Economics and Data Science 1 (2025) 251114

Economics and Data Science

journal homepage: https://www.innoviair.cn/journal/EDS

Institutional Innovation in Opening-Up and the Governance of Corporate Greenwashing: Evidence from China's Pilot Free Trade Zones

Cheng Cheng[a], Yanming Chen[a,*], Jingyun Li[b]

[a]Hunan University, Changsha, Hunan 410000, China

[b]Waseda University, Tokyo, Japan

ARTICLEINFO

Keywords:
Free Trade Pilot Zone
Greenwashing Behavior
Geographic Information System
International Supply Chain
Government-Enterprise Collaboration

ABSTRACT

Under China's "dual circulation" development paradigm, whether FTZ policies can promote truthful environmental disclosure and curb corporate greenwashing is a key issue. Using GIS technology to precisely identify listed firms and subsidiaries located within FTZs, this study applies a difference-in-differences model to examine the impact of FTZ policies on greenwashing. The results show that FTZ policies significantly reduce greenwashing, with stronger effects for firms having more subsidiaries, higher subsidiary shares, and greater registered capital in FTZs. Mechanism analyses indicate that improved financing access, strengthened government–enterprise green collaboration, and deeper integration into international supply chains—particularly through trade facilitation reforms—are the main channels. No significant spillover effects are found for non-FTZ firms in the same city, underscoring the importance of precise GIS-based identification. These findings provide robust evidence on how FTZ policies curb corporate greenwashing and support firms' participation in sustainable global development.

1.Introduction

The 20th CPC National Congress emphasizes green, low-carbon transformation as central to high-quality development. President Xi (2023) highlighted that a high-quality ecological environment underpins sustainable development and modernization. Enterprises, as major economic actors and pollution sources, play a key role in environmental governance, guided by the 2020 Modern Environmental Governance Opinions, the 14th Five-Year Plan, and Party directives. Economically, environmental quality is a public good, and without effective regulation or incentives, firms underinvest in protection. Even with stronger regulation under carbon goals, weak incentives for real performance may lead to symbolic compliance or greenwashing[1,2].

Greenwashing — firms' exaggeration of environmental performance — undermines sustainable development. China's Pilot Free Trade Zones (FTZs) introduce institutional innovations in investment, trade, finance, and regulation to boost efficiency and internationalization. Using GIS data on listed firms and 152,000 subsidiaries with a difference-in-differences approach, this study finds FTZ policies significantly reduce greenwashing, especially for firms with more or larger subsidiaries, mainly via improved financing, government-enterprise green collaboration, and integration into international supply chains through trade facilitation, with no spillover to non-FTZ firms.

This paper contributes to the literature in three respects.

Most FTZ studies use city- or province-level identification, obscuring firm-level effects. Using GIS mapping of 67 subzones, this study precisely identifies firms' exposure and finds no significant impact on non-zone firms, highlighting boundary-based identification. Drawing on incentive and social network theories, we show that institutional innovations enhance government – enterprise green coordination and trade

* Corresponding author.
E-mail address: yanmingchen@aliyun.com
https://doi.org/10.65455/3ke7f284
Received 18 November 2025; Received in revised form 18 December 2025; Accepted 20 December 2025; Available online 31 December 2025

facilitation embeds firms in high-standard international supply chains, disciplining environmental behavior. Greenwashing is measured via a national-standard disclosure dictionary and green patents, providing a more accurate assessment than ESG-based metrics.

2.Theoretical Analysis and Research Hypotheses

As frontier platforms for the "dual-circulation" strategy, FTZs shape firms' sustainable development through incentives and constraints. FTZ policies curb greenwashing via three channels: lowering financing costs to support green investment, strengthening government-enterprise coordination to embed environmental objectives into operations, and promoting integration into international supply chains with high environmental standards. This study examines these effects through financing optimization, green collaboration, and supply-chain embeddedness.

2.1.Financing Optimization Effect

Resource Dependence Theory posits that firms' access to external resources, especially capital, shapes strategic behavior[3,4]. Under tight financing constraints, firms tend to prioritize short-term returns, underinvest in environmental governance, and rely on low-cost symbolic actions such as greenwashing[5]. This tendency is particularly pronounced among Chinese SMEs, which face persistent financing frictions and information asymmetry in green credit markets[6,7].

Financial reform is a core component of China's FTZ experimentation. Since 2013, FTZs have introduced interest-rate liberalization, fintech-based inclusive finance, and green financial instruments, expanding financing channels and alleviating firms' financing constraints[8,9]. Improved access to diversified, lower-cost capital enables firms to increase substantive investment in green technologies and R&D, enhance operational efficiency, and reduce reliance on symbolic environmental disclosure. As a result, firms' incentives to engage in greenwashing weaken, highlighting financing optimization as a key mechanism through which FTZ policies curb greenwashing and promote genuine green transformation.

2.2.Government–Enterprise Coordination for Green Transition

Incentive Theory suggests firms respond to structured rewards and penalties[10]. By strengthening environmental regulation, setting green targets, and supporting green finance, governments encourage firms to integrate environmental objectives into core strategies rather than rely on symbolic disclosure[11]. Closer government – enterprise coordination increases policy incentives and regulatory scrutiny, motivating substantive investments in emission reduction, energy conservation, and cleaner production[12,13], while reducing operational and reputational risks and greenwashing incentives[14,15].

China's FTZs implement green trade and governance initiatives covering supply chains, carbon trading, ecological compliance, and disclosure. Guangdong FTZ streamlined environmental impact assessments, while Shaanxi FTZ established green certification and integrated supervision. By delegating authority and coordinating governance, FTZs shift firms from passive compliance to proactive green practices, aligning regulation with green transition goals and curbing greenwashing.

2.3.International Supply-Chain Embedding Effect

As competition intensifies, supply chains are shifting from transactional exchanges to interconnected networks, replacing traditional vertical integration[16]. Relational embeddedness theory emphasizes that trust, goal alignment, and information sharing create unique resources that enhance firm performance and corporate social responsibility, attracting clients and strengthening reputation[17-20]. In green international supply chains, collaboration with high-standard partners improves governance and transparency, reducing greenwashing[21]. FTZ trade facilitation reforms boost customs efficiency and trade, helping domestic firms integrate into global supply chains[22,23], though China still lags developed countries in environmental knowledge and practices[24,25].

FTZ policies strengthen supply-chain links between Chinese firms and partners in developed countries, enabling adoption of advanced environmental practices. Deeper cooperation provides access to superior management and operational standards, promoting substantive governance and reducing misleading environmental claims. Stronger supply-chain ties enhance global market integration, resource access, competitiveness, and incentives to greenwash[26]. Collaboration with international partners also improves governance, managerial capabilities, and stakeholder trust.

Hypothesis H1: FTZ policies significantly reduce corporate greenwashing by optimizing financing, enhancing government-enterprise green transition synergy, and promoting international supply-chain embeddedness.

3.Data Sources and Empirical Model

3.1.Data Sources

This study analyzes 4,266 Chinese listed firms (2009–2022), excluding financial and ST companies. Data on 152,000 subsidiaries' locations and capital were obtained from CNRDS and GTA. Maps of 67 FTZ subzones across 21 cities were compiled and geocoded using GIS and the Gaode Map API. Patent and financial data came from CSMAR, with continuous variables winsorized at 1% to reduce outliers.

