Green Finance Reform and Corporate Carbon Disclosure Quality: The Roles of Financing Constraints and Capital Market Attention

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Abstract. Comparable and verifiable carbon information is essential for environmental risk pricing and green capital allocation. Using the staggered establishment of China's green finance reform and innovation pilot zones, the archived analysis covers 18,652 firm-year observations for A-share listed firms from 2012 to 2023 and a 0-8 carbon disclosure quality index (CDI). The fully controlled two-way fixed-effects estimate is 0.421 (firm-clustered standard error 0.081; 95% confidence interval 0.262-0.580), or 14.8% of mean CDI. Archived post-treatment estimates rise from 0.098 in the adoption year to 0.612 after four or more years, and mechanism and heterogeneity coefficients are directionally consistent with financing constraints and analyst attention. However, the firm-level panel, address crosswalk, code, pre-treatment event-study coefficients, jurisdiction-clustered inference, and Sun-Abraham and Callaway-Sant'Anna outputs are not available in the revision archive. The reported estimates should therefore be interpreted as archived conditional associations, not as independently reproduced causal effects.

Keywords: green finance reform and innovation pilot zones; carbon disclosure quality; staggered difference-in-differences; financing constraints; capital market attention.

1 Introduction

Digital platforms can lower the cost of processing environmental information, but they cannot substitute for reliable corporate data. Green finance can price environmental risk only when firms report comparable information on emissions, intensity, reduction targets, implementation, and assurance. Current disclosure often remains qualitative, with unclear accounting boundaries and limited quantification. We therefore examine disclosure quality, defined by completeness, quantification, and verifiability, rather than the binary decision to disclose.

China approved its first green finance reform and innovation pilot zones in 2017, added Lanzhou New Area in 2019, and approved a municipality-wide Chongqing pilot in 2022 (People's Bank of China et al., 2017, 2019, 2022). The schemes develop green

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credit, green bonds, environmental-rights financing, project registries, and information systems. These reforms can increase both the financing value of environmental information and the cost of weak disclosure. Existing studies examine green innovation, ESG performance, air quality, and greenwashing (Hu et al., 2021; Chen et al., 2022; Han et al., 2022; Wang et al., 2023; Xu et al., 2023; Tong et al., 2024), but provide less evidence on carbon information quality.

We connect green-finance policy research with the literature on carbon disclosure by examining the staggered pilot-zone rollout. Using archived 2012-2023 A-share results, we describe a 0-8 carbon disclosure quality index (CDI), a location-based treatment protocol, and estimates for financing constraints, analyst attention, and firm heterogeneity. The study shifts policy evaluation from report issuance to decision-useful information quality. Because the unit-level data and code are not available in the revision archive, the evidential boundary is explicit: the numerical results are transcribed from retained outputs and cannot support stronger causal claims than those outputs permit.

2 Theoretical Analysis and Hypotheses

2.1 Information Value and Disclosure Incentives

Under conventional lending, carbon information may have little connection to financing terms. Pilot-zone reforms incorporate environmental factors into assessment and post-loan monitoring, making emissions, mitigation plans, and verification relevant to green eligibility. High-quality disclosure can reduce information asymmetry and signal transition capability (Lee, 2020), while digital platforms make selective reporting easier to detect.

H1. The establishment of green finance reform and innovation pilot zones improves the carbon disclosure quality of listed firms in treated regions.

2.2 Financing-Constraint Mechanism

High-quality disclosure requires data collection, personnel, and verification, which constrained firms may defer. Green credit and project registries can support reporting capacity and strengthen disclosure incentives. Financing constraints are measured with the absolute Hadlock and Pierce (2010) SA index, and mechanism estimates are interpreted as directional evidence rather than definitive mediation.

H2. A reduction in financing constraints is an important channel through which pilot-zone reform improves corporate carbon disclosure quality.

2.3 Capital-Market Attention Mechanism

Disclosure quality also depends on external interpretation and verification. Analyst coverage subjects vague reporting to professional scrutiny and makes carbon data more

useful for valuation and financing. By raising information demand, pilot zones can strengthen incentives for specific and standardized disclosure.

H3. Greater capital-market attention contributes to higher corporate carbon disclosure quality following pilot-zone reform.

The channels are complementary: finance supports reporting capacity, while market scrutiny raises the value of reliable disclosure. We test them separately and do not interpret coefficient changes as complete mediation.

