The Impact of Semiconductor's Technology Regulations from the U.S., Japan, and the Netherlands on China's Economy

Jiann-Chyuan Wang

Vice President & Director, The Third Research Division, Chung-Hua Institution for Economic Research

Yu-Chun Ma

Assistant Research Fellow, The Third Research Division, Chung-Hua Institution for Economic Research

Abstract

This article analyzes the impact of restrictions imposed by the U.S., Japan, and the Netherlands on China's semiconductor exports. The restrictions include the *Chips and Science Act* and technology controls, as well as the controls imposed by the Netherlands and Japan on China's exports of semiconductor-related equipment and raw materials. It then discusses the potential impact of these regulations on China's semiconductor development, including chip production independence and the possible impact on the development of advanced manufacturing processes and related industries. Finally, it analyzes the influence of these regulations on Taiwan and how to respond to it.

Keywords: Semiconductor, Chips and Science Act, Technology Regulation, Equipment and Material Control, Chip Production Independence

I. Introduction

With the outbreak of the Russia-Ukraine war, the grand strategy of the U.S. has become increasingly clear. It aims to weaken Russia's military power and to curb the rapid rise of an increasingly belligerent China. Amid all this, global technology and the economy have become more relevant than ever.

In key areas, especially semiconductor technology, the determination of the U.S. to prevent China's rise is quite obvious. The recently passed U.S. *Chip and Science Act* demonstrates the ambition of the U.S. government to enhance local manufacturing capabilities and weaken China's rise in high-end manufacturing processes.

With China's Semiconductor Manufacturing International Corporation (SMIC) claiming to be able to develop 7-nanometer (nm) chips, and concerns that advanced manufacturing processes may be applied to missile technology and military platforms, the U.S.' technology control has become more stringent. The export of technology and equipment below 16nm to China requires that a firm first apply for a license. High-level semiconductor talents with American citizenship are also forced to choose sides: refuse to work in China, or work in China and consequently lose their U.S. citizenship. This wave of regulations in the U.S., which have been expanded from individual companies to overall technology and equipment exports, added to talents regulation, will have a major impact on the global semiconductor industry and related industries. In addition to the U.S., Dutch equipment, Japanese materials and equipment have also joined the U.S. in ceasing exports to China.

Semiconductors have become Taiwan's sacred mountain for protecting the country, and exports account for nearly 35% of its total exports (see Table 1). This has had a decisive impact on Taiwan's exports, investment, and industrial competitiveness (see Table 2). Therefore, geopolitics are influencing the policy development of several countries and cannot be ignored. Although Taiwan has powerful capabilities in IC design, wafer foundry, packaging and testing, it still relies on imports of materials, equipment and technologies from Japan, Europe and the U.S. (see Table 3). Under the pressure of this internal and external environment, we must pay close attention to any disturbance in global semiconductor policies and respond effectively in order to maintain Taiwan's long-term competitiveness.

With these factors in mind, this paper analyzes the U.S. *Chip and Science Act* and technology regulations, as well as the impact of export regulations from the Netherlands and Japan on China's semiconductor industry. This paper has four sections. Following the introduction, section II discusses the impact of the U.S.

Chip and Science Act and technology regulations on China. Section III analyzes the influence of Japanese and Dutch semiconductor restrictions on Chinese industries. The last section provides concluding remarks.

Table 1. The Importance of Taiwan's Semiconductor Industry

Items	Rate
Share of manufacturing industry's production value	about 20%
Share of manufacturing industry's employment	about 20% (Accounting for 7% of the total employed population of the country)
Share of its exports over Taiwan's total exports	34.8%
Share of its trade surplus over Taiwan's trade surplus to China	70%

Source: Compiled by this paper.

Table 2. Detailed Output Value of Taiwan's Semiconductor Industry

Unit: 100 million U.S. dollars, %

Items	2021			2022(e)		
	Amount	proportion	annual growth rate	Amount	proportion	annual growth rate
IC design industry	12,147	29.76	42.4	13,848	28.81	14.0
IC manufacturing	22,289	54.60	22.4	27,264	56.73	22.3
Foundry	19,410	47.55	19.1	24,076	50.09	24.0
Memory and other manufacturing	2,879	7.05	51.0	3,188	6.63	10.7
IC packaging industry	4,354	10.67	15.3	4,750	9.88	9.1
IC testing industry	2,030	4.97	18.4	2,200	4.58	8.4
IC Industry ouput value	40,820	100.00	44.0	48,062	100.00	17.7

Source: Wang Jiann-Chyuan, "Advantages, Disadvantages and Prospects of Taiwan's Semiconductor Industry and Supply Chain," paper presented at the Taiwan-Japan Economic Industry Exchange Seminar (Taipei City: Chung Hua Institution for Economic Research and Mizuho Bank, April 28, 2022).