3.2.Identification of Treated Firms

China's FTZ policies are strictly location-based, with preferential treatments available only to firms physically located within zone boundaries. Because most FTZs cover limited areas, parent headquarters are rarely inside zones; instead, firms typically access FTZ benefits through in-zone

subsidiaries. To identify FTZ exposure, this study collects address data for 152,000 subsidiaries from Qichacha and Tianyancha and links them to parent firms. Using GIS, we delineate 67 subzones across 21 FTZs and map firm locations to determine in-zone status. Firm and subsidiary establishment dates are then matched with FTZ inception dates to identify initial exposure and policy shocks.

Figure 1 illustrates the identification of FTZ treatment firms, using the Shanghai, Tianjin, Shenzhen, and Guangzhou FTZs. Shaded areas show FTZ boundaries; black dots represent parent companies, gray dots their subsidiaries. A firm is considered exposed if its parent or any subsidiary is in the FTZ at the subzone's establishment. If a subsidiary enters the FTZ later while the parent remains outside, exposure starts from the subsidiary's establishment year. Firms with in-zone parent companies or subsidiaries form the treatment group; those entirely outside FTZs form the control group.

Table 1. presents the timeline of the establishment of each FTZ and its corresponding subzones.

FTZ Name	No.	Subzone Name	City / Municipality	Year of Approval
Shanghai FTZ	1	Waigaoqiao Bonded Area Subzone	Shanghai	2013
	2	Lujiazui Subzone (incl. Expo Subzone)		2015
	3	Jinqiao Subzone		2015
	4	Zhangjiang Subzone		2015
	5	Lin-gang New Area		2019
Guangdong FTZ	6	Nansha New Area Subzone	Guangzhou	2015
	7	Qianhai–Shekou Subzone	Shenzhen	2015
	8	Hengqin Subzone	Zhuhai	2015
Tianjin FTZ	9	Tianjin Port (Dongjiang) Subzone	Tianjin	2015
	10	Tianjin Airport Subzone		2015
	11	Binhai New Area CBD Subzone		2015
Fujian FTZ	12	Fuzhou Subzone	Fuzhou	2015
	13	Xiamen Subzone	Xiamen	2015
	14	Pingtan Subzone	Fuzhou	2015
Liaoning FTZ	15	Shenyang Subzone	Shenyang	2017
	16	Dalian Subzone	Dalian	2017
	17	Yingkou Subzone	Yingkou	2017
Zhejiang FTZ	18	Offshore (Islands) Subzone	Zhoushan	2017
	19	Northern Subzone	Zhoushan	2017
	20	Southern Subzone	Zhoushan	2017
	21	Ningbo Subzone	Ningbo	2020
	22	Hangzhou Subzone	Hangzhou	2020
	23	Jinyi Subzone	Jinhua	2020
Henan FTZ	24	Zhengzhou Subzone	Zhengzhou	2017
	25	Kaifeng Subzone	Kaifeng	2017
	26	Luoyang Subzone	Luoyang	2017
Hubei FTZ	27	Wuhan Subzone	Wuhan	2017
	28	Yichang Subzone	Yichang	2017
	29	Xiangyang Subzone	Xiangyang	2017
Chongqing FTZ	30	Liangjiang Subzone	Chongqing	2017
	31	Xiyong Subzone	Chongqing	2017
	32	Guoyuan Port Subzone	Chongqing	2017
Sichuan FTZ	33	Tianfu New Area Subzone	Chengdu	2017
	34	Qingbaijiang Railway Port Subzone	Chengdu	2017
	35	Southern Sichuan Port Subzone	Luzhou	2017
Shaanxi FTZ	36	Central Subzone	Xi'an	2017
	37	Xi'an International Trade & Logistics Park	Xi'an	2017
	38	Yangling Demonstration Zone Subzone	Xianyang	2017
Hainan FTZ	39	Entire Hainan Island	Hainan	2018
Shandong FTZ	40	Jinan Subzone	Jinan	2019
	41	Qingdao Subzone	Qingdao	2019
	42	Yantai Subzone	Yantai	2019
Jiangsu FTZ	43	Nanjing Subzone	Nanjing	2019
	44	Suzhou Subzone	Suzhou	2019
	45	Lianyungang Subzone	Lianyungang	2019
Guangxi FTZ	46	Nanning Subzone	Nanning	2019
	47	Qinzhou Port Subzone	Qinzhou	2019

Hebei FTZ	48	Chongzuo Subzone	Chongzuo	2019
	49	Xiong'an Subzone	Baoding	2019
	50	Zhengding Subzone	Shijiazhuang	2019
	51	Caofeidian Subzone	Tangshan	2019
	52	Daxing Airport Subzone	Langfang	2019
Yunnan FTZ	53	Kunming Subzone	Kunming	2019
	54	Honghe Subzone	Honghe	2019
	55	Dehong Subzone	Dehong	2019
Heilongjiang FTZ	56	Harbin Subzone	Harbin	2019
	57	Heihe Subzone	Heihe	2019
	58	Suifenhe Subzone	Suifenhe	2019
Beijing FTZ	59	Science & Technology Innovation Subzone	Beijing	2020
	60	International Business Services Subzone	Beijing	2020
	61	High-end Industries Subzone	Beijing	2020
Hunan FTZ	62	Changsha Subzone	Changsha	2020
	63	Yueyang Subzone	Yueyang	2020
	64	Chenzhou Subzone	Chenzhou	2020
Anhui FTZ	65	Hefei Subzone	Hefei	2020
	66	Wuhu Subzone	Wuhu	2020
	67	Bengbu Subzone	Bengbu	2020

Data source: Compiled by the authors based on official development plans of the pilot free trade zones and information disclosed on relevant government websites.

Fig 1. Identification of Firms in the FTZ Treatment Group

3.3.Measurement of Greenwashing

Firms may greenwash to attract investment, creating a gap between disclosed and actual environmental performance[27]. Existing studies often use limited keywords, ignoring the multidimensional nature of green disclosure. This study measures disclosure across procurement, design, production, logistics, and recycling using a 133-term dictionary[28-30] and Python text mining of 2008–2021 A-share reports. Firm-year green patent applications and grants provide a direct proxy for actual performance, forming a firm-level greenwashing index (GWS):

$$GWS_{i,t}=\left(\frac{Greensc_{dis\ i,t}-\overline{Greensc_{dis}}}{\sigma_{dis}+1}\right)-\left(\frac{Greenac_{per\ i,t}-\overline{Greenac_{per}}}{\sigma_{per}+1}\right) \quad (1)$$

where $GWS_{i,t}$ denotes the greenwashing score of firm in year ttt. $Greensc_{dis\ i,t}$ represents the firm's level of green information disclosure, measured by the total frequency of green disclosure keywords (as defined in Table 2) appearing in the firm's annual report. $\overline{Greensc_{dis}}$ denotes the industry-level mean of green information disclosure, and σ_{dis} is the corresponding industry-level standard deviation.

$Greenac_{per\ i,t}$ is proxied by the firm's green patent activity, measured alternatively by the number of green patent applications (*GreenApply*) and the number of green patent grants (*GreenGrant*). $\overline{Greenpatent_{per}}$ denotes the industry-level mean of the corresponding green patent variable, and σ_{per} represents the industry-level standard deviation. The resulting greenwashing measures are denoted as *GWS1* and *GWS2*, respectively.

