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BI-HUEI TSAI
National Yang Ming Chiao Tung University, Taiwan

PEI-PEI WANG
National Yang Ming Chiao Tung University, Taiwan

THE IMPACT OF THE SEMICONDUCTOR EXPORTS BANS TO CHINA ON THE STOCK PRICES IN TAIWAN'S SEMICONDUCTOR INDUSTRY

Abstract:

This study finds that the U.S. sanctions on Chinese semiconductors result in significantly negative abnormal returns for Taiwan's semiconductor industry, including the upstream IC design sector and the midstream manufacturing sector. The U.S. sanctions enable investors to expect the difficulty of Taiwan’s IC design industry in obtaining orders from Chinese companies. Investors sell the stock of Taiwan’s IC design industry, so the stock prices of Taiwan’s IC design industry decline substantially. Negative abnormal returns are generated during the announcement of U.S exports bans to China. The impact of U.S. sanctions on Chinese semiconductors is obviously more significant on Taiwan's upstream IC design industry than on the midstream manufacturing and downstream packaging and testing industries. Conversely, the gap between IC manufacturing and packaging industries is small.

Keywords:

Semiconductor; Event Study; Stock Prices; Sanctions; Abnormal Return

JEL Classification: G18, E44, F13

1. Introduction

This paper explores how the announcement that U.S. restricts Taiwan exports advanced semiconductor exports to China affect the abnormal return of Taiwan's semiconductor firms. Schneider–Petsinger et al. (2019) pointed out that the origin and development of the US–China trade war can be traced back to longstanding disputes over global trade rules and technological hegemony, which center on competition for global technological leadership. During the Trump administration, the United States criticized China, accusing it of excessive trade surplus, infringement of intellectual property rights, and forced technology transfer, while China questioned existing global standards and institutions and sought to create a new paradigm in setting technical standards. China's policies and efforts in the high-tech field threaten the United States' longstanding technological hegemony, and in particular, its Made in China 2025 plan threatens the competitiveness of the United States and Western countries in the high-tech field. Bown (2020) pointed out that the reason why the US–China trade war has evolved into a chip war is mainly because of the core position of semiconductor technology in the global economy and national security. The United States regards its semiconductor technology as a strategic asset and China's investment and rise in the semiconductor field has gradually put the United States' leading position in harm's way. In this context, the United States has adopted a series of measures to limit the outflow of its semiconductor technology to China (Kapustina et al., 2020; Liu and Woo, 2018). These measures are not only designed to protect the United States' technological advantages but also aimed at weakening China's military capabilities by restricting its developments in the global semiconductor industry.

Globalization and the closeness of economic ties are such that financial crises and trade wars affect nonparticipating countries through multiple channels, especially when national securities markets are involved (Claessens and Forbes, 2004). Itakura (2019), through model simulation, pointed out that the US–China trade war may intensify the US's trade deficit with China in the long run and may lead to a decline in global real GDP. This trade war has created trade opportunities for other countries and has had a positive impact on their exports (Fajgelbaum et al., 2022; Zeng et al., 2022). Semiconductor technology is the core of modern economic and military power. Controlling its supply chain is tantamount to controlling the lifeblood of technological innovation. The United States has accused Chinese semiconductor firms of being security concerns and of having inappropriate connections with the Chinese government, and it has tried to weaken China's position in the global semiconductor industry and protect its technological advantages by implementing strict export controls and supply chain restrictions. The Bureau of Industry and Security in the Department of U.S. Commerce implemented "New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China" in 2022. As the conflict escalated on October 7, 2022, the United States Department of Commerce and Bureau of Industry and Security announced new measures (the "US Chip Sanction against China") restricting China's ability to purchase and manufacture advanced technology chips. Besides, the Bureau of Industry and Security visits of technical personnel from specific companies and organizations to China without US permission slow down China's technological and military development. Points 1, 3, and 4 of the core sanctions include the addition of high-performance computing chips in the Commerce Control List, an expansion of export restrictions on foreign-made advanced computing equipment, and a ban on the export of unauthorized advanced chip technology to China. These measures, especially the export restriction on chips below 16 nm, DRAMs below 18 nm, and NAND flash memory above 128 layers, will have a serious impact on Taiwan's IC design and manufacturing industry.

