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Supply chain sustainability and its impact on firm market competitiveness: A perspective based on ESG practices

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ABSTRACT

This study uses A-share listed companies from 2012 to 2022 as the sample and employs a DID model to analyze the impact of supply chain sustainability on firm market competitiveness. The findings indicate that supply chain sustainability significantly enhances firm market competitiveness. Robustness tests confirm the reliability of the results, and the impact of supply chain sustainability on market competitiveness exhibits distinct characteristics. Mechanism tests reveal that supply chain sustainability enhances firm market competitiveness through two pathways: promoting ESG practices and alleviating financing constraints.

1. Introduction

In the increasingly complex global economic environment, supply chain sustainability has become crucial for countries to achieve long-term market competitiveness. Supply chain sustainability requires companies to balance environmental protection, social responsibility, and economic benefits. The goal is to achieve long-term, comprehensive, and balanced development across all segments of the supply chain by reducing negative environmental impacts, enhancing social well-being, and improving economic efficiency. For example, the European Union's Green Deal emphasizes environmental and social responsibility within the supply chain. Similarly, the United States launched the Supply Chain Resilience Plan in 2021 to strengthen the resilience of supply chains and reduce dependence on single sources of supply. In 2018, the Ministry of Commerce, along with seven other departments, issued the "Notice on the Pilot Program for Supply Chain Innovation and Application," (SCIA)which promoted the implementation of this concept. The policy encourages companies to adopt sustainable measures to improve and optimize supply chain management, thereby enhancing overall market competitiveness. The tasks required of pilot enterprises outlined in the notice are closely related to the essence of supply chain sustainability. These tasks include improving supply chain management and coordination, strengthening information upgrades and standardization to optimize resource allocation and increase production efficiency, all of which are linked to economic sustainability. Additionally, the notice advocates for the greening of the entire supply chain process, promoting the development of a high-tech, low-pollution industrial supply chain system, which aligns with environmental sustainability requirements. Finally, the notice emphasizes the importance of enhancing the integration of systems and data among upstream and downstream enterprises, building and improving supply chain platforms, and fostering cooperation with universities and research institutions to advance the application of digital, intelligent, and green technologies, which are all related to social well-being. This provides a foundation for the present study

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to explore the relationship between supply chain sustainability and corporate market competitiveness.

The connotation of supply chain sustainability encompasses three dimensions: environmental, social, and economic. Environmental sustainability focuses on reducing emissions, improving energy efficiency, and promoting green technologies. Research indicates that by implementing green technologies and energy-saving measures, companies can decrease their environmental footprint while simultaneously improving their operational efficiency, which in turn increases their market competitiveness, thereby boosting their market competitiveness (Liu et al., 2024). Social sustainability emphasizes improving the well-being of all stakeholders in the supply chain, including better working conditions, employee health, and fulfilling social responsibilities (Lou et al., 2023). Enhancing social sustainability helps improve a company's social image and employee satisfaction, which can increase market competitiveness and investment attraction in the long run (Chen & Zhang, 2024). Economic sustainability aims at maximizing economic benefits by optimizing resource allocation and improving production efficiency to strengthen corporate competitiveness (Hasan et al., 2024). The relevant literature reveals how these factors affect corporate performance and market position through different mechanisms, allowing us to comprehensively analyze the impact of supply chain sustainability on corporate market competitiveness. Moreover, the application of advanced digital technologies has significantly improved supply chain transparency and responsiveness, reduced resource waste, improved environmental management, and optimized overall supply chain efficiency (Yu et al., 2024), thus promoting the sustainable development of supply chains. Regarding ESG practices, research shows that good ESG performance can significantly enhance corporate market competitiveness (Martins, 2022; R. Wang, Wang, & Yan, 2024). Specifically, ESG practices improve corporate reputation, attract more investment, and enhance operational efficiency, leading to better market performance, including increased market share, higher investment returns, and improved total factor productivity (Xue et al., 2024). Despite existing studies providing important references for understanding the relationship between supply chain sustainability and corporate market competitiveness, there is still a lack of comprehensive consideration of how supply chain sustainability affects corporate market competitiveness. This paper extends the existing literature by exploring how supply chain sustainability and ESG practices influence corporate market competitiveness and analyzing the role of financing constraints in this context.

This study seeks to investigate the link between supply chain sustainability and corporate market competitiveness. By constructing a DID model and utilizing the SCIA pilot policy as a natural experiment, we systematically analyze the combined effects of supply chain sustainability, ESG practices, and financing constraints on corporate market competitiveness, thereby enriching the research perspective on the relationship between supply chain sustainability and corporate market competitiveness.

The research findings indicate that supply chain sustainability significantly enhances the level of corporate market competitiveness. Firstly, the implementation of the SCIA pilot policy can significantly strengthen the competitive advantage of companies in the market. Secondly, the policy implementation positively affects corporate market competitiveness by promoting ESG practices and alleviating financing constraints. Further analysis indicates that the effect of supply chain sustainability on corporate market competitiveness varies across different contexts.

The value of this study lies in its in-depth analysis of the relationship between supply chain sustainability and corporate market competitiveness, as well as the exploration of potential influencing mechanisms, thus enriching the relevant literature on supply chain sustainability. Moreover, the research findings provide valuable references and guidance for companies, regulatory agencies, and other stakeholders, contributing to the improvement and optimization of corporate supply chain management and promoting sustainable development for companies.

