

Digital gold mine: how data assets unlock green innovation potential in the textile industry

DOI: 10.35530/IT.077.01.202550

CAIHUA ZHANG
KUNJIAN ZHAO

XUE LEI

ABSTRACT – REZUMAT

Digital gold mine: how data assets unlock green innovation potential in the textile industry

The textile industry faces increasing dual pressures of digital transformation and environmental compliance due to its traditionally resource-intensive and pollution-heavy operations. Simultaneously, textile manufacturers struggle with accessing sufficient capital for green technology investments despite urgent sustainability imperatives. This study examines how data asset capitalisation drives green innovation through alleviating financing constraints. Analysing Chinese textile listed firms (2013–2023), we find that data-rich companies achieve significantly greater environmental innovation performance. Our text-based measure of data assets reveals they function as quality signals to capital markets, reducing information asymmetry and easing resource constraints for green investments. This effect is amplified by analyst coverage and becomes more pronounced under environmental uncertainty and regulatory pressure. The temporal analysis shows an inverted U-shaped pattern with peak influence occurring two years after data asset development, suggesting an incubation period for capability building. Using geographic distance to data trading centres as an instrumental variable confirms the causal relationship. The findings highlight a critical pathway through which digital transformation catalyses sustainable development in the textile industry, bridging information economics and environmental innovation literature. Our research provides practical implications for textile manufacturers seeking to leverage digital capabilities for environmental competitiveness and for policymakers designing incentives at the intersection of digital and green development.

Keywords: data asset capitalisation, green innovation, financing constraints, information asymmetry, environmental policy, textile industry

Mina de aur digitală: modalitatea prin care activele de date deblochează potențialul de inovare ecologică în industria textilă

Industria textilă se confruntă cu presiuni duble din ce în ce mai mari din partea transformării digitale și a conformității cu normele de mediu, datorită operațiunilor sale tradiționale, care consumă multe resurse și poluează intens. În același timp, producătorii din domeniul textil se luptă să acceseze capital suficient pentru investiții în tehnologii ecologice, în ciuda imperativelor urgente de sustenabilitate. Acest studiu examinează modul în care capitalizarea activelor de date stimulează inovarea ecologică prin atenuarea constrângerilor financiare. Analizând firmele textile chineze cotate la bursă (2013–2023), constatăm că firmele bogate în date obțin performanțe semnificativ mai bune în materie de inovare ecologică. Măsurarea bazată pe text a activelor de date relevă faptul că acestea funcționează ca semnale de calitate pentru piețele de capital, reducând asimetria informațională și atenuând constrângerile de resurse pentru investițiile ecologice. Acest efect este amplificat de acoperirea analiștilor și devine mai pronunțat în condiții de incertitudine ecologică și presiune reglementară. Analiza temporală arată un model inversat în formă de U, cu o influență maximă care apare la doi ani după dezvoltarea activelor de date, sugerând o perioadă de incubație pentru consolidarea capacităților. Utilizarea distanței geografice față de centrele de tranzacționare a datelor ca variabilă instrumentală confirmă relația cauzală. Concluziile evidențiază o cale critică prin care transformarea digitală catalizează dezvoltarea durabilă în industria textilă, făcând legătura între economia informației și literatura de specialitate privind inovarea în domeniul mediului. Cercetarea noastră oferă implicații practice pentru producătorii din industria textilă care doresc să valorifice capacitățile digitale pentru a-și spori competitivitatea în materie de mediu, precum și pentru factorii de decizie care elaborează stimulente la intersecția dintre dezvoltarea digitală și cea ecologică.

Cuvinte-cheie: capitalizarea activelor de date, inovare ecologică, constrângeri financiare, asimetrie informațională, politică de mediu, industria textilă

INTRODUCTION

In the dual transition toward digital economy and sustainability, textile firms increasingly face the imperative to transform both their data management practices and environmental performance [1, 2]. The textile industry, as one of China's traditional manufacturing

pillars, faces particularly acute challenges due to its resource-intensive processes and significant environmental footprint. While digital transformation and sustainable development have traditionally been studied as separate domains [3, 4], their potential synergies remain largely unexplored, especially in

traditionally pollution-intensive sectors like textile manufacturing.

