How Does the Resilience of Semiconductor Supply Chain Affected by Major Power Competition ?

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Abstract. In the era of great power competition, Sino-US trade friction has become increasingly tense, especially in the high-tech industries represented by the semiconductor industry, which has created fierce competition. This study focuses on the risk of semiconductor supply chain interruption in the context of competition between major powers. Taking the Sino-US trade friction incident that began in 2018 as the research background and the semiconductor supply chain resilience as the research object, we construct an evaluation index system for the resilience of China's semiconductor industry chain and a score-matched difference-in-difference (PSM-DID) event impact assessment model uses Stata16.0 to process and calculate a total of 2424 samples from 2017 to 2022. Evaluate the impact of international uncertain events on the resilience of China's semiconductor supply chain through empirical analysis. The research results show that international uncertain events may have an adverse impact on the resilience level of enterprises related to China's semiconductor industry. Enterprises of different sizes have different impacts on the resilience of international uncertain events. The impact of international uncertain events on enterprise resilience There may be a certain lag in adverse effects. The research results help to correctly assess the impact of trade friction on the supply chain resilience of my country's semiconductor industry, and provide scientific support for the formulation of policies related to the semiconductor supply chain and the governance of multiple entities.

Keywords: supply chain resilience; great power competition; difference-in-difference; propensity matching; semiconductor industry.

1. Introduction

The current era is regarded as an era of great power competition, and the high-tech industry represented by the semiconductor industry is regarded as the primary area of great power competition. In the fiercely competitive semiconductor field, great power competition is mainly reflected in the competition between China and the United States. The United States uses the Sino-US trade deficit as an excuse to impose tariffs on Chinese exports, restrict imports of products from China, and block technical and knowledge fields [1]. In recent years, the number of cases in which the United States has restricted the import of technologies and products by Chinese companies has continued to increase. The number of affected semiconductor companies has continued to increase, and the scope of radiation has continued to expand. The negative impact on my country's semiconductor industry has also continued to intensify. Sino-US economic and trade relations, once regarded as the "ballast stone" of Sino-US relations, have begun to encounter unprecedented challenges. As the cornerstone of the entire information technology industry, the semiconductor industry has fundamental, leading and strategic significance. As the forefront of contemporary science and technology development, the semiconductor industry has become one of the important engines of global economic development and plays an increasingly important role in promoting economic development and industrial transformation and upgrading. At present, the risk of interruption in the semiconductor supply chain has led to reduced supply chain operating efficiency, increased costs, and even chain structure rupture and failure, and the supply chain resilience has been severely damaged.

Therefore, this study focuses on the risk of semiconductor supply chain interruption in the context of competition between major powers, and proposes the need to correctly assess the impact of trade frictions on the supply chain resilience of my country's semiconductor industry, in order to provide scientific support for the formulation of policies related to the semiconductor supply chain and the governance of multiple entities.

2. Literature review

In the current research and discussion around "supply chain resilience", research on "supply chain resilience" from an economic perspective focuses more on how to ensure that in the face of supply disruptions such as physical isolation caused by the COVID-19 epidemic and political factors. Production safety, how to produce in a more localized and diversified manner while maintaining efficiency, and how this change affects the production efficiency of countries and enterprises, global value chains and globalization participation [2-4]. In addition, in this part of the research, "geopolitical security" is the focus, and there is even some intention to establish an institutional exclusion system for specific countries in the name of creating a flexible supply chain [2]. But even if the above trends exist, there are double paradoxes in the "supply chain resilience" strategy of the United States and Europe, namely, the paradox between rapid recovery from emergencies and inefficient remaining capacity, as well as the paradox between stable and reliable supply relationships and flexible and variable supply relationships. Paradox between channels [3]. An important reason for the existence of this paradox is that the existing industrial chain itself also has another binary paradox - a country's global competitiveness and influence in a certain industrial chain field, and its influence on the country's industrial chain. It is difficult to have both complete autonomy and controllability and no dependence on foreign imports [4].

At the theoretical level of supply chain resilience analysis, Professors Christopher and Peck first proposed the definition of supply chain resilience in 2004 as "the ability of the supply chain to return to its original state or a more ideal state after being disrupted" [5]. Lee and Rha proposed that the process of building dynamic capabilities is also a process of improving supply chain resilience [6]. Brusset and Teller [7] used dynamic capabilities theory to verify the positive effects of flexibility and integration capabilities on supply chain resilience. Pu Guoli et al. [8] combined the perspectives of dynamic capabilities and risk management and believed that supply chain flexibility can be characterized from flexible capabilities, agility capabilities, and adaptability. Based on the dynamic capabilities theory, Sirmon et al. [9] indicate that enterprises need to readjust their resources and processes to quickly adapt to changes brought about by disruption threats. From the existing literature, we found that flexibility, agility, and reinvention are currently the focus of discussions in the supply chain resilience literature based on the perspective of dynamic capabilities theory. Attributes such as flexibility, agility, and reinvention reflect a dynamic capability of an enterprise, which can help enterprises adjust resource allocation and transform operational activities to effectively respond to disruptions and achieve rapid recovery. Therefore, this study studies the impact of flexibility, agility, and reinvention on supply chain resilience based on dynamic capabilities theory [10].