The importance of Taiwan's semiconductor industry lies in its global market share and technological leadership (Wang et al., 2023): in the IC design industry, Taiwan has a global market share of up to 20.77%, ranking second in the world; in the IC foundry sector, Taiwan accounts for 77.6% of the global market; and in the field of IC packaging and testing, Taiwan ranks first in the world with a market share of 53.9%. This demonstrates Taiwan's key role in each stage of the semiconductor manufacturing industrial chain. In 2022, Taiwan accounted for three of the world's top ten IC design manufacturers, one of the world's top ten IC manufacturers, and four of the world's top ten IC packaging and testing manufacturers. These data highlight Taiwan's position in the entire semiconductor industry chain from upstream IC design to midstream manufacturing to downstream packaging and testing, making it an indispensable force in the global semiconductor supply chain and the development of advanced technologies. After the US Chip Sanction against China, Yasar et al. (2020) pointed out, based on the literature on perceived risks in the past, that people would respond to it based on reliable sources of information. Pflueger et al. (2020) pointed out that investors' risk perception has a significant impact on the market.

This study offers an original perspective by emphasizing that Taiwan is driven by export trade and that the US Chip Sanctions against China will directly impact Taiwan's semiconductor industry by affecting the shipments and operating incomes of the upstream IC design and midstream IC manufacturing sectors. This study aims to contribute to the exploration of the impact of the US Chip Sanctions against China on Taiwan's semiconductor supply chain, test whether the stock prices of the midstream IC manufacturing and upstream IC design industries have exhibited the largest declines and provide a reference for investment and industry analysis.

2. Research Hypothesis

When the United States imposed the trade ban on China's semiconductor industry, it led to a supply shortage of semiconductors in the Chinese market and limited the export of Taiwanese chips. Taiwan plays a key role in the global semiconductor supply chain, especially in advanced semiconductor manufacturing. Geopolitical dynamics, especially any major events in the technological hegemony between the United States and China, will have an impact on the supply and demand balance of the semiconductor industry (Kamasa, 2022). Since Taiwan is the world's main production base for advanced semiconductors, US sanctions will have a major impact on Taiwan's exports of finished chips, which will in turn have a negative impact on the stock price of Taiwan's semiconductor industry.

The stock price performance of semiconductors is directly related to expected future cash flows, and stock price changes can be used as an indicator to predict industry performance (Thorbecke, 2021). Therefore, the implementation of a trade ban by the United States will lead to constraints on Taiwan's semiconductor exports and affect future operating cash inflows, and the impact of these measures will be reflected in abnormal declines in stock prices. The US sanctions on China's semiconductor industry had a short-term impact on the Chinese stock market (Wang, 2022), and the securities markets of various countries are known to fluctuate due to major international events or policy changes (Claessens and Forbes, 2004), therefore similar market dynamics may also apply to Taiwan's semiconductor industry, especially when faced with adverse policies from important trading partners, which will have direct impacts on Taiwan's stock market.

On 5 October 2022, several foreign media outlets indicated that the United States was about to issue a new wave of semiconductor bans on China (the 5 October 2022 news). Then on 7 October 2022, US President Biden signed a bill banning the export to China of high-end

semiconductor chips below 16 nm, NAND flash memory with more than 128 layers, DRAM below 18 nm, and so forth, as well as equipment, software, technology and semi-finished parts for the production of the above products. The bill also prohibited US citizens and green card holders from engaging in any development or production in China of these controlled ICs (Bureau of Industry and Security, 2022). Since this ban restricted trade in the semiconductor industry, and China was also an important trading partner of Taiwan's semiconductor industry, it might cause a reduction in shipments and operating income for Taiwan's semiconductor industry, thereby further affecting the operating cash flow of the enterprises. Investors perceived this risk. In order to avoid losses, they are likely to sell their holdings, causing the stock price of the semiconductor industry to fall. Therefore, this study establishes Hypothesis 1:

> *Hypothesis 1. After news reports about upcoming US chip sanctions against China, stocks in Taiwan's semiconductor industry generate negative abnormal returns.*

Mark and Roberts (2023) indicate that US semiconductor policies have far-reaching implications on the global semiconductor supply chain, especially the transnational supply chain centered in East Asia, which includes major semiconductor exporting countries such as Taiwan. These restrictions may lead to a repositioning of the supply chain, which may affect the performance and strategies of companies in different supply chain links, with a particularly profound impact on the equipment and technology of advanced chips. The upstream (IC design) and midstream (IC manufacturing) sectors of Taiwan's semiconductor industry will suffer greater impacts in the face of trade restrictions because they involve more advanced technologies. Arcuri and Lu (2022) pointed out that TSMC was the first manufacturer in the world to specialize in IC manufacturing and accounted for 54% of global foundry revenue in 2020, while the largest IC manufacturer in the United States, Global Foundries, accounted for only 7%. Many large American technology companies, including Apple, Amazon, Google, and Nvidia, rely on Taiwan's chip foundry to produce nearly 90% of their chips. Taiwan dominates the IC foundry market as a leader in technology and quality and is one of the few countries in the world that can manufacture semiconductors below 5 nm.

Tsai and Li (2009) indicate that Taiwan’s IC Industry are featured by the vertical disintegration structure, dividing the whole semiconductor industry into upstream IC design, midstream IC manufacturing and downstream IC package and test industries. Since both the upstream and midstream sectors of Taiwan's semiconductor industry are highly dependent on advanced technology and equipment, the US ban may restrict the export of these key technologies and equipment from Taiwan, causing a significant impact on the upstream and midstream industries. Tsai (2024) emphasize the close relations between Taiwan and China in the semiconductor industry through the cluster transformation from Taiwan to China. When news reports on the impending US trade ban on Chinese semiconductors were released, investors would expect that stocks in the midstream industry would face greater risks, causing their negative abnormal returns to be higher than those in the downstream industry. The sanctions in the US–China trade ban adding high-performance computing chips and their electronic products to the Commerce Control List, expand the scope of application of export control rules to cover foreign-made advanced computing equipment and supercomputer products, and prohibit the shipment of advanced chips and their manufacturing equipment to China without a license, all of which will have a major impact on Taiwan's IC design industry. If high-performance computing chips designed by Taiwanese companies are included in the US Commerce Control List or are used in supercomputers or advanced computing equipment, the export of these chips may be restricted. Point 4—which prohibits the shipment to China of advanced chips with 16 nm processes or below, DRAM memories of processes below 18 nm, and NAND flash memories

above 128 layers, along with their manufacturing equipment—will have a major impact on the shipments and operating incomes of Taiwan's IC manufacturing industry companies through the direct ban on the export of high-end chip to China. This study explores whether domestic investors can perceive the varying impacts of the ban on the upstream, midstream, and downstream sectors of Taiwan's semiconductor industry by assessing the varying degrees of loss aversion (the selling of holdings) across these sectors. Hence, the following hypotheses were formulated:

Hypothesis2. Upon the 5 October 2022 news about upcoming US Chip Sanctions against China, abnormal returns differed significantly between the upstream, midstream, and downstream sectors of Taiwan's semiconductor industry.

3. Research Design

This study selected 5 October 2022 as the event day. On that day, foreign news media indicated that the United States was going to enact major export control measures on China's semiconductor industry in the near future. The Taiwan stock market traded normally on 5 October 2022, so that was the time when Taiwanese investors perceived and reacted to the news. This study focuses on the Taiwan Stock Exchange and over-the-counter (OTC) stocks of upstream, midstream, and downstream companies in Taiwan's semiconductor industry. A total of 117 listed and OTC semiconductor companies in Taiwan were selected as research samples, including 87 IC design companies, 10 wafer manufacturing companies, and 20 IC packaging and testing companies. The sample data was collected from the Taiwan Economic Journal (TEJ) database.

