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Artificial Intelligence Innovation and Development Pilot Zones and Corporate Green Low-Carbon Development: Empirical Evidence from Chinese Listed Companies

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Abstract: *Leveraging new-generation artificial intelligence technologies to drive corporate low-carbon transformation has become a critical approach to addressing emission reduction challenges and realizing coordinated economic and ecological development. This paper takes the policy of Artificial Intelligence Innovation and Development Pilot Zones as a quasi-natural experiment. Using the data of A-share listed companies from 2010 to 2021, this study adopts a staggered DID method to systematically evaluate the impact of the pilot zone policy on corporate carbon emission intensity. The empirical results show that the policy of artificial intelligence innovation and development pilot zones can significantly reduce corporate carbon emission intensity. Mechanism tests indicate that this policy curbs corporate carbon emissions mainly through three transmission paths: empowering enterprises via digital technologies, expanding the scale of green innovation, and improving the quality of green innovation. Heterogeneity analysis reveals that regional green financial development, government service capacity and corporate financing constraints exert prominent differentiated impacts on the policy's emission reduction effect. The research conclusions provide theoretical references and empirical evidence for further expanding the scope of artificial intelligence innovation pilots and establishing a long-term mechanism for enabling green transformation with digital technologies.*

Keywords: *Artificial Intelligence Innovation And Development Pilot Zones; Digital Technology; Carbon Emissions; Difference-in-Differences Method*

1. Introduction

Global warming has led to increasingly severe ecological carrying capacity degradation. As micro-enterprises constitute the main source of carbon emissions in the production sector, their low-carbon transformation is the core foothold for implementing regional carbon emission reduction tasks. Since China put forward the dual carbon strategy, traditional emission reduction approaches dominated by end-of-pipe treatment and production capacity contraction have shown obvious diminishing marginal benefits. Such approaches not only witness declining emission reduction potential, but also squeeze the profit space of the real economy, and thus fail to meet the demand for coordinated economic and ecological development. Zhou et al.,(2024) argue that boasting technical strengths including full-factor energy consumption perception, dynamic production scheduling and accurate carbon emission tracing, artificial intelligence has provided a technological breakthrough for enterprises to achieve endogenous carbon reduction[10].In this context, the Ministry of Science and Technology launched the National New-Generation Artificial Intelligence Innovation and Development Pilot Zones in 2019 in accordance with the New Generation Artificial Intelligence Development Plan. In line with official construction guidelines, the pilot regions were granted four pioneering policy privileges: shared computing power resources, approval exemption for intelligent application scenarios, special subsidies for industry-university-research cooperation, and regulatory tolerance. A total of 18 pilot zones were established in batches. Each region has built characteristic application scenarios of "artificial intelligence and energy conservation and carbon reduction" based on local leading industries. Breaking away from the single orientation of traditional efficiency improvement, the institutional policy dividends reduce the costs of corporate intelligent low-carbon transformation, which provides a typical quasi-natural experiment for investigating the micro-level carbon reduction effect of AI-oriented regional policies.

As a new general-purpose technology, artificial intelligence has been widely discussed for its role in

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green development, and it also makes up for the limitations of traditional digital technologies in carbon reduction. At the macro level, artificial intelligence can optimize regional energy and industrial structures and reduce regional carbon emission intensity. At the micro level, existing studies confirm that artificial intelligence can break information barriers in industrial chains, enhance enterprises' capacity for collaborative green innovation, activate data factors to foster new productive forces, and cut production energy consumption through intelligent energy management. Most studies on the carbon reduction effect of artificial intelligence innovation pilot zones mainly focus on the implementation of AI technology scenarios and technology spillovers, while ignoring the driving role of supporting institutions in pilot zones. Micro empirical research on the systematic impact of relevant policies on corporate carbon emissions is still insufficient.

