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The Impact of Digital Policies on Corporate ESG Performance—Based on Big Data Pilot Zones

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Abstract. This research investigates how national digital strategies affect corporate ESG performance. Utilizing data from Chinese A-share listed companies spanning 2011-2023, we empirically examine the impact of the National Big Data Comprehensive Pilot Zones policy on corporate ESG and its underlying mechanisms using a multi-period difference-in-differences (DID) approach. The findings reveal that: (1) This policy significantly enhances firms' overall ESG performance; (2) The policy effect emerges after a 2-3 year lag, aligning with the "technology absorption → organizational adaptation → governance optimization" transmission path; (3) The policy impact exhibits heterogeneity: responses are more pronounced among firms in the eastern region and non-state-owned enterprises (non-SOEs), while the effect is insignificant for firms in the central and western regions and state-owned enterprises (SOEs). This indicates that decision-making differences stemming from regional resource endowments and corporate ownership structure are key influencing factors. This study provides evidence for understanding the micro-mechanisms through which digital policies drive corporate sustainable development, offering policy implications for optimizing pilot zone construction, promoting coordinated regional development, and precisely guiding enterprises to enhance ESG practices.

Keywords: National Big Data Comprehensive Pilot Zone, Corporate ESG Performance, Multi-period Difference-in-Differences Method, Heterogeneity of Policy Effects

1. Introduction

In the context of digital globalization, digital technologies represented by big data are becoming an important factor promoting economic growth. China has gradually proposed digital strategic policies - in 2015, the State Council first introduced the Action Plan for Promoting Big Data Development, and then successively laid out policy pilot zones such as national big data comprehensive pilot zones and smart city pilots, so as to realize the flow of data elements in the market through institutional innovation and resource tilting. ESG (Environment, Society and Governance), as a yardstick to measure the sustainable development capability of enterprises, has also been incorporated into the "Double Carbon" goal and high-quality development strategic framework.

Current research on corporate ESG can be roughly divided into two aspects: the driving factors of ESG and the impact mechanism on enterprises. In terms of driving factors research, the influence of

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macro policies has become increasingly prominent. Lin Yongsheng [1] found that countries with a high level of sustainable development, such as Sweden and Germany, can enable enterprises to improve their sustainable development level through environmental regulations and policy incentives such as carbon taxes and renewable energy subsidies. Liu Yifang et al [2]. added that the policy pressure of China's "Double Carbon" goal is pushing the ESG disclosure of enterprises from "passive release" to "voluntary publication". However, the strategies of enterprises to cope with institutional pressure are obviously differentiated - Xiao Hongjun et al [3].proposed the "ESG silence" phenomenon: nearly 90% of enterprises in the environmental protection service industry have achieved emission reduction goals, but deliberately downplay climate communication, and this avoidance strategy of "doing more and saying less" is worthy of vigilance. In the research on the impact mechanism on enterprises, it mainly analyzes and verifies the economic value of ESG. Based on the analysis of 6,139 listed companies in 55 countries around the world, According to Lin Youtsheng, a nation's sustainability advancement directly boosts corporate ESG metrics and indirectly creates economic value via financial performance optimization. Li Jinglin [4]studied Chinese listed enterprises and found that enterprises with outstanding ESG performance have significantly increased patent applications, especially in non-state-owned enterprises and heavily polluting industries, the effect of improving return on assets through innovation is more prominent. Liu Yifang et al [5]. revealed another path: ESG performance improves economic benefits by enhancing investor confidence, but we need to be alert to the "greenwashing" behavior - only when the integrity of information disclosure matches the actual environmental risk level can this benefit be truly released.

As a cornerstone of digital policy, the National Big Data Comprehensive Pilot Zone serves as a strategic implementation for fostering data factor marketization. Quasi-natural experimental evidence from Sun Weizeng et al [6].confirms the policy's efficacy in enhancing firm-level digital transition by facilitating technological proliferation and resource consolidation. Separately, academic investigations establish that digital restructuring influences corporate ESG manifestations principally through technological innovation channels. Kuang Zengjie and Zhou Xindi [7] found that digital transformation optimizes environmental management efficiency through green technology research and development, but excessive digitalization may lead to misallocation of innovation resources, and the impact of digital transformation on corporate ESG performance presents an "inverted U-shaped" relationship. Hu Jie [8] studied the mechanism of digitalization on information disclosure and pointed out that digital technology breaks information barriers and improves ESG transparency; Chen Huimeng [9] took commercial banks as an example to show how big data integrates environmental penalties, carbon emissions and other data to build a dynamic risk early warning system and strengthen corporate environmental responsibility constraints.