2. Theoretical analysis and research hypotheses

2.1. Supply chain sustainability and corporate market competitiveness

The SCIA pilot policy aims to promote continuous innovation and application in supply chain management, fostering long-term, comprehensive, and balanced development of the supply chain, thereby enhancing the level of corporate market competitiveness. Firstly, supply chain sustainability helps companies optimize resource allocation, strengthen technological innovation, and reduce costs, thereby gaining a favorable position in price competition (Shi et al., 2022; Xu & Lin, 2024). Secondly, by guiding the green development of the supply chain, companies demonstrate a responsible social image, attracting more consumers and investors who prioritize environmental performance, thereby enhancing market competitiveness. Additionally, the promotion and application of new supply chain technologies and models, as well as the digitization and intelligentization of the supply chain, can increase its transpa d traceability, improving the ability to identify and respond to supply chain risks (Liu & Zheng, 2024), thus maintaining instabilityamid market fluctuations (H. Shi, Liu, & Yang, 2024). Therefore, the following hypothesis is proposed.

H1. *Supply chain* sustainability *enhances corporate market competitiveness.*

2.2. Supply chain sustainability, ESG practices, and corporate market competitiveness

A company's commitment to ESG practices plays a key role in its sustainable development. Environmental initiatives like cutting carbon emissions, boosting energy efficiency, and utilizing renewable energy sources can elevate a company's brand perception and appeal, drawing in eco-aware consumers and investors (X. Zhang, Wan, & Zhou, 2024). This, in turn, enhances its position in the market (Chen, 2024). Additionally, social practices, such as improving employee welfare, strengthening community engagement, and managing suppliers, can increase employee satisfaction and loyalty, maintain good relationships with the community and supply chain partners, and promote collaboration and innovation, thereby enhancing the company's production efficiency and innovation

capabilities (D. Kong et al., 2023; G. Kong et al., 2023; Yang et al., 2024). Lastly, governance practices, such as increasing transparency, strengthening board governance, and preventing corruption (Ma et al., 2024; T. Wang, Wang, & Yan, 2024), can improve the company's management efficiency and decision-making quality, reduce operational risks, and enhance market competitiveness (K. Zhang, Wan, & Zhou, 2024). Therefore, the following hypothesis is proposed.

H2. Supply chain sustainability promotes corporate market competitiveness through ESG practices.

2.3. Supply chain sustainability, financing constraints, and corporate market competitiveness

Financing constraints are a significant factor affecting a company's ability to expand and develop in market competition. Optimizing supply chain management significantly enhances internal management and production efficiency (Zhao et al., 2024), improves financial performance (Jia & Li, 2024), and increases attractiveness in capital markets, thereby alleviating financing constraints. Additionally, supply chain sustainability promotes technological and managerial innovation. Continuous environmental and social responsibility practices improve credit ratings (Fernandez, 2021), attract the attention of venture capital and innovation funds, and strengthen relationships with financial institutions, making it easier to obtain loans and investments (Hao & Wu, 2024). Moreover, an increasing number of investors prefer to invest in companies with sustainable development capabilities (R. Shi, Liu, & Yang, 2024; R. Wang, Wang, & Yan, 2024), thus alleviating financing constraints. Therefore, the following hypothesis is proposed.

H3. *Supply chain* sustainability *positively promotes corporate market competitiveness by alleviating financing constraints.*

3. Research design

3.1. Sample and data sources

The initial research sample of this study comprises data from all A-share listed companies from 2012 to 2022. The data sources include the CAMAR database and the Huazheng ESG official website, with the list of pilot enterprises obtained from the official website of the Ministry of Commerce. The sample was processed as follows: (1) Excluding samples from the financial industry; (2) Excluding ST and PT samples for the respective years; (3) Excluding samples of insolvent companies; (4) Excluding samples with missing or duplicate values for relevant variables; (5) To avoid the impact of outliers, all continuous variables were winsorized at the 1 % and 99 % levels. This process resulted in a final effective sample of 33,360 observations.

3.2. Model construction and variable definitions

To verify Hypothesis 1, this paper employs a DID model (Ren & Liu, 2024) to examine the impact of supply chain sustainability and ESG practices on corporate market competitiveness. The following model is constructed:

$$EMC_{it} = \alpha_0 + \alpha_1 DID_{it} + \sum \text{Control}_{it} + \mu_i + \theta_t + \varepsilon_{it} \tag{1}$$

where i represents the firm, t represents time, and the dependent variable EMC_{it} represents corporate market competitiveness. The core explanatory variable, DID_{it}, captures supply chain sustainability (DID = Treat × Post). The SCIA pilot policy is considered an exogenous policy shock variable. When a firm is located in a pilot city for supply chain innovation and application, Treat is set to 1; otherwise, it is set to 0. When the sample data is from 2018 onwards, Time is set to 1; otherwise, it is set to 0. The interaction term of the grouping dummy variable Treat and the time dummy variable Time measures supply chain sustainability. $\sum \text{Control}_{ift}$ represents firm-level control variables, μ_i represents firm fixed effects, θ_t represents time fixed effects, and ε_{it} represents the random error term. The standard errors are clustered at the firm level.