Table 3. Key Indicators for Global Semiconductors

The global IC design industry has a scale of about 120 Billion US dollars

The main manufacturers are from the United States, with a market share of 64%

Three of the world's top ten IC design manufacturers are Taiwanese: MediaTek, Realtek, Novatek

Country	Global market share on an enterprise basis							
	IDM	IC desidn	foundry	Parkaging and testing	EDA	IP	Equipmemt	Materials
United States	50	64	9	10	70	92	42	11
Taiwan	2	18	64	40	-	-	-	22
South Korea	30	1	17	3	-	-	4	16
Japan	8	1	-	4	2	2	32	19
European Union	9	1	-	-	5	5	18	12
Others	-	-	5	3	-	-	-	4
China	1	15	5	40	1	1	4	16

Source: Wang Jiann-Chyuan, "Advantages, Disadvantages and Prospects of Taiwan's Semiconductor Industry and Supply Chain."

II. The Impact of the Chip and Science Act and Technology Regulations on China's Semiconductor Industry

This section discusses the *Chip and Science Act*, the content of technology regulations, and their possible impact on China's semiconductor industry.

1. Chip and Science Act

To prevent China's rise in the high-end semiconductor manufacturing sector, the U.S. has implemented the *Chip and Science Act* and blocked China through the Chip 4 alliance. However, the U.S. *Chip and Science Act* not only subsidizes and provides tax incentives for local and foreign semiconductor manufacturers to invest in the U.S., but also imposes additional conditions, requiring manufacturers receiving U.S. subsidies not to invest in or expand advanced manufacturing processes below 28nm in China. In retaliation, China has in turn proposed that semiconductor manufacturers that receive U.S. subsidies be barred from investing in China, set up new factories or expand old

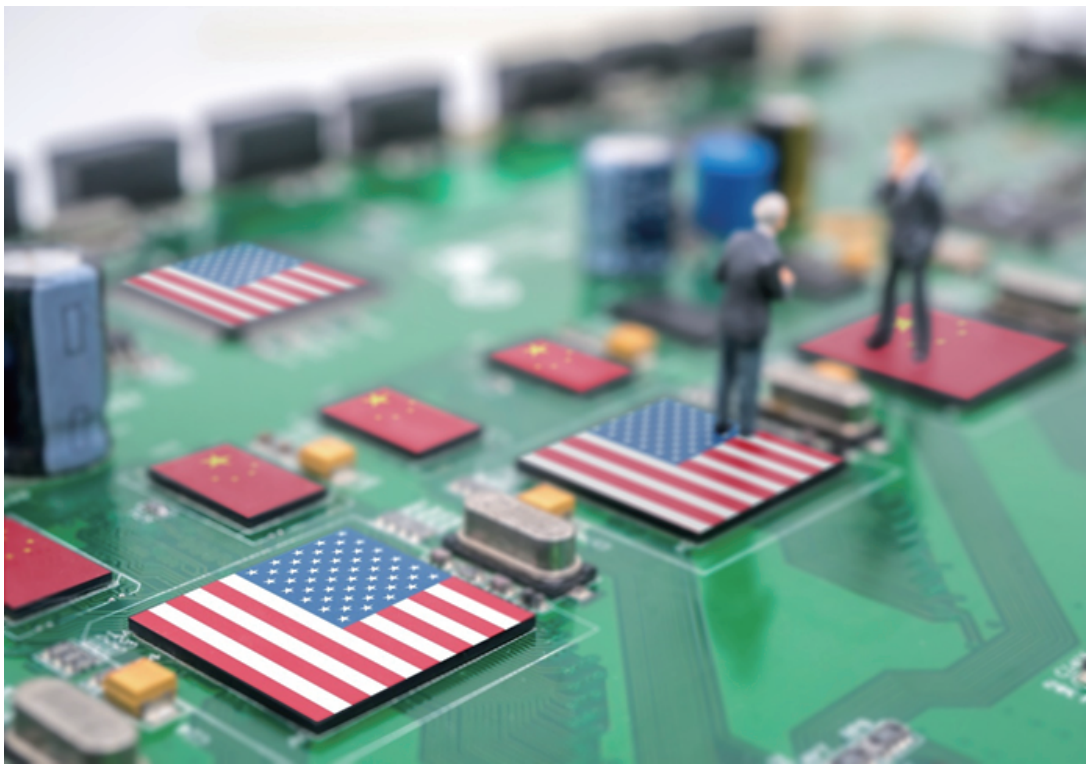

Figure 1. The U.S. Chip and Science Act

Source: Depositphotos.

factories. The resulting geopolitical controversy has forced Taiwanese, South Korean and the American manufacturers to take sides. Inevitably, they will have to sacrifice a certain share of the China market.