Collectively, academic research has addressed enterprise ESG manifestations and the Big Data Pilot Zone initiative, whereby studies systematically evaluate the policy's economic-social outcomes, corporate digital transitions, and ESG performance influencers through heterogeneous analytical frameworks. However, there are still few studies on how national digital policies affect the performance and development of corporate ESG. Whether and how the institutional environment and institutional support provided by the digital policy of the pilot zone act on the ESG practice of enterprises, and the impact mechanism therein lacks systematic empirical testing. Especially under the strategic framework of the "Double Carbon" goal and high-quality development, it is crucial to understand the transmission path of the digital policy pilot zone to sustainable development.

Therefore, against the backdrop of intensifying digital-sustainability integration, probing the National Big Data Pilot Zone's ESG transmission channels holds substantive theoretical-practical

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value. Our empirical approach employs quasi-natural experimentation to uncover operational mechanisms, delivering scientific evidence and regulatory guidance for policymakers to enhance zone configurations and strategically harness digital instruments toward sustainable enterprise development and geographical decarbonization transitions.

2. Theoretical analysis and research hypotheses

2.1. Policy background

The National Big Data Comprehensive Pilot Zone constitutes China's principal policy mechanism for resolving data marketization constraints—particularly ownership delineation, circulation friction, and value transformation—within designated experimental regions. Following the State Council's foundational 2015 Action Plan for Promoting Big Data Development, which pioneered zone implementation in Guizhou and elsewhere, the NDRC established secondary zones in 2016: two interregional pilots (Beijing-Tianjin-Hebei & Pearl River Delta), four territorial demonstration zones (Shanghai, Henan, Chongqing, Shenyang), and Inner Mongolia's infrastructure development zone. These initiatives prioritize data element market reform and industry digitalization, leveraging policy frameworks to accelerate digital infrastructure advancement and data convergence. Since then, supporting policies such as the 14th Five-Year Plan for the Development of the Digital Economy have further strengthened the trinity strategic goal of "technology-industry-governance", providing a quasi-natural experimental scenario for studying policy exogenous shocks [10].

2.2. Theoretical hypotheses

Digital governance instruments serve as pivotal catalysts for elevating corporate ESG performance through market restructuring effects, enhanced allocative efficiency, and strengthened regulatory frameworks. From an innovation perspective, Schumpeter's creative destruction paradigm articulates market competition's innovation-inducing pressure on enterprises [11]. The National Big Data Pilot Zone establishment delivers policy-enabled incentives and fiscal stimuli to facilitate corporate digital transitions. At the incentive tier, this policy manifestation effectively activates enterprise digitalization momentum. Concurrently, the initiative furnishes localized digital transformation subsidies while systematically enhancing regional digital ecosystems within pilot jurisdictions.. At the same time, the perspective of organizational economics further reveals that digital policies can promote the reconstruction of the internal governance model of enterprises. The application of policy-driven industrial Internet platforms and blockchain technologies promotes enterprises to transform into flat organizations, enhancing the transparency of internal audits and risk control capabilities. The real-time supervision system supported by big data can automatically identify environmental protection compliance loopholes or supply chain labor rights risks, and improve the response speed of enterprises to environmental and social emergencies. According to the view of new institutional economics, social norms and the institutional environment jointly regulate the behavior of enterprises. Therefore, digital policies increase the attention of the government and the public to enterprise activities by enhancing information transparency [12]. The ESG data disclosure standards compulsively implemented by the policy, such as the Environmental Information Disclosure Guidelines for Financial Institutions, and the opening of public environmental databases place enterprise environmental behaviors under the supervision of multiple subjects such as the government and investors. When high exposure will bring reputational risks to enterprises,

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enterprises generally tend to take the initiative to strengthen ESG practices to accumulate social capital. Based on the above analysis, this paper proposes:

H1: Digital policies significantly improve the comprehensive ESG performance of enterprises.