Data assets, digitised information resources that can be leveraged for organisational value creation, have emerged as critical strategic resources in the information age [5]. For textile manufacturers, these data assets encompass production parameters, supply chain information, energy consumption metrics, and customer preference data that can drive process optimisation and product innovation. Simultaneously, green innovation has become essential for textile firms responding to mounting environmental challenges and stringent industry-specific regulatory pressures [6]. The textile sector faces particularly rigorous environmental scrutiny due to issues such as high water consumption, chemical usage, and waste generation. However, the mechanisms linking these two strategic priorities remain underexamined despite their growing importance to contemporary textile industry strategy.

Green innovation in textile manufacturing, characterised by the development of environmentally beneficial technologies and processes such as waterless dyeing, recycled fibre processing, and energy-efficient weaving, typically requires substantial upfront investments with uncertain and distant returns [7, 8]. This distinctive innovation profile creates significant financing hurdles, particularly in emerging economies where capital market frictions are pronounced. Financing constraints have been consistently identified as a critical barrier to green innovation adoption in the textile sector [9, 10], with firms often struggling to secure adequate capital for environmentally oriented projects due to information asymmetries between firms and capital providers regarding the value and potential of such innovations.

Recent literature suggests that corporate digitisation initiatives may improve firms' ability to access external financing through enhanced information disclosure and reduced information asymmetry [11, 12]. Building on this insight, we theorise that data asset capitalisation, the process of transforming raw data into structured, analyzable resources with recognised economic value, may facilitate green innovation in textile firms by alleviating financing constraints. This potential mechanism is particularly relevant in the Chinese textile industry context, where capital market frictions are significant and government-driven environmental policies are creating urgent imperatives for green transformation across the textile value chain [13, 14].

Despite the theoretical importance of understanding how digital resources might enable sustainable innovation in the textile industry, several research gaps persist. First, empirical evidence on the direct relationship between data assets and green innovation outcomes remains scarce, particularly in traditional manufacturing sectors like textiles. Second, the transmission mechanisms through which data assets might influence green innovation have received limited attention, particularly from the perspective of financing accessibility in capital-intensive industries.

Third, contingency factors that may moderate these relationships have not been systematically examined in the context of pollution-intensive sectors undergoing digital transformation.

To address these gaps, we investigate three interrelated research questions: (1) Does data asset capitalisation enhance textile firms' green innovation performance? (2) Do financing constraints serve as a transmitting mechanism in this relationship? (3) How do analyst coverage, environmental uncertainty, and policy pressure condition these relationships in the textile industry? By addressing these questions, we integrate insights from resource-based theory, information asymmetry theory, and contingency theory to develop a comprehensive understanding of the data-sustainability nexus in textile manufacturing.

We examine these questions using a sample of Chinese textile listed firms from 2013 to 2023, employing an innovative text analysis methodology to measure data asset capitalisation through semantic analysis of corporate disclosures. Our empirical strategy includes baseline regressions, instrumental variable analysis, and cross-sectional comparisons to establish robust causal inferences about the relationships.

This study offers several contributions to the literature. First, we establish an empirical link between data asset capitalisation and green innovation in the textile industry, bridging previously separate research streams on digital transformation and corporate sustainability in traditional manufacturing. Second, we uncover financing constraints as a key mechanism through which data assets facilitate green innovation in textile firms, extending existing work on the financing of environmental technologies. Third, we demonstrate the contextual nature of these relationships by identifying important boundary conditions specific to the textile sector. Finally, from a practical perspective, our findings provide actionable insights for textile manufacturers seeking to leverage their digital transformation initiatives to support sustainability goals, as well as for policymakers designing incentives at the intersection of digital and green development in traditionally pollution-intensive industries.

RESEARCH DESIGN

Variable measurement

Our study examines the relationship between data asset capitalisation and green innovation. Green innovation, our dependent variable, is primarily measured through Green Patent Intensity (GPI) – the ratio of granted green invention patents to total patents granted. For robustness checks, we employ Green R&D Investment (GRI), calculated as green R&D expenditure relative to total R&D expenditure. The focal explanatory variable, Data Asset Capitalisation (DA), is measured using text analysis methodology. We develop a comprehensive lexicon based on data asset regulations, using “information”, “network”, “digital”, and “data” as seed words. Through Word2Vec neural network modelling and

deep learning techniques, we construct a corpus of semantically similar terms and quantify their frequency in corporate annual reports to assess companies' data asset capitalisation levels.