3. Data and methodology

3.1 Measurement of supply chain resilience

In order to measure the resilience of China's semiconductor industry chain, this study takes micro-enterprises as the research object and integrates enterprise indicators into industry and industry chain indicators. Based on the connotation of industrial chain resilience, China's semiconductor industry chain resilience evaluation index system is constructed from four perspectives: resistance, recovery, evolution, and government power, as shown in the table 1.

Table 1 Semiconductor industry chain resilience evaluation index system

Criterion layer	Evaluation index layer	Indicator definition/explanation	Indicator characteristics
Resistance	number of employees	Total number of employees in the company	+
	equity ratio	The ratio of total liabilities to total owners' equity reflects the company's long-term solvency	-
	Operating cost	Including main business costs and other business costs	-
Recovery	Sales margin	Net profit to sales revenue ratio	+
	Roe	Ratio of net profit to average net assets	+
	Inventory turnover	Cost of goods sold to average inventory balance ratio	+
	operating income	Including main business income and other business income	+
Evolution	R & D spending	Various expenditures incurred during corporate research and development	+
	return on invested capital	Measure the efficiency of the use of funds from the perspective of the overall invested capital of the enterprise	+
Government power	government subsidy	The amount of various government subsidies to enterprises	+
	Taxes payable	The total amount of various taxes and fees paid by the enterprise in accordance with national regulations	+

Resistance. Resistance reflects the ease with which a company can deviate from its current development trajectory when faced with external shocks. The cost management of an enterprise directly affects profit realization and determines the risk resistance [1 2]. At the same time, the smaller the scale of the enterprise, the weaker its ability to resist risk shocks [13-14]. Therefore, this study selects the industrial chain from the two perspectives of cost and scale. The evaluation indicators of resistance include three indicators: number of employees, equity ratio, and operating costs.

Recovery. Resilience mainly refers to the ability of an enterprise to restore its original development path through adaptive transformation measures such as organizational structure changes when it suffers external shocks. Drawing on the views of Fan Xuemei et al. [15], Wang Zeyu et al. [16], and Zhang Hu et al. [17], this study selects evaluation indicators from two aspects: capital income and turnover, mainly including net sales interest rate, return on net assets, inventory turnover rate and operating income 4 indicators.

Evolution. Evolutionary capability refers to the ability of an enterprise to continuously accumulate knowledge capital and carry out technological innovation during the development process, and to continuously cultivate competitive advantages. Evolutionary capability focuses on innovation and efficiency. For this reason, this study chooses two indicators, R&D investment and return on capital investment, to measure evolutionary capability.

Government power. Government regulation plays an important role in the process of industrial chain coupling. For this reason, this study incorporates government power into the industrial chain resilience rating index system. Government power is considered from two aspects: assistance and supervision. Based on the availability of data, this study selects government subsidies and payable taxes. Among them, government subsidies are one of the most intuitive manifestations of the government’s support for the industrial chain, and payable taxes represent the government's ability to regulate the market.

3.2 Sample selection and data sources

Based on the availability of data, this study selects the data of listed companies in China's semiconductor industry according to the Eastern Industry Classification Standard (New), with a time span of 2017-2022 (the time period before and after the start of the Sino-US trade war in 2018). A total of 513 listed companies in the semiconductor industry, 6 indicators. Due to the large number of subjects and the long time span, in order to facilitate vertical and horizontal analysis and comparison, this study deletes companies with a large number of missing values, leaving 404 listed companies. Enterprise data with a small number of missing values were filled using the mean method. The data comes from the Choice financial database.

According to the previously mentioned series of events in the Sino-US trade conflict since 2018, which have had a huge impact on China’s semiconductor industry, this study identifies 72 semiconductor-related listed companies as the treatment group, and other listed companies as the control group. Finally, the samples included a total of 2424 samples from 2017 to 2022. The data statistics and analysis work mainly used Excel2019, Stata16.0, Choice financial terminal and other software, and used Stata16.0 to conduct descriptive statistics on the main variables., the statistical results are shown in Table 2.