The impact of digital policies on corporate ESG performance may show structural differentiation because big data comprehensive experimental zones are distributed in different provinces, and there are differences in geographical resources, local policies and enterprise attributes among provinces. Specifically, the eastern region, as the core region of China's economic development, has outstanding advantages in digital infrastructure, technical talent reserve and capital market vitality. Driven by digital policies, eastern enterprises can efficiently integrate data resources, build cross-enterprise collaboration networks, and accelerate technology diffusion and capital agglomeration, so as to more comprehensively optimize environmental management, such as digital energy monitoring, strengthen social responsibility fulfillment, such as supply chain transparency improvement, and improve governance mechanisms, such as data-driven decision-making systems. In contrast, the central and western regions are restricted by lagging digital infrastructure, weak technical absorption capacity and narrow financing channels, and it is difficult to fully transform policy dividends, resulting in limited improvement of ESG of their enterprises. Ownership distinctions engender differential policy implementation capacities. State-owned enterprises command privileged resource allocation advantages over privately-owned counterparts while bearing institutional responsibilities for political, societal, and cultural non-economic goals. This constitutional mandate—serving governmental priorities in ecological governance, social accountability, public welfare, and stability maintenance—renders their ESG performance intrinsically determined. Non-SOEs' ESG motivations remain predominantly profit-driven, serving investor signaling purposes. As state-property entities, SOEs inherently shoulder national policy response obligations. Thus, digital policy effects manifest asymmetrically across ownership models, leading to our formal hypothesis:

H2: Digital policies have a stronger ESG improvement effect on eastern enterprises and state-owned enterprises.

3. Research design

3.1. Data source

Given policy relevance and data accessibility, this study focuses on A-share listed enterprises within China's National Big Data Pilot Zones (2011-2023) as its empirical sample. ESG metrics originate from Huazheng ESG Evaluation Database, while financial and firm-level variables derive from CSMAR (Guotaian Database). Data processing followed sequential steps: (1) exclusion of ST/*ST entities; (2) removal of financial institutions; (3) elimination of observations with incomplete records; (4) 1% winsorization of continuous variables to mitigate extreme-value distortion. This protocol yielded 39,050 valid firm-year observations.3.2 Definition of Main Variables

3.1.1. Explained variable: ESG performance

The explained variable is corporate ESG. This paper uses the ESG rating published by Huazheng as the corporate ESG performance, because the ESG rating index not only reflects the quality of corporate ESG information disclosure, but also can reflect corporate ESG performance. This paper uses the ESG rating published by Huazheng as the core measurement index, and its rationality is mainly based on three academic considerations: data foundation reliability, evaluation system

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scientificity and local context adaptability. At the data level, the Huazheng database systematically covers the full-cycle ESG performance of China's A-share market, and its continuous observations from 2011 to 2023 are highly matched with the research samples of this paper, effectively supporting the multi-period DID model to capture the dynamic effects of policies. At the methodological level, the rating adopts a nine-level classification system from AAA to C, and constructs a dual capture mechanism of "information disclosure quality" and "substantive performance" by integrating hundreds of underlying indicators such as environmental resource consumption, supply chain ethics, and board governance. This multi-dimensional evaluation framework can more comprehensively reflect the comprehensive capability of enterprise sustainable development than single-dimensional indicators. It is particularly critical that as a local rating agency, the Huazheng system is deeply embedded in the institutional context and policy orientation of Chinese characteristics - its indicator weight design fully responds to the "Double Carbon" target constraints and high-quality development requirements, and can more accurately identify the ESG behavior variation of Chinese enterprises after being impacted by digital policies than international ratings [13]. This local adaptability has irreplaceable analytical value for evaluating the implementation effect of Chinese characteristic policy tools such as the national big data comprehensive pilot zone.