To sum up, the environmental governance value of artificial intelligence technology has been verified. Different from the application of conventional artificial intelligence technologies, the National New-Generation Artificial Intelligence Innovation and Development Pilot Zones are exogenous institutional pilots at the national level. Equipped with perception, learning and autonomous decision-making capabilities, advanced artificial intelligence can be embedded into the whole chain of corporate production and governance through autonomy and interactivity, promote the coordinated linkage of technology, organization and management models, and improve emission reduction performance via value co-creation. Currently, few studies integrate institutional pilots and artificial intelligence to analyze corporate carbon emissions. On this basis, this paper incorporates both elements into a unified analytical framework, which complements the existing literature and provides practical basis for policy optimization of pilot zones and corporate low-carbon transformation.

This paper has the following marginal contributions. First, different from existing literature that focuses on the impact of artificial intelligence technology application on corporate innovation, this paper expands the research scope to the policy dimension, and supplements new literature and empirical evidence for the carbon reduction effect of artificial intelligence policies on enterprises. Second, this paper conducts mechanism tests from three perspectives including digital technology empowerment, scale of green innovation and quality of green innovation, which uncovers the "black box" of how the policy affects corporate carbon emission reduction. Third, this paper carries out heterogeneity analysis in terms of urban financial development, government attention and corporate financing constraints to explore differentiated policy effects, which provides important references for subsequent policy optimization.

2. Theoretical Analysis and Research Hypotheses

2.1 Mechanisms of AI Policies Affecting Corporate Carbon Emissions

The policies of artificial intelligence innovation and development pilot zones exert a direct inhibitory effect on corporate carbon emissions through multi-dimensional institutional and technological support. In terms of production process optimization, relying on open computing power and intelligent monitoring scenarios, the policies encourage enterprises to adopt artificial intelligence technologies to realize real-time perception of energy consumption and dynamic load scheduling, so as to reduce no-load and invalid energy consumption, improve energy efficiency and cut carbon emissions. In terms of factor allocation guidance, special subsidies and industrial docking guide the flow of data, capital and talents to green and low-carbon sectors, driving enterprises to phase out high-energy-consumption traditional operation modes and shift to AI-driven low-carbon development paths. In terms of green innovation incentives, R&D incentives and regulatory tolerance reduce the R&D costs of low-carbon technologies, and encourage enterprises to develop intelligent applications such as carbon footprint tracing and carbon capture and utilization. These efforts consolidate the foundation of carbon reduction from the source and reduce corporate carbon emission intensity. Accordingly, we propose the following hypothesis:

H1: The policies of artificial intelligence innovation and development pilot zones significantly inhibit corporate carbon emissions.

2.2 Influencing Mechanisms of AI Policies on Corporate Carbon Emissions

2.2.1 Digital Technology Empowerment Effect

The policies of new-generation artificial intelligence innovation and development pilot zones take artificial intelligence, big data and other digital technologies as the starting point to empower corporate

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development, and restrain corporate carbon emissions through multiple dimensions. Song et al. (2024) point out that in terms of environmental supervision, digital intelligent monitoring systems enable real-time monitoring, accurate identification and dynamic early warning of pollutant emissions, helping enterprises timely investigate and renovate production links with high emissions[5]. In production and operation, artificial intelligence is deeply integrated into production scheduling, equipment management, resource allocation and other links, transforming corporate management into data-driven and refined modes, and substantially reducing invalid energy consumption and resource waste. Meanwhile, relevant policies continue to improve digital infrastructure such as computing power and network facilities, and build innovation cooperation platforms, which lower the R&D costs of corporate green technologies, facilitate the application of clean production technologies, continuously optimize corporate energy consumption structure and improve energy utilization efficiency, so as to effectively control corporate carbon emissions. Thus, we put forward:

H2a: The policies of artificial intelligence innovation and development pilot zones inhibit corporate carbon emissions through digital technology empowerment.