The GWS index measures the gap between disclosed and actual green performance, with higher values indicating greater greenwashing.

3.4.Model Specification and Variable Definitions

Given the staggered rollout of China's FTZs, firms experience policy exposure at different times and locations. Following[31], a staggered difference-in-differences (DID) framework is employed for the baseline regression:

$$GWS_{i,t}=\beta_0+\beta_1 FTZ_{i,t-1}+\lambda Controls_{i,t-1}+\gamma_t+\mu_i+\varepsilon_{i,t} \quad (2)$$

In this specification, $GWS_{i,t}$ denotes the greenwashing index of firm i in year t. $FTZ_{i,t-1}$ is a dummy variable indicating whether the firm's parent company or any of its subsidiaries is located within a Free Trade Zone. Specifically, $FTZ_{i,t-1}$ equals 1 if the parent firm or at least one subsidiary was located within an FTZ in the previous year and thus exposed to FTZ policies; otherwise, it equals 0, indicating no exposure to FTZ policies. To address potential endogeneity, all explanatory and control variables are lagged by one year. Controls include firm size, cash flow, leverage, revenue growth, TMT share, largest shareholder share, board size, CEO–chair duality, proportion of independent directors, firm age, and ownership type. Year (γ_t) and firm (μ_i) fixed effects are included, with standard errors clustered at the firm level.Table 3 provides detailed definitions of the variables used in the analysis.

Table 2. Keywords for Corporate Green Information Disclosure

Category	Green Information Disclosure Keywords
Green Design	Green design; eco-design; environmental design; recyclable design; environmentally friendly design; energy-saving design; detachable design; extended lifecycle design; green packaging; reduced packaging; energy-efficient and environmentally friendly design concepts; standardized component design; low-carbon packaging; biodegradable design; biodegradable material packaging; innovative eco-friendly packaging materials; green materials; life-cycle assessment; recyclable materials; material recycling; material reuse; environmentally friendly materials
Green Procurement	Green procurement; green raw materials; environmentally friendly materials; supplier green performance evaluation; green delivery; low-carbon suppliers; green suppliers; green partners; green strategic partners; green supply chain collaboration; supplier environmental performance; supplier carbon emissions; supplier ESG performance
Green Production	Green production; green processes; pollution treatment processes; green equipment; green products; green factories; cleaner production; clean technologies; clean energy; emission reduction processes; carbon capture technologies; low-carbon manufacturing; green manufacturing; energy-efficient manufacturing; environmentally responsible manufacturing
Green Logistics	Green logistics; green transportation; green warehousing; green packaging; new energy vehicle transportation; low-carbon logistics; reverse logistics; green distribution; intelligent warehousing; multimodal transport
Green Recycling	Green recycling; closed-loop supply chain; reverse supply chain; recycling and reuse; waste recycling; material regeneration; hazardous waste management; toxic substance management

Data source: National Standards Full-Text Public Disclosure System (https://openstd.samr.gov.cn/bzgk/gb/) and related regulatory documents.

Table 3. Variable Definitions

Variable Category	Variable Name	Symbol	Definition
Dependent Variable	Greenwashing Index	*GWS1*	The gap between a firm's disclosed green practices and its actual green performance
Dependent Variable	Greenwashing Index	*GWS2*	Alternative measure of the gap between disclosed green practices and actual green performance
Independent Variable	FTZ Exposure	*FTZ*	Equals 1 if the firm's parent company or any subsidiary was located within an FTZ in the previous year, and 0 otherwise
Independent Variable	Number of FTZ Subsidiaries	*FTZNum*	Natural logarithm of (number of subsidiaries located within FTZs in the previous year + 1)
Independent Variable	Registered Capital of FTZ Subsidiaries	*FTZAmt*	Natural logarithm of (total registered capital of subsidiaries located within FTZs in the previous year + 1)
Independent Variable	Ratio of FTZ Subsidiaries	*FTZNumRatio*	Number of FTZ subsidiaries divided by total number of subsidiaries in the previous year
Independent Variable	Capital Ratio of FTZ Subsidiaries	*FTZAmtRatio*	Total registered capital of FTZ subsidiaries divided by total registered capital of all subsidiaries in the previous year
Control Variable	Firm Size	*Size*	Natural logarithm of the total number of employees
Control Variable	Cash Flow	*Cashflow*	Cash flow from operating activities divided by total assets
Control Variable	Leverage	*Leverage*	Total liabilities divided by total assets
Control Variable	Revenue Growth	*Growth*	Growth rate of operating revenue
Control Variable	TMT Shareholding	*TMTshare*	Shares held by top management team divided by total shares outstanding
Control Variable	Largest Shareholder Ownership	*Top1*	Ownership share of the largest shareholder
Control Variable	Board Size	*Board*	Natural logarithm of (number of board directors + 1)
Control Variable	CEO–Chair Duality	*Dual*	Equals 1 if the chairman also serves as CEO, and 0 otherwise
Control Variable	Independent Directors Ratio	*Indep*	Number of independent directors divided by total number of directors
Control Variable	Firm Age	*Age*	Natural logarithm of the number of years since the firm was listed
Control Variable	Ownership Type	*SOE*	Equals 1 if the firm is state-owned, and 0 otherwise

3.5.Descriptive Statistics

Table 4 presents descriptive statistics. The greenwashing indices (GWS1, GWS2) exhibit substantial variation, with means of 0.0015 and −0.1674 and wide ranges across firms. The FTZ indicator (FTZ) has a mean of 0.218, indicating that 21.8% of listed firms were exposed to FTZ policies, highlighting the broad but heterogeneous coverage of these policies. The effectiveness of FTZ policies in curbing greenwashing remains an empirical question.

Table 4. Descriptive Statistics

Variable	Observation	Mean	Standard Deviation	Median	Minimum	Maximum
GWS1	34240	0.0015	1.1454	-0.1251	-30.6109	9.5206
GWS2	34240	-0.1674	1.7210	-0.1478	-53.3229	9.5044
FTZ	34240	0.2180	0.4129	0.0000	0.0000	1.0000
Size	34240	22.0743	1.2810	21.8919	19.6838	26.0622
Cashflow	34240	0.0466	0.0705	0.0463	-0.1695	0.2455
Leverage	34240	0.4231	0.2122	0.4133	0.0503	0.9369
Growth	34240	0.2642	0.6850	0.1221	-0.6094	4.8266
TMTshare	34240	0.0777	0.1439	0.0013	0.0000	0.6156
Top1	34240	34.3983	14.7578	32.1400	8.8800	74.2400
Board	34240	2.2431	0.1760	2.3026	1.7918	2.7726
Dual	34240	0.2892	0.4534	0.0000	0.0000	1.0000
Indep	34240	0.3746	0.0525	0.3333	0.3333	0.5714
Age	34240	2.0027	0.9388	2.1972	0.0000	3.3322
SOE	34240	0.3633	0.4810	0.0000	0.0000	1.0000

4.Empirical Results and Interpretation

4.1.Baseline DID Estimates

Using Model (2), Table 5 shows that FTZ exposure — whether a firm's parent or any subsidiary is located within an FTZ — significantly reduces greenwashing. This negative effect remains robust after controlling for firm characteristics, supporting Hypothesis H1 that FTZ policies curb greenwashing by facilitating genuine environmental engagement.

