for 20.4% and Japan for 15.8% (2022). Furthermore, these three countries have been experiencing constant competition in the exports of electronic components as Figure 6 demonstrates.

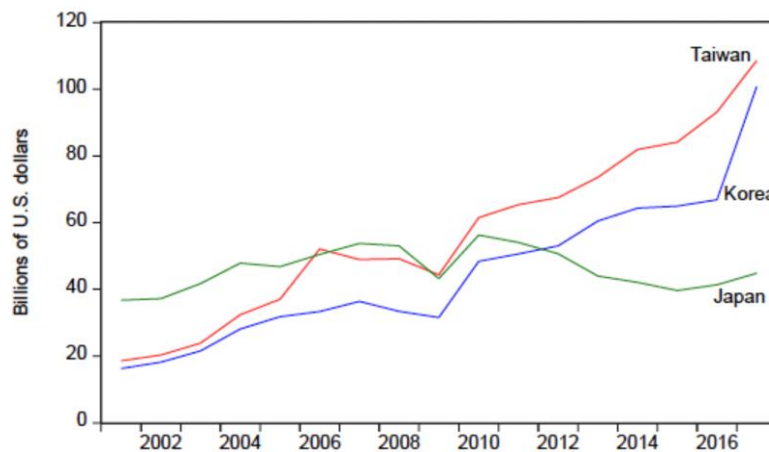


Figure 7: The value of electronic parts and components exports from Japan, South Korea, and Taiwan

Source: Thorbecke, 2019

South Korea

General description

South Korea currently stands as one of the main competitors in the semiconductor market, as portrayed in Figure 7. Kim explains that it is currently one of the most trade-reliant sectors for South Korea (2022), hosting some of the biggest semiconductor producers, such as

Samsung and SK Hynix. S President Yoon expressed intentions to further expand this sector by increasing the current quota and incrementing the number of specialists at engineering universities (Park, 2022).

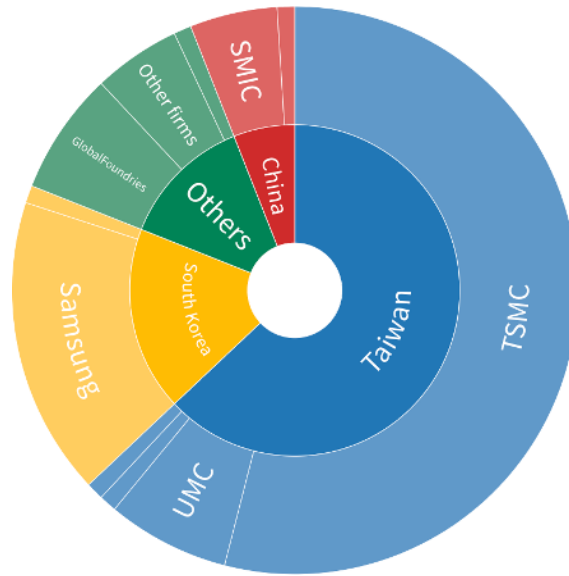


Figure 8: Semiconductor contract manufacturers by market share
Source: Lee, 2021

Despite these claims, according to Kim, semiconductor production in South Korea slid by 1.7% in August, which was the lowest since January 2018. This coincides with an inventory soar of 67.3% and a factory shipment drop of 20.4%. This suggests a cooling in the demand for electronics which supports Samsung Electronics Co.'s argument, stating that there is a discouraging outlook for the second half of the year (2022). The Chip 4 initiative aims to avoid this, as its purpose is to stabilize semiconductor supply chains through an alliance between Japan, South Korea, Taiwan, and the US. However, this potential partnership would exclude China and disrupt their economic ties with South Korea. This may not be beneficial to South Korea as 24% of their total exports are to China, of which 60% were of semiconductors. Also, Samsung and SK Hynix produce 20% and 40% of their semiconductors in China respectively (Howokawa and Hoyama, 2022).

Hence, the South Korean economy is at risk with increasing tensions between the US and China. Park explains the Chip 4 initiative will not only bring downfalls for South Korea, as they will need to seek new markets, but it will also cause a decrease in the growth of China’s Semiconductor Manufacturing International Corporation (SMIC) as they will not be included. Consequently, China will suffer from these drastic restrictions imposed in the international markets affecting their current production and growth (2022).

Financial description

The South Korean market has experienced a drop in the last months. According to Eun-Jin, the global market dropped US\$240 billion from October 7-11 due to the US restrictions imposed on China. As a result, the Korean firms Samsung and SK Hynix have decreased their stock price by 5% (2022). Furthermore, there has been an increase in the stock market of semiconductors due to the increasing number of foreign investors switching from the Chinese market to the South Korean market. Hence, the KOSPI has risen 9% in one month adding to this index 4.5425 trillion won, while the South Korean semiconductor stock absorbed a high share of the investment outflow (Young-Sil, 2022). Following what was previously mentioned, the South Korean semiconductor market is experiencing a bumpy ride due to the slow number of orders (Ji-Hyoung, 2022). Figures 9 and 10 portray this as they show a downstream trend in the last year.