Table 2 Descriptive statistics of enterprise samples

VARIABLES	N	mean	sd	min	max
AR	2,424	37.20	17.72	1.98	103.0 0
NP	2,424	2.62	1.25	-9.68	3.04
HC	2,424	-4.4 4	2.57	-3.89	1.04
EM	2,424	1.79	0.99	1.02	21.36
FS	2,424	21.49	1.41	17.17	26.83
FAR	2,424	0.19	0.13	0.00	0.73
Resilience	2,424	0.04	0.12	0.00 _	1.00 _

3.3 Modelling

listed companies are affected by major power competition events, their resilience changes mainly come from the following three aspects: First, the differences in resilience changes caused by the differences in the company's own resistance capabilities; second, due to the inertia of the company over time or changes in the economic situation, its resilience changes Differences caused by differences; third, differences caused by government power acting on enterprises. The difference-in-differences model (DID) can effectively separate the effect of great power competition events on corporate resilience using the treatment group and the control group, but its premise is that the two groups of samples have the same time trend. However, there are differences in corporate characteristics between pilot companies and non-pilot companies. For example, different types of companies have different willingness to respond to major power competition events, which may lead to sample bias. Therefore, this study further uses the propensity score matching method (PSM) to solve the problem of sample bias.

Table 3 variable settings

nature	**name**	**symbol**	**definition**
Explained variable	Corporate resilience	R esilience	Enterprise's ability to cope with risk shocks
Explanatory variables	group dummy variable	t reacted	treated=1, the enterprise is an affected enterprise and belongs to the treatment group;

			treated=0, the enterprise is an unaffected enterprise and belongs to the control group
	event implementation variables	time _	time=1, the year is 2019 and later; time=0, the year is before 2019
	interaction term	DID _	If treated and time are 1, the value is 1, otherwise it is 0
Control variables	Enterprise size	F S	The natural logarithm of the company's total assets at the end of the year
	Assets and liabilities	A R	a company's total liabilities to its total assets
	fixed asset ratio	f _	Total fixed assets/total assets of the enterprise at the end of the year
	net profit	N P	Profit after tax or net income
	Equity Multiplier	E M	Expressed as the reciprocal of the shareholders' equity ratio, it reflects the company's financial leverage.
	Hematopoietic volume	H C	A business's ability to generate cash flow

In the propensity score matching method, for the selection of matching variables, this study also considers enterprise size, asset-liability ratio, fixed asset ratio, net profit, equity multiplier, and hematopoietic volume. These factors may affect the possibility of enterprise resilience being affected by major power competition events.

For example, equation (1) is a logit regression model used to estimate the probability that a company is considered to be affected by major power competition events. treated is a dummy variable for whether the company is an affected company. When the company is an affected company, treated takes 1, otherwise the value is 0.

$$treated_i = \alpha_0 + \alpha_1 AR + \alpha_2 NP + \alpha_3 HC + \alpha_4 EM + \alpha_5 FS + \alpha_6 FAR + u_i \quad (1)$$

As shown in Equation (2), the matched samples are used for double difference estimation.

$$\mathrm{Re}silience_{it} = \beta_0 + \beta_1 treated_{it} + \beta_2 time_{it} + \beta_3 treated_{it} \times time_{it} + \beta_4 Control_{it} + \varepsilon_{it} \quad (2)$$

Among them, Resilience is the level of enterprise resilience, and the core explanatory variables are the group dummy variable (treated), the time dummy variable (time) and its interaction term (treated × time) of the supply chain resilience affected enterprises, and the coefficient of the interaction term is The focus of attention reflects the net effect of major power competition events on corporate resilience. Control is a control variable that affects corporate resilience.

4. Empirical results

4.1 Propensity matching results

During matching, we performed one-to- one nearest neighbor matching for each enterprise affected by Sino -US competition events. At the same time, we stipulated caliper matching to control the score deviation of the matching objects within 0.05, and imposed "common support" (Common Support) conditions, select non-pilot enterprises with similar scores. The estimation results of the logit model are shown in Table 3. The size and p-value of each matching variable coefficient reflect the corresponding indicator's influence on the pilot decision-making and its probability.

Table 3 Estimation results

Variable	Coef.	Std. Err.	z	P>z
	-0.028	0.005	-6.010	0.000
NP	3.68e-11	4.66e-11	0.790	0.430
HC	-2.92e-11	2.07e-11	-1.410	0.158
EM	0.085	0.085	1.000	0.315
FS	0.040	0.047	0.860	0.392
FAR	-1.632	0.469	-3.480	0.001

To check whether the matching results satisfy the common support assumption, figure 1 visually shows the common value range of the propensity score values of the treatment group and the control group. It can be seen that the propensity scores of the samples of enterprises affected by the great power competition events and those of the enterprises that were not affected are mostly within the common value range (On support), indicating that we did not lose many samples after performing PSM matching.