1. Dependent variable
   Corporate market competitiveness (EMC). The reason for choosing main business revenue as a measure of business market competitiveness (EMC) is that main business revenue directly reflects the core operations of a company. This indicator effectively reflects the company's share of the market and its standing relative to industry peers, which helps to objectively assess how supply chain sustainability impacts a company's competitiveness in the market. A higher value of this indicator signifies greater market concentration within the industry, indicating that a few companies dominate the market and that the company has strong competitiveness in the market.
2. Independent variable
   Difference-in-differences (DID). The SCIA pilot policy issued by the Ministry of Commerce and seven other departments in 2018 reflects the high level of national attention towards innovation and sustainability in supply chain management. The policy aims to leverage the demonstration effect of pilot enterprises to encourage more firms to adopt sustainability practices, thereby optimizing supply chain management, reducing operational costs, improving efficiency, and enhancing market responsiveness. This policy not only has a profound impact on corporate operational models and market competitiveness but also provides a natural experiment environment to study how supply chain sustainability affects corporate market competitiveness through ESG practices and financing constraints. By using the 2018 SCIA pilot policy notice as the policy shock variable, we can clearly identify changes in corporate market competitiveness before and after the policy implementation, revealing the role of supply chain sustainability in

enhancing corporate competitiveness under policy support. This choice not only provides a solid policy background for the research but also offers valuable empirical evidence for policy-making in related fields.

3. Mediating variables

Financing constraints (SA) and ESG.

The formula for calculating the SA index is as follows:

$$SA = -0.737*Size + 0.043*Size^2 - 0.040*Age$$

Financing constraints are a significant factor affecting a company's ability to expand its business and achieve sustainable development. Effective management of supply chain sustainability requires substantial financial investment. Alleviating financing pressures provides companies with additional financial resources, which can enhance their investment and innovation in supply chain sustainability, such as establishing sustainable logistics systems. By easing financing constraints, firms can better improve their supply chain management, further boosting their market competitiveness. Thus, financing constraints play a crucial mediating role between supply chain sustainability and corporate market competitiveness.

ESG factors are essential indicators for evaluating a company's sustainability and social responsibility. ESG practices are viewed as critical components of long-term competitiveness and have increasingly become a focal point for investors and regulators. The Huazheng ESG comprehensive score reflects a company's performance in environmental protection, social responsibility, and corporate governance. Strong ESG performance can enhance a company's brand value and public image, attracting more investors and customers. Therefore, ESG practices play a crucial bridging role between supply chain sustainability and the enhancement of corporate market competitiveness.

4. Control variables

To ensure the reliability of the research results, the following control variables are selected: company size (*Size*), asset-liability ratio (*Lev*), cash flow ratio (*Cashflow*), whether the chairman and the CEO roles are combined (*Dual*), company age (*FirmAge*), board size (*Board*), equity concentration (*Top1*), independent director ratio (*Indep*), institutional investor shareholding (*Inst*). Table 1 presents the specific calculation methods.

3.3. Descriptive statistics

Table 2 presents the descriptive statistics for the main variables. The *EMC* ranges from a minimum value of 1.4288 to a maximum of 42.9668, with a standard deviation of 7.5809, indicating significant variability in market competitiveness among firms. The *DID* has a mean of 0.0084 and a standard deviation of 0.0912. The minimum value of the *ESG* index is 55.0000, the maximum value is 85.5400, the mean is 73.2010, and the standard deviation is 4.9372. This indicates a high level of environmental, social, and governance standards among the companies, suggesting that the *ESG* practices of the listed companies in the sample are relatively strong. Lastly, the *SA* has a mean of −3.8336 and a standard deviation of 0.2521, suggesting that most firms experience some degree of financing constraint pressure.

Table 1
Definitions of variables.

Type	Variable name	Symbol	Definition
Dependent variable	Enterprise market competitiveness	*EMC*	HHI_ main business revenue: The sum of the squares of the ratios of each company's main business revenue to the total main business revenue in the industry.
		EMC1	HHI_ sales revenue: The sum of the squares of the ratios of each company's sales revenue to the total sales revenue in the industry.
		EMC2	HHI_ assets: The sum of the squares of the ratios of each company's total assets to the total assets in the industry.
Independent variable	Difference-in-differences variable	*DID*	Treat × Post
Mediator variable	ESG practices	*ESG*	Huazheng ESG Index
	Financing constraints	*SA*	SA Index
Control variables	Company size	*Size*	Natural logarithm of total assets
	Debt to asset ratio	*Lev*	Total liabilities/Total assets
	Cash flow ratio	*Cashflow*	Net cash flow from operating activities/Total assets
	CEO duality	*Dual*	1 if the same person holds the positions of CEO and chairman, 0 otherwise
	Company age	*FirmAge*	Logarithm of the difference between the current year and the year of enterprise listing plus one
	Board size	*Board*	Natural logarithm of the number of board members
	Equity concentration	*Top1*	Number of shares held by the largest shareholder/Total number of shares
	Independent directors ratio	*Indep*	Number of independent directors/Total number of directors
	Institutional investors shareholding	*Inst*	Total shares held by institutional investors/Total number of shares

Table 2
Summary statistics.