We examine financing constraints (FC) as a transmission mechanism between data asset capitalisation and green innovation, with higher FC values indicating more severe financing limitations. Analyst coverage (AC), measured as the natural logarithm of analysts following a firm, captures external information intermediation and transparency levels. Our framework further incorporates environmental uncertainty (EU, measured via five-year rolling coefficient of variation in quarterly industry sales) and environmental policy pressure (EP, measured through environmental terminology frequency in municipal government work reports) to examine contextual contingencies.

Data sources and model setup

Our sample comprises Chinese textile listed firms from 2013 to 2023. Data sources include the Wind database, CSMAR database, corporate annual reports, the China National Intellectual Property Administration patent database, and municipal government work reports. We specify the following baseline regression model:

$$GPI_{i,t} = \alpha + \beta_1 DA_{i,t} + \gamma Controls_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where $GPI_{i,t}$ represents green innovation intensity, $DA_{i,t}$ denotes data asset capitalisation degree, and $Controls_{i,t}$ encompasses a vector of control variables detailed in table 1.

CONTROL VARIABLES DEFINITIONS AND CALCULATIONS	
Variable	Definition and calculation method
Size	Natural logarithm of total assets
ROA	Net profit/Total assets
Growth	Revenue growth rate
RD	R&D expenditure/Revenue
CFO	Net operating cash flow/Total assets

RESULTS

Baseline model results

Our empirical analysis begins with examining the relationship between data asset capitalisation and green innovation. Table 2 presents the baseline regression results with two model specifications. In column (1), without control variables, data asset capitalisation (DA) exhibits a positive and statistically significant coefficient ($\beta = 0.092$, $p < 0.05$), suggesting that firms with higher levels of data asset capitalisation tend to demonstrate greater green innovation intensity. This relationship persists in column (2) after introducing our comprehensive set of control variables, where the coefficient remains positive and significant

($\beta = 0.081$, $p < 0.05$), albeit slightly attenuated. This attenuation suggests that firm characteristics partially explain the relationship, yet the independent effect of data asset capitalisation remains robust.

BASELINE RESULTS		
Variables	(1)	(2)
	GPI	GPI
DA	0.092** (2.54)	0.081** (2.24)
Size	-	0.043*** (3.12)
ROA	-	0.067* (1.86)
Growth	-	0.025 (1.34)
RD	-	0.139*** (3.56)
CFO	-	0.052* (1.77)
Constant	0.208*** (4.65)	0.187*** (4.29)
Industry FE	Yes	Yes
Year FE	Yes	Yes
Observations	4327	4327
R-squared	0.159	0.217

Note: T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Robustness tests

To verify the stability of our findings, we conducted several robustness tests as reported in table 3. When employing green R&D investment ratio (GRI) as an alternative dependent variable in column (1), we observe a positive coefficient ($\beta = 0.074$) that remains statistically significant, albeit at a lower confidence level ($p < 0.1$). This suggests that data asset capitalisation influences not only patent-based outcomes but also firms' strategic allocation of research resources toward environmental sustainability. Column (2) implements firm fixed effects to control for time-invariant unobservable firm characteristics, and the effect persists ($\beta = 0.072$, $p < 0.1$), though with slightly reduced magnitude and significance. This finding indicates that while stable firm-specific factors contribute to the relationship, they do not fully account for the observed association between data asset capitalisation and green innovation. Column (3) reveals particularly interesting temporal dynamics in the relationship between data asset capitalisation and green innovation. The impact of data asset capitalisation intensifies over time, with coefficients increasing from 0.081 ($p < 0.05$) for contemporaneous effects to 0.093 ($p < 0.05$) for one-year lags and reaching a peak of 0.107 ($p < 0.05$) for two-year lags, before declining to 0.076 ($p < 0.1$) for

three-year lags. This inverted U-shaped pattern indicates that data assets require an incubation period to fully manifest their benefits for green innovation. Initially, firms may need time to develop capabilities for leveraging data assets effectively, reaching peak efficiency around the two-year mark, after which the marginal returns begin to diminish. This finding aligns with organisational learning perspectives that suggest firms experience a period of capability development before realising maximum returns on digital investments.