2.2.2 Scale Expansion Effect of Green Innovation

Supported by intellectual property protection, fiscal and financial incentives and the agglomeration of innovation resources, the pilot zone policies significantly expand the scale of corporate green innovation. Ji & Gu (2021) point out that on the one hand, the policies establish fast-track channels for patent examination and intellectual property infringement early warning mechanisms, improve the efficiency of intellectual property protection, and reduce the risk of infringement on green innovation achievements, thus motivating enterprises to conduct more R&D on energy conservation, carbon reduction and pollution control technologies[2]. As Liu et al. (2021) demonstrate, on the other hand, tax incentives, additional deductions for R&D expenses, financing guarantees and loan interest subsidies directly reduce corporate R&D costs and financial pressure, and provide sufficient cash flow for green innovation[3]. In addition, talent cultivation and innovation platform construction gather high-end talents, data and computing power required for green innovation. Enterprises can accurately identify the R&D directions of green technologies with the support of artificial intelligence algorithms and reduce R&D trial-and-error costs. The cross-stakeholder cooperation platforms built by the policies also accelerate the flow of innovation factors, leading to a substantial increase in the number of corporate green patents and providing large-scale technical support for corporate carbon emission reduction. Hence, we hypothesize that:

H2b: The policies of artificial intelligence innovation and development pilot zones inhibit corporate carbon emissions by expanding the scale of green innovation.

2.2.3 Quality Improvement Effect of Green Innovation

AI-related policies provide data, computing power and application scenarios for green technology R&D, and promote the in-depth integration of artificial intelligence with clean production, energy conservation and carbon reduction. Meanwhile, a sound intellectual property protection and innovation incentive system guides enterprises to shift from low-level and homogeneous green patent applications to the R&D of high-value and implementable core green technologies. As documented by Quan and Li (2025)[4], within the open innovation ecosystem supported by the policies, enterprises carry out in-depth cooperation with research institutions and upstream and downstream partners, accelerating the sharing and iteration of green innovation knowledge and promoting breakthroughs in key green technologies such as clean production techniques and energy-saving processes. Moreover, supporting measures for innovation achievement transformation help high-value green patents realize market-oriented application, further enhancing the technical influence and industrial recognition of green innovation achievements. This is reflected in a notable rise in the citation times of corporate green patents, which provides high-quality technical guarantees for long-term and stable carbon reduction. Accordingly, we propose:

H2c: The policies of artificial intelligence innovation and development pilot zones inhibit corporate carbon emissions by improving the quality of green innovation.

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3. Econometric Model and Data Processing

3.1 Model Specification and Variable Selection

3.1.1 Econometric Model

Given that the National New-Generation Artificial Intelligence Innovation and Development Pilot Zones were launched in batches at different time points and form a typical quasi-natural experiment, this paper adopts a staggered difference-in-differences model to test the impact of the pilot policy on corporate carbon emission intensity. The specific model is set as follows:

$$CEI_{it}=\alpha_0 + \alpha_1 AIPZ_{it} + \sigma X_{it} + \mu_t + \gamma_i + \varepsilon_{it} \quad (1)$$

Where i denotes the enterprise and t denotes the year. X_{it} refers to the set of control variables. μ_t and γ_i stand for year fixed effects and firm fixed effects respectively. $\varepsilon_{it}$is the random disturbance term.

3.1.2 Selection of variables

(1) Dependent Variable: Corporate Carbon Emission Intensity (CEI). Referring to Yin et al. (2026)[9], this variable is measured by the ratio of an enterprise's annual carbon emissions to its operating income, which reflects the level of corporate low-carbon development. A lower value means a better emission reduction performance. (2) Core Explanatory Variable: Artificial Intelligence Innovation Pilot Zone Policy (AIPZ). For enterprises located in pilot cities,$AIPZ_{it}$is assigned a value of 1 in and after the policy implementation year, and 0 otherwise. For enterprises in non-pilot cities, $AIPZ_{it}$ always equals 0. (3) Control Variables: Following Wei et al. (2025)[8], we select financial leverage (Lev), firm age (Age), Tobin's Q (TobinQ), firm size (Size), return on total assets (ROA), net cash flow (Cashflow), urban per capita GDP (Pgdp) and equity concentration (Top1) as control variables.

3.2 Data Sources and Processing

The research sample covers A-share listed companies in Shanghai and Shenzhen Stock Exchanges from 2010 to 2021. Corporate financial data are sourced from the China Stock Market & Accounting Research (CSMAR) Database; corporate carbon emission data are obtained from the carbon emission derivative calculation sub-database of CSMAR; corporate green innovation data come from the Chinese Research Data Services Platform (CNRDS). We exclude ST, *ST and financial enterprises, as well as samples with missing indicators, and finally obtain 20,223 valid observations. City-level data are collected from the annual China Urban Statistical Yearbooks and statistical bureaus of prefecture-level cities, and matched with listed companies by prefecture-level city codes.