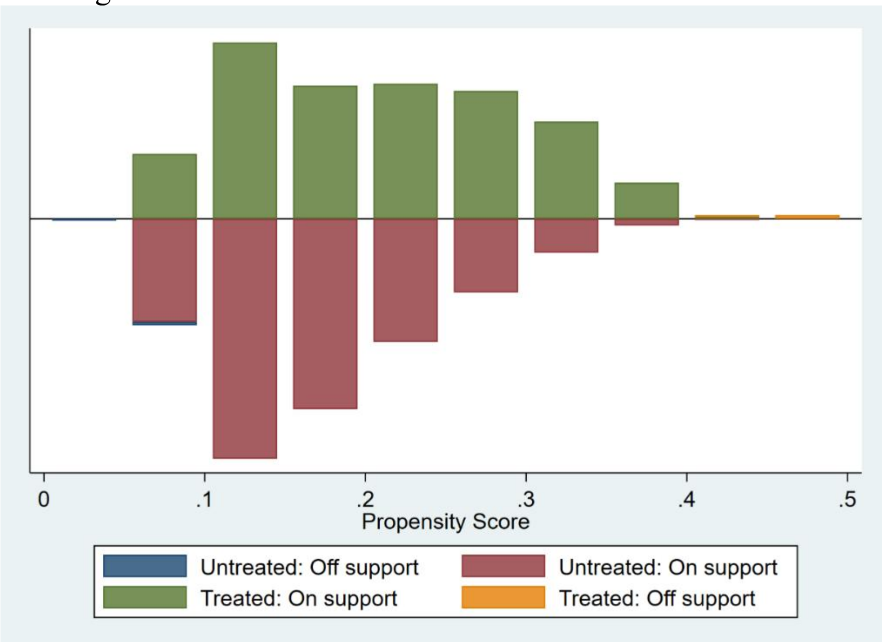

Figure 1 The value range of the propensity score of the treatment group and the control group

4.2 Heterogeneity analysis

In order to further study the heterogeneity of the impact of a series of events in Sino-US competition on corporate resilience, this study groups companies by size type and measures the impact of events on the resilience of different types of companies. Specifically, companies with a size greater than the median in the total sample are divided into a subsample group of large-scale companies, while companies with a size smaller than the median are divided into a subsample group of small-scale companies. The results of heterogeneity test are shown in Table 4.

Table 4 Heterogeneity analysis

Model	(10)	(11)

Enterprise size	small scale	large scale
variable	Resilience	Resilience
did	-0.001	-0.037**
	(0.001)	(0.018)
Constant	-0.094***	-2.178***
	(0.015)	(0.266)
Observations	378	349
Number of id code	172	171
R-squared	0.521	0.460
Year fix	YES	YES
Id code fix	YES	YES

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

The regression results grouped by enterprise size show that as the enterprise scale expands, Sino-US competition events have a greater weakening effect on enterprise resilience, and only the coefficient value of large-scale enterprises is significant, which can be calculated from (10) - (11) The size of the DID coefficient can be seen. On the one hand, large enterprises themselves play an important role in the supply chain and are more likely to be targeted or sanctioned in major power competition events; on the other hand, small enterprises will be affected by the risks of major power competition events to a certain extent. This suggests that large-scale firms are more negatively affected by great power competition events than small scale firms.

5. Conclusion

This study takes the Sino-US competition events starting in 2021 as the research object, constructs the resilience evaluation index system of China's semiconductor industry chain and a double difference (PSM-DID) model based on propensity score matching, and uses Stata16.0 to analyze the 2017 ~ 20226 A total of 2424 samples were processed and calculated during the year. Evaluate the impact of international uncertain events on the resilience of China's semiconductor supply chain through empirical analysis. To sum up, this study mainly draws the following three conclusions:

(1) International uncertain events may have an adverse impact on the resilience level of companies related to China's semiconductor industry. Even taking into account sample selection bias, endogeneity problems caused by omitted variables, and other statistical biases, the core conclusions remain robust. This shows that the impact of Sino-US competition events is obvious.

(2) Enterprises of different sizes have different impacts on resilience to international uncertain events. Large-scale companies are more likely to be targets of sanctions and are therefore more adversely affected by Sino-US competition incidents. At the same time, small-scale enterprises will also be affected by competition between China and the United States.

(3) The adverse impact of international uncertainties on corporate resilience may have a certain lag. In other words, the impact may not immediately significantly change the trend of the company before the event, but may only become apparent after the event occurs.

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