3.1.2. Core explanatory variable: big data comprehensive pilot zone policy

The model's key independent variable is the National Big Data Comprehensive Pilot Zone Policy (Policy). As China's flagship digital strategy initiative, Guizhou was designated the inaugural pilot zone in 2015, followed by Beijing, Tianjin, Shanghai, Chongqing, Hebei, Henan, Guangdong, Inner Mongolia, and Liaoning in 2016. We construct a binary treatment indicator: Treat = 1 if a firm is registered within a pilot city, else 0. Post = 1 for years after the city's inclusion in the pilot program, else 0. The policy effect is captured by the interaction term:

$$Policy_{\mathrm{it}} = Treat_i \times Post_t$$

3.1.3. Control variables

To mitigate potential omitted variable bias, five firm-level financial and governance metrics are incorporated as controls, consistent with established empirical practices (Chen & Chang, 2022). The specific variable explanations are shown in Table 1.

Table 1. Variables definition and data sources

Variable Type	Variable Name	Variable Symbol	Variable Definition and Measurement Method	Data Source
Explained Variable	ESG Comprehensive Score	ESG	Huazheng ESG rating (AAA=9, AA=7, A=5, BBB=3, BB=1, C=0), comprehensively reflecting environmental, social and governance performance	Huazheng ESG Database
Core Explanatory Variable	Big Data Pilot Zone Policy	Policy= treat×post	treat: Registration place is in the pilot zone city=1, otherwise=0post: Year after policy implementation=1, otherwise=0	Development and Reform Commission Documents
Control Variables	Enterprise Size	size	Natural logarithm of total assets (ln(total assets))	CSMAR Database

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Table 1. (continued)

Profitability	roa	Return on Total Assets = Net Profit / Total Assets	CSMAR Database
Asset-Liability Ratio	lev	Total Liabilities / Total Assets	CSMAR Database
Equity Concentration	top1	Proportion of shares held by the largest shareholder (%)	CSMAR Database
Total Asset Growth Rate	growth	Operating Income Growth Rate (%)	CSMAR Database

3.1.4. Descriptive statistics

Comprehensive sample profiling (Table 2) reveals three notable characteristics:ESG performance dispersion: Scores range from 1.00 to 7.75 (mean =4.157, SD =0.835), indicating moderate-to-strong sustainability practices with substantial cross-firm variation. Policy group representation: 31.8% of firm-year observations belong to pilot zones (Policy mean = 0.318), satisfying the DID requirement for adequate treatment group size. Control variable distributions: Financial metrics align with typical listed companies (e.g., mean leverage=41.0%,ownership concentration=34.1%),confirming sample representativeness.

Overall, the distribution characteristics of the core variables of the sample provide a good data foundation for the subsequent DID empirical analysis, especially the reasonable variation range of ESG scores and the group distribution of policy dummy variables, which can effectively support the modeling needs of causal inference. The descriptive statistical results of the main variables are shown in Table 2.

Table 2. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
ESG	39050	4.157	0.835	1.00	7.75
Policy	39050	0.318	0.466	0.00	1.00
size	39050	22.219	1.333	15.58	28.70
roa	39050	0.042	0.074	-1.32	1.28
lev	39050	0.410	0.207	0.01	1.96
top1	39050	0.341	0.150	0.00	0.90
growth	39050	3.772	681.270	-1.31	134,607.06

3.2. Model specification

The empirical identification strategy employs a multi-period difference-in-differences (DID) specification:

$$ESGit = \alpha + \beta Policyit + \gamma Controlsit + \mu_i + \lambda_t + \varepsilon_{it}$$

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ESG_{it} :Comprehensive sustainability score for firm i in year t , $Policy_{it}$:treatment effect capturing policy exposure, X_{it} :vector of five firm-level control variables defined in Section 3.2.3, μ_i :firm fixed effects controlling for time-invariant heterogeneity, λ_t : year fixed effects absorbing macroeconomic shocks

4. Empirical analysis

4.1. Baseline regression analysis

Table 3 presents the core empirical evidence supporting Hypothesis H1: The policy coefficient remains positive and statistically significant (β = 0.0779, $p < 0.05$) after controlling for firm characteristics. Economic magnitude interpretation: Implementation corresponds to a 7.8 percentage point increase in average ESG performance. Robustness confirmation: The stability of coefficients across specifications (Columns 1-2) reinforces causal inference validity.