4. Empirical Tests

4.1 Benchmark Regression

We conduct regression tests based on the full sample. The results are reported in Table 1. After controlling for firm and year two-way fixed effects, the coefficient of the artificial intelligence innovation pilot zone policy ($AIPZ_{it}$) is significantly negative at the 1% level regardless of whether control variables are included. When all control variables are incorporated, the coefficient is -0.0305, which indicates that the pilot zone policy can significantly reduce corporate carbon emission intensity. The preliminary research conclusion is thus verified.

Table 1 Benchmark Regression Results

	(1) CEI	(2) CEI
AIPZ	-0.0256***	-0.0305***
	(-3.0417)	(-3.6314)
Lev		0.0129*
		(1.8927)
Age		-0.0178***
		(-12.1591)
TobinQ		-0.0035**
		(-2.5004)
Size		0.0037

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		(0.6627)
Roa		-0.2943***
		(-9.1665)
Cashflow		-0.1558***
		(-4.4979)
Top1		-0.0936***
		(-3.4864)
_cons	0.6757***	1.1844***
	(78.2553)	(7.2149)
Firm FE	yes	yes
Year FE	yes	yes
Observations	20223	20223
R-squared	0.052	0.063

4.2 Robustness Tests

4.2.1 Parallel Trend Test

The reliability of estimation results of the difference-in-differences model is based on the parallel trend assumption, which requires that the dependent variables of the treatment group and the control group maintain a consistent changing trend before policy implementation. This paper adopts the event study method to conduct the parallel trend test and dynamic effect analysis. The model is specified as follows:

$$CEI_{it}=\beta_0 + \sum_{f=-6}^{-2} \varphi_f D_{if} + \sum_{f=0}^{2} \varphi_f D_{if} + \beta_1 X_{it} + \mu_t + \gamma_i + \varepsilon_{it} \quad (2)$$

As shown in Figure 1, the estimated coefficients of time dummy variables are not significant before the policy implementation, which implies that there is no significant difference in corporate carbon emission intensity between the treatment group and the control group prior to the policy launch. The parallel trend assumption cannot be rejected. The coefficient turns negative in the policy implementation year, and remains significantly negative with increasing absolute values in the first and second years after implementation.

4.2.2 Placebo Test

Following Guan et al. (2026)[1], this paper carries out a placebo test by constructing pseudo-treatment groups and hypothetical policy time points. This approach helps eliminate confounding effects from other unobserved factors and further validates the reliability of the baseline regression results. We randomly select enterprises equal in number to the real treatment group as the pseudo-treatment group, and randomly assign policy implementation years to construct a fictitious policy variable $AIPZ^{false}$. The above procedure is repeated 500 times.As shown in Figure 2, the kernel density distribution of the estimated coefficients of $AIPZ^{false}$ is centered around zero, which is distinctly separated from the significantly negative real coefficient (vertical dashed line) in the benchmark regression. This result proves that the reduction in corporate carbon emission intensity identified in the benchmark regression is indeed driven by the actual artificial intelligence innovation pilot zone policy rather than random factors, which confirms the robustness of the benchmark conclusions.