3 Research Design

3.1 Sample and Data

The archived sample covers non-financial A-share firms listed in Shanghai or Shenzhen from 2012 to 2023. Financial, ST, and *ST firms, newly listed firms, and observations with missing key variables were excluded, and continuous variables were winsorized at the 1st and 99th percentiles. The retained summary reports an unbalanced panel of 2,378 firms and 18,652 firm-year observations. Financial variables were sourced from CSMAR, and carbon disclosure was manually coded from corporate reports. The archived manuscript reports 93.5% raw agreement between two coders followed by reconciliation, but the firm-year coding file, disagreement log, and analysis code are not included in the revision archive.

Treatment is assigned at the official pilot-jurisdiction level, never province-wide. The firm-year registered office in the annual report governs; headquarters and operating sites do not. City addresses are normalized to National Bureau of Statistics six-digit codes. Huzhou, Quzhou, Guangzhou, Hami, Changji, Karamay, and Chongqing are matched by the named prefecture-level unit, whereas Ganjiang, Gui'an, and Lanzhou New Areas require the official new-area name in the address because they do not map one-to-one to prefecture codes. Policy equals one from the cohort year; never-treated and not-yet-treated firm-years are controls. A mover check excludes firms changing matched jurisdiction. The archived address crosswalk is unavailable, so retained estimates cannot be independently verified against this rule.

3.2 Variable Measurement

The 0-8 carbon disclosure quality index (CDI) awards one point for each item: total emissions; emission intensity; emission sources; reduction targets; mitigation actions and investment; third-party verification; carbon trading; and verifiable quantitative data. CDI measures disclosure completeness and verifiability, not actual emissions.

$$CDI_{it} = \Sigma_{m=1}^{8} Score_{m,it} \quad (1)$$

Quantitative-data credit requires a stated unit, period, or accounting boundary. The 93.5% raw coder agreement is not chance-adjusted, and missing coding records prevent retrospective calculation of Cohen's kappa or Krippendorff's alpha.

Policy equals one for matched firm-years in or after the cohort year in Table 1. Mechanism variables are the absolute SA index and Monitor, the logarithm of analyst coverage plus one. Controls cover size, leverage, profitability, listing age, ownership, board characteristics, auditing, institutional ownership, provincial GDP per capita, and environmental regulation.

Table 1. Official pilot cohorts, implementation dates, jurisdictions, and treatment coding.

Cohort and date	Official pilot jurisdiction(s)	Annual treatment coding
2017 (14 Jun approval; 23 Jun plans)	Huzhou and Quzhou (Zhejiang); Ganjiang New Area (Jiangxi); Guangzhou, with Huadu District as the core (Guangdong); Gui'an New Area (Guizhou); Hami, Changji, and Karamay (Xinjiang)	Named city/new-area match; no province-wide assignment; Policy = 1 from 2017
2019 (28 Nov)	Lanzhou New Area (Gansu)	Explicit new-area address match; not all Lanzhou or Gansu; Policy = 1 from 2019
2022 (19 Aug)	Chongqing Municipality; official priorities include Liangjiang New Area and Wanzhou, Yuzhong, Jiangbei, and Nan'an districts	Municipality-wide match under the official Chongqing plan; Policy = 1 from 2022

Note: The archived specification starts exposure in each cohort's approval or issuance calendar year. A first-full-calendar-year sensitivity would begin in 2018, 2020, and 2023, respectively, but no output for that recoding is retained. Sources: People's Bank of China et al. (2017, 2019, 2022).

3.3 Identification Strategy

The archived baseline is a two-way fixed-effects (TWFE) difference-in-differences model with firm and year fixed effects. Policy compares treated firms after adoption with never-treated or not-yet-treated firms. The retained output uses firm-clustered standard errors. Because treatment varies by jurisdiction, preferred inference clusters by policy jurisdiction, checks two-way firm-jurisdiction clustering, and applies wild-cluster bootstrap correction when clusters are few. These outputs are absent from the archive.

$$CDI_{it} = \alpha + \beta Policy_{it} + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Staggered-adoption TWFE can be biased when effects vary by cohort or event time. A rerun should report the Sun and Abraham (2021) interaction-weighted event study and Callaway and Sant'Anna (2021) group-time effects with never-treated or not-yet-treated controls; the year before treatment is the event-study reference. The archive contains several post-treatment points but no pre-treatment vector, confidence intervals, cohort weights, or output from either robust estimator. The methods define the required estimands, not completed evidence.

$$CDI_{it} = \alpha + \Sigma_{k \neq -1} \beta_k \, Event_{it}^{k} + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

The archived mechanism specifications estimate the association of Policy with SA and Monitor and then include each variable in the CDI equation. Because SA and Monitor are post-treatment variables, coefficient changes are interpreted only as directional consistency checks, not causal mediation shares. The archived heterogeneity results are likewise subgroup associations unless re-estimation establishes valid policy-level inference and reports formal interaction tests.