Table 5. Baseline Regression Results on the Effect of FTZ Policies on Corporate Greenwashing

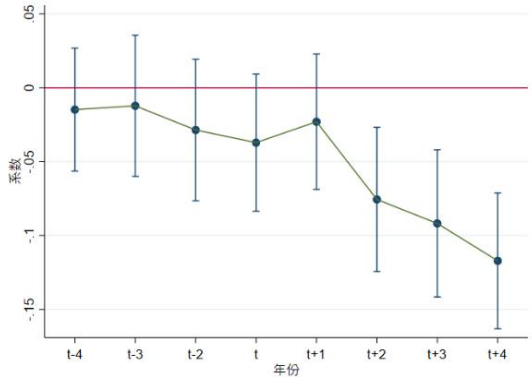
Variables	*GWS1*	*GWS2*	*GWS1*	*GWS2*
	(1)	(2)	(3)	(4)
FTZ	-0.0596**	-0.1058***	-0.0522**	-0.0768**
	(-2.2673)	(-2.6446)	(-1.9996)	(-2.0103)
Size			-0.0082	-0.1188***
			(-0.4042)	(-2.8768)
Cashflow			0.1238	0.0967
			(1.5246)	(0.7589)
Leverage			-0.0937	-0.1749*
			(-1.5066)	(-1.9601)
Growth			0.0134*	0.0249
			(1.7054)	(1.5585)
TMTshare			0.0864	0.2412
			(0.9812)	(1.4696)
Top1			0.0022*	0.0014
			(1.6800)	(0.6307)
Board			-0.0839	-0.3093*
			(-0.9649)	(-1.9543)
Dual			-0.0020	-0.0477
			(-0.0863)	(-1.1196)
Indep			-0.5493**	-0.8486**
			(-2.3113)	(-2.0728)
Age			0.0295	0.0201
			(1.3648)	(0.6631)
SOE			-0.0298	-0.0017
			(-0.5848)	(-0.0243)
Constant	0.0145**	-0.1443***	0.4888	3.4533***
	(2.5326)	(-16.5522)	(0.9139)	(2.8182)
Indivisual Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Number of Observations	34,240	34,240	34,240	34,240
Adjusted R^2	0.5970	0.5770	0.5974	0.5786

Notes: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses. The same notation applies to the following tables.

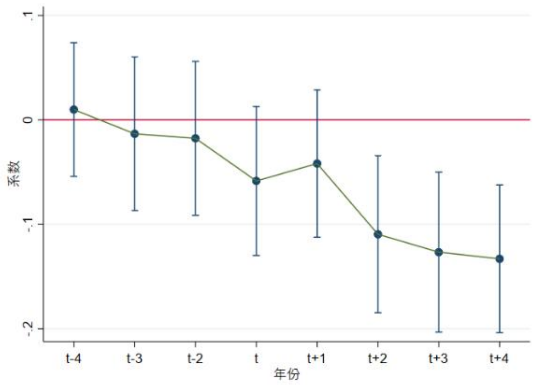
4.2.Tests for Endogeneity and Robustness

4.2.1.DID Parallel Trend Verification

The baseline regression shows a significant negative relationship between FTZ policies and corporate greenwashing. However, causal inference requires addressing potential endogeneity, as FTZs may be established in regions with higher pre-existing environmental standards or attract firms already performing well environmentally.Following the approach of Bertrand and Mullainathan[32], we define the year a firm is first exposed to the FTZ policy as $FTZStart_t$=1 (1 if affected, 0 otherwise). The four years preceding and following this initial exposure are labeled $FTZStart_{t-1}$ to $FTZStart_{t-4}$ and $FTZStart_{t+1}$ to $FTZStart_{t+4}$, respectively, allowing us to examine the dynamic effects of the FTZ policy on corporate greenwashing behavior from four years before to four years after its implementation.



(a) *GWS1* DID Dynamic Effects



(b) *GWS2* DID Dynamic Effects

Fig 2. Parallel Trend Test of the Effect of FTZ Policy on Corporate Greenwashing

Figure 2 presents the results of the DID parallel trend test examining the impact of the FTZ policy on corporate greenwashing. It can be observed that the coefficients for $FTZStart_{t-2}$, *FTZStartt-3*, and $FTZStart_{t-4}$ are not statistically significant prior to the policy shock, ruling out the alternative explanation that firms within the FTZ already had higher environmental standards than those outside the zones before the policy. After the policy implementation, the greenwashing index of firms within the FTZ declines significantly in the second, third, and fourth years ($FTZStart_{t+2}$, $FTZStart_{t+3}$, and $FTZStart_{t+4}$). These results indicate that the FTZ policy is indeed an important driver of the observed reduction in corporate greenwashing.

4.2.2.Instrumental Variable (2SLS) Tests

FTZ establishment may be endogenous, as it depends on local economic and financial conditions. Using the reciprocal of a city's distance to the nearest port interacted with a time dummy as an instrument, first-stage regressions confirm relevance, and second-stage results show FTZs still significantly reduce greenwashing, supporting baseline findings.

Table 6. 2SLS Results for the Impact of FTZs on Corporate Greenwashing

Variables	(1) *FTZ*	(2) *GWS1*	(3) *GWS2*
Distance	0.4293***		
	(10.5786)		
FTZ		-1.1318***	-2.0863***
		(-4.1797)	(-5.0905)
Controlled Variables	YES	YES	YES
Industry Fixed Effects	YES	YES	YES
Time Fixed Effects	YES	YES	YES
Sample Size	34206	34206	34206
Adjusted R^2	0.2639	0.0827	0.1123
Kleibergen-Paap LM statistic		116.807***	
Cragg-Donald Wald F statistic		111.908	
Kleibergen-Paap Wald F statistic		59.573	

4.2.3.Propensity-Score Matching (PSM) Test

To address firm heterogeneity, propensity score matching (PSM) is applied. After one-to-one nearest neighbor matching, covariate differences between treatment and control groups are balanced. Regressions on the matched sample show that FTZ policies still significantly reduce corporate greenwashing, confirming the robustness of the baseline results.

Table 7. PSM Estimation of the Effect of FTZ Policy on Corporate Greenwashing

Variables	*FTZ* (1)	*FTZ* (2)	*GWS1* (3)	*GWS2* (4)
FTZ			-0.1137***	-0.1659***
			(-2.6968)	(-2.6676)
Size	0.3738***	0.0128	-0.1349***	-0.3109***
	(24.0874)	(0.6776)	(-4.1040)	(-5.8912)
Cashflow	-0.7266***	-0.0132	0.2584	0.3550
	(-4.3263)	(-0.0576)	(1.3018)	(1.1507)
Leverage	-0.2380***	0.0575	0.1255	0.0934
	(-2.5779)	(0.5133)	(1.6039)	(0.8339)
Growth	0.0287*	-0.0289	-0.0213	-0.0465
	(1.9086)	(-1.4600)	(-1.2820)	(-1.6184)
TMTshare	0.4371***	-0.0217	-0.0343	0.0890
	(3.1602)	(-0.1253)	(-0.2966)	(0.4948)
Top1	-0.0098***	0.0016	0.0025	0.0021
	(-8.2920)	(1.0826)	(1.5249)	(0.9134)
Board	-0.8934***	-0.0035	-0.1142	-0.3247
	(-8.0988)	(-0.0257)	(-0.8274)	(-1.5116)
Dual	0.0812**	-0.0119	-0.0674	-0.1583**
	(2.2836)	(-0.2681)	(-1.5363)	(-2.2305)
Indep	-0.4555	-0.1981	-1.5566***	-2.2299***
	(-1.3696)	(-0.4780)	(-3.4043)	(-3.0630)
Age	0.2794***	0.0265	0.0931***	0.1780***
	(11.9879)	(0.9526)	(3.6482)	(4.2056)
Soe	-0.4229***	-0.0565	-0.1293**	-0.1503*
	(-10.1906)	(-1.1242)	(-2.2734)	(-1.6694)
Individual Effects	YES	YES	YES	YES
Year Effects	YES	YES	YES	YES
Sample Size	34,240	11,053	11,053	11,053
Pseudo /Adj R^2	0.1395	0.0286	0.0243	0.0583