The *Chip and Science Act* provides about $52 billion in subsidies for semiconductor factories investing in the U.S. for production and research, as well as four-year tax incentives of about $24 billion. In addition, $200 billion will be provided to promote scientific research and development over a period of ten years to facilitate competition with China, of which more than $80 billion will be allocated to the National Science Foundation (NSF). Subsidies, tax incentives and investment for the entire chip bill are about $280 billion. However, subsidized manufacturers are not allowed to invest or expand their investment in semiconductors below 28nm to China within the next ten years. This huge package of subsidies, investment, tax

incentives, and additional restrictions also represents the ambition of the U.S. to develop its semiconductor industry, as well as its determination to use technological chips to prevent the rise of China's semiconductor industry. This *Chip and Science Act* has substantial influence. Its impact on the future global semiconductor industry is analyzed below.

First is the determination of the U.S. government to localize the U.S. semiconductor industry. In the past, the U.S. focused on investment in IC design, semiconductor-related equipment, and intellectual property with higher profit margins abroad, and outsourced semiconductor manufacturing, packaging and testing with lower profit margins abroad. However, due to the impact of COVID-19, as well as geopolitical developments such as the U.S.-China technology war and the Russia-Ukraine war, chip chains were disrupted, affecting high-tech, weapons, and missile technology. Therefore, it is necessary to subsidize domestic and foreign manufacturers to manufacture semiconductors in the U.S. to reduce the impact of geopolitics on the U.S. and strengthen the chips and technology related to national security. Besides Intel and TSMC investments in Arizona, Samsung is expected to invest and set up a factory in Texas, Micron will invest $40 billion to produce advanced memory chips in the U.S., and Global Foundries will invest in expanding production of semiconductors in New York. In addition to subsidies and maintaining a relationship with the U.S. government, serving customers nearby and avoiding U.S. restrictions on technology and equipment are also a crucial factor. After the U.S. encouraged the above-mentioned manufacturers to invest in production, key chips used in the military, aerospace, and high-tech sectors will be produced in the U.S. By doing so, the U.S. can reduce the broken supply chain and reduce the geopolitical risks.

Second is the fight against China's rise in advanced semiconductor manufacturing. China's SMIC shocked the U.S. government by claiming it could develop 7nm chips without DUV equipment. In order to maintain the core competitiveness of science and technology, the U.S. government's control over semiconductors in China, including the export of advanced technology and equipment, will also become more stringent. In terms of export controls aimed at China's semiconductor equipment, it will also be expanded from the current 10nm to 14nm. Technology regulations will also be revised down from 7nm to 14nm to effectively

suppress China's semiconductor industry. In addition, the U.S.-Japan-Taiwan-Korea Chip 4 alliance is currently being formed. Once the alliance is established, it is conceivable that in future advanced semiconductor manufacturing processes, equipment, software, key components, certain consumer products, and so on will be controlled and not exported to China. It will effectively widen the competitiveness gap between the U.S. and China in the semiconductor sector. The future direction of the U.S. policy will require allied manufacturers to de-centralize advanced manufacturing processes and decentralize mature manufacturing processes. This development trend could become the new normal.

2. Scope and Influence of Technology Regulations

According to the latest technology control order announced by the U.S. government, the U.S.' efforts to suppress the semiconductor sector in China have expanded from the "point" (limited to specific companies) to a wide range (including technology, equipment, technology exports, and talents regulation). These export controls and limits on personnel represent a comprehensive containment of the Chinese semiconductor industry, a "zero-clearing policy" of U.S. semiconductors against China. Table 4 details the technical regulations adopted by the U.S.