Table 3

ROBUSTNESS TESTS			
Variables	(1)	(2)	(3)
	GRI	GPI	Temporal dynamics
DA	0.074*	0.072*	0.081**
	(1.89)	(1.95)	(2.24)
DA (t-1)	-	-	0.093**
	-	-	(2.27)
DA (t-2)	-	-	0.107**
	-	-	(2.41)
DA (t-3)	-	-	0.076*
	-	-	(1.84)
Controls	Yes	Yes	Yes
Industry FE	Yes	No	Yes
Year FE	Yes	Yes	Yes
Firm FE	No	Yes	No
Observations	4327	4327	3269
R-squared	0.198	0.247	0.237

Table 4 addresses potential endogeneity concerns through an instrumental variable approach. Using geographic distance to the nearest major data trading centre (DIST) as an instrument, we find that proximity to digital clusters significantly influences data asset development (first-stage coefficient = -0.193 , $p < 0.01$). The instrument demonstrates adequate strength with a first-stage F-statistic of 17.83, exceeding the conventional threshold of 10. In the second stage, the instrumented data asset capitalisation variable maintains a significant positive effect on green innovation ($\beta = 0.093$, $p < 0.05$), providing greater confidence in the causal nature of the relationship. This instrumental variable analysis suggests that our findings are unlikely to be driven by reverse causality or omitted variables, lending credibility to our proposed directional influence from data asset capitalisation to green innovation.

Mechanism analysis

To deepen our understanding of how data asset capitalisation promotes green innovation, we explored potential pathways through which this relationship operates, as presented in table 5. Column (1) reveals that data asset capitalisation is associated with reduced financing constraints ($\beta = -0.128$, $p < 0.05$),

Table 4

INSTRUMENTAL VARIABLE ANALYSIS		
Variables	First Stage	Second Stage
	DA	GPI
DIST	-0.193***	-
	(-4.22)	-
DA (Instrumented)	-	0.093**
	-	(2.07)
Controls	Yes	Yes
Industry FE	Yes	Yes
Year FE	Yes	Yes
Observations	4327	4327
R-squared	0.236	0.209
First-stage F-statistic	17.83	-

suggesting that firms with greater data assets encounter fewer obstacles in accessing capital. This finding aligns with the view that data assets serve as informational signals that reduce information asymmetry between firms and capital providers. In column (2), when both data asset capitalisation and financing constraints are included in the green innovation model, the direct effect of data asset capitalisation diminishes in magnitude and significance ($\beta = 0.063$, $p < 0.1$), while financing constraints exhibit a strong negative effect on green innovation ($\beta = -0.141$, $p < 0.01$). This pattern suggests that financing accessibility represents a critical pathway through which data asset capitalisation facilitates green innovation. Financial resources unlocked through reduced capital constraints appear to enable firms to undertake environmentally beneficial projects that might otherwise remain unfunded due to their typically longer payback periods and higher uncertainty. Column (3) examines how analyst coverage (AC) moderates the relationship between data asset capitalisation and green innovation. The results show that

Table 5

MECHANISM ANALYSIS			
Variables	(1)	(2)	(3)
	FC	GPI	GPI
DA	-0.128**	0.063*	0.061*
	(-2.56)	(1.74)	(1.68)
FC	-	-0.141***	-
	-	(-2.89)	-
AC	-	-	0.089**
	-	-	(2.27)
AC × DA	-	-	0.096**
	-	-	(2.31)
Controls	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4327	4327	4327
R-squared	0.251	0.253	0.264

