



Impact Mechanism of Data Element Market Construction on Green Innovation in High-Carbon Industries

Lin Sun* and Jun Zeng

Shandong Vocational and Technical University of International Studies, Rizhao, 276826, China

*Correspondence: Lin Sun; E-mail: linsun202511@gmail.com

Abstract. This paper investigates how the construction of data element markets—represented by the establishment of local data trading platforms and supporting institutional rules—shapes green innovation in high-carbon industries. Using a firm-level panel of China’s listed firms in high-carbon sectors from 2011 to 2023, the paper employs a multi-period difference-in-differences design with two-way fixed effects to identify the policy effect. Results indicate that data element market construction significantly raises green innovation, with dynamic effects that strengthen after platform establishment and no evidence of pre-trends. Mechanism tests reveal that the policy works by lowering data search and compliance costs, accelerating digital transformation, and improving access to green finance and risk pricing. Heterogeneity analyses show stronger effects among non-state-owned firms and in regions with stricter environmental regulation. A set of robustness checks—including alternative measurements, sample trimming, and randomized adoption placebos—supports the main findings. The paper provides actionable implications for building interoperable data trading infrastructures and aligning data governance with low-carbon industrial upgrading.

Keywords: data element market; data trading platform; high-carbon industries; green innovation; digital transformation; green finance; difference-in-differences

1 Introduction

Achieving carbon neutrality requires accelerating green innovation in carbon-intensive sectors such as steel, cement, chemicals, and power generation. These industries face hard-to-abate process emissions and capital lock-in, so sustained innovation in cleaner processes, energy efficiency, and low-carbon products is essential for reconciling environmental targets with productivity growth ^[1]. In parallel, data has been elevated to a key production factor, and many regions are actively building data element markets through data exchanges, standardized data products, and compliance governance. This institutional shift can matter for green innovation because it changes who can access high-quality operational, environmental, and supply-chain data—

© The Author(s) 2026

H. Li et al. (eds.), *Proceedings of the 2026 5th International Conference on Big Data Economy and Digital Management (BDEDM 2026)*, Advances in Economics, Business and Management Research 383,

https://doi.org/10.2991/978-94-6239-640-1_29

inputs increasingly needed for abatement technology development, carbon accounting, and green finance screening.

Yet, the green-innovation implications of data element market construction remain underexplored at the firm level, especially for high-carbon industries where information frictions and financing constraints are pronounced. Existing evidence is mostly at the city level or focuses on digital outcomes; it remains unclear whether data market institutions themselves generate additional green innovation beyond broader digitalization trends. Moreover, the mechanisms are not fully pinned down: data exchanges may (i) reduce search, verification, and compliance costs; (ii) accelerate firms' digital transformation and data-driven R&D; and (iii) strengthen carbon-risk pricing and access to green finance ^[2,3].

This study addresses these gaps by exploiting the staggered establishment of local data trading platforms as a quasi-natural experiment and estimating a multi-period difference-in-differences model with firm and year fixed effects. Recent econometric research cautions that conventional two-way fixed-effects event-study specifications can be biased in staggered-adoption settings when treatment effects are heterogeneous ^[4]; accordingly, we align our identification strategy and dynamic analyses with modern multi-period DiD frameworks. Using firm-level panel data (2011–2023), the paper contributes by (1) providing causal evidence on whether data element market construction boosts green innovation in high-carbon industries; (2) testing a mechanism chain that integrates digital transformation and green finance channels; (3) offering heterogeneity evidence across ownership types and regulatory contexts; and (4) translating findings into actionable recommendations for data governance and green industrial upgrading.

2 Literature Review and Hypotheses

Existing studies begin to document that the development of data element markets can stimulate green innovation at both city and firm levels. City-level evidence suggests that data factor market development can significantly enhance urban green innovation by reducing search and transaction costs and by improving the efficiency of factor matching ^[5]. Firm-level studies further indicate that data element market construction can promote green technology innovation through easing information asymmetry and improving factor matching ^[6].