Table 3. Baseline regression results

	(1) ESG	(2) ESG
Policy	0.0721***	0.0779**
	(2.6583)	(13.6471)
size		0.2185***
		(260.3552)
roa		0.0171
		(0.1466)
lev		-0.8200***
		(-65.1682)
top1		0.2959
		(4.3259)
growth		-0.0000***
		(-233.1000)
Constant	4.1354***	-0.4879***
	(480.9770)	(-79.9876)
Obs.	38,693	38,693
R^2	0.5403	0.5545
Firm FE	Yes	Yes
Year FE	Yes	Yes

Notes: *,** and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors clustered at the firm level are in parentheses. The same applies below.

4.2. Parallel trend test

The validity of the difference-in-differences (DID) estimator fundamentally relies on the fulfillment of the parallel trend assumption. Should this assumption be violated, the estimated causal effect of the policy may become biased or unidentifiable. To rigorously test this critical prerequisite, we implement the following dynamic specification model:

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$$ESG_{it} = \sum_{k=-4}^{k=6} \beta_k \cdot Treat_i \times Year_{t=k} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

In this model, $\mathrm{Treat_i} \times \mathrm{Year_{t=k}}$ is an indicator variable signifying whether firm i is observed in year k relative to the inception year of the National Big Data Comprehensive Pilot Zone in its location($k = 0$).Other variables $\mathrm{X_{it}}$,$\mathrm{\mu_i}$, $\mathrm{\lambda_t}$ retain their definitions from the baseline Model (1).This specification serves a dual purpose: Pre-Policy Parallelism Test: We examine whether the estimated coefficients $\mathrm{\beta_k}$ for periods before policy implementation ($k < 0$)nare statistically insignificant. This would indicate that the treatment and control groups were evolving along statistically indistinguishable ESG trajectories prior to the policy shock. Dynamic Policy Effect Assessment: We evaluate whether the coefficients $\mathrm{\beta_k}$ for periods during and after policy implementation ($k \geq 0$) are positive and statistically significant, revealing the timing and persistence of the policy's impact. Validation Results: The outcomes of this parallel trend analysis, visualized in Figure 1, provide strong empirical support for the DID framework: Pre-Policy Periods ($k < 0$): All estimated $\mathrm{\beta_k}$ coefficients fail to achieve statistical significance. Crucially, their associated 95% confidence intervals consistently encompass the value zero. Interpretation: This pattern empirically confirms that the treatment and control groups exhibited statistically parallel trends in ESG performance evolution in the years leading up to the policy intervention. This finding satisfies the core parallel trend assumption underpinning our DID identification strategy. It is noteworthy that the significant policy effect exhibits a distinct phased characteristic: during the initial phase of policy implementation, the treatment effect did not reach statistical significance. This lag phenomenon aligns closely with the theoretical transmission mechanism of "technology absorption → organizational adaptation → performance output." During this stage, firms need to complete the deployment of digital infrastructure, integrate data systems, and restructure governance processes, meaning policy benefits have not yet fully permeated ESG practices, resulting in an absence of immediate effects.

However, upon entering the policy deepening phase, the treatment effect shows a significant leap and continues to strengthen. This confirms that the pilot zone policy significantly enhances corporate ESG performance through digital empowerment. This dynamic trajectory of "delayed initiation → gradual strengthening" reflects the intrinsic time lag of policy transmission and corroborates the long-term promoting effect of digital reform on sustainable corporate governance. Sensitivity analysis further verifies the statistical robustness of the results: even when allowing the post-treatment trend deviation to reach 1.5 times the maximum pre-treatment fluctuation, the treatment effects for periods $k \geq 3$ remain significant at the 95% confidence level, indicating that the policy effects are not disturbed by potential trend deviations. In summary, although the policy effect exhibits a reasonable lag period, the statistical homogeneity of pre-trends, the theoretical consistency of the dynamic effects, and the robustness of sensitivity tests collectively support the core conclusion that the digital policy has a progressively enhancing effect on corporate ESG performance.