3.4 Identification Boundaries

Pilot designation was non-random and may reflect prior green-finance capacity, governance, or disclosure trends. Firm/year fixed effects and retained regional controls do not remove differential trends. A rerun should add province trends and region-year economic, industrial, fiscal, environmental, and financial controls. The archived 500-reassignment placebo tests chance assignment, not targeted selection. Without pre-treatment and expanded-specification outputs, parallel trends remain unverified and estimates are conditional associations.

4 Empirical Results

4.1 Descriptive Statistics

Mean CDI is 2.847 with a standard deviation of 2.136, indicating generally low and heterogeneous disclosure quality. Mean Policy is 0.182, so 18.2% of archived firm-year observations are exposed under the original coding. Other financial and governance variables remain within plausible ranges. Table 2 reports the archived descriptive statistics.

Table 2. Archived descriptive statistics.

Variable	N	Mean	SD	Min	Max
CDI	18,652	2.847	2.136	0	8
Policy	18,652	0.182	0.386	0	1
Size	18,652	22.153	1.267	19.632	26.014
Lev	18,652	0.426	0.204	0.058	0.923
ROA	18,652	0.041	0.058	-0.186	0.213
Age	18,652	2.132	0.786	0	3.332
Inst	18,652	0.089	0.103	0	0.467

4.2 Baseline Results

Group means provide descriptive evidence: treated firms' CDI rises from 2.415 to 3.892, whereas control firms rise from 2.328 to 2.654. The unadjusted difference-in-differences is 1.151, but it is not causal because it ignores covariates and common shocks.

Table 3 reports the archived baseline estimates. The Policy coefficient declines from 0.536 to 0.421 as controls are added. In the fully controlled specification, the retained firm-clustered standard error is 0.081, implying a conventional 95% confidence interval of 0.262-0.580. The point estimate equals 14.8% of mean CDI. Because policy-jurisdiction clustering and robust staggered-DID estimates are unavailable, statistical significance under the preferred inference cannot be established from the revision archive.

Table 3. Archived TWFE estimates for green finance reform and carbon disclosure quality.

Variable	(1)	(2)	(3)
Policy	0.536***	0.448***	0.421***
	(0.089)	(0.082)	(0.081)
Size		0.312***	0.308***
		(0.034)	(0.034)
Lev		-0.186**	-0.179**
		(0.078)	(0.078)
ROA		0.892***	0.876***
		(0.264)	(0.263)
Other firm controls	No	Yes	Yes
Regional controls	No	No	Yes
Firm/year FE	Yes	Yes	Yes
N	18,652	18,652	18,652
R-squared	0.312	0.428	0.431

Note: Values are transcribed from archived output. Firm-clustered robust standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels under that archived inference. Treatment-jurisdiction clustering, two-way clustering, and wild-cluster bootstrap inference were not retained and are not inferred from these stars.

4.3 Dynamic Effects and Robustness

The archived materials do not contain the pre-treatment event-study coefficients, their confidence intervals, or the event-study sample size; parallel trends therefore cannot be declared satisfied. Retained post-treatment point estimates are 0.098 at event time 0, 0.213 at +1, 0.387 at +2, 0.526 at +3, and 0.612 at +4 or later. Only event time 0 retains a t statistic (1.12), from which the standard error is 0.0875 and the conventional 95% confidence interval is -0.074 to 0.270. The increasing sequence is descriptive and cannot replace a complete event-study graph with pre-treatment coefficients and confidence intervals.

Table 4 consolidates every dynamic, robustness, placebo, and identification result that can be recovered from the archived manuscript. PSM-DID, alternative-outcome, overlapping-policy, winsorization, and cohort-exclusion summaries preserve positive coefficients under the original firm-level inference. The 500-reassignment placebo distribution has mean 0.003 and a reported 95th percentile of 0.127. Neither these checks nor rescaling CDI supplies the missing pre-trend, modern staggered-DID, or policy-clustered evidence.

Table 4. Archived dynamic, robustness, placebo, and identification evidence.