Varname	Obs	Mean	SD	Median	Max	Min
EMC	33360	8.4236	7.5809	5.7914	42.9668	1.4288
EMC1	33360	8.5326	7.8021	6.1316	47.7472	1.4223
EMC2	33360	7.1833	6.5985	4.9618	48.7334	1.0481
DID	33360	0.0084	0.0912	0.0000	1.0000	0.0000
ESG	33360	73.2010	4.9372	73.4500	85.5400	55.0000
SA	33360	−3.8336	0.2521	−3.8344	−3.0776	−4.5613
Size	33360	22.2095	1.2964	22.0177	26.4523	18.7993
Lev	33360	0.4133	0.2044	0.4035	0.9064	0.0381
Cashflow	33360	0.0477	0.0685	0.0466	0.2735	−0.2003
Dual	33360	0.3022	0.4592	0.0000	1.0000	0.0000
FirmAge	33360	2.9314	0.3230	2.9957	3.6109	1.6094
Board	33360	2.1138	0.1968	2.1972	2.7081	1.6094
Top1	33360	0.3384	0.1475	0.3151	0.7579	0.0806
Indep	33360	0.3769	0.0537	0.3636	0.6000	0.2857
Inst	33360	0.4292	0.2484	0.4408	0.9333	0.0010

4. Empirical analysis

4.1. Baseline regression result

Table 3 presents the results of the baseline regression analysis. Column (1) shows the results of the univariate regression, while Column (2) includes individual and year fixed effects along with control variables. The coefficient for *DID* is significantly positive at the 1 % level in both columns, indicating that supply chain sustainability significantly enhances market competitiveness, supporting Hypothesis 1.

The SCIA pilot policy has substantively improved the market competitiveness of pilot enterprises. This improvement likely stems from the policy's support in refining and optimizing supply chain management. Internally, the policy has driven innovations and technological upgrades within the supply chain, enhancing internal management and efficiency, thus providing competitive advantages in the market. Additionally, pilot enterprises have benefited from the policy's impact on brand enhancement and market

Table 3
Baseline regression.

	(1)	(2)
	EMC	*EMC*
DID	2.4640***	2.3243***
	(3.2806)	(3.0611)
Size		−0.3552**
		(−2.0444)
Lev		−0.6878
		(−1.1898)
Cashflow		1.1625*
		(1.9067)
Board		0.6389
		(1.1701)
Indep		1.1904
		(0.7926)
Dual		0.0429
		(0.3213)
Top1		2.3582**
		(2.2919)
FirmAge		−4.5964***
		(−3.7230)
Inst		1.7943***
		(2.8582)
_cons	8.4029***	26.6162***
	(1332.9231)	(4.9464)
Id FE	Yes	Yes
Year FE	Yes	Yes
N	33360	33360
Adj. R^2	0.7417	0.7444

Note: *** indicates $p < 0.01$, ** indicates $p < 0.05$, * indicates $p < 0.1$. The values enclosed in parentheses represent t-statistics. This notation is consistent across subsequent tables.

recognition, further strengthening their external market competitiveness.

4.2. Parallel trends test

The premise for conducting the DID test is that the market competitiveness levels of the control group and the treatment group exhibit parallel trends before the implementation of the SCIA pilot policy (Liu & Wang, 2024). To obtain a more accurate and clear causal estimation, Model (2) is constructed to test whether this premise holds.

$$EMC_{it} = \beta_0 + \sum_{n=-5}^{4} \beta_n DID_n + \sum \text{Control}_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (2)$$

Where DID_n is a dummy variable for the n-th year since the implementation of the SCIA pilot policy, and β_n reflects the differences in market competitiveness between the treatment and control groups. Other variables are consistent with Model (1). The base year is the year before the policy implementation ($n = -1$), and the results are presented in Table 4. From Table 4 and it is evident that when $n < 0$, the coefficients for DID_n are not statistically significant, indicating that the market competitiveness trends of the treatment and control groups were parallel before the policy intervention. This ensures the validity of the DID model's assumption and eliminates the potential influence of pre-policy trend differences on the results. When $n \geq 1$, the coefficients for DID_n are significantly positive, showing that post-policy, supply chain sustainability significantly enhanced market competitiveness, and this effect gradually strengthened over time. The lack of significance for the *DID* coefficient in the year of policy implementation may be due to the time required for policy transmission and implementation. Companies might need time to adjust their supply chain management and optimize resources to adapt to external market changes. Over time, as companies adapt to the changes brought by the policy, the effect of supply chain sustainability on market competitiveness becomes more pronounced.

4.3. Placebo test

To ensure that the experimental results are not influenced by other unobserved factors, this study replaces the treatment and control groups while keeping the policy shock time unchanged. Specifically, a pseudo-treatment group is created by randomly selecting the same number of pilot enterprises from the initial sample as in the baseline regression, and this process is repeated 500 times. Fig. 1 illustrates the distribution of coefficient estimates and p-values for these random samples. From Fig. 1, it is observed that the estimated coefficients are concentrated around zero, which significantly differs from the actual estimated coefficient of 2.3243. Moreover, the p-values for the majority of these estimated coefficients exceed 0.05, indicating that in 500 random samples, the effect of the SCIA pilot policy on enterprise market competitiveness is not significant. This analysis shows that the baseline regression outcomes remain stable and unaffected by unseen variables, ensuring the reliability of the study's conclusions.