Green innovation research further suggests that policy and market signals translate into cleaner technologies through firms' innovation responses. The Porter hypothesis argues that well-designed regulation can induce innovation offsets, and panel evidence shows environmental compliance pressures are associated with increased R&D and patenting in manufacturing. Induced innovation studies also document that energy price signals can redirect inventive activity toward energy-efficient technologies. These findings imply that the effect of data element market construction may be especially relevant for high-carbon industries because improved data availability and verification can strengthen the transmission of regulatory and price signals into firm-level green innovation.

Mechanism discussions increasingly emphasize digital transformation as a key channel linking data market institutions to green innovation. Evidence based on the establishment of local data trading platforms indicates that data element market construction significantly accelerates corporate digital transformation, which in turn helps firms upgrade technologies and practices that support greener innovation outcomes [7]. Related research also highlights that marketization of data elements improves innovation quality by facilitating a high-quality allocation of digital inputs [8].

In addition to being an outcome of data market policies, digital transformation is itself a documented driver of corporate green innovation. Firm-level evidence shows that digital transformation can increase both the quantity and quality of green patenting by improving information processing, reducing internal agency problems, and alleviating financing constraints [9]. From a capability perspective, data exchanges and standardized data products can lower the fixed costs of data acquisition and integration, accelerating adoption of analytics and industrial internet applications that support cleaner production and product redesign. This literature provides a stronger behavioral foundation for the mediating role posited in H2.

At the institutional level, a growing body of work analyzes the governance architecture of data trading platforms and data marketplaces. Prior studies propose that effective marketplace governance requires clear decision domains (e.g., access control, quality assurance, and compliance) and coordinated rules to support scalable, trustworthy transactions. In parallel, institutional analyses emphasize that market-oriented allocation of data elements hinges on innovations in data property rights and clarifying the bundle of rights and responsibilities among data producers, processors, and users [10]. Complementarily, research on data asset valuation and pricing shows that pricing mechanisms and market structure jointly shape transaction incentives and service levels, which are central to sustaining a healthy circulation of data assets [11].

Financial channels also matter for green innovation in heavy industries. Empirical evidence on the integration of digital inclusive finance and green finance indicates that data element market construction can improve financial resource allocation and strengthen green-oriented funding supply. At the firm level, digital transformation may enhance carbon resilience and improve growth performance among high-carbon-emission enterprises. In addition, studies on carbon pricing mechanisms under the “dual-carbon” constraints underscore that carbon price signals and policy mixes affect firms’ innovation incentives and abatement decisions .

Methodologically, estimating the policy effect of data trading platforms requires careful handling of staggered policy adoption. Recent econometric work shows that two-way fixed-effects estimators in staggered difference-in-differences settings can be interpreted as weighted averages of multiple 2×2 comparisons and may yield misleading dynamics when treatment effects are heterogeneous. To strengthen identification, we employ a multi-period DiD framework and dynamic analyses consistent with modern estimators for staggered adoption designs. Under the parallel-trends assumption, this approach allows us to interpret estimated post-treatment changes in green innovation as causal effects of data element market construction.

Based on the above literature, the following hypotheses are proposed:

H1: Data element market construction significantly increases green innovation in high-carbon industries.

H2: Digital transformation mediates the relationship between data element market construction and green innovation.

H3: Green finance access and risk pricing mediate the relationship between data element market construction and green innovation.

H4: The positive effect is stronger among non-state-owned firms and in regions with stricter environmental regulation.

3 Data and Methodology

The empirical analysis is based on a firm-level panel of China's A-share listed companies in high-carbon industries from 2011 to 2023. High-carbon industries are identified using industry classifications that cover energy production and major carbon-intensive manufacturing, such as power generation, steel, cement, coal, and petrochemicals. Green innovation is measured using green patent applications matched by green technology classification codes, aggregated at the firm-year level. The key explanatory variable captures the construction of local data element markets and equals one for firms located in provinces after the establishment of a local data trading platform and related institutional arrangements. Firm-level financial and governance controls are obtained from standard financial databases. All continuous variables are winsorized at the 1% and 99% levels.

Table 1. Variable definitions and measurement.