4.2.4.Alternative Independent Variable

Only 1.8% of firms have parent companies in an FTZ without subsidiaries; most benefit via in-zone subsidiaries. To capture the effect of FTZ investment, we replace the FTZ

dummy with four measures: number of subsidiaries (FTZNum), registered capital of subsidiaries (FTZAmt), proportion of subsidiaries in the FTZ (FTZNumRatio), and proportion of subsidiary capital in the FTZ (FTZAmtRatio). Regressions show that larger numbers or shares of subsidiaries and higher registered capital in FTZs are associated with greater reductions in greenwashing, indicating that both the scale and depth of FTZ investment enhance firms' environmental performance.

Table 8. Effects of Alternative Independent Variables on Corporate Greenwashing

Variables	*GWS1* (1)	*GWS2* (2)	*GWS1* (3)	*GWS2* (4)	*GWS1* (5)	*GWS2* (6)	*GWS1* (7)	*GWS2* (8)
FTZNum	-0.0585*	-0.1186*						
	(-1.6539)	(-1.8371)						
FTZNumRatio			-0.3407***	-0.4869*				
			(-2.7649)	(-1.7219)				
FTZAmt					-0.0057*	-0.0091*		
					(-1.7005)	(-1.7202)		
FTZAmtRatio							-0.2078**	-0.3208*
							(-2.2790)	(-1.7365)
Controlled Variables	YES	YES	YES	YES	YES	YES	YES	YES
Individual Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year effects	YES	YES	YES	YES	YES	YES	YES	YES
Sample Size	34,240	34,240	34,240	34,240	34,240	34,240	34,240	34,240
Adjusted R^2	0.5974	0.5787	0.5975	0.5787	0.5974	0.5786	0.5974	0.5786

4.2.5.Replacement of the Dependent Variable

For robustness, we construct alternative greenwashing indices (GWS3 – GWS5) using environmental investment and the environmental dimensions of Bloomberg and Huazheng ESG scores. Re-estimating Model (2) with these indices, the FTZ policy coefficients remain significantly negative, confirming that FTZ policies consistently promote genuine corporate environmental performance.

Table 9. Effects of FTZ Policy on Corporate Green Innovation Using Alternative Dependent Variables

Variables	*GWS3* (1)	*GWS4* (2)	*GWS5* (3)
FTZ	-0.0420*	-0.0502*	-0.1169**
	(-1.6851)	(-1.7649)	(-2.0348)
Controlled Variables	YES	YES	YES
Individual Effects	YES	YES	YES
Year effects	YES	YES	YES
Sample Size	34,240	34,240	10,096
Adjusted R^2	0.3544	0.4398	0.5552

4.2.6.Double Machine Learning

Table 10. Double Machine Learning Regression Results

Variables	*GWS1* (1)	*GWS2* (2)	*GWS1* (3)	*GWS2* (4)
FTZ	-0.0186*	-0.0360**	-0.0505***	-0.0656***
	(-1.8156)	(-2.1375)	(-3.2263)	(-2.7177)
Controlled Variables	YES	YES	YES	YES
Individual Fixed Effect	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Sample Size	34,240	34,240	34,240	34,240

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The values in parentheses are the z-statistics of the estimated coefficients.

To address potential endogeneity from non-random FTZ adoption, we apply a double machine learning (DML) approach using random forest and Lasso algorithms. As shown in Table 10, FTZ policies continue to significantly reduce corporate greenwashing, confirming the robustness of our results.

4.2.7.Controlling for Firms' Openness

To account for firms' openness, we control for the proportion of overseas executives (OverseaRatio) and a firm-level globalization index (Global). Table 11 shows that, even with these controls, FTZ policies (FTZ) remain significantly negative, confirming that they continue to reduce corporate greenwashing and reinforcing the robustness of our results.

Table 11. Robustness Test Controlling for Firms' Openness

Variables	*GWS1* (1)	*GWS2* (2)	*GWS1* (3)	*GWS2* (4)
FTZ	-0.0587**	-0.1030***	-0.0519**	-0.0761**
	(-2.2490)	(-2.5937)	(-1.9955)	(-1.9906)
OverseaRatio	-0.1807	-0.5818	-0.1846	-0.4965
	(-1.0368)	(-1.2884)	(-1.0742)	(-1.1728)
Global	-0.0003	-0.0011***	-0.0003	-0.0008**
	(-1.0655)	(-2.6836)	(-1.0576)	(-2.0219)
Controlled Variables	NO	NO	YES	YES
Individual Fixed Effects	YES	YES	YES	YES
City Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Sample Size	34,240	34,240	34,240	34,240
Adjusted R^2	0.5970	0.5775	0.5975	0.5789

4.2.8.Controlling for City Fixed Effects

To account for time-varying city characteristics, we include city fixed effects. Table 12 shows that the FTZ policy coefficient remains negative and statistically significant, indicating that FTZ policies continue to reduce corporate

greenwashing, confirming the robustness of the baseline results.

Table 12. Robustness Test Controlling for City Fixed Effects

Variables	*GWS1* (1)	*GWS2* (2)	*GWS1* (3)	*GWS2* (4)
FTZ	-0.0570**	-0.1007**	-0.0499*	-0.0724*
	(-2.1423)	(-2.4476)	(-1.9014)	(-1.8780)
Controlled Variables	NO	NO	YES	YES
Individual Fixed Effects	YES	YES	YES	YES
City Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Sample Size	34,240	34,240	34,240	34,240
Adjusted R^2	0.5977	0.5776	0.5981	0.5792

4.2.9.Excluding Hainan Province Samples

Hainan differs from other city-centered FTZs in scope and administration, potentially skewing results. Excluding Hainan, Table 13 shows that the FTZ policy coefficient remains negative, indicating that FTZ policies still significantly reduce corporate greenwashing, confirming robustness.

Table 13. Robustness Test Excluding Hainan Province Samples

Variables	*GWS1* (1)	*GWS2* (2)	*GWS1* (3)	*GWS2* (4)
FTZ	-0.0635**	-0.1083***	-0.0558**	-0.0785**
	(-2.3965)	(-2.6779)	(-2.1210)	(-2.0334)
Controlled Variables	NO	NO	YES	YES
Individual Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Sample Size	34,014	34,014	34,014	34,014
Adjusted R^2	0.5977	0.5788	0.5981	0.5804

5.Mechanism Analysis

5.1.Financing Channel Optimization Effect

Stable funding is crucial for firms' investment in environmental technologies and sustainability projects. Using CSMAR data, this study measures corporate financing through bank loans (BankLoan), external financing relative to total assets (ExfinRatio), debt financing costs (Debtcost), and financing constraints via the SA and FC indices, where higher values indicate tighter constraints.