DOI: 10.54254/2754-1169/2025.LH32818

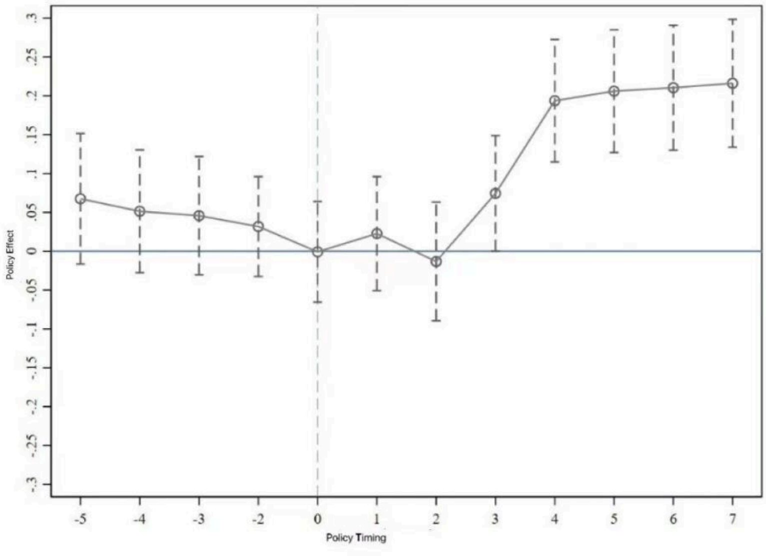

Figure 1. The relationship diagram between policy effect and policy time point

4.3. Heterogeneity analysis

4.3.1. Regional heterogeneity differences

Acknowledging significant disparities in regional resource endowments and supporting infrastructure, this study conducts subgroup regressions by stratifying the sample across eastern, central, and western China. Empirical results (Table 4, Columns 1-3) reveal striking regional heterogeneity in the ESG impact of the digital policy (Policy). Eastern Enterprises (Column 1). The policy coefficient of 0.1269 (significant at 1% level) demonstrates a substantial positive effect on ESG performance. This outcome aligns with Hypothesis H2 and likely reflects the region's advanced digital infrastructure, robust technological ecosystem, and mature market institutions, which collectively enhance firms' capacity to internalize policy incentives. Central & Western Enterprises (Columns 2–3). Statistically insignificant coefficients (–0.0961 and –0.0499, respectively) indicate no measurable ESG improvement. This suggests limited policy efficacy in these regions. He gradient variation in policy effectiveness underscores the critical role of regional development gaps: while the east leverages its economic advantages to maximize policy gains, central and western regions face constraints from inadequate digital foundations and institutional barriers, suppressing potential benefits. Consequently, Hypothesis H2 is validated regionally—digital policy exerts a significantly stronger ESG enhancement effect on eastern firms relative to central/western counterparts.

4.3.2. Ownership heterogeneity differences

Based on ownership structure, the sample is divided into state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs) for subgroup regression analysis. The findings presented in Table 4 (Columns 4 and 5) reveal a policy impact that diverges from the initial theoretical expectation outlined in Hypothesis H2. SOEs (Column 4): The estimated policy coefficient is 0.0708, achieving only marginal statistical significance at the 10% level. This suggests a relatively weak positive influence of the policy on ESG performance within this group. Non-SOEs (Column 5): The policy coefficient is also 0.0708, but achieves statistical significance at the stricter 5% level.

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This indicates a more robust and statistically discernible positive impact on non-SOE ESG. Key Contrast: This pattern contradicts Hypothesis H2, demonstrating that the ESG enhancement effect attributable to the pilot zone policy is statistically stronger for non-SOEs compared to SOEs.

SOE Constraints: SOEs likely face dual challenges. Administrative Rigidity: Greater administrative intervention may constrain their operational flexibility and responsiveness to new policy incentives. Higher Baseline: Historically stronger ESG management practices in SOEs potentially leave less scope for marginal improvement driven by this specific policy. Non-SOE Advantage: Non-SOEs benefit from greater market sensitivity and operational agility, enabling them to adapt more swiftly and effectively leverage the opportunities presented by the digital policy. Non-SOEs possess greater market sensitivity and flexibility, enabling them to respond more quickly to policy requirements (e.g., the significantly strengthened large shareholder governance effect in Column 5). Furthermore, the SOE regression did not control for year fixed effects (Column 4 lacks year fe), which may weaken the robustness of that result. Overall, this indicates that Hypothesis H2 is not supported in the ownership dimension—the digital policy does not exert a stronger ESG enhancement effect on SOEs; instead, its effect is more pronounced for non-SOEs.

