



Exploring the Global Trends in Semiconductor Supply Chain Development from the Perspective of US-China Relations

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Abstract. In the global news, there is malicious speculation regarding the strategic harm of other countries in the China-US trade war. However, this article takes an analysis from the perspective of the chip industry to examine the hazards, opportunities, and development trends of the global supply chain within the context of intense geopolitical factors. It discusses the convenient speculation and fragile contradictions in the current state of globalization, considering economic theory, government policies, game theory, and other aspects. Through such an analysis, it aims to provide a clearer understanding of the intricate relationships within the supply chain, while reminding individuals to analyze the underlying fears and make more rational predictions about international conflicts.

Keywords: Chip supply chain, globalization downturn, China-US trade, technological containment.

1 Introduction

Since World War II, Texas Instruments collaborated with the U.S. Air Force on missile projects. The combination of microelectronics and explosives showcased the significance of technological prowess and military power, propelling the world from the era of coal and steel into the atomic age. The immense power of computation was realized, leading to a growing demand for computing, and sparking a competition among nations in the development of hardware infrastructure.

As a rapidly evolving industry, even a slight lag in product innovation can swiftly lead to obsolescence for companies. Thus, timeliness in industry advancements becomes crucial. From silicon-based semiconductors to transistors, and further to integrated circuits, there has been a progressive move towards miniaturization. The introduction of Moore's Law in 1965 became the semiconductor industry's guiding principle. Scientists diligently developed more sophisticated technologies year after year to transition from laboratory experiments to large-scale production, painstakingly fulfilling Moore's prediction. With the proliferation of chips, the industry entered the realm of consumer applications. "The number of transistors that can be accommodated on an

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integrated circuit doubles approximately every 18 to 24 months." Simultaneously, as semiconductor technology became commercialized, the finance and venture capital sectors entered the industry, giving rise to emerging tech companies in Silicon Valley.

Initially, the business model primarily revolved around in-house production and sales. However, as chip categories became more specialized, each iteration of logic chips, memory chips, and analog chips increased the demand for higher-cost wafer fabs. No single enterprise could sustain the entire industrial investment process. It was not until Morris Chang was attracted to Taiwan and took advantage of inexpensive labor and favorable policies to establish TSMC (Taiwan Semiconductor Manufacturing Company), that the separation of semiconductor design and manufacturing began. Gradually, the global semiconductor supply chain took shape. Jerry Sanders also initially resisted separating AMD's business, but as the need for technological investments multiplied, collaboration with manufacturers proved more effective in achieving performance results. Eventually, AMD shifted its focus to graphics cards and mobile communication markets [1]. Today, the chip industry chain mainly consists of design, manufacturing, and packaging, with core technologies in design software and chip design being largely controlled by Silicon Valley. In the midstream manufacturing industry, TSMC holds about 60% of the high-end production, while Samsung, Sony, and Japan also have a certain market share. China currently produces the most advanced chips at 28 nanometers, limited to mid-to-low-end manufacturing, design, and packaging work mainly handled by Southeast Asian countries [2].

TSMC's advantage lies in its focus solely on chip manufacturing, without any overlapping interests with EDA software and chip design companies. Companies like Cadence, Synopsys, Ansys, and Keysight are more willing to collaborate with foundries such as TSMC, while Samsung, Intel, and other companies possess both electronic design and manufacturing divisions. In this industry chain, no country can achieve self-sufficiency. The United States lacks advanced lithography technology, skilled labor for chip manufacturing, and a significant number of chip manufacturers and fabs. China's position is in the middle and downstream, and throughout the history of chip development, it missed the opportunity to lead due to policy reasons in the 1960s and 1970s, resulting in its current status as a country that develops its industry passively. Some enterprises have attempted to rise, such as Zhang Ruimin's SMIC (Semiconductor Manufacturing International Corporation), which utilizes its resources to attract engineers from Taiwan and the United States to develop the industry in the mainland using a strategy of combining experienced and new talent [1]. While ZTE's penalty for violating regulations received government protection, the contraction of the industry has had a significant impact on the company. The intensifying competition between China and the United States in chip technology has been escalating, with the implementation of the U.S. Chip and Science Act in August 2022 further exacerbating the situation. Taiwan, caught between these two major powers, has also demonstrated a firm stance due to TSMC's influence.

2 Weakening of International Governance and the Rise of Technological Nationalism

For the United States, the primary concern lies in maintaining its industrial competitiveness on the international stage [3]. Starting with the technological advancement strategy led by Alexander Hamilton in the 18th century, the United States has focused on developing industries and manufacturing, successfully surpassing Britain to become a global hegemon. The book "Chip War" also mentions that while the United States and its allies possess advanced technologies in the chip industry, the increasing precision of manufacturing processes, reaching levels below 1-2 nanometers, has led to a bottleneck in sustaining Moore's Law, and the growth in chip demand in the United States does not match its manufacturing capabilities [1]. Based on these two points, there is a need for greater caution and vigilance regarding the development of developing countries, particularly China, to prevent potential "theft" of existing technological achievements under the guise of cooperation. Moreover, China's government provides full financial and policy support, fostering a close relationship that could potentially surpass the United States in industry development.

Secondly, the United States faces significant internal class disparities, with increasing income inequality between the working class and capitalists. Joseph Stiglitz argues that this is also due to the government's failure to regulate and intervene effectively, resulting in a decline in economic vitality and loss of competitiveness. Furthermore, pressures from interest groups require the United States to constantly address social welfare and related issues. Since the Obama administration in 2009, the United States has considered global supply chain security as a national strategy and proposed the concept of "reshoring" manufacturing. The subsequent Trump administration prioritized "America First" and aimed to create more job opportunities.