This study uses the single index model proposed by Sharpe (1963), which posits a linear relationship between the return rate of a security and the return rate of the market, to perform a least-squares regression analysis between the market return rate and the return rate of a single security in Equation (1) and then estimates the daily abnormal return by subtracting the actual daily return rate from the expected daily return rate in Equation (2):

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \text{ , } t = -260, \dots, -11 \quad (1)$$

$$\widehat{AR}_{it} = R_{it} - E(\hat{R}_{it}) = R_{it} - \hat{a}_i - \hat{\beta}_i R_{mt} \text{ , } t = -10, \dots, 10 \quad (2)$$

where

R_{it}: Actual rate of return of security *i* on the day *t* (*t* = 0 is the event day)

R_{mt}: Market rate of return on day *t*

ε_{it}: Residual term for security *i* on day *t*

$\widehat{AR}_{it}$: Estimated value of excess return (abnormal return) on day *t* for security *i*

Since an event may have a continuous impact on stock price before and after the event date, in order to understand the cumulative effect of the event, the average abnormal return is calculated across the event period to obtain the cumulative abnormal return (CAR), through the equations

$$\overline{\widehat{AR}_t} = \frac{1}{N}\sum_{i=1}^{N} \widehat{AR}_{it} \text{ , } t = -10, \dots, 10 \quad (3)$$

$$CAR(-10, T) = \sum_{t=-10}^{T} \overline{\widehat{AR}_t} \quad (4)$$

where

$\overline{\widehat{AR}_t}$: The average estimated abnormal return rate on day *t*

N: Sample size

CAR (−10, *T*) = Cumulative average abnormal return from the 10th day before the event day to day *T*

This study uses traditional t-tests, cross-sectional tests, and sign tests to verify Hypothesis 1: Upon the 5 October 2022 news about upcoming US Chip Sanctions against China, Taiwan's semiconductor industry generated negative abnormal returns. In order to explore Hypothesis 2 (upon the 5 October 2022 News about an upcoming US Chip Sanctions against China, the abnormal returns in the stocks of Taiwan's upstream, midstream, and downstream semiconductor industries differ significantly), this study uses ANOVA tests to assess whether the mean abnormal returns of upstream, midstream, and downstream companies' stocks are significantly different. If the result is yes, a pairwise post hoc test is conducted to confirm which industry sector's abnormal returns are different from those of others.

4. Empirical Analysis

4.1 Impact of the US Chip Sanctions against China on Taiwan's Semiconductor Stock Prices

As can be seen in Table 1, on 5 October 2022, the event day (day 0), the stock prices of Taiwan's semiconductor industry companies showed negative abnormal returns, with an average abnormal return rate of −1.72%, and the traditional t-test statistic was −7.40, the cross-sectional t-test statistic was −6.41, and the sign test statistic was −6.38, all reaching the 1% significance level ($p < 0.01$), therefore, the null Hypothesis 1, H_{10}, is rejected, and the empirical result supports Hypothesis 1: *upon the 5 October 2022 news about upcoming US chip sanctions against China, Taiwan's semiconductor industry registered significant negative abnormal returns.*

