



# Financial Technology Empowers Enterprises' Green Total Factor Productivity

Yifan Zheng\*, Yujie Gong, Zhenning Zhang, Jiali Yao, Zuomin Gan, Tingyue Guan

Changchun University of Science and Technology, Changchun, Jilin, 130013, China

\*1492017244@qq.com

**Abstract.** Using data from Chinese A-share listed companies spanning 2007 to 2024, this study applies the SBM-Malmquist-Luenberger (SBM-ML) index to measure firms' green total factor productivity (GTFP). It further adopts a panel double fixed-effects model, supplemented by robustness tests and instrumental variable methods, to systematically investigate the enabling effects of financial technology (fintech) on corporate GTFP and the heterogeneity of these effects. The results indicate that fintech significantly and positively promotes corporate GTFP—a conclusion that remains valid even after addressing endogeneity issues and conducting multiple robustness tests. At the regional level, fintech exerts a significant impact on GTFP in eastern and western China but has no significant effect in central China.

**Keywords:** FinTech; Green Total Factor Productivity; Corporate Green Transition.

## 1 Introduction

Green development serves as the foundation of high-quality development, while enhancing enterprises' green total factor productivity (EGTFP)—a term consistently used throughout this study—acts as the core driver for advancing the comprehensive green transformation of the economy and society. The integration of financial technology (FT) and green finance has emerged as a key pathway to achieving this objective.<sup>[1]</sup>The Report of the 20th National Congress of the Communist Party of China explicitly puts forward the strategic arrangement of “actively and steadily advancing carbon peaking and carbon neutrality” and “accelerating the development of Digital China,” thereby defining the direction for the coordinated advancement of digital technology and green development. The Central Financial Work Conference has incorporated green finance into the “five major tasks” of the financial sector and emphasized the establishment of a framework for the coordinated development of technology finance, green finance, and digital finance. The Central Economic Work Conference has further clarified the work requirements, including “coordinately advancing carbon reduction, pollution control, and green growth” and “accelerating the comprehensive green transformation of economic and social development”. Guided by these policies, the People's Bank of China

and the National Financial Supervision and Administration Bureau have successively issued documents, including the Financial Technology Development Plan (2022–2025) and the Implementation Plan for the High-Quality Development of Green Finance in the Banking and Insurance Sectors. These documents propose leveraging big data, AI, and blockchain technologies—among other digital tools—to enhance the intelligent identification of green enterprises, improve carbon footprint accounting standards, and innovate green financial products and services. In doing so, they provide concrete pathways for FT to empower enterprises' green transformation<sup>[2]</sup>. Against the dual backdrop of policy-driven momentum and technological innovation, exploring the enabling mechanisms and effects of FT on EGTFP is not only an imperative response to national strategic deployment but also a crucial practical exploration for advancing the high-quality development of green finance.

A review of the existing literature reveals that studies relevant to the theme of this paper primarily cover three aspects: (1) Providing macro-level contextual support and theoretical foundations. Existing studies confirm that digital technologies—represented by big data<sup>[3]</sup> and AI<sup>[4]</sup>—act as key drivers of green economic and social transformation. This finding provides a solid theoretical foundation and logical starting point for this paper's focus on "FT" as a specific application of digital technology in the financial sector<sup>[5]</sup>. (2) Validating the core causal logic. Existing literature demonstrates from multiple perspectives that improving green development performance can be achieved through two pathways: promoting green technological innovation<sup>[6–8]</sup> and optimizing resource allocation efficiency<sup>[9]</sup>. This indirectly corroborates the theoretical mechanism proposed in this paper, whereby FT enhances EGTFP by "empowering green technological innovation" and "optimizing the allocation of resources and the environment." (3) Providing methodological references and comparative benchmarks: Relevant studies provide direct and reliable methodological references for this research, particularly regarding the SBM-Malmquist-Luenberger (SBM-ML) index<sup>[10]</sup> for measuring EGTFP, empirical strategies, such as fixed-effects models<sup>[11]</sup> and instrumental variable methods<sup>[12]</sup>, and dimensions of heterogeneity analysis<sup>[13]</sup>. Meanwhile, these studies serve as the academic foundation for dialogue and comparison in this research, thereby helping to highlight the distinctive features and contributions of this study.

