Growth of the Chinese Semiconductor Industry

Jaehee Choi

Abstract

This research paper discusses the current state of the semiconductor industry in China, how the Chinese government has invested in the industry to increase its production capacity and quality of semiconductors, and the impact of US policies on the growth and development of the Chinese semiconductor industry. It further examines the components of the semiconductor manufacturing process, the countries' involvement in the process, and the implications of the US-China trade war on the semiconductor industry. Additionally, it analyzes the Chinese government's policies to accelerate the growth of the industry, the effect of Chinese labor costs on the industry, and the potential of the Chinese semiconductor industry to become a major player in the global semiconductor industry. Finally, after examining economic growth statistics, politics and policies, international trade, and other aspects of the semiconductor industry, the paper concludes and recommends how China can continue to grow its semiconductor industry in the long term, and what this could mean for its future economic growth. All in all, the following paper provides a comprehensive overview of the semiconductor industry in China and its potential to become a major player in the global semiconductor industry.

Introduction

The semiconductor industry is one of the most important industries in the world. It is a key driver of economic growth, innovation, and development. While the Chinese semiconductor manufacturing industry has grown exponentially since the late 1980s, it is still only a small part of the global semiconductor manufacturing industry (Bao, 2020). As demand for electronic products has grown, the semiconductor industry in China has become increasingly important. The Chinese government has invested heavily in the industry. By providing tax incentives, subsidies, and other financial support, the government hopes to expand the country's production capacity and quality of semiconductors (Thomas, 2015). This has allowed the industry to invest in new technologies and expand production capacity. As a result, China is now a major center for research and development of new semiconductor technologies. By partnering with international corporations, China has acquired advanced technology and machinery to manufacture semiconductors efficiently. The semiconductor industry in China is now a major source of jobs, investment, and economic growth. China is now home to the production areas that require intensive Capital expenditure and labor, such as raw materials, wafer fabrication, and APT. However, the US semiconductor industry leads the market in areas that demand intensive R&D, such as EDA (Electronic Design Automation), core IP (Intellectual Property), chip design, and manufacturing equipment (Thomas, 2021). As a result, the US brings in 47 percent of global sales of semiconductors, by far the most. To retain its current position, the US is imposing trade restrictions on semiconductor imports and exports from China ("Will China", 2022). These restrictions have deterred the growth and development of the semiconductor industry in China despite continued efforts.

Review

China has become a major player in the semiconductor manufacturing industry over the last few decades but still lags behind other countries. The Chinese semiconductor industry is heavily reliant on foreign technology and imports and has not yet been able to catch up with the more advanced technology that other countries have. To understand why this is the case, an understanding of the semiconductor manufacturing process is necessary. The semiconductor manufacturing process involves several steps and takes place in a variety of countries. The first step is wafer fabrication, which is often done in more advanced countries such as the United States, Taiwan, and South Korea. This step involves creating the semiconductor chips from silicon wafers, which are cut and shaped. The second step is packaging and assembly, which is usually done in countries with low labor costs, such as China, Malaysia, and the Philippines. This step involves packaging the chips in protective cases and assembling them into more complex systems. Finally, testing and quality assurance, often done in countries such as Japan, is the last step. This step tests each chip and ensures the quality meets industry standards. As demonstrated by the process, countries like the US, Taiwan, and South Korea, which are all countries with sufficiently developed infrastructure to manufacture semiconductors, execute the process of creating the core of the semiconductors. Whereas China is responsible for packaging and assembly, a straightforward process with little technology and machinery requirements. As a result, every year, China imports more than $300 billion (US) of semiconductors (“Will China”, 2022). Major American semiconductor companies source 25% of their sales from the Chinese market (Orr, 2014).

China does not have access to the required technology and machinery to manufacture semiconductors at an industrial level. China has $< 1\%$ of electronic design software, semiconductor tools, and materials needed to produce a semiconductor (Bao, 2020). Additionally, China has a $< 1\%$ share in the most important end-product categories, such as logic chips (Bao, 2020). These chips are advanced memory chips used to store mass amounts of data. While China has made significant progress in recent years, it still has a long way to go in terms of developing its own technology to produce more advanced chips. The Chinese government has taken steps to encourage more domestic production and research and development through its market policies, but the country still relies heavily on US foreign technology and imports. As a result, China is still behind other countries in terms of semiconductor manufacturing.