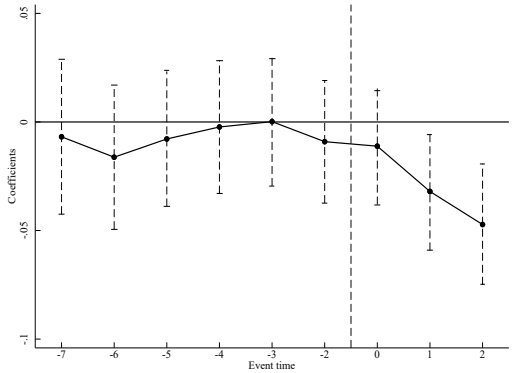

Figure 1 Parallel trend test

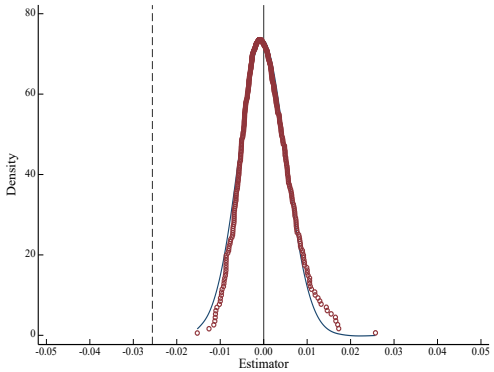

Figure 2 Placebo Test Results

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4.3 Mechanism Tests

The benchmark regression results confirm that the artificial intelligence innovation pilot zone policy can significantly reduce corporate carbon emission intensity. On this basis, we further explore the internal influencing mechanisms, and conduct mechanism tests from three dimensions: digital technology empowerment, scale of green innovation and quality of green innovation.

4.3.1 Digital Technology Empowerment Effect

Theoretical analysis indicates that the artificial intelligence innovation pilot zone policy reshapes the cost-benefit structure of corporate operation via supporting measures such as digital industry support and computing power subsidies, and motivates enterprises to promote comprehensive digital transformation. This paper adopts the comprehensive score of digital infrastructure to measure corporate digitalization level (Digitization). Column (1) of Table 2 shows that the coefficient of policy variable AIPZ is significantly positive at the 1% level, which verifies that the artificial intelligence innovation pilot zone policy effectively accelerates the digital transformation of pilot enterprises. After the policy is implemented, regional digital supporting facilities are expanded. Enterprises rely on digital infrastructure to realize full-process digital management of production and energy consumption: real-time energy consumption monitoring reduces invalid energy loss, and intelligent scheduling optimizes factor allocation and improves energy utilization efficiency, thereby lowering carbon emissions per unit output.

4.3.2 Scale Expansion Effect of Green Innovation

Theoretically, talent cultivation and R&D subsidy policies of the pilot zones lower the capital and technical barriers for corporate green R&D, and stimulate enterprises to expand green innovation output. Referring to Wang and Wang (2021)[7], this paper adopts the total number of annual green patent applications of enterprises to measure the scale of green innovation (Greenpatent). Column (2) of Table 2 shows that the coefficient of the core explanatory variable AIPZ is significantly positive at the 1% level, which means that the pilot policy greatly expands the scale of corporate green innovation. The pilot zones provide supporting computing power, algorithms and R&D funds, lower the threshold for low-carbon technology R&D, and drive enterprises to continuously develop energy-saving, pollution-control and clean energy technologies and accumulate green patents. The large-scale application of green patents renovates traditional high-carbon production lines and cuts carbon emissions from the source, thereby restraining corporate carbon emission intensity.

4.3.3 Quality Improvement Effect of Green Innovation

Theoretically, the AI-related policies promote the in-depth integration of artificial intelligence technologies and low-carbon R&D, and help enterprises develop high-quality green innovation achievements with stronger emission reduction performance. We adopt the cumulative citation times of corporate green patents to measure green innovation quality (Citation). Column (3) of Table 2 shows that the coefficient of AIPZ is also significantly positive at the 1% level, which proves that the pilot policy effectively improves the quality of corporate green innovation. A higher citation frequency of green patents indicates stronger breakthrough value and practical value of low-carbon technologies. Supported by artificial intelligence-enabled R&D advantages in the pilot zones, the high-citation green patents developed by enterprises can realize in-depth transformation of energy structure and construction of circular production systems. Compared with ordinary green patents, such high-quality technologies deliver stronger and more lasting emission reduction effects, continuously tap the potential of corporate carbon reduction and curb the growth of carbon emission intensity.