Compared with the existing literature, the marginal contributions of this paper are as follows: It shifts the research focus from macro-level policies and technological environments to micro-level FT-related factors. While prior studies often examine the impacts of environmental regulations or the broader digital economy, this study specifically focuses on FT—a fusion of technological empowerment and financial functions. In doing so, it identifies new pathways through which endogenous technological forces within markets drive enterprises' green transformation. This enriches the research on the dynamic mechanisms underlying EGTFP.

## 2 Theoretical Analysis and Research Hypotheses

The improvement of EGTFP fundamentally depends on three pillars: green technological advancement, green efficiency optimization, and the mitigation of environmental constraints. FT, through the in-depth integration of digital technology and financial functions, can provide targeted and critical support for these three core requirements<sup>[14]</sup>. First, FT alleviates green financing constraints faced by enterprises<sup>[15]</sup>. Traditional financial institutions subject green projects to the “high financing costs and high risks” dilemma, primarily due to information asymmetry and the difficulty of risk assessment. FT—by leveraging big data-based credit evaluation, AI-driven risk control, and blockchain-enabled traceability—reduces information barriers and expands green financing channels. In doing so, it secures capital for enterprises' green R&D activities and equipment upgrades. Second, FT can empower enterprises' green technological innovation<sup>[16]</sup>. While green technological innovation serves as the core driver of EGTFP, its high investment requirements and risk levels dampen enterprises' enthusiasm for engaging in such innovation. FT can accelerate the transfer of green technologies by establishing industry-academia-research collaboration platforms and mitigate innovation risks via green financial derivatives. This, in turn, incentivizes enterprises to increase their investment in green R&D activities. Finally, FT can optimize the allocation of resources and the environment<sup>[17]</sup>. By leveraging big data and the Internet of Things (IoT) to conduct real-time monitoring of enterprises' energy consumption and emissions, FT optimizes their production processes. Digital carbon footprint accounting promotes the internalization of environmental costs, while green supply chain platforms drive collaborative green transformation and reduce the costs associated with green transition. Based on the above analysis, the following research hypothesis is proposed: The development of FT can significantly promote the improvement of EGTFP.

## 3 Research Design

### 3.1 Model Construction

This study incorporates FT as a core explanatory factor into the analytical framework for investigating EGTFP. The primary objective of this analytical framework is to dissect the direct impact of FT development on EGTFP and validate Research Hypothesis H. To achieve this objective, we construct the following panel data double fixed-effects model for the empirical analysis:

$$GTFP_{it} = \alpha_0 + \alpha_1 FT_{it} + \theta X_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

Where:  $i$  and  $t$  denote city and year, respectively;  $GTFP$  is an indicator measuring corporate green total factor productivity;  $FT$  reflects the level of fintech development;  $X$  represents a set of control variables;  $\alpha_0$  denotes the intercept term;  $\alpha_1$  represents the estimated coefficient for the core explanatory variable;  $\theta$  is the esti-

mated coefficient for the control variables;  $\mu_i$  and  $\delta_t$  denote city fixed effects and time fixed effects, respectively;  $\varepsilon_{it}$  constitutes the random error term.

## 3.2 Variable Selection

### 3.2.1 Dependent Variable.

The dependent variable selected in this study is EGTFP. This study incorporates enterprises' environmental pollution into EGTFP evaluation framework and, following the methodological approach proposed by Huang et al.<sup>[18]</sup>, employs the non-radial SBM-ML index—hereafter referred to as the “ML index”—to measure EGTFP.

### 3.2.2 