Table 4. U.S. Regulations on China's Latest Semiconductor Technologies

Control direction	Content
1. Prohibition of outflow of technology/equipment	Logic chips made below 16nm, memory below 18nm, flash memory equipment with more than 128 layers and related technologies must obtain an export license to China.
2. Banning China's use of supercomputer technology	Supercomputers (machines capable of performing 10 floating-point operations per second within 41,600 cubic feet), and applications that obtain chips with computing capabilities exceeding 4,800 teraflops, are regulated.
3. Control of Talent Export	Restrictions on U.S. citizenship or permanent residency (green card) persons: (1) Do not support the development or production of chips in China's semiconductor factories; (2) Chinese returnees working in China's semiconductor factories must choose between giving up their American citizenship or leaving their jobs.

Source: Table content is compiled, and part of it is revised with reference from Hou Liang-Ru, Tan Wei-Sheng et al., "Full Analysis of Chips War," *Today Weekly*, No. 1348, October 2022, pp. 56-68.

The impact of U.S. technology regulations on the semiconductor industry in China and Taiwan is as follows:

(1) China will make every effort to develop mature process manufacturing capabilities

As the U.S., the Netherlands, and Japan jointly restrict China's access to key semiconductor manufacturing equipment, materials and technologies, China's own development of advanced process manufacturing capabilities will be frustrated, and it is expected to attempt to fully develop mature processes using lower technological levels. Since the threshold for mature process manufacturing technology and equipment manufacturing is relatively low, and China already has mass production capacity, it is bound to fully develop equipment development and manufacturing capabilities related to mature processes.[1]

According to the "*Announcement on Promoting the High-Quality Development of the Semiconductor Industry and Software Industry Enterprise Income Tax Policy*" issued by the Ministry of Finance of China in December 2020, the main purpose is to develop the technologies, key materials and equipment required for mature manufacturing processes. If the manufacturing process is below 130nm, the income obtained according to different manufacturing processes and different operating years can be exempted from corporate income tax, up to ten years. It shows that under the U.S. containment policy, China has shifted the focus of semiconductor development to mature manufacturing processes.

(2) Taiwan's mature process manufacturers will face greater threats

Under these circumstances, China is trying its best to develop mature manufacturing processes due to the U.S.' strengthening containment. This constitutes a new threat for Taiwanese manufacturers. With the relatively low threshold for mature manufacturing process technology and low equipment purchase costs, there will be more manufacturers with commercial mass production capabilities, and most of them are concentrated in Taiwan, such as United Microelectronics Corporation (UMC) and Vanguard.

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1. Wang Jiann-Chyuan, "The U.S. Chip and Science Act must be filed by the government," *Business Times*, A2, August 23, 2022.

If China is fully dedicated to a mature process, it will inevitably grab orders from UMC, Vanguard and other firms. Establishing technical barriers and maintaining customer relationships will be serious issues for Taiwanese operators.

The impact of technology regulations on semiconductors in China and Taiwan are shown in Table 5.[2]

Table 5. The Impact of Technology Regulations on Semiconductors in China and Taiwan

	Influences
Impact on China	(1) Comprehensive controls on technology, processes, equipment and personnel, as well as restrictions on terminal applications, will contain the development of China's semiconductor industry. (2) Comprehensive restrictions on the development of China's high-end semiconductor manufacturing process, will affect the application of high-end computing and supercomputers, AI, 5G, 6G, and missile technology. The above restrictions will have devastating effects on China's development of advanced military-equipment. (3) To regulate American technical personnel as well as China's returnees to support China's semiconductor in R&D and manufacturing. As a result, the lack of high-level talents will restrict China's independent research and development capabilities and reduce its ability to compete with the U.S.
Impact on Taiwan	(1) Semiconductor manufacturing, export, and trade surplus have a huge impact on Taiwan, and any drastic changes will hurt Taiwan. (2) The semiconductor business is declining, and the *Chip and Science Act* and technology regulations will make the situation even worse. (3) Taiwan has become a geopolitical center (cross-Strait tensions). Countries and major manufacturers are seeking to diversify risks. They will go overseas to set up factories. The worries about brain drain and industry hollowing out will come up (4) Fierce competition from Chinese semiconductors in mature manufacturing processes. (5) Any impact on Taiwan's export and trade surplus will affect Taiwan's economy, the stability of the NT dollar and foreign direct investment (FDI), and could even result in the withdrawal of foreign capital in Taiwan.

Source: Table content is compiled, and part of it is revised with reference from Hou Liang-Ru, Tan Wei-Sheng et al., "Full Analysis of Chips War," pp. 56-68.

2. Wang Jiann-Chyuan, "The Impacts and Responding Strategies of U.S. Chips and Science Act and Technology Regulations," *Industrial Magazine*, December 2022, pp. 3-11.