Table 14. Financing Optimization Effect of FTZ Policy

Variables	*BankLoan* (1)	*ExfinRatio* (2)	*Debtcost* (3)	*SA* (4)	*FC* (5)
FTZ	0.6340***	0.0101**	-0.0002*	-0.0225***	-0.0055*
	(2.8910)	(2.5001)	(-1.9158)	(-7.6876)	(-1.6528)
Controlled Variables	YES	YES	YES	YES	YES
Individual Fixed Effects	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES
Sample Size	34,240	34,239	34,240	34,239	33,708
Adjusted R^2	0.5896	0.6134	0.2539	0.9491	0.8334

Table 14 shows that FTZ policies significantly increase bank loans and external financing while lowering debt costs, and they also alleviate financing constraints as reflected in both indices. These results indicate that FTZs improve firms' access to diversified, lower-cost capital and enhance financial support for green investment. By easing financial pressure and enabling more substantive environmental actions, FTZ policies weaken firms' incentives to rely on greenwashing.

5.2.Green Transformation Synergy Effect

Following Ge et al.[33] and Xiao et al.[34], we measure how well firms align with government green targets using the government–enterprise green transformation coupling degree (Catena) and coordination degree (Concert).The calculation methods for the coupling degree and coupling coordination degree are as follows:

$$Catena_{ijt}=2\times\sqrt{\frac{IndexC_{ijt}\times IndexG_{jt}}{\left(IndexC_{ijt}+IndexG_{jt}\right)^2}} \quad (3)$$

Here, *i*, *j*, and t denote firm, city, and year. *IndexC* is the firm's green transformation index (proportion of green keywords in annual reports, Min–Max standardized), and *IndexG* is the local government's index (from city work reports, similarly standardized). A higher coupling degree indicates stronger firm–government synergy in green transformation. To avoid the problem of spurious coupling when both indices are low, we further compute the government–enterprise green transformation coupling coordination degree based on the coupling degree as follows:

$$Concert_{ijt}=\sqrt{Catena_{ijt}\times\frac{\left(IndexC_{ijt}+IndexG_{jt}\right)}{2}} \quad (4)$$

A higher coupling coordination degree reflects stronger government–enterprise synergy in green transformation. Using green transformation keywords from Table 2, we extract terms from firms' annual reports and local government work reports. Columns (1)–(2) of Table 15 show that FTZ policies significantly increase Catena and Concert, indicating enhanced government–enterprise coupling. This reciprocity incentivizes firms to align with government green targets, reducing greenwashing. Additionally, regressing government environmental subsidies (ESub) on FTZ policies (Column 3) yields a significantly positive coefficient, showing that FTZs

further encourage firms to undertake government-endorsed environmentally friendly projects.

Table 15. Synergistic Effect of FTZ Policy on Government–Enterprise Green Transformation

Variables	*Catena*	*Concert*	*ESub*
	(1)	(2)	(3)
FTZ	0.0117**	0.0046**	0.4053***
	(2.2056)	(1.9817)	(3.2164)
Controlled Variables	YES	YES	YES
Individual Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES
Sample Size	33,411	33,411	34,237
Adjusted R^2	0.5315	0.6009	0.3367

5.3.International Supply Chain Embedding Effect

The establishment of FTZs promotes trade liberalization and lowers trade barriers, enabling firms to deepen international supply chain integration. Building on existing theory, this study argues that FTZ policies can further curb greenwashing by facilitating cooperation with firms in developed countries and those with high environmental standards.

Most prior studies rely on the top five suppliers and customers disclosed in annual reports or on domestic databases, limiting analysis to domestic supply chains[16,35-37]. To address this limitation, we collaborated with Tianyancha to construct a comprehensive supply-chain dataset using business registration, judicial records, news, and corporate disclosures. This expands the CSMAR (2001–2022) data from 266,000 to 538,000 customer records and from 175,000 to 359,000 supplier records, achieving near-complete coverage of listed firms' supply chains.

We first removed observations with incomplete customer or supplier names and matched the remaining firms in the Tianyancha database to obtain domestic registration information. Unmatched overseas customers and suppliers were then identified using the BVD ORBIS global database, which covers over 380 million firms. After screening, we obtained registration data for 11,858 overseas customers and 3,673 overseas suppliers. For each firm-year, we computed the natural logarithm of one plus the number of overseas customers (OSClient) and suppliers (OSSupplier) to assess whether FTZ policies promote international supply chain expansion.

To further test whether firms' supply chain cooperation with developed countries can more effectively reduce greenwashing and improve environmental performance, we generated dummy variables indicating whether the country of each overseas customer or supplier belongs to the OECD high-income member states (OECDClient/OECDSupplier)[1]. If the firm's customer (supplier) is located in an OECD high-income country, the variable takes a value of 1; otherwise, it is 0.

Similarly, to assess whether cooperation with high environmental-standard countries further curbs greenwashing, we construct dummy variables indicating whether a firm's overseas customer or supplier is located in an Environmental Goods Agreement (EGA) member country (EGAClient/EGASupplier = 1, 0 otherwise).The Environmental Goods Agreement (EGA) is a multilateral trade agreement aimed at promoting global trade in environmental goods by reducing tariffs and non-tariff barriers on environmentally friendly products and services. Its main objectives are to support environmental protection and climate change mitigation while fostering sustainable global economic growth[2].

Table 16 reports the effects of FTZ policies on corporate greenwashing via the international supply chain channel. Column (1) shows that FTZ policies significantly increase the number of overseas customers at the 5% level, indicating that by reducing tariffs, simplifying customs procedures, and lowering trade barriers, FTZs help firms expand into international markets.

To examine whether cooperation with developed or high-environmental-standard countries under FTZ policies more effectively reduces greenwashing, we include interaction terms between FTZ exposure and dummy variables for OECD and EGA country customers. Columns (2)–(3) show that the FTZ × OECDClient interaction significantly reduces the greenwashing index at the 5% level, while Columns (4)–(5) show the same effect for FTZ × EGAClient. This suggests that cooperating with firms in countries with higher environmental standards compels domestic firms to meet stricter requirements, thereby curbing greenwashing. Overall, FTZ policies not only promote international trade and market expansion but also encourage collaboration with Table 16 examines the international supply chain channel. Column (1) shows that FTZ policies significantly increase the number of overseas customers, indicating that tariff reductions and customs facilitation help firms expand into global markets. Further analysis introduces interaction terms between FTZ exposure and OECD/EGA customer dummies. Columns (2)–(5) show that FTZ × OECDClient and FTZ × EGAClient significantly reduce greenwashing, suggesting that cooperation with firms in developed or high-environmental-standard countries imposes stricter external constraints and curbs symbolic environmental behavior. Overall, FTZs promote not only trade expansion but also engagement with environmentally advanced partners, supporting sustainable development.

In contrast, Column (6) shows that FTZ policies do not significantly affect the number of overseas suppliers. Columns (7)–(10) further indicate that interactions with OECD or EGA

[1] Note: High-income member countries of the Organisation for Economic Co-operation and Development (HIE OECD) include the United States, Germany, France, the United Kingdom, Japan, Italy, Canada, South Korea, Luxembourg, Switzerland, Norway, Ireland, Denmark, Australia, Sweden, Austria, Finland, Belgium, New Zealand, Spain, Portugal, Greece, Slovenia, the Czech Republic, Iceland, Slovakia, Poland, Israel, Estonia, Latvia, Hungary, Lithuania, and Chile.