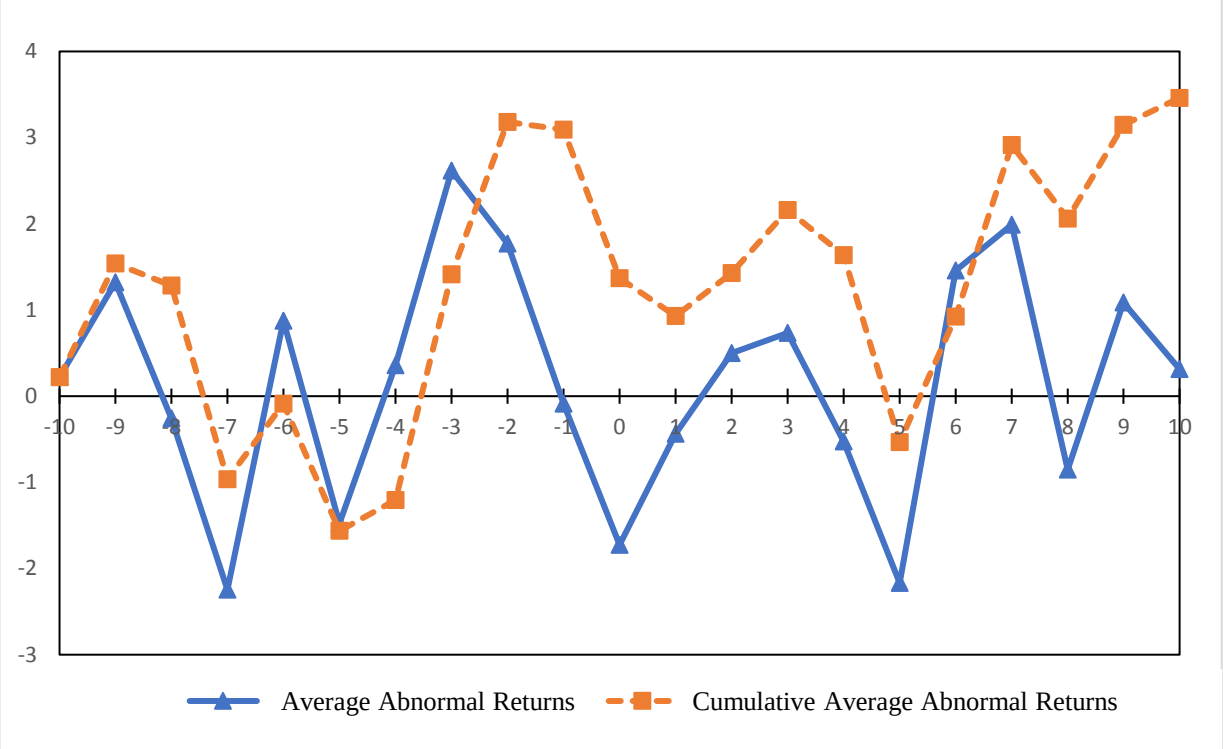
Table 1: Average Abnormal Returns and Cumulative Average Abnormal Returns

Event day	Average abnormal return AR (%)	Average cumulative abnormal return CAR (%)	Traditional t-test statistic	Cross-sectional t-test statistic	Sign test statistic
−10	0.22	0.22	0.95	1.72 *	1.76 *
−9	1.32	1.54	5.66 ***	8.29 ***	7.30 ***
−8	− 0.26	1.28	− 1.11	− 1.28	− 0.09
−7	− 2.25	− 0.96	− 9.64 ***	− 10.51 ***	− 7.67 ***
−6	0.88	− 0.09	3.76 ***	4.70 ***	3.79 ***
−5	− 1.48	− 1.56	− 6.34 ***	− 7.57 ***	− 6.01 ***
−4	0.36	− 1.20	1.54	1.75 *	2.13 **
−3	2.62	1.41	11.23 ***	11.88 ***	8.23 ***
−2	1.77	3.18	7.59 ***	7.04 ***	6.56 ***
−1	− 0.09	3.09	− 0.37	− 0.39	− 1.20
0	− 1.72	1.37	− 7.40 ***	− 6.41 ***	− 6.38 ***
1	− 0.44	0.93	− 1.88 *	− 1.92 *	− 2.50 **
2	0.50	1.43	2.14 **	2.97 ***	1.94 *
3	0.73	2.16	3.14 ***	3.63 ***	3.24 ***
4	− 0.53	1.64	− 2.26 **	− 1.97 **	− 1.20
5	− 2.17	− 0.53	− 9.31 ***	− 8.42 ***	− 6.38 ***
6	1.46	0.92	6.25 ***	5.72 ***	5.45 ***
7	1.99	2.91	8.54 ***	7.10 ***	6.56 ***
8	− 0.85	2.06	− 3.66 ***	− 3.97 ***	− 3.42 ***
9	1.09	3.15	4.66 ***	5.61 ***	4.90 ***
10	0.31	3.46	1.35	1.41	0.46

*p < 0.1, **p < 0.05, *** p < 0.01.