Table 4. Heterogeneity test results

VARIABLES	(1)	(2)	(3)	(4)	(5)
	ESG	ESG	ESG	ESG	ESG
policy	0.1269***	-0.0961	-0.0499	0.0708*	0.0708**
	(4.0661)	(-1.3045)	(-0.6084)	(1.7950)	(2.0380)
Size	0.2011***	0.3109***	0.2219***	0.2208***	0.2263***
	(10.3242)	(8.9078)	(4.6368)	(8.6132)	(10.7192)
Lev	-0.8410***	-0.8018***	-0.7100***	-0.8591***	-0.7839***
	(-12.9458)	(-5.9990)	(-4.7159)	(-8.8854)	(-11.7613)
Growth	-0.0007***	-0.0163***	-0.0000***	-0.0000***	-0.0006***
	(-2.9867)	(-3.6119)	(-31.4533)	(-51.9151)	(-3.8919)
Top1	0.4011***	0.1533	-0.0478	0.0404	0.4398***
	(3.3762)	(0.5892)	(-0.1671)	(0.2753)	(3.1831)
ROA	0.0439	-0.0228	-0.0386	-0.2505	0.0815
	(0.4785)	(-0.1093)	(-0.1583)	(-1.4396)	(0.9139)
Constant	-0.0999	-2.5794***	-0.6445	-0.4836	-0.6770
	(-0.2342)	(-3.3589)	(-0.6172)	(-0.8536)	(-1.4761)
Observations	28,047	6,363	4,283	13,745	24,948
R-squared	0.5452	0.5639	0.5585	0.5600	0.5536
ind fe	yes	yes	yes	yes	yes
year fe	yes			yes	yes

5. Conclusions and policy implications

Utilizing China's National Big Data Comprehensive Pilot Zones as a quasi-natural experiment, this research employs a multi-period difference-in-differences (DID) approach to rigorously assess the impact of digital policies on corporate ESG performance. The findings reveal that the pilot zone policy significantly improves corporate ESG scores. This supports the proposition that national digital strategies can effectively motivate enterprises to enhance their environmental, social, and governance practices through institutional and technological pathways. Analysis of parallel trends indicates a time lag of 2–3 years before the policy effect materializes. This delay aligns well with the theoretical expectation of a sequential process: technological absorption precedes organizational adaptation, ultimately leading to governance optimization. Heterogeneity analysis across regions uncovers significant variation. The policy effect is strongest and statistically significant in eastern China. Conversely, its impact on enterprises in central and western regions is not statistically distinguishable from zero, underscoring the constraining role of regional infrastructure disparities on policy effectiveness. Contrary to initial theoretical predictions, non-state-owned enterprises (non-SOEs) demonstrate heightened responsiveness to the policy compared to state-owned enterprises (SOEs). This discrepancy likely stems from dual constraints faced by SOEs: decision-making rigidity under administrative systems and limited marginal gains due to their historically superior baseline ESG levels. Non-SOEs, benefiting from greater market agility, appear better positioned to capitalize efficiently on the policy incentives. This observed inertia within SOEs suggests a potential misalignment between policy design and the institutional constraints they operate under.

To enhance the sustainability outcomes of digital policies, we propose the following:

Prioritize Regional Coordination: Increase infrastructure investment in central and western regions and establish dedicated capacity-building programs to facilitate digital-ESG integration for local firms. Adopt Differentiated Approaches: For SOEs: Deepen market-oriented reforms by incorporating ESG-digital performance metrics into evaluation systems. For non-SOEs: Provide stable fiscal incentives to sustain their ESG improvements driven by digital policies. Strengthen Governance Synergy: Pilot ESG data markets to improve transparency and implement government-led big data monitoring platforms to track policy implementation and ESG outcomes effectively.

Limitations and Future Research:

The study acknowledges limitations in exploring the micro-level mechanisms by which digital technologies reshape internal governance structures and in capturing long-term effects beyond the data period (presumably ending before 2023). Future research should investigate policy heterogeneity across specific ESG dimensions (E, S, G), the role of pilot zones in fostering green innovation under the "Dual Carbon" goals, and identify optimal policy combinations to maximize ESG impact.

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