[2] Members of the Environmental Goods Agreement (EGA) include all EU member states, Australia, Canada, China, Hong Kong (China), Iceland, Israel, Japan, Korea, New Zealand, Norway, Singapore, Switzerland, Taiwan (China), Turkey, and the United States

suppliers have no significant impact on greenwashing. This implies that FTZ trade facilitation mainly strengthens export-oriented customer linkages, while its effects on import-side supplier expansion and governance remain limited.

Table 16. International Supply Chain Embedding Effect of FTZ Policy

Variables	*OSClient* (1)	*GWS1* (2)	*GWS2* (3)	*GWS1* (4)	*GWS2* (5)	*OSSupplier* (6)	*GWS1* (7)	*GWS2* (8)	*GWS1* (9)	*GWS2* (10)
FTZ	0.0216**	-0.0494*	-0.0729*	-0.0498*	-0.0722*	-0.0039	-0.0520**	-0.0766**	-0.0478*	-0.0704*
	(2.2628)	(-1.8879)	(-1.8949)	(-1.8949)	(-1.8702)	(-0.7597)	(-1.9967)	(-2.0028)	(-1.8455)	(-1.8374)
OECDClient		-0.0554**	-0.0456							
		(-2.2513)	(-1.5787)							
FTZ×OECDClient		-0.1111**	-0.1909**							
		(-2.2454)	(-2.1320)							
EGAClient				-0.0436*	-0.0186					
				(-1.9517)	(-0.6346)					
FTZ×EGAClient				-0.1052**	-0.1916**					
				(-2.4570)	(-2.2225)					
OECDSupplier							-0.0046	-0.0249		
							(-0.1404)	(-0.6495)		
FTZ×OECDSupplier							-0.0095	-0.0097		
							(-0.1008)	(-0.0808)		
EGASupplier									0.0004	-0.0041
									(0.0150)	(-0.1174)
FTZ×EGASupplier									-0.1295	-0.1922
									(-1.4418)	(-1.5615)
Controlled Variables	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Individual Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sample Size	34,240	34,240	34,240	34,240	34,240	34,240	34,240	34,240	34,240	34,240
Adjusted R^2	0.3168	0.5975	0.5786	0.5975	0.5786	0.2365	0.5974	0.5786	0.5974	0.5786

6.Further Analysis

6.1.Heterogeneous Effects of Different Types of FTZ Institutional Innovations

Since Shanghai launched the first FTZ in 2013, more than 1,400 institutional innovations have been introduced, some later promoted nationwide through multiple batches of the State Council's FTZ reform notices. This study collects 167 national-level innovations released up to 2022 and classifies them into four categories: investment and financial (FTZInvest), trade facilitation (FTZTrade), service-sector and human resources (FTZService), and customs supervision (FTZSupervise). By linking policy release dates with their nationwide rollout, we examine the heterogeneous effects of different FTZ innovations on corporate greenwashing.

Table 17. Heterogeneous Effects of FTZ Policies on Corporate Greenwashing

Variables	*GWS1* (1)	*GWS2* (2)	*GWS1* (3)	*GWS2* (4)	*GWS1* (5)	*GWS2* (6)	*GWS1* (7)	*GWS2* (8)
FTZInvest	-0.0403	-0.0964**						
	(-1.2696)	(-2.0866)						
FTZTrade			-0.0625**	-0.1118**				
			(-1.9785)	(-2.3904)				
FTZService					0.0018	-0.0171		
					(0.0479)	(-0.2840)		
FTZSupervise							-0.2078**	-0.3208*
							(-2.2790)	(-1.7365)
Controlled Variables	YES	YES	YES	YES	YES	YES	YES	YES
Individual Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Effects	YES	YES	YES	YES	YES	YES	YES	YES
Sample Size	34,240	34,240	34,240	34,240	34,240	34,240	34,240	34,240
Adjusted R^2	0.5973	0.5786	0.5974	0.5787	0.5972	0.5784	0.5972	0.5785

Table 17 shows that trade facilitation innovations significantly reduce greenwashing. By lowering trade barriers and administrative costs, these reforms expand firms' overseas customer bases and expose them to higher environmental standards and international best practices. In contrast, investment–financial, service-sector, and customs

supervision innovations mainly support operations and market expansion but have weaker direct effects on environmental governance. This highlights trade facilitation as the most effective FTZ innovation for curbing greenwashing and promoting corporate green development.

6.2.Spillover Effects of FTZ Policies on Non-FTZ Firms in the Same City

Most FTZ studies focus on cities or provinces, assuming all firms in the city are affected[8,38-40]. In reality, only firms physically located within FTZs benefit from policies, as FTZs occupy a small portion of their host cities[41]. To test spillover effects, we define FTZCity = 1 for firms in the FTZ city but outside the zone. Table 18 shows that non-FTZ firms in FTZ cities exhibit no significant change in greenwashing, while firms inside FTZs show a stronger and significant reduction. This confirms that FTZ institutional innovations reduce greenwashing and underscores the importance of GIS-based identification of actual FTZ boundaries.

Table 18. Spillover Effects of FTZ Policies on Non-FTZ Firms in the Same City

Variables	*GWS1*	*GWS2*	*GWS1*	*GWS2*
	(1)	(2)	(3)	(4)
FTZCity	-0.0037	-0.0075	-0.0339	-0.0526
	(-0.1790)	(-0.2372)	(-1.4649)	(-1.6411)
FTZ			-0.0684**	-0.1020**
			(-2.3365)	(-2.5601)
Controlled Variables	YES	YES	YES	YES
Individual Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Sample Size	34,240	34,240	34,240	34,240
Adjusted R^2	0.5972	0.5784	0.5974	0.5786

7.Conclusion

As China pursues high-quality development, FTZs play a key role in promoting sustainable reforms. Using GIS to identify firms within FTZs, we find that FTZ policies significantly reduce greenwashing, especially for firms with more or larger in-zone subsidiaries. Mechanisms include better financing, stronger government-enterprise green collaboration, and integration into international supply chains, with trade facilitation having the largest effect. Spillovers to non-FTZ firms are insignificant, highlighting the importance of precise FTZ targeting to curb greenwashing and support green transformation.

First, FTZs should be leveraged as hubs of institutional innovation to reduce corporate greenwashing. Policies curb greenwashing by improving financing, fostering government–enterprise green collaboration, and promoting integration into international supply chains. Linking environmental disclosure quality to approvals, providing fiscal incentives, and enforcing audits can encourage substantive green performance and limit misleading claims.

Second, FTZs should continue promoting genuine green transformation through high-standard international supply chain collaboration. Exposure to firms in developed countries strengthens regulatory and market incentives, improving environmental performance. Institutional innovations should harmonize cross-border standards and support green certification to enhance technological capabilities, competitiveness, and reputation.

Third, FTZs' successful experiences should be systematically shared. Spillovers to non-FTZ firms are limited, so local platforms and national strategies should facilitate information sharing, strengthen inter-firm links, and support green transformation and regional economic upgrading.