CROSS-SECTION ANALYSIS				
Variables	Low EU	High EU	Low EP	High EP
DA	0.053	0.104**	0.058*	0.112**
(1.64)	(2.28)	(1.69)	(2.35)	
Controls	Yes	Yes	Yes	Yes
Industry & Year FE	Yes	Yes	Yes	Yes
R-squared	0.201	0.237	0.198	0.228
Difference Test	p=0.042**		p=0.049**	

analyst coverage itself has a positive and significant effect on green innovation, indicating that firms followed by more analysts tend to engage in greater green innovation activities. More importantly, the interaction term between data asset capitalisation and analyst coverage displays a significant positive coefficient, suggesting that the positive effect of data asset capitalisation on green innovation is amplified when firms receive greater analyst attention. This finding supports the notion that external information intermediaries enhance the market recognition and valuation of firms' data assets, thereby strengthening the relationship between data assets and green innovation outcomes. For firms operating with high visibility in capital markets, data assets appear to yield greater green innovation benefits, possibly because analyst scrutiny helps validate the quality and potential of these digital resources, facilitating their effective deployment toward environmentally beneficial innovations.

Cross-section analysis

Table 6 presents our cross-sectional analysis exploring how environmental conditions moderate the relationship between data asset capitalisation and green innovation. The results reveal meaningful heterogeneity across different levels of environmental uncertainty (EU) and environmental policy pressure (EP). In low environmental uncertainty contexts, the coefficient for data asset capitalisation ($\beta = 0.053$) is positive but not statistically significant, whereas in high uncertainty environments, the effect becomes substantially stronger and statistically significant ($\beta = 0.104$, $p < 0.05$). The difference between these coefficients is statistically significant ($p = 0.042$), suggesting that the benefits of data asset capitalisation for green innovation are amplified under conditions of greater environmental volatility. This finding aligns with the perspective that data assets provide particularly valuable decision support in turbulent business environments, where real-time insights and predictive capabilities become critical advantages for navigating uncertainty.

Similarly, the influence of data asset capitalisation appears contingent on environmental policy pressure. In regions with low policy pressure, data asset capitalisation shows a modest association with green innovation ($\beta = 0.058$, $p < 0.1$), but this effect nearly doubles in magnitude in high-pressure regions

($\beta = 0.112$, $p < 0.05$), with the difference being statistically significant ($p = 0.049$). This suggests that data asset capitalisation becomes especially valuable for green innovation when firms face stronger environmental regulatory requirements. When policy mandates create imperatives for environmental performance, firms with sophisticated data capabilities appear better positioned to respond effectively through accelerated green innovation activities. This interaction between internal data capabilities and external policy pressures highlights the contextual nature of digital resources' value for sustainability initiatives.

CONCLUSION

This study advances our understanding of how digital transformation, specifically through data asset capitalisation, contributes to Chinese textile listed companies' environmental sustainability efforts by facilitating green innovation. Our findings reveal that data asset capitalisation has both direct effects on green innovation and indirect effects through alleviating financing constraints in the textile industry, with these relationships being contingent upon environmental uncertainty and policy pressures. The temporal dynamics observed suggest that textile manufacturers experience an incubation period of approximately two years before fully realising the environmental benefits of their data assets, indicating the need for sustained investment in digital capabilities.

These findings illuminate a critical pathway through which traditional manufacturing industries can navigate the dual challenges of digital transformation and environmental compliance. For textile manufacturers, the results suggest that investing in comprehensive data systems capturing production efficiency, resource consumption, and waste management metrics serves dual purposes: signalling technological sophistication to capital providers while building the analytical foundation for environmental improvements. The two-year incubation period we identify underscores the importance of patience and persistence in digital capability building, particularly given the textile industry's traditionally conservative approach to technology adoption. Policymakers can leverage these insights by designing incentive structures that recognise data asset development as a precursor to environmental innovation, while investors should view data asset capitalisation as an early indicator of firms' capacity for sustainable transformation in pollution-intensive sectors.

LIMITATIONS AND FUTURE RESEARCH

Several limitations constrain our findings' generalizability and suggest avenues for future research. Our single-country focus on Chinese textile listed firms limits applicability to other institutional contexts, while our text-based measurement of data assets may not capture tacit knowledge or informal data practices that contribute to green innovation capabilities. Despite employing instrumental variables, unobserved heterogeneity affecting both data asset development and environmental innovation outcomes cannot be eliminated. Future research should explore cross-country comparative studies examining institutional moderators, firm-level case studies investigating organizational processes beyond financing constraints, differential effects of various data asset

types (production process, supply chain, consumer behaviour data) on green innovation dimensions, and longitudinal studies tracking digital maturity stages to deepen understanding of temporal dynamics in data-driven environmental transformation.