Figure 1 shows that on and around the event day, the average abnormal returns of Taiwanese semiconductor companies' stock prices showed obvious volatility, with a significant decline on the event day, followed by a rapid rebound within a few days, which may reflect the market's initial overreaction and subsequent reassessment of the impact of the event; the cumulative average abnormal return line gradually climbed after the event day, indicating that the market gradually digested the long-term impact of the news after initial concerns about the ban, and investors still held a positive view of Taiwan semiconductor stocks.

Figure 1: Abnormal Returns and Cumulative Abnormal Returns over the Event Period

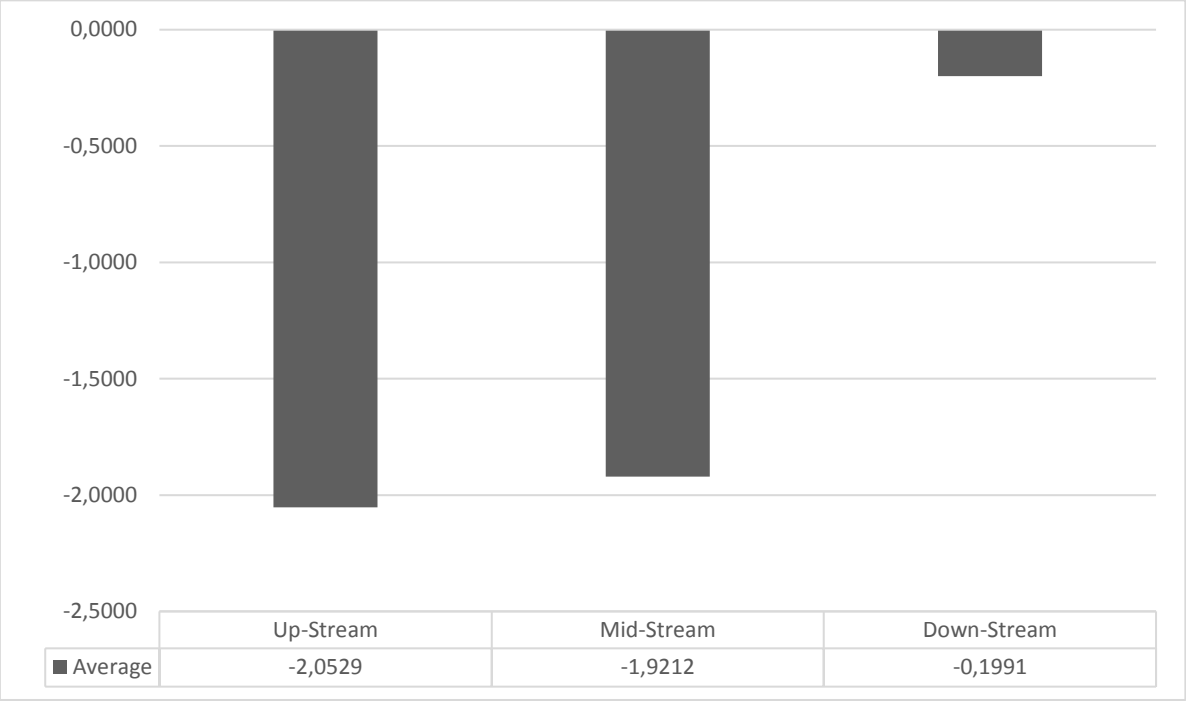


Although the direct target of the US chip ban is China, Taiwan is also affected by spillover effects, as it plays an important export role in the global semiconductor market. It is shown from the market reaction that the average abnormal return also had a significant abnormal decline of −0.44% on the first day after the event day, reflecting the herd effect of the stock market. Investors sold stocks in the early days of the news due to widespread panic, but as market sentiment eased, the impact was reassessed and the stock price recovered.

4.2 Differences in the Impacts of the US Chip Sanctions against China on Stock Prices in Taiwan's Upstream, Midstream and Downstream Semiconductor Industries

Figure 2 shows the average abnormal returns of stocks in the upstream, midstream, and downstream sectors of Taiwan's semiconductor industry on 5 October 2022, the day the US Chip Sanctions against China were announced. It can be seen that the upstream-sector companies were most significantly affected, with an average abnormal return of −2.05%. The average abnormal return of the midstream-sector companies was −1.92%, suggesting a slightly less severe, but still significant, negative impact relative to that seen in the upstream-sector companies, and the downstream-sector companies' average abnormal return was −0.20%, indicating a relatively minor impact.