To accelerate the growth of the Chinese semiconductor industry, the government has instituted a wide range of policies in the past decade. These numerous policies can broadly be divided into five categories. First, financial incentives. The Chinese government has offered various financial incentives to attract foreign investment in the semiconductor industry. The National Industrial Investment Foundation and provincial organizations determine how to allocate the investments. These organizations will make investments in a variety of areas, including project financing, local and international acquisitions, as well as customary tax breaks and subsidies for R&D. Second is technology transfer (Thomas 2021). After the government attracts foreign corporations to China, the Chinese government encourages foreign companies to transfer their

advanced technologies to local Chinese companies. Leading local foundries like Shanghai Huali Microelectronics Corporation, SMIC, and XMC are in a prime position to benefit from the growth of a true technology cluster (Thomas 2021). As global giants like Samsung, Taiwan Semiconductor Manufacturing Company, and Texas Instruments establish operations in China, these benefits have materialized. This helps the local industry to catch up with the global market. Third is domestic manufacturing.

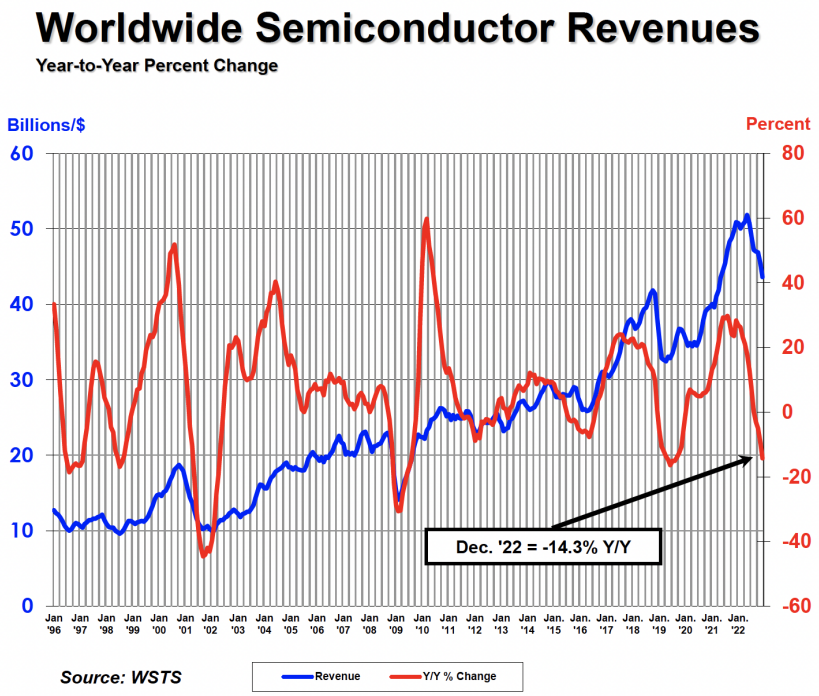
In addition, the Chinese government has implemented policies that encourage domestic companies to manufacture semiconductor components within China. This helps to keep the industry competitive and reduce reliance on foreign imports. Fourth is mergers and acquisitions. The Chinese government has encouraged domestic semiconductor companies to engage in mergers and acquisitions with foreign companies. This helps to bring the latest technologies and expertise to the local market. Lastly, intellectual property protection. The Chinese government has implemented a number of policies to protect the intellectual property of semiconductor companies operating in the country (Bao 2020). This helps to ensure that local companies are not taken advantage of by foreign competitors. Moreover, the Chinese government has refined its policies, learning from past mistakes that led to fragmentation issues. The government will concentrate on developing national champions—a small group of leaders in each crucial sector of the semiconductor market (including design, manufacturing, tools, assembly, and testing). For instance, the Beijing Economic and Technological Development Area is home to a 300-millimeter fab being constructed by SMIC, a renowned foundry with its headquarters in Shanghai (Bao 2020). The business announced a combined investment of $1.2 billion and inked cooperation agreements with the federal, state, and municipal governments.

Overall, these new policies have been largely a success, unlike their predecessors, which led to fragmentation issues. As a result of their intense mergers and acquisitions, China's back-end manufacturing market share has nearly quadrupled since 2015 to 40% market share of global back-end manufacturing of semiconductors (“Will China” 2022). Back-end manufacturing is the labor-intensive process wherein a processed semiconductor wafer is divided into individual chips, packaged, and furnished with electrical connections. Moreover, Chinese firms' market share in fabless design has also almost doubled, mostly due to HiSilicon, the semiconductor division of Huawei, the largest Chinese manufacturer of consumer electronics. As a result, China now currently competes in almost every phase of the supply chain, including chemicals, materials, tools, and production (“Will China” 2022). However, some of their technology still lags behind corporations of other nations. The Chinese semiconductor sector will surely grow more competitive during the next ten years. There remains extensive untapped potential within the Chinese semiconductor industry. However, whether this potential will be reached depends on the strategies and execution by Chinese engineers.