Table 4
Parallel trends test.

	(1)	(2)
	EMC	*EMC*
DID_{-5}	−0.7775	−0.7519
	(−0.7678)	(−0.7465)
DID_{-4}	−0.4832	−0.4470
	(−0.5132)	(−0.4779)
DID_{-3}	0.4574	0.5251
	(0.5378)	(0.6275)
DID_{-2}	0.6603	0.6564
	(1.0828)	(1.1287)
current	1.2831	1.2407
	(1.5366)	(1.5235)
DID_1	1.5778*	1.5069*
	(1.7242)	(1.6842)
DID_2	2.9664**	2.8575**
	(2.5576)	(2.4917)
DID_3	2.9865**	2.8035**
	(2.4675)	(2.3402)
DID_4	3.2197**	3.0288**
	(2.3786)	(2.2440)
_cons	8.4283***	26.5906***
	(648.3509)	(4.9400)
Controls	No	Yes
Id FE	Yes	Yes
Year FE	Yes	Yes
N	32918	32918
Adj. R^2	0.7430	0.7457

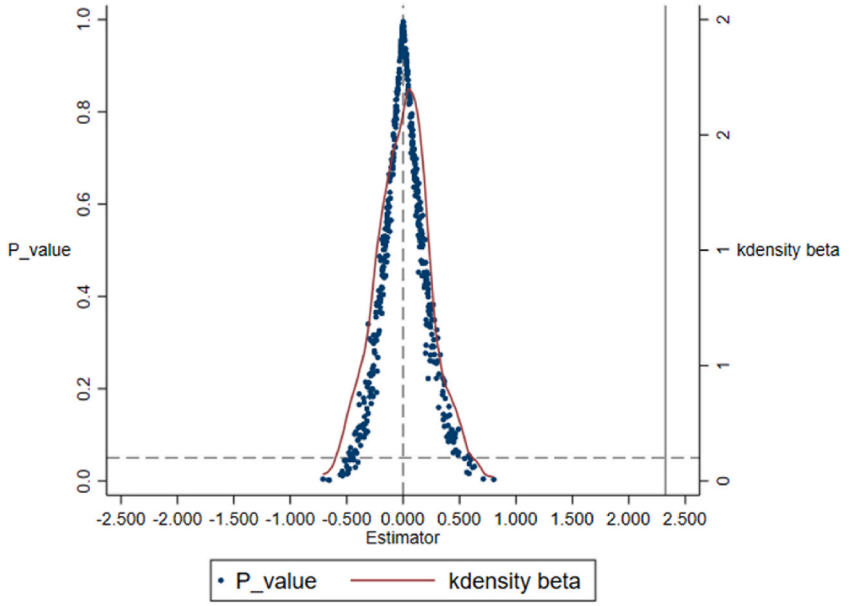

Fig. 1. Placebo test.

4.4. Robustness test

4.4.1. Propensity score matching

To reduce sample selection bias, this study employs the PSM method on a yearly basis to screen the sample. Additionally, we use the DID method to control for time and fixed effects, enhancing the accuracy and reliability of policy effect estimates. Firstly, a Logit model is used to estimate the probability of each sample receiving treatment in each year, and samples are matched based on these probabilities. Two matching methods are applied: Caliper 1:1 matching and kernel matching. The regression results in Table 5 present findings from different matching methods. Columns (1) and (2) report results for Caliper 1:1 matching and kernel matching, respectively, with coefficients of 2.2288 and 2.2310, both significant at the 1 % level. This suggests that policy implementation significantly boosts market competitiveness while controlling for other variables.

4.4.2. Replacement of core variables

To verify the consistency of the impact of supply chain sustainability on corporate market competitiveness and to test the robustness of the results across different measurement indicators, this study employs a replacement of core variables approach. Specifically, the dependent variable *EMC* is replaced with *EMC1* and *EMC2*.

The results, presented in Table 5, columns (3) and (4), show *DID* coefficients of 2.4500 and 2.2208, both significant at the 1 % level. This suggests that even with variable replacements, the beneficial effect of supply chain sustainability in strengthening corporate market position remains robust, reinforcing the reliability of the research findings.

Table 5
Robustness test results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	PSM-DID		Replace variables		Add fixed effects		Shorten sample period
	EMC	*EMC*	*EMC1*	*EMC2*	*EMC*	*EMC*	*EMC*
DID	2.2288***	2.2310***	2.4500***	2.2208***	1.8991***	1.8331***	1.6056**
	(2.9057)	(2.9085)	(3.2117)	(5.5483)	(3.2304)	(3.1044)	(2.3885)
_cons	23.8783	23.8944	29.4424***	26.8485***	34.2564***	34.6328***	6.8493
	(3.7486)	(3.7526)	(5.1268)	(5.2951)	(7.7513)	(7.8088)	(1.4793)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Id FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind FE	No	No	No	No	Yes	Yes	No
Pro FE	No	No	No	No	No	Yes	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	20758	20773	33360	33360	33360	33360	24431
Adj. R^2	0.7689	0.7688	0.7287	0.6882	0.8047	0.8047	0.8459

4.4.3. Addition of fixed effects

In column (5), industry fixed effects are introduced to account for industry-specific differences that might affect the experimental results. Column (6) further incorporates provincial control effects to account for regional differences that might influence corporate market competitiveness. The results show *DID* coefficients of 1.8991 and 1.8331, both significant at the 1 % level. This indicates that even after controlling for additional unobserved fixed effects, the positive impact of supply chain sustainability on corporate market competitiveness remains significant, further validating the robustness of the results.