ACKNOWLEDGMENTS

This research was funded by Guangzhou Xinhua University within the framework of the University-level Scientific Research Project with project no. 2025KYYBSK10, supported by the Characteristic Innovation Project of General Higher Education Institutions in Guangdong Province with project no. 2023WTSCX154, and also backed by the 2016 Guangdong Province Key Discipline Construction Project in Public Administration (2020STSZD01) as well as the Guangdong Province Key Discipline Research Capacity Enhancement Project (2021ZDJS141, 2022ZDJS151).

REFERENCES

- [1] Jin, X., Lei, X., Wu, W., *Can digital investment improve corporate environmental performance? Empirical evidence from China*, In: Journal of Cleaner Production, 2023, 414
- [2] Guo, G., Lin, O., Li, Y., et al., *Corporate carbon emission governance: The mediating role of financial leverage*, In: International Review of Economics & Finance, 2024, 96, 103734
- [3] Zhang, X., Liu, Y., Yu, S., et al., *Impact of environmental protection tax on enterprise digital transformation: Evidence from Chinese listed firms*, In: International Review of Economics & Finance, 2025, 97, 103743
- [4] Lei, X., Lin, O., Lin, J., *Evolutionary game analysis of enterprises' green production behaviour in the context of China's economic green transformation*, In: Global Nest Journal, 2024, 26, 3
- [5] Amit, R., Han, X., *Value creation through novel resource configurations in a digitally enabled world*, In: Strategic Entrepreneurship Journal, 2017, 11, 3, 228–242
- [6] Wang, Z., Feng, Y., Yao, N., et al., *Impact of policy interventions on low-carbon technology innovation diffusion in supply networks*, In: Managerial and Decision Economics, 2024, 45, 7, 5040–5053
- [7] Lei, X., Xu, X., *The "Spider Web" of Venture Capital: An Invisible Force Driving Corporate Green Technology Innovation*, In: Technology in Society, 2025, 82, 03, 102882
- [8] Quan, S., Cheng, P., Zhai, J., *Do climate risks impede green innovation?*, In: International Review of Financial Analysis, 2025, 104, 104295
- [9] Yu, C.-H., Wu, X., Zhang, D., et al., *Demand for green finance: Resolving financing constraints on green innovation in China*, In: Energy Policy, 2021, 153, 112255
- [10] Li, Y., Chu, E., Nie, S., et al., *Fintech, financing constraints and corporate green innovation*, In: International Review of Financial Analysis, 2024, 96, 103650
- [11] Zhao, Y., Liu, R., Xue, J., et al., *Environmental protection tax law and corporate financial fraud: Evidence from listed firms in China*, In: International Review of Financial Analysis, 2024, 96, 103537
- [12] Hu, S., Chen, P., Zhang, C., *How does green finance reform affect corporate ESG greenwashing behavior?*, In: International Review of Financial Analysis, 2025, 102, 104037
- [13] Duan, K., Qin, C., Ma, S., et al., *Impact of ESG disclosure on corporate sustainability*, In: Finance Research Letters, 2025, 78, 107134
- [14] Jin, X., Lei, X., *The Impact of China's New Environmental Law on the Financial Performance of Heavy Polluting Enterprises*, In: Polish Journal of Environmental Studies, 2024, 33, 4

Authors:

CAIHUA ZHANG¹, KUNJIAN ZHAO², XUE LEI³

¹Guangzhou Xinhua University, School of Economics and Trade,
Postal address: 19 Huamei Road, Tianhe District, 510520, Guangzhou, Guangdong, China
e-mail: zhang_caihua@outlook.com

²Zhongnan University of Economics and Law, School of Accounting, Postal address: 182 Nanhu Avenue,
Donghu New Technology Development Zone, 430073, Wuhan, Hubei, China
e-mail: zhaokunjian95@163.com

³Shanghai University, School of Management,
Postal address: 599 Shangda Road, Baoshan District, 200444, Shanghai, China

Corresponding author:

XUE LEI
e-mail: leixue_work@shu.edu.cn