In response to the risks posed by the international status of industrial competitiveness, there is a growing call for trade protectionism in the United States. The analysis by Paul Samuelson on U.S.-China trade in 2004 and the analysis by Albert Hirschman on the global economic depression of 1973 have become theoretical foundations for some researchers and policymakers in the United States [4]. This has led to the development of the concepts of "Samuelson's fear" and "Hirschman's trap" by Joseph Nye to explain the current international environment. The state capitalist relationship between the Chinese government and its enterprises has resulted in unfairness in the global market and could distort free markets and disrupt international order due to its limited capabilities [5]. While Samuelson's theory of "conditional trade" is rigorous and logical, it has certain limitations. However, in the current heightened sense of crisis, it has been used as a theoretical basis for trade protectionism. The United States is closely linking national security, technology, and geopolitics as a response to the current situation, under the guise of new technological nationalism.

The implementation of bills such as the "Endless Frontier Act" and the "Chip and Science Act" has cast doubts on the United States' willingness to lead the world as a hegemon. Technological nationalism and free trade globalization are in opposition [3]. Technological nationalism advocates for government intervention to actively support and protect technological advancements, representing a shift by the United States from

the interdependence of global liberalism toward a realism-driven approach with trade discrimination.

3 Global Industrial Chain Decline and the Formation of Interest Communities

Since the 21st century, globalization has led to economic interdependence among nations. However, countries, as independent entities, are always seeking their own self-interests. Developing countries strive to find breakthroughs to join the ranks of developed countries, and the world economic environment is constantly changing. Developed countries have relatively stable economic environments and better social welfare, but their development pace is comparably slower. Developing countries follow the path of agricultural and manual industries, industrialization, and the service sector, gradually progressing alongside the world. As an industry of the electronic information era, the technological revolution drives the advancement of the service sector. However, this progress also poses threats to the interests of other nations. Once such contradictions arise, dominant countries make efforts to restrain their development and weaponize the global industrial chain [6]. This phenomenon is particularly evident in post-Cold War organizations, as seen in the continued impact of US restrictions on technology exports to members of the Wassenaar Arrangement [7].

Imposed restrictions from the United States put pressure on its allies, forcing them to make passive choices. Prior to the supply chain disruption in 2020, Huawei HiSilicon was the second-largest customer of TSMC, accounting for 14% of its total profits. In 2021, ASML derived 15% of its revenue from China but had to give up due to US component pressure [7].

After the chip legislation was enacted, the Chinese government attempted to reduce its dependence on the US by "de-Americanizing" Silicon Valley. However, China still heavily relies on the supply chain for high-end chips and faces many obstacles in terms of technological upgrades [8]. For example, 95% of imported EDA software comes from US companies such as Cadence, Synopsys, and Mentor Graphics. ASML, based in the Netherlands, has a virtual monopoly in the photolithography market. Japan and the Netherlands suspended the sales of immersion lithography machines and chip materials to China from the end of 2022. The domestic 14nm process still requires the continuous importation of related equipment and materials. Recently, the official website of SMIC (Semiconductor Manufacturing International Corporation) temporarily removed its 14nm foundry services.

The actions taken by the United States against China have created opportunities for some third-party multinational semiconductor companies to receive subsidies for investment in the US or to sell products in China. Moreover, the total production capacity of foreign and Taiwanese companies' fabs established in mainland China is comparable to that of local mainland manufacturers. Therefore, the United States faces difficulties in containing China's ability to attract foreign investment. For example, Israel is the only developed country that has not signed the Wassenaar Arrangement, and it has

strong complementary characteristics with China. Thus, industrial cooperation between the two nations is possible.

On the contrary, in the early stages of the semiconductor industry, countries such as Taiwan, South Korea, Japan, and the Netherlands established connections with Silicon Valley. Although their overall scale may not match that of the United States, they dominate or have a significant share in corresponding industry sectors. This forms a group of interest communities based on the perceived common interests and worldviews of nations, resulting in regional dependency alliances in the globalized supply chain. It is no longer a matter of purely treating the globalization of supply chains as a comparative advantage with equal treatment, but rather a complex interplay of politics, national circumstances, and development goals.

4 Conclusion

Why is the United States increasingly imposing sanctions on China? Firstly, it arises from the crisis in its own technological development and the sense of urgency brought about by unreasonable policy and economic rules. Secondly, it is due to China's traditional technological nationalism, which has transitioned from being a manufacturing powerhouse to becoming a technology powerhouse, evident in areas such as rare earth minerals and the global deployment of 5G, where it possesses competitive advantages. This shift has made the US political sphere realize that it is no longer as simple as subsidizing weak countries to develop and utilizing comparative advantages in the economy.

From the aircraft and artillery in the Vietnam War to the microelectronic weapons in the Persian Gulf War, semiconductor technology has become a key player in the ongoing economic war between China and the US. The level of attention generated by Nancy Pelosi's visit to Taiwan reflects the irreplaceable significance of TSMC in the global chip supply chain. It is challenging for the US to build large-scale fabs domestically in the short term, but it is also concerned about the geographical risks associated with Taiwan and South Korea, with which it has cooperative relationships.

Looking at these international situations and the actual development of industries, it boils down to the strategic development of each country and the market share of high-tech companies. Following a series of US sanctions, it becomes essential for us to have a more rational understanding of the current global situation. In an environment where national security issues are increasingly sensitive, how to prudently handle the potential crisis of the free market and the government's guidance, how to balance the advantages and disadvantages of international cooperation relationships for domestic enterprises in the face of globalization and its transformations, and ultimately, how to avoid being eliminated in this semiconductor technology war are the key considerations for countries around the world.

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