4.4.4. Shortening the sample period

The "Opinions on Deepening the Reform of the Circulation System and Accelerating the Development of the Circulation Industry," issued in 2016 by the Ministry of Commerce and other departments, aimed to optimize supply chain management and might have positively influenced corporate market competitiveness. To ensure an accurate estimate of the effects of the 2018 〞Notice on the Pilot Program for Supply Chain Innovation and Application," this study excludes data from 2016. This approach helps control for other potential policy factors affecting corporate market competitiveness, ensuring that the results reflect the impact of the 2018 policy intervention alone. As shown in column (7) of Table 5, the DID coefficient is 1.6056. Although this is slightly lower compared to other models, it remains significantly positive, ruling out the possibility of interference from other policy factors and confirming the robustness and reliability of the study's conclusions.

4.5. Mechanism test

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To test Hypothesis 2 and Hypothesis 3, we construct models (3) and (4) to examine the mediating effects of ESG practices and financing constraints (Zhang & Zhou, 2022).

$$EMC_{it} = \gamma_0 + \gamma_1 DID_{it} + ESG_{it} + \sum \text{Control}_{it} + \mu_i + \theta_t + \varepsilon_{it} \tag{3}$$

$$EMC_{it} = \delta_0 + \delta_1 DID_{it} + SA_{it} + \sum \text{Control}_{it} + \mu_i + \theta_t + \varepsilon_{it} \tag{4}$$

In these models, ESG_{it} and SA_{it} are the mediating variables representing ESG performance and financing constraints, respectively, while the other variables remain the same as in Model (1).

(1) ESG mediating effect

Columns (1) and (2) in Table 6 present the regression results for *DID* and *ESG's* impact on *EMC*. The results in column (1) indicate that the core explanatory variable, *DID*, has a significant positive effect on *EMC*. In column (2), where ESG is included as a mediating variable, the coefficient for *DID* decreases but remains significant. Additionally, the coefficient for *ESG* on *EMC* is significantly positive, suggesting that *ESG* plays a partial mediating role. This implies that supply chain sustainability enhances corporate market competitiveness through improved *ESG* performance. This improvement is likely due to companies focusing more on environmental, social responsibility, and governance practices in response to the policy. Enhanced *ESG* practices not only improve the company's sustainability capabilities but also strengthen its market image, attracting more investors and customers, thereby boosting its market competitiveness.

(2) Financing constraints mediating effect

Table 6
Mediating effects.

	(1)	(2)	(3)
	EMC	*EMC*	*EMC*
DID	2.3243***	2.3017***	1.8849**
	(3.0611)	(3.0241)	(2.5007)
ESG		0.0218**	
		(2.3368)	
SA			5.6510***
			(4.4021)
_cons	26.6162***	25.5357***	46.7244***
	(4.9464)	(4.7635)	(6.8102)
Controls	Yes	Yes	Yes
Id FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	33360	33360	33360
Adj. R^2	0.7444	0.7445	0.7457

The regression results in columns (1) and (3) of Table 6 show that after including SA, the coefficient for *EMC* decreases, while the coefficient for *SA* is significantly positive. This suggests that reducing financing constraints aids in boosting corporate market competitiveness, where SA acts as a partial mediator. The implementation of the SCIA pilot policy likely improved supply chain management and coordination, enhancing corporate creditworthiness and transparency. Additionally, the policy encourages companies to collaborate with financial institutions, engage in supply chain finance activities, and innovate supply chain finance models to optimize cash flow, further alleviating financing pressures. As a result, the policy not only directly enhances corporate market competitiveness but also indirectly strengthens competitive advantages by easing financing constraints.

5. Further analysis

① Marketization level analysis

The level of marketization significantly impacts a company's operational environment and policy responsiveness (Li et al., 2023; Yu & Deng, 2021). To better understand the policy effects in different market environments and reveal how marketization levels influence corporate market competitiveness, this study categorizes the sample based on the median marketization level.

Empirical results are presented in Table 7. Column (1) shows a *DID* coefficient of 4.1839, which is statistically significant at the 1 % level, while Column (2) reports a *DID* coefficient of 1.2789 with a significance level of 5 %. These results indicate that in regions with higher marketization levels, supply chain sustainabil tly enhances corporate market competitiveness. Conversely, in regions with lower marketization levels, the impact of dolphin choirsustainability is weaker.

High marketization levels are associated with a usiness environment, more comprehensive laws and regulations, transparent information disclosure, and efficient market mechanisms. These factors collectively create a favorable external environment for business development, allowing companies to more effectively utilize resources, technology, and policy incentives for innovation and supply chain optimization. Consequently, firms in high marketization regions are better equipped to adapt and respond to market competition, thereby enhancing their competitiveness. In contrast, regions with lower marketization levels, due to less developed market mechanisms, face more limitations and challenges in resource allocation, technology application, and policy responsiveness. This results in less pronounced effects of policy implementation in these areas.