Figure 2: Abnormal Returns of the Upstream, Midstream, and Downstream Sectors



First, Levene's test was used to test whether the variances of each sector's abnormal returns data were homogeneous. As shown in Table 2, the p-value is 0.16, which means that the variances were not different ($p > 0.05$). Thus, the homogeneity of variance prerequisite for ANOVA was met. According to the ANOVA results, shown in Table 2, the F-value is 3.47, and the corresponding p-value is 0.03, which is less than 0.05, thus the null Hypothesis 2, H_{20}, is rejected at the 5% significance level. This supports Hypothesis 2: there is a statistically significant difference in the abnormal returns of stock prices between the midstream- and downstream-sector companies in Taiwan's semiconductor industry. Companies in different industrial chain positions have different sensitivities to external policy changes, and thus, global political and economic events may have different degrees of impact on different parts of the industrial chain.

Table 2: Homogeneity of variance test and ANOVA results

Homogeneity of variance test	
Levene statistics	1.84
p-value	0.16
ANOVA results	
F statistics	3.47
p-value	0.03 **

*p < 0.1, **p < 0.05, *** p < 0.01.

Finally, Tukey's HSD test was used to further explore which specific sectors exhibited significantly different abnormal returns. The test results are shown in Table 3, the abnormal returns of the upstream and downstream sectors were significantly different at the 5% significance level ($p = 0.03$), with an average difference of −1.85 (the upstream sector's average minus the downstream sector's average), which means on the day of the US chip sanction announcement, the upstream sector was more significantly negatively affected than the downstream, while there was no significant differences between other sectors.

Table 3: Post hoc comparison results

Group	Mean difference	Standard error	p-value
Upstream–midstream	−0.13	0.95	0.99
Upstream–downstream	−1.85	0.71	0.03 **
Midstream–downstream	−1.72	1.10	0.27

*p < 0.1, **p < 0.05, *** p < 0.01.

5. Conclusion

The research results show that new of the US ban produced significant negative abnormal returns for Taiwan's semiconductor industry as a whole but especially for the upstream IC design and midstream IC manufacturing industries. The upstream IC design industry relies on innovation and rapid technological progress to maintain its competitive advantage and is therefore extremely sensitive to any external policies that may hinder technology acquisition or market expansion. This shows that companies that are highly dependent on the global technology supply chain and international markets present more volatile market performances when facing political or economic obstacles. Taiwan's midstream IC manufacturing industry also showed significant negative abnormal returns following the announcement of the US ban. As a key link in the semiconductor industry, the IC manufacturing industry is highly dependent on technological progress and international trade. Since the IC manufacturing industry is capital-intensive and technology-intensive, any external policy changes that affect its capacity utilization or technology imports may have immediate and far-reaching impacts on companies' stock prices. In contrast, Taiwan's downstream IC packaging and testing industry was less responsive to the US ban.

This research also found that the impact of the US ban on stock prices in Taiwan's upstream IC design industry was significantly greater than that in the downstream packaging and testing industry. Since the IC design industry is highly dependent on advanced technology and innovation, its market sensitivity and risk perception is relatively high. Additionally, in the sales chain of the semiconductor industry, upstream IC designers actually play the role of sellers. After receiving orders and completing the design, the upstream IC design manufacturers entrust midstream IC manufacturers with the task of manufacturing the ICs according to the design drawings and then hand them over to downstream packaging and testing manufacturers for packaging and testing. After testing, the upstream IC design manufacturers will eventually ship the finished product to the next step. Therefore, when facing a ban on semiconductors, those affected first are the upstream IC designers. The U.S. sanctions restrict these manufacturers' capabilities to sell products to Chinese companies (including military, technology, mobile phones, automobiles, and other fields with huge demand for high-end chips), which will directly affect the turnover and operating cash flow of the upstream IC design industry. The results of this study show that stock price performance was significantly negatively affected, with the upstream IC design industry being the most affected. This is consistent with observations of the sales chain.

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