International trade has supported China’s expansion in the semiconductor industry through the acquisition of foreign intellectual property. However, not all trade partners support this growth. Most notably, rising tensions between China and the US are impeding the growth of the Chinese semiconductor industry. These tensions are the greatest threat to China’s continued development of its semiconductor manufacturing. US foreign policy is intent on sustaining its position as a world leader in the semiconductor industry. China poses a threat to US supremacy. For example, the Trump presidency has developed international trade policies that would inhibit

the technological advancement of China (Amaro, 2023). Moreover, another motive of the US in developing these policies stemmed from the belief that China is a threat to global security. The continued expansion of their technology would only further threaten global security. America's battle with Chinese telecom giant Huawei exemplifies this position. The US has long accused this company of posing a threat to national security due to its close ties with the Chinese government and its alleged spying. The US has imposed a number of sanctions on Huawei. In 2018, the US banned the export to the Chinese firm of American microchips essential for its products. It appears that this had the desired outcome. For the first time in ten years, Huawei's revenues decreased by over thirty percent in 2021. However, China adapted. They began to develop their own chips instead of importing them from the US. To combat this, the US established the EU-US Trade and Technology Council in June of 2021. During the council's initial meeting in Pittsburgh, Pennsylvania in September, a joint statement announced its desire to work together to "rebalance" international chip supply chains. This implied the common desire to keep China from controlling the semiconductor supply chain. For example, when the Dutch semiconductor company ASML attempted to sell its most sophisticated tools to SMIC, the largest chipmaker in China, the American and Japanese governments formally pressured the Dutch government. Capitulating to this pressure, the Dutch government ultimately blocked the export of ASML's machinery and technology to China.

Conclusion and Reccomendations



Although China may still lag behind other countries in their capability to design and manufacture semiconductors, the government should continue investing to support long-term economic growth in China. As the diagram above shows, the semiconductor industry still has enormous potential as its worldwide revenues have steadily grown since 1996. According to the Semiconductor Industry Association, annual sales of semiconductors increased by 313 percent

from $139 billion in 2001 to $573.5 billion in 2022 (Casanova, 2023). Moreover, another study by the Semiconductor Industry Association and Boston Consulting Group (BCG) projects an additional 56 percent increase in global demand for semiconductor manufacturing capacity by 2030. Semiconductor firms will need to make greater investments in research, development, and production to meet this continued long-term trend of chip demand in the coming years. Without a doubt, there will be hindrances along the way, as the US will likely continue to impede China's growth in the semiconductor industry.

Another important point of discussion is the fact that China's low-cost labor era is coming to an end. According to GlobalData, China's labor cost index, which "measures change over time in wage and salary cost for employee jobs, unaffected by changes in the quality or quantity of work performed," increased by 37.1% between 2010-2021. China is losing its competitive edge on cheap labor, the primary aspect that induced colossal economic growth. Research by the Reshoring Institute concluded that China could no longer be considered a low-labor-cost country as its labor costs have risen significantly over time. Furthermore, there has been speculation that China has reached the Lewis Turning Point. The Lewis Turning Point is when the manufacturing industry fully absorbs excess rural workers during periods of economic growth. Very often, as the Lewis Turning Point is reached, there is a shortage of rural labor, which causes upward pressure on the wages of unskilled labor. As China's average wage level has tripled between 2005 and 2016, IMF economists speculate that China will encounter the Lewis Turning Point anytime between 2020 and 2025 (Shah, 2014). Hence, China will reach the Lewis Turning Point very soon if they have not already reached it. This is a serious problem for China. China can no longer rely on its enormous population for cheap labor, which was its key competitive advantage in the world economy (Coates, 2023).

Nevertheless, even with foreign firms moving production to other countries, such as Vietnam and Mexico, China remains the "World's Factory," responsible for 28.7% of global manufacturing output, by far the greatest market share of any country ("China's grip", 2018). However, the latest data shows that China's market dominance is being slowly eroded. In 2019, the Chinese manufacturing sector accounted for nearly 30% of its total economic output. China needs to reduce this reliance to induce economic growth in the long term. Therefore, China needs to shift to manufacturing and designing more advanced goods, such as semiconductors. Other countries, such as the US and South Korea, have made this switch and achieved immense economic growth. China's continued efforts to expand the semiconductor industry will be instrumental in determining its ranking among economic superpowers in the coming decades.

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