② Analysis based on business capability

Examining how companies with different levels of operational capability respond to supply chain sustainability policies provides valuable insights for policymakers. Therefore, this study divides the sample into high and low business capability groups based on the median book-to-market ratio and analyzes the role of business capability in enhancing corporate market competitiveness.

The regression results in Table 7, Columns (3) and (4), show that for firms with higher operational capability, the *DID* coefficient is 2.4133, which is statistically significant at the 1 % level, indicating a significant positive impact of the policy on market competitiveness. This suggests that the SCIA pilot policy substantially improves market competitiveness for companies with strong operational capabilities. In contrast, for firms with weaker operational capability, the *DID* coefficient is 2.2389, significant at the 5 % level. Although still positive and significant, the impact is less pronounced compared to firms with higher operational capability. The p-value for the inter-group coefficient test is 0.0000, further confirming that the positive effect of supply chain sustainability is more significant for firms with stronger operational capabilities.

Business capability directly affects the efficiency of resource allocation and market responsiveness. Companies with higher operational capability typically exhibit better management practices and market adaptability, allowing them to fully leverage policy benefits and effectively implement and optimize sustainability measures. This leads to a more pronounced increase in market competitiveness. In contrast, firms with weaker operational capability face limitations in internal management and resource

Table 7
Marketization level and corporate operational capacity.

	(1)	(2)	(3)	(4)
	High Marketization Level	Low Marketization Level	Strong Operational Capacity	Weak Operational Capacity
	EMC	*EMC*	*EMC*	*EMC*
DID	4.1839***	1.2789**	2.4133***	2.2389**
	(2.8116)	(2.2221)	(2.5871)	(2.2669)
_cons	37.8110***	18.2438**	21.5611***	37.9865***
	(5.7277)	(2.0616)	(3.1100)	(4.9694)
ChowTest	5.42		10.48	
ChowP	0.0045		0.0000	
Controls	Yes	Yes	Yes	Yes
Id FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	16698	16662	16680	16680
Adj. R^2	0.7560	0.7744	0.8025	0.7343

allocation, resulting in a less noticeable impact of the policy.

③ Analysis based on technological attributes

High-tech industries often possess advanced technological innovation capabilities and strong market adaptability, enabling them to quickly translate these advantages into competitive market benefits in response to SCIA pilot policy. Therefore, this study divides the sample into high-tech and non-high-tech sectors to explore the heterogeneous effects of supply chain sustainability policies across different industry types.

The regression results in Table 8, Columns (1) and (2), show that in high-tech firms, the *DID* coefficient is 2.0602, which is significant at the 1 % level, indicating a substantial positive impact of the policy on market competitiveness. In contrast, for non-high-tech firms, the *DID* coefficient is 1.3078, with a lower significance level of 10 %. Furthermore, the Chow test p-value is 0.0000, demonstrating a significant difference in the *DID* coefficients between the two groups. This suggests that the impact of supply chain sustainability on market competitiveness is more pronounced in high-tech industries.

The higher technological content and innovation capability of high-tech firms enable them to better respond to policies. These firms exhibit greater flexibility and innovation in product development, production processes, and management practices, allowing them to more effectively utilize the resources and opportunities provided by the policy. This results in a greater competitive advantage in the market. In contrast, non-high-tech firms may rely on traditional production models and technologies, limiting their ability to respond to policies effectively. Therefore, the impact of supply chain sustainability policies varies significantly across different industry types, with high-tech firms benefiting more from these policies.

④ Analysis based on environmental attributes

Non-heavy pollution industries generally face less environmental pressure during production, which enhances their ability to adapt to and respond to policies. This study divides the sample into high-pollution and low-pollution sectors to analyze the heterogeneous effects of supply chain sustainability policies on firms with different pollution profiles. The results are shown in Table 8, Columns (3) and (4).

The regression results indicate that in heavy pollution industries, the *DID* coefficients are 0.9819 and 2.2626, with both being significant at the 1 % level. In contrast, for non-heavy pollution firms, the *DID* coefficients are relatively larger, and the Chow test p-value is 0.0000, showing that the supply chain sustainability policy has a significant positive effect on market competitiveness in both high-pollution and low-pollution firms, but the effect is more pronounced in non-heavy pollution industries.

Non-heavy pollution firms typically do not require significant expenditures on technological enhancements and experience less adverse effects from environmental policies. This allows them to adapt and respond more effectively to policies, leading to a faster conversion of policy benefits into enhanced market competitiveness. On the other hand, heavy pollution firms face higher costs for policy adaptation, with less flexibility in supply chain management and market strategies, resulting in a smaller increase in market competitiveness compared to non-heavy pollution firms. Therefore, the positive impact of supply chain sustainability policies is more pronounced in non-heavy pollution industries.

⑤ Analysis based on factor intensity

Labor-intensive industries and non-labor-intensive industries exhibit significant differences in resource allocation, production methods, and market competitiveness. This study conducts a heterogeneity test by grouping the sample to reveal the heterogeneous effects of the policy under different production structures and resource dependency patterns. The results are presented in Table 8,

Table 8
Industry attributes and factor attributes.

	(1)	(2)	(3)	(4)	(5)	(6)
	High-tech	Non-high-tech	Heavy pollution	Non-heavy-polluting	Labor-intensive	Non-labor-intensive
	EMC	*EMC*	*EMC*	*EMC*	*EMC*	*EMC*
DID	2.0602***	1.3078*	0.9819***	2.2626***	2.6985***	0.3411
	(2.6163)	(1.8584)	(3.0123)	(3.0433)	(3.2733)	(0.4882)
_cons	33.1765***	22.1209***	−17.2763**	41.9672***	33.4839***	26.5733***
	(3.9817)	(3.6381)	(−2.2502)	(6.9011)	(3.5651)	(4.3384)
ChowTest	140.05		26.17		168.38	
ChowP	0.0000		0.0000		0.0000	
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Id FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	14518	18842	7305	26055	11358	22002
Adj. R^2	0.7135	0.8074	0.9192	0.7100	0.7488	0.7813

Columns (5) and (6).

The empirical results indicate that the influence of supply chain sustainability on market competitiveness varies significantly across labor-intensive and non-labor-intensive industries. Specifically, in labor-intensive industries, supply chain sustainability has a notable positive impact, with the *DID* coefficient reaching significance at the 1 % level. Conversely, in non-labor-intensive industries, the *DID* coefficient does not show statistical significance.

This finding suggests that labor-intensive firms benefit more from the policy, potentially due to their greater flexibility in resource allocation and cost control. They can quickly adapt to policy requirements, leading to a more pronounced improvement in competitiveness. On the other hand, non-labor-intensive industries, which typically involve more complex production processes and higher technology requirements, may take longer for policy-induced changes to manifest. As a result, the short-term impact on market competitiveness in these industries is less significant compared to labor-intensive industries.

6. Conclusion and recommendations

This paper explores the relationship between supply chain sustainability and corporate market competitiveness using a DID model. The results indicate that supply chain sustainability significantly enhances corporate market competitiveness, with this conclusion being validated through a series of robustness tests. Meanwhile, improvements in corporate ESG practices and alleviation of financing constraints both contribute to higher levels of corporate market competitiveness. Further research shows that the effect of supply chain sustainability on corporate market competitiveness exhibits heterogeneity. Specifically, the positive influence of supply chain sustainability is more pronounced in firms located in areas with higher marketization levels, firms with stronger operational capabilities, high-tech industries, non-heavy-polluting industries, and labor-intensive industries.

Based on the research findings of this paper, the following recommendations are proposed: (1) Promote supply chain innovation actively. The government should play an active role by offering extensive technical support and financial subsidies. It is essential to establish a system of rewards and penalties that encourages companies to emulate the successful strategies of pilot enterprises. Additionally, there needs to be a concerted effort to strengthen the monitoring and evaluation of these pilot projects to ensure their effective implementation and broader dissemination. This approach not only spreads best practices but also incentivizes continual improvement in supply chain operations. (2) Improve ESG reporting and evaluation systems. Clear and robust reporting frameworks and evaluation systems are vital. These systems should require companies to disclose comprehensive ESG reports, thereby raising awareness of corporate social responsibility, enhancing market transparency, and fostering a competitive advantage. To further drive compliance and performance, the introduction of both incentives for adherence and penalties for non-compliance is recommended. Such measures will promote better corporate behavior and enhance overall ESG performance across industries. (3) Enhance the financing environment. Collaboration between financial institutions and government bodies is crucial to create a more supportive financing environment for s edium-sized enterprises. This can be achieved by offering low-interest loans, risk compensation mechanisms, and financing guarentees. Additionally, the establishment of green financial products and services, such as green bonds and green funds, will enco stors to put their money into eco-friendly projects. Advancing financial market reforms to optimize credit structures and reduce financing costs will further support supply chain innovations and sustainable development initiatives. (4) Advance market-oriented reforms. In pilot cities and economically disadvantaged regions, efforts should be made to increase the level of marketization, optimize the business environment, streamline approval processes, reduce administrative costs, and enhance the efficiency of government services. These actions will assist enterprises in adapting to policy changes, boosting their competitiveness, and promoting the sustainable development of their supply chains. (5) Implement industry-specific policies. There is a need to encourage industries, especially high-tech and non-heavy-polluting sectors, to actively participate in sustainable supply chain practices. Providing additional policy support and allocating resources can enhance their market competitiveness and promote sustainable development through technological innovation and optimized management practices. These industry-specific policies should focus on enabling companies to leverage new technologies and management systems that contribute to sustainability. (7) Enhance operational capabilities. For companies with weaker operational capabilities, it is essential to provide specialized training and consulting services. These should be complemented by policy guidance and market incentives to help improve their operational efficiency, supply chain management, and sustainability practices. Enhancing these capabilities will not only improve their competitive edge but also ensure they are capable of implementing and benefiting from sustainable practices. Additionally, efforts should be made to foster partnerships among businesses, government, and non-governmental organizations to create a more cohesive approach to sustainable development. These partnerships can help standardize sustainable practices and make them more accessible to smaller enterprises that might otherwise struggle to implement such measures on their own. Furthermore, public awareness campaigns can be launched to educate consumers and businesses about the benefits of sustainable supply chain practices, thereby creating a stronger market demand for sustainable products and services. Regular policy assessments and adjustments should also be considered to respond effectively to new challenges and opportunities in the marketplace, ensuring that sustainability remains a key component of business strategy. This comprehensive approach will not only strengthen the individual businesses but also contribute to the broader goal of sustainable economic development.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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