Evidence item	Archived estimate or result	Evidence status
Panel A: event time	Post-treatment dynamics	Not a parallel-trends test
Post-treatment coefficients	k = 0: 0.098 (t = 1.12; SE = 0.0875; 95% CI [-0.074, 0.270]); k = +1: 0.213 (10%); k = +2: 0.387 (1%); k = +3: 0.526 (1%); k >= +4: 0.612 (1%)	Only k = 0 retains a standard error and CI; event-study N not retained
Pre-treatment leads	No coefficient vector, CI, or event-study N retained	Parallel trends not verified
Panel B: archived checks	Alternative specifications and placebo	Original firm-level inference
Alternative specifications	PSM-DID: 0.398 (t = 4.67); log outcome: 0.038 (4.52); 100-point CDI: 5.263 (5.18); exclude overlapping policies: 0.408 (4.89); 5%-95% winsorization: 0.415 (5.06); exclude 2019 cohort: 0.432 (5.14)	Positive under archived inference; rescaling does not alter identification
500 reassignments	Mean = 0.003; 95th percentile = 0.127	Does not resolve targeted pilot selection
Panel C: required inference	Estimator or test	Output and claim status
Robust staggered DID	Sun-Abraham interaction-weighted event study; Callaway-Sant'Anna group-time ATT	No output from either estimator; neither is reported as completed
Policy-level inference	Jurisdiction clustering; firm-jurisdiction two-way clustering; wild-cluster bootstrap	No output; significance and p values unverified
Selection controls	Province trends and expanded region-year controls	No output; selection remains a limitation

5 Mechanisms and Heterogeneity

5.1 Mechanisms

In the archived output, Policy is associated with a 0.058 reduction in SA and a 0.187 increase in Monitor; both variables are associated with CDI in the expected directions. Adding SA and Monitor reduces the Policy coefficient from 0.421 to 0.382 and 0.365, respectively. These patterns are consistent with H2 and H3, but they neither establish causal mediation nor correct the staggered-treatment and clustering limitations. Table 5 reports the retained coefficients.

Table 5. Archived financing-constraint and capital-market-attention estimates.

Variable	(1) SA	(2) CDI	(3) Monitor	(4) CDI
Policy	-0.058*** (-3.42)	0.382*** (4.56)	0.187*** (3.89)	0.365*** (4.38)
SA		-0.672*** (-5.87)		

Variable	(1) SA	(2) CDI	(3) Monitor	(4) CDI
Monitor				0.298*** (6.12)
Controls	Yes	Yes	Yes	Yes
Firm/year FE	Yes	Yes	Yes	Yes
N	18,652	18,652	18,652	18,652
R-squared	0.386	0.445	0.412	0.452

5.2 Heterogeneity

Archived Policy estimates are 0.587 (t = 5.34; N = 7,823) for heavy polluters versus 0.213 (1.89; 10,829) otherwise, p = 0.012; 0.534 (5.12; 8,256) for state-owned firms versus 0.312 (2.78; 10,396) for private firms, p = 0.048; and 0.548 (4.78; 9,326) for high-constraint firms versus 0.289 (2.56; 9,326) for low-constraint firms, p = 0.038. All models include controls and firm/year fixed effects. These archived comparisons remain suggestive without policy-level or robust staggered-DID inference.

6 Discussion

The archived positive association is consistent with green-finance reform changing capital allocation and the information environment. The rising post-treatment sequence may reflect institutional learning and carbon-accounting investment, but missing pre-treatment estimates preclude a causal dynamic interpretation.

Subgroup differences suggest uniform implementation may be inefficient. Heavy polluters need continuous emissions and assurance reporting, while private and constrained firms may benefit from standardized accounting tools and suitable financial products.

Four limitations bind the evidence: CDI measures content rather than accuracy or mitigation; SA and analyst coverage are proxies; non-random selection and spillovers may violate counterfactual trends; and the panel, address crosswalk, coding record, and code are absent. Pre-trend, policy-clustered, wild-bootstrap, Sun-Abraham, Callaway-Sant'Anna, province-trend, and expanded-control results therefore cannot be verified as completed tests.

7 Conclusions and Implications

The archived analysis reports a 0.421-point association between pilot exposure and CDI and larger post-treatment points after year two. Mechanism and subgroup coefficients are directionally consistent with the hypotheses, but a reproducible rerun still requires the exact location protocol, complete event-time estimates, robust staggered DID, and policy-level inference.

Policy should integrate harmonized carbon accounting into project classification and credit monitoring, but archived magnitudes require unit-level reproduction before calibration.

Data Availability

Financial data are licensed CSMAR and reports are public. Missing CDI, address, panel, and code files prevent regeneration of Tables 2-5. No simulated or invented data or results are reported; Table 1 defines treatment reconstruction.

Disclosure of Interests

The authors declare no competing interests.

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