Table 2 Mechanism Test Results

	(1) Digitization	(2) Greenpatent	(3) Citation
AIPZ	0.0132***	0.0877***	11.5369***
	(14.6436)	(4.5760)	(4.3061)
Control Variables	yes	yes	yes
Firm FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	20223	20223	20223
R-squared	0.411	0.291	0.019

4.4 Heterogeneity Analysis

To further refine the research conclusions, this paper conducts grouped regression from three

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dimensions: regional green financial development, government service capacity and corporate financing constraints, and explores the heterogeneous characteristics of the policy's emission reduction effect. The regression results are reported in Table 3. Referring to Sun et al. (2026)[6], we adopt the entropy weight method to calculate the green financial development index, and divide the full sample into low and high green financial development groups by the median value. Column (1) shows that in regions with low green financial development, the coefficient of core explanatory variable AIPZ is -0.0142 and fails to pass the significance test. Column (2) indicates that in regions with high green financial development, the coefficient of AIPZ is -0.0285 and significant at the 5% level. It means that the carbon reduction effect of the artificial intelligence innovation pilot zone policy only exists in regions with sound green financial development. We divide the sample according to the level of government service supply. Column (3) shows that the coefficient of AIPZis -0.0171 and statistically insignificant in the group with low government service supply. Column (4) reveals that the coefficient of AIPZ is -0.0339 and significant at the 1% level in the group with high government service supply. This result indicates that high-quality government services can amplify the emission reduction effect of the pilot zone policy. We divide the sample according to the degree of corporate financing constraints. Column (5) shows that the coefficient of AIPZ is -0.0374 and significant at the 1% level for enterprises with low financing constraints. Column (6) shows that the coefficient of AIPZ is -0.0257 and statistically insignificant for enterprises with high financing constraints. It can be seen that the pilot zone policy delivers a more prominent carbon reduction effect on enterprises with low financing constraints.

Table 3 Heterogeneity Grouping Test Results

	(1) Low Green Finance	(2) High Green Finance	(3) Low Government Service	(4) Low Government Service	(5) Low Financing Constraint	(6) High Financing Constraint
AIPZ	-0.0142	-0.0285**	-0.0171	-0.0339***	-0.0374***	-0.0257
	(-0.84)	(-2.23)	(-1.28)	(-2.76)	(-5.08)	(-1.63)
Control Variables	yes	yes	yes	yes	yes	yes
Observations	10129	10094	10118	10105	10112	10111
Firm FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes

5. Conclusions and Policy Recommendations

Based on the data of A-share listed companies in China from 2010 to 2021, this paper draws the following main conclusions. First, the benchmark regression results show that the policy of National New-Generation Artificial Intelligence Innovation and Development Pilot Zones can significantly reduce the carbon emission intensity of enterprises in pilot regions. This conclusion remains valid after parallel trend test and placebo test. Second, mechanism tests reveal that the artificial intelligence innovation pilot zone policy achieves carbon reduction through three paths: promoting corporate digital technology empowerment, expanding the scale of green innovation and improving the quality of green innovation. The three paths jointly drive corporate carbon emission reduction. Third, heterogeneity analysis shows that the policy effect presents obvious differentiation. The policy can effectively exert its effect only in regions with high-level green financial development and strong government service capacity, as well as among enterprises with low financing constraints. External supporting environment and corporate capital conditions are important factors affecting policy implementation performance.

Based on the above conclusions, we put forward relevant policy recommendations. First, expand the coverage of artificial intelligence (AI) innovation pilot zones, promote the in-depth integration of intelligent technologies with energy-intensive industries, support research and development of low-carbon intelligent technologies, realize full-process carbon management and control across the entire production chain via digital tools, and break the lock-in of high-carbon path dependence. Second, implement targeted, region-differentiated policies. Local governments should develop customized intelligent transformation schemes according to local green finance development and industrial energy consumption patterns, address low-carbon financing constraints in financially underdeveloped regions, and narrow regional disparities in emission reduction outcomes. Third, establish a multi-stakeholder collaborative environmental governance system. Governments should coordinate administrative regulation with digital technology empowerment, incorporate AI-enabled low-carbon indicators into the environmental governance framework, mitigate the potential substitution effect of administrative emission reduction measures on technology-driven emission reduction, and foster a long-term

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collaborative mechanism among multiple stakeholders for sustained carbon reduction.

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