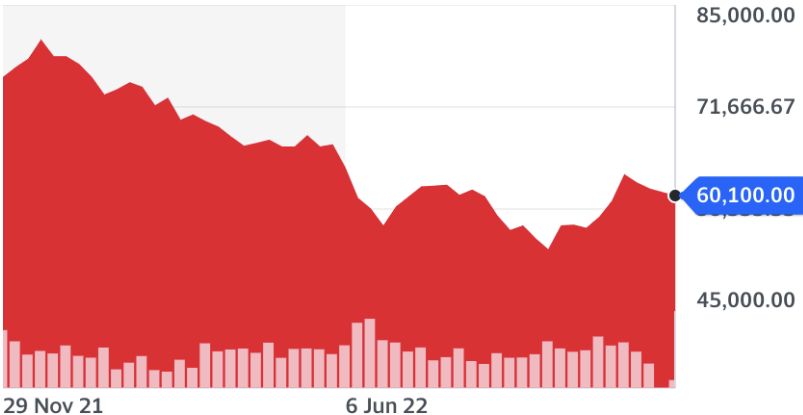


Figure 9: Samsung Electronics Co. stocks (currency KRW)

Source: Yahoo Finance, 2022



Figure 9: SK Hynix stocks (currency KRW)

Source: Yahoo Finance, 2022

Japan

General description

The Japanese semiconductor industry has been a significant competitor over the last three decades. According to Uno, from 1970 to 1990, Japan was responsible for most of the semiconductor industry, accounting for 51% of the global sales in 1988. However, due to the failure to adapt from the traditional vertical model to highly specialized firms, like TSMC, the Japanese semiconductor market has struggled to recover, leading to a decline in market share (2022). Also, Thorbecke explains that the appreciation of the Japanese yen and the depreciation of the New Taiwan dollar led to a comparative advantage for South Korea and Taiwan, yet a disadvantage for Japan (2019).

On the other hand, Dooley and Hisako explain that Japan possesses some essential products for developing semiconductors, such as chemicals and silicon wafers, in which they hold a monopolistic position. Nonetheless, they still lack the expertise in cutting-edge chips compared to South Korea or Taiwan (2022). Additionally, the Japanese sector of ceramic capacitors, produced mainly by Murata Manufacturing, has not experienced a disadvantage concerning the competition with Taiwanese ceramic capacitors. This is because they manufacture high-end products compared to Taiwan's and therefore there is less price competition (Thorbecke, 2019). This proves that Japan still has relevant market power in some niches as compared to certain Asian countries without being influenced drastically by exchange rates.

Furthermore, the Japanese Government is seeking coalitions with the US and the EU to build a less geographically concentrated semiconductor supply chain (Dooley & Hisako, 2022). Togashi explains that Japan's position in the semiconductors market is set to improve as Prime Minister Kishida approved ¥774 billion in 2021 to support the semiconductor home production. However, they also approved a ¥400 billion subsidy to TSMC's new foundry in Kumamoto, Japan (2022). This could be an act of seeking independence in the semiconductors market to prioritize Japan's economic security and improve its comparative advantage and position in the market.

Financial description

According to Wagatsuma, the MSCI Japan/Semiconductors & Semiconductors Equipment Index jumped 14% in October (the best month in over two years). This accomplishment has occurred since the Japanese firms faced limited impact over concerns of rising interest rates and sector valuations compared to the tight regulations imposed on Chinese exports by the US. Furthermore, the Japanese firms increased over four times more compared to the US semiconductor stocks analyzed through the Philadelphia Semiconductor Index. Also, the best performer was the Japanese firm Lasertec Corp. dedicated to ultraviolet lithography chipmaking with a 45% increase in stocks (2022).

Outlook

The South Korean market appears to be more stuck as the stocks from the major competitors in the semiconductor industry, Samsung and SK Hynix, are experiencing an irregular road with an uncertain forecast due to the tension between the Chinese and US trade war. Moreover, South Korea's future has a tight relationship on how the political situation for China will resolve and their decision to be part of the Chip 4 initiative. On the other hand, the semiconductor market for Japan looks brighter as the MSCI Japan index shows an increase in the share price, and the in-house political measures will benefit this industry to reposition itself in the market.

5. Conclusion

In a nutshell, realizing the importance of semiconductors from an economic, geopolitical and technological perspective is crucial. Taiwan currently leads the way, however, the disturbance of Moore's law combined with international efforts to decrease supply chain risks and a local dysfunctional banking system pose significant future challenges to TSMC and the Taiwanese semiconductor ecosystem.

Despite their increasing fear from a possible invasion by China and how they may take over major semiconductor firms, from an economic perspective, this does not result in a benefit for either country. Even if it already decreased TSMC's stock value, Taiwan's heavily integrated production will not allow China to gain from this. The impossibility to secure economic advantage from taking over Taiwan's semiconductor sector combined with export sanctions by the US to China have decreased stock values of SMIC, Shanghai Fudan Microelectronics, and other Chinese-based firms due to the increasing uncertainty in the market. Nevertheless, some predict relevant growth in the Chinese semiconductor market in the upcoming decade, but at the moment it is still significantly behind its main competitors.

Moreover, the South Korean markets of semiconductors look uncertain as the Chip 4 alliance remains unresolved, and the potential economic outcome for both China and South Korea could be more compromising than beneficial. On the other hand, the Japanese market looks more promising as they are currently investing in the infrastructure of this industry in their country and transitioning from a material supplier to a semiconductor developer.

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