III. Restrictions by Japan and the Netherlands

1. Japanese Regulation

The Japanese government is expected to implement export controls on six types of equipment used to manufacture wafers, covering cleaning, deposition, annealing, lithography, etching, and testing. When the restrictions come into effect, ten companies, including Tokyo Electron, a major Japanese semiconductor manufacturer, will be affected.

The latest measures focus on advanced semiconductor manufacturing equipment, with the Extreme Ultraviolet (EUV) equipment needed to make semiconductors also included. These 23 items contain: three types of cleaning equipment, 11 types of thin film deposition equipment, one type of annealing equipment, four types of lithography/exposure equipment, three types of etching equipment, and one type of testing equipment.

2. Dutch Regulations

In addition to the world's most advanced EUV equipment being banned for export to China, under pressure from the U.S., the Dutch government has agreed to set up a limit for Deep Ultraviolet (DUV) exports to China. The world's largest manufacturer of DUV, EUV machines, ASML, must now obtain permission from the Dutch government before exporting those to China.

Table 6 highlights contents of the agreement reached by the U.S., Japan, and the Netherlands.

3. Impact

The U.S. has persuaded the Dutch government to cooperate in restricting exports of key items to China, mainly ASML's second largest product line - immersion DUV. Although DUV is not the most advanced exposure model, it can still achieve 7-20nm process technology with multiple exposure technology, which is expected to become a potential loophole in the blockade of China's advanced process.[3]

Table 6. Agreement between the U.S., Japan, and the Netherlands on Controlling the Export of Technical Equipment to China

Date	Contents
2023.01.27	The U.S. Japan and the Netherlands have reached a consensus that Japan and the Netherlands will apply some of the export control measures to China initiated by the U.S.: 1. The U.S. maintains the control measures of 2022.10.7. 2. The Japanese government announced revisions to the "Foreign Exchange and Foreign Trade Management Law" on March 31, and listed 23 items such as cutting-edge semiconductor manufacturing equipment as export control items, involving cutting-edge products used in film formation, exposure, etching, and cleaning process equipment. For example, manufacturing equipment for extreme ultraviolet (EUV)-related products and etching equipment for three-dimensional stacking of memory elements (necessary for manufacturing cutting-edge products below 10nm to 14nm). Export to China requires special permission from the Ministry of Economy, Trade and Industry. 3. The Dutch government announced that the export of chip equipment to China before this summer will be expanded from advanced extreme ultraviolet (EUV) machines to second-order deep ultraviolet (DUV) machines.

Source: Organized by this paper.

Restrictions on China's manufacturing process may be expanded to 28-45nm. Once the Netherlands cooperates with the U.S. on the export ban to China, it will not only affect China's 10-20nm process, but the 20-45nm process as well. Once China is unable to obtain follow-up, it will be very difficult to expand production for the 28-45nm process, which is currently in high demand in the market.[4]

However, China is unlikely to give up on the development of its semiconductor industry; the ban and restrictions will cause Chinese local industry players to accelerate their transition to mature manufacturing processes. If the development of manufacturing processes below 45nm is further restricted, it is estimated that China will concentrate on 55nm and accelerate the procurement of corresponding dry-type DUV machines for processes of more than one meter.

3. "ASML: 2022 Q3 report on the impact of Holland's technology prohibition," December 20, 2022, *Statement Dog*, <statementdog.com/blog/archives/13157>.

4. "ASML: 2022 Q3 report on the impact of Holland's technology prohibition."

Among them, in IC manufacturing, although the Chinese government promotes localization, it is limited by obstacles such as the development of semiconductor manufacturing equipment. It is estimated that the current localization rate of chips in China is below 20%. Negotiations are still in process. If the Netherlands and Japan finally cooperate with the U.S. in banning the export of DUV, the chip production of China's mature process will be greatly affected. The Chinese government's goal – to achieve a semiconductor self-sufficiency rate of 70% in 2025 – may be hard to achieve.[5]