Symbol	Variable	Definition	Data source
Green-Innov	Green innovation output	$\ln(1 + \text{number of green invention patent applications})$	CNIPA green patent match
DataMarket	Data element market construction	1 if province has established a data trading platform and supporting rules by year t	Provincial platform records
Digital-Trans	Digital transformation	Text-based digital transformation index or digital investment intensity	Annual reports; digital keywords
Green-Finance	Green finance access	Composite index of green credit and financing constraints	Financial statements; green credit
Size	Firm size	Natural log of total assets	Financial database
Leverage	Leverage ratio	Total liabilities / total assets	Financial database
ROA	Profitability	Net profit / total assets	Financial database
Age	Firm age	Years since listing	Exchange records

Table 1 summarizes the definitions, measurements, and data sources of the key variables used in the empirical analysis.

3.1 Baseline Model

The baseline specification adopts a multi-period difference-in-differences model with firm and year fixed effects:

$$GreenInnov_{\{i,t\}} = \alpha + \beta \cdot DataMarket_{\{p,t\}} + \gamma'X_{\{i,t\}} + \mu_i + \lambda_t + \varepsilon_{\{i,t\}} \quad (1)$$

In the equation, i denotes firm, p denotes province, and t denotes year. $X_{\{i,t\}}$ is a vector of firm controls, μ_i captures time-invariant firm heterogeneity, and λ_t captures common shocks.

3.2 Dynamic Effects and Parallel Trends

To verify parallel trends and inspect dynamic impacts, an event-study specification is estimated by replacing $DataMarket_{\{p,t\}}$ with a set of event-time indicators:

$$GreenInnov_{\{i,t\}} = \alpha + \sum_{\{k \neq -1\}} \delta_k \cdot 1[EventTime = k] + \gamma'X_{\{i,t\}} + \mu_i + \lambda_t + \varepsilon_{\{i,t\}} \quad (2)$$

3.3 Mechanism Tests

Mechanism tests employ mediation-style regressions where DigitalTrans and GreenFinance serve as intermediate variables:

$$Mediator_{\{i,t\}} = \alpha + \theta \cdot DataMarket_{\{p,t\}} + \rho'X_{\{i,t\}} + \mu_i + \lambda_t + \nu_{\{i,t\}} \quad (3)$$

$$GreenInnov_{\{i,t\}} = \alpha + \beta \cdot DataMarket_{\{p,t\}} + \pi \cdot Mediator_{\{i,t\}} + \gamma'X_{\{i,t\}} + \mu_i + \lambda_t + \varepsilon_{\{i,t\}} \quad (4)$$

4 Empirical Results

Descriptive statistics are reported in Table 2; baseline regression results are presented in Table 3, and dynamic policy effects are plotted in Fig. 1.

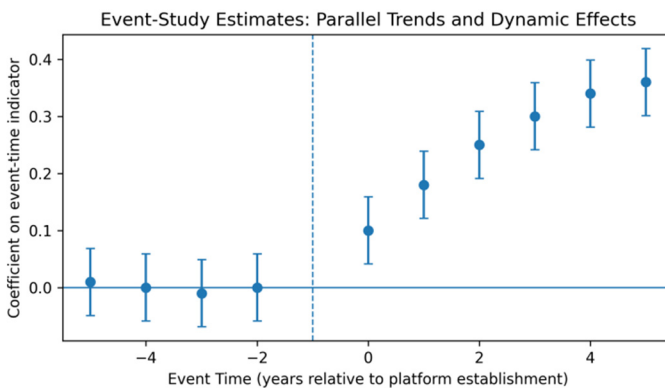
Table 2. Descriptive statistics.

Variable	Mean	Std. Dev.	Min	Max
GreenInnov	-0.304	0.636	-2.774	1.790
DataMarket	0.447	0.497	0.000	1.000
DigitalTrans	0.233	0.442	-1.382	1.882
GreenFinance	0.121	0.328	-0.937	1.347
Size	22.215	1.010	18.723	26.262
Leverage	0.450	0.148	0.050	0.950
ROA	0.050	0.040	-0.095	0.186
Age	22.101	10.130	5.000	39.000

Table 3. Baseline effect of data element market construction on green innovation.

Variable	Model (1)
DataMarket	0.286*** (0.025)
Size	0.041*** (0.007)
Leverage	-0.081* (0.049)
ROA	0.334* (0.178)
Age	-0.000 (0.001)
Firm FE	Yes
Year FE	Yes
Observations	7800
Adj. R2	0.021

Table 3 reports the baseline estimates. The coefficient on DataMarket is positive and statistically significant at the 1% level, indicating that platform establishment and institutional construction of data element markets increase green innovation in high-carbon industries after controlling for firm characteristics and two-way fixed effects. In magnitude, the estimated effect corresponds to a meaningful increase in green patent output, consistent with the view that data circulation lowers innovation frictions.

**Fig. 1.** Event-study estimates of dynamic policy effects (95% confidence intervals).

As shown in Fig. 1, the pre-policy coefficients are close to zero, supporting the parallel trends assumption. Post-establishment effects become positive and grow over time, suggesting that the benefits of data element market construction materialize gradually as platforms mature and complementary governance rules take effect.

Table 4. Mechanism tests: digital transformation and green finance channels.

Variable	Model (2): Digital- Trans	Model (3): Green- Finance	Model (4): Green- Innov
DataMarket	0.295*** (0.018)	0.237*** (0.013)	0.232*** (0.026)
DigitalTrans	—	—	0.123*** (0.018)
GreenFinance	—	—	0.073*** (0.023)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	7800	7800	7800
Adj. R2	0.038	0.045	0.028

Table 4 supports the proposed mechanisms. Data element market construction significantly increases the digital transformation index and improves green finance access. When both mediators enter the outcome regression, the direct effect of DataMarket attenuates while both mediators remain positive and significant, consistent with partial mediation.

4.1 Heterogeneity Analyses

Table 5. Heterogeneity results (key coefficient on DataMarket).

Group	Coef. on DataMarket	Obs.
SOEs	0.250*** (0.045)	2717
Non-SOEs	0.302*** (0.031)	5083
High EnvReg	0.324*** (0.031)	3900
Low EnvReg	0.276*** (0.033)	3900

As shown in Table 5, the policy effect is stronger among non-state-owned enterprises, consistent with higher sensitivity to information frictions and financing constraints. Moreover, regions with stricter environmental regulation exhibit larger innovation responses, suggesting complementarity between data market institutions and regulatory pressure.

4.2 Robustness Checks

Table 6. Robustness checks.

Specification	Key coef.	Obs.
Baseline (FE)	0.286*** (0.025)	7800
Winsorized GI (1-99%)	0.281*** (0.025)	7800
Exclude 2020-2023	0.276*** (0.029)	5400
Continuous DEM index	0.321*** (0.029)	7800
Randomized adoption (placebo)	0.034 (0.027)	7800

Table 6 summarizes the robustness checks. The estimated effect remains stable under winsorization, sample exclusions, and alternative measurements of data market construction. A randomized adoption placebo yields an insignificant coefficient, reducing concern that the results are driven by spurious time patterns.

5 Discussion and Policy Implications

The results suggest that data element market construction can function as a cross-cutting institutional lever that complements conventional environmental regulation by improving the information infrastructure needed for green innovation in carbon-intensive industries. Consistent with the mechanism tests, data trading platforms appear to reduce data search and verification costs, accelerate digital transformation, and strengthen green-oriented financial allocation. In high-carbon sectors—where emissions monitoring, process optimization, and supply-chain coordination are particularly data-intensive—these channels help explain why the estimated effect is economically meaningful and more pronounced for firms facing tighter regulatory constraints and stronger innovation incentives.

Policy implications can be made more actionable by tailoring recommendations to specific stakeholders: (1) Government bodies and regulators should (a) prioritize interoperable standards for data product definition, metadata, and audit-ready compliance; (b) harmonize data-rights rules with environmental MRV and carbon accounting standards so that carbon-related datasets can be legally shared and verified; and (c) use targeted incentives to encourage participation by high-carbon firms with high abatement potential. (2) Data exchanges and platform operators should (a) develop sector-specific “green data product” catalogs, (b) provide secure sandboxes and privacy-preserving computation services to lower compliance barriers, and (c) publish transparent pricing and quality-assurance protocols to build trust. (3) Private firms—especially in heavy industry—should strengthen internal data governance (data ownership mapping, quality control, and security) and integrate platform datasets into digital transformation roadmaps for cleaner production and green R&D; firms can also form data-sharing alliances with suppliers to unlock supply-chain emissions reductions. (4) Financial institutions should embed platform-verified datasets into ESG and carbon-risk models, expand green credit and supply-chain finance products linked to measurable emissions performance, and use transaction histories to reduce adverse selection in green lending. (5) Research institutions should work with exchanges and regulators to develop open (or controlled-access) benchmark datasets, evaluation metrics, and causal evidence on which data products and governance designs most effectively translate into green innovation.

Finally, the study is primarily quantitative and relies on policy shocks and administrative records. A natural next step is to incorporate primary qualitative data—such as semi-structured interviews with platform operators, compliance officers, and R&D managers in high-carbon firms—to validate mechanism micro-foundations. Future mixed-method designs can also help uncover implementation bottlenecks, such as

data quality heterogeneity and cross-platform fragmentation, thereby improving the external validity and practical guidance of data factor market policies.

6 Conclusion

This paper examines the impact mechanism of data element market construction on green innovation in high-carbon industries using firm-level panel evidence from 2011 to 2023. Multi-period difference-in-differences estimates show a statistically and economically significant increase in green innovation after the establishment of local data trading platforms. Dynamic analysis indicates no pre-trends and growing post-policy effects. Mechanism tests highlight the roles of digital transformation and green finance, while heterogeneity analyses underscore complementarity with environmental regulation and stronger effects among non-state-owned firms. The results support the view that well-governed data factor markets can contribute to decarbonization by reducing innovation frictions and improving the allocation of digital and financial resources.

References

1. Porter, M. E., & van der Linde, C. (1995). Toward a new conception of the environment–competitiveness relationship. *Journal of Economic Perspectives*, 9(4), 97–118. <https://doi.org/10.1257/jep.9.4.97>
2. Wang, D., Huang, J., Zhang, X., & Wang, H. (2023). Is China's carbon trading market an effective way to reduce regional emissions? Evidence from a quasi-natural experiment. *Environmental Science and Pollution Research*, 30, 101651–101670. <https://doi.org/10.1007/s11356-023-26088-5>
3. Nie, J., & Yang, Y. (2023). Carbon and financial risks: The role of green innovation. *Journal of Environmental Management*, 330, 117165. <https://doi.org/10.1016/j.jenvman.2023.117165>
4. Sun, L., & Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, 225(2), 175–199. <https://doi.org/10.1016/j.jeconom.2020.09.006>
5. Liu, Y. (2023). Data element market empowering urban green innovation: Evidence from Chinese cities. *Guizhou Social Sciences*, (1), 124–133. <https://doi.org/10.13713/j.cnki.cssci.2023.01.018>
6. Liu, L., & Yang, Y. (2025). Data element market construction and corporate green technology innovation. *Commercial Research*, (2), 33–41. <https://doi.org/10.13902/j.cnki.syyj.2025.02.010>
7. Jiang, H., Chen, Q., & Sun, M. (2025). Data element market construction and corporate digital transformation: Evidence from the establishment of local data trading platforms. *Journal of Xi'an Jiaotong University (Social Sciences)*, 45(5), 41–50. <https://doi.org/10.15896/j.xjtuskxb.202505004>
8. Pang, R., & Wang, H. (2024). Data marketization and high-quality innovation. *Scintometrics*, 129(7), 4651–4684. <https://doi.org/10.1007/s12525-023-00631-w>

9. Bai, X. (2025). Carbon resilience, digital transformation, and high-carbon enterprises' growth performance: U-shaped impact, mechanism, and heterogeneity. *Technology Economics*, 44(10), 136–152. <https://doi.org/10.12404/j.issn.1002-980X.J25032409>
10. Wang, Y. (2025). Market-oriented allocation of data elements: Institutional innovation in data property rights. *Journal of Northeastern University (Social Science Edition)*, 27(6), 1–5. <https://doi.org/10.15936/j.cnki.1008-3758.2025.06.001>
11. Li, J., He, X., & Jiang, H. (2025). Carbon pricing mechanism, supply chain optimization, and firm green innovation. *International Review of Economics & Finance*, 95, 104043. <https://doi.org/10.1016/j.iref.2025.104043>

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