References

[1] LI Q, XIAO Z. Heterogeneous Environmental Regulation Tools and Incentives for Corporate Green Innovation: Evidence from Green Patents of Listed Companies. Economic Research Journal, 2020, (9).

[2] LI Z. Will Users Abandon "More Talk Than Action" Environmental Disclosure? The World Economy, 2018, (12).

[3] BARNEY J. Resource-Based Theories of Competitive Advantage: A Ten-Year Retrospective on the Resource-Based View. Journal of Management, 2001, 27(6): 643–650.

[4] PFEFFER J, SALANCIK G. External Control of Organizations — Resource Dependence Perspective. London, UK: Routledge, 2015.

[5] FALAVIGNA G, IPPOLITI R. Financial Constraints, Investments, and Environmental Strategies: An Empirical Analysis of Judicial Barriers. Business Strategy and the Environment, 2022, 31(5): 2002–2018.

[6] PENG Y, HUANG Z. Causes and Governance of Economic "De-Realization": Understanding the 19th CPC Financial Reform. The World Economy, 2018, (9).

[7] ZHOU X Y, CALDECOTT B, HOEPNER A G F, et al. Bank Green Lending and Credit Risk: An Empirical Analysis of China's Green Credit Policy. Business Strategy and the Environment, 2022, 31(4): 1623–1640.

[8] XIANG H, HE K, YU Y. Establishment of FTZs, Trade Development, and Capital Flows: Evidence from Shanghai FTZ. Financial Research, 2016, (10).

[9] HAN R, BO F. Effects of Free Trade Zones on Capital Flows: Evidence from a Quasi-Natural Experiment. Journal of International Finance, 2019, (7).

[10] ELLINGSEN T, JOHANNESSON M. Pride and Prejudice: The Human Side of Incentive Theory. American Economic Review, 2008, 98(3): 990–1008.

[11] ZHENG M, CHANG Z. Green Low-Carbon Transformation and Corporate ESG Responsibility: Quasi-Natural Experiment Based on Low-Carbon City Pilots. Economic Management Research, 2023, (7).

[12] HART S L. A Natural-Resource-Based View of the Firm. The Academy of Management Review, 1995, 20(4): 986–1014.

[13] SCHERER A G, PALAZZO G. The New Political Role of Business in a Globalized World: A Review of a New Perspective on CSR and Its Implications for the Firm, Governance, and Democracy. Journal of Management Studies, 2012, 32(2): 117–118.

[14] STOSS L. Global Climate Change: An Issue That Mandates Government or Corporate Social Responsibility. Journal of International Business and Law, 2018, 17(2): 5.

[15] ZHOU J, LIU Y. Institutional Embedding, Green Technological Innovation, and Carbon Reduction of Entrepreneurial Firms. China Population, Resources and Environment, 2021, (6).

[16] TANG S, XIE X. How Equity-Holding Financial Institutions Serve the Real Economy: Perspective of Supply Chain Embedding Effect. China Industrial Economics, 2021, (11).

[17] GRANOVETTER M. Economic Action and Social Structure: The Problem of Embeddedness. American Journal of Sociology, 1985, 91(3): 481–510.

[18] DYER J H, SINGH H. The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage. Academy of Management Review, 1998, 23(4): 660–679.

[19] SOBRERO M, ROBERTS E B. The Trade-off Between Efficiency and Learning in Interorganizational Relationships for Product Development. Management Science, 2001, 47(4): 493–511.
[20] LI Q, LI Y, ZHANG Y. Information Spillover Effect of Enterprise Digital Transformation: Evidence from Supply Chain Perspective. China Industrial Economics, 2023, (7).
[21] MARQUIS C, BATTILANA J. Acting Globally but Thinking Locally: The Enduring Influence of Local Communities on Organizations. Research in Organizational Behavior, 2009, 29: 283–302.
[22] XIE Q. Trade Facilitation, Trade Development, and China's Reform Practices. Economic Dynamics, 2018, (1).
[23] KANG J, ZHENG W. Trade Creation Effect of Inland Free Trade Zones in China: Expanding Imports or Boosting Exports? Journal of International Trade, 2021, (2).
[24] XIE H, LÜ X. Responsible International Investment: ESG and Chinese OFDI. Economic Research Journal, 2022, (3).
[25] SHAIKH I. Environmental, Social, and Governance (ESG) Practice and Firm Performance: An International Evidence. Journal of Business Economics and Management, 2022, 23(1): 218–237.
[26] GU H, YANG S, CHENG C. The Impact of Supply Chain Finance on Firm Internationalization from the Perspective of Supply Chain Spillover. Journal of International Finance, 2023, (3).
[27] SU D, LIU Z. Does Green Finance Reform Affect Corporate Green Performance and Greenwashing Risk? Journal of International Finance, 2023, (4).
[28] XIE X, HAN Y. How Domestic Manufacturing Firms Achieve "Gorgeous Transformation" in Green Innovation: A Multiple Case Study Based on Attention-Based View. Management World, 2022, (3).
[29] MAO Y, KORABAYEV R, WEI Z. Construction of a Green Full-Industry Chain Evaluation Index System: Empirical Evidence. Sun Yat-sen University Journal (Social Science Edition), 2020, (2).
[30] TIAN Z, CHEN C. Construction and Optimization of Modern Enterprise Green Supply Chain Management Model. Science & Technology Management Research, 2007, (10).
[31] CHEN Z, XIONG R. Comparative Advantage and Industrial Policy Effects: Evidence from a Quasi-Experiment in Export Processing Zones. Management World, 2015, (8).
[32] BERTRAND M, MULLAINATHAN S. Enjoying the Quiet Life? Corporate Governance and Managerial Preferences. Journal of Political Economy, 2003, 111(5): 1043–1075.
[33] GE P, HAN Y, WU X. Measurement and Evaluation of the Coupling and Coordination Between Innovation and Economic Development in China. Quantitative & Technical Economics Research, 2020, (10).
[34] XIAO H, SHEN H, ZHOU Y. Client Enterprise Digitalization, Supplier ESG Performance, and Supply Chain Sustainability. Economic Research Journal, 2024, (3).
[35] YANG Z, TANG S, LI Z. Capital Market Information Disclosure, Relational Contracts, and Supply-Demand Bullwhip Effect: Evidence from Supply Chain Information Spillovers. Management World, 2020, (7).
[36] LI W, LIU H, LONG Z. Enterprise Digital Transformation and Supply Chain Geographic Distribution. Quantitative & Technical Economics Research, 2023, (8).
[37] CHENG C, TIAN X, XU Z. Supply Chain Finance and Enterprise Efficiency Upgrading: Evidence from Listed Company Announcements and Local Policy Documents. Financial Research, 2023, (6).
[38] JIANG L, LU Y, ZHANG G. Construction of Free Trade Zones and China's Export Behavior. China Industrial Economics, 2021, (8).
[39] WANG A, FANG Y, YU B. China's Free Trade Zones and Regional Economic Growth: Comparison of Transmission Paths and Driving Mechanisms. Finance & Trade Economics, 2020, (8).
[40] FANG Y, LIU J. Can the Establishment of Free Trade Zones Promote Enterprise Innovation? Evidence from GEM-Listed Companies. Journal of International Finance, 2021, (9).
[41] WANG H, YAN G. Does the Establishment of FTZs Alleviate Corporate Financing Constraints? Evidence from Listed Companies. Journal of Nanjing Audit University, 2023, (3).