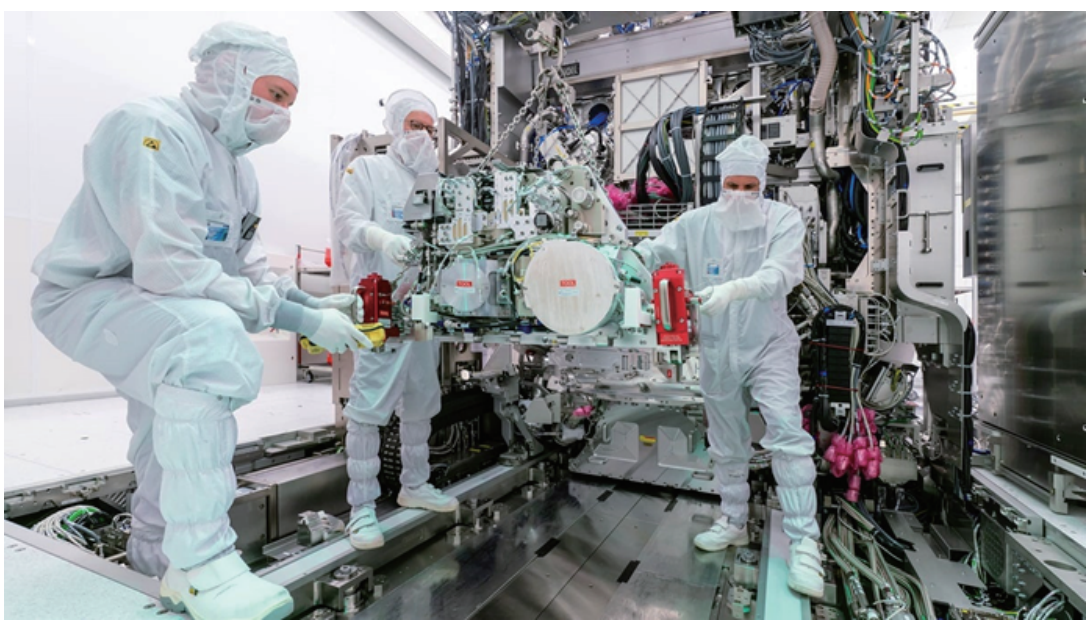

Figure 2. The U.S. Persuades the Netherlands to Restrict Exports of EUV to China

Source: ASML, "The road to EUV," May 22, 2023, accessed, *ASML*, <https://www.asml.com/en/products/euv-lithography-systems>.

In the semiconductor market in 2020, 28nm processes and above accounted for two-thirds of the market. It is obvious that mature process chips can meet the needs

5. Zhuang Mao-Jie, "SEMI Warning: USA cannot stop DUV equipment exporting to China, red supply chain can still engage in price war," February 3, 2023, *The News Lens*, <thenewslens.com/article/180528>.

of home appliances, communications, transportation, consumer electronics and other fields, which also shows the importance of mature process for the development of various applications.

Once the Netherlands and Japan restrict the export of DUV equipment to China, the chip expansion plans of companies such as SMIC will be hindered, due to mature processes being greatly affected. The development of related applications will also be negatively impacted. For example, automotive chips mostly come from mature processes. New green energy vehicles are not only a key industry for China's future development, but China is also the largest market for such and the leader in lithium batteries. As a result, when the production of mature process chips is restricted, it will also affect the development of China's new green energy vehicle industry.

On the whole, the U.S. hopes to cooperate with Dutch and Japanese companies to expand export controls on China's semiconductor equipment, further delaying China's chip production and research and development. If the U.S. strategy succeeds, the development of China's semiconductor industry will be severely hit. Not only will the localization progress fall seriously behind, but the development of related industries will also be affected.

IV. Concluding Remarks

With the comprehensive controls over China's semiconductors by the U.S., Japan, and the Netherlands, the competitiveness of China's semiconductors will be greatly frustrated, and the goal of chip independence will also be delayed. Without advanced chips, China's competitiveness in missile technology, weapons systems, as well as AI and 5G will be undermined. As a consequence, the pressure on U.S. technology and the military will be reduced, and the pressure on Taiwan's semiconductor high-end process and IC design will be relieved. However, the high-end manufacturing process cannot be exported to China, which will inevitably affect the revenue of Taiwan's high-end manufacturing process in China. At the same time, the revenue of European and American manufacturers in China will also be revised down, which will impact their subcontracting orders for Taiwan's semiconductor foundry.

In addition, if China is unable to purchase advanced manufacturing processes and equipment, it is bound to fully invest in mature manufacturing processes, which will crowd out Taiwan's business opportunities in mature manufacturing process foundry and IC design area. Taiwan's government must therefore take precautions in advance and seek alternative markets.

Taiwan must come up with a countermeasure as soon as possible. This is also the point of view that Tsai Ming-Kai, chairman of MediaTek, who has repeatedly called on the government to invest more resources in the development of semiconductors and put forward the Taiwan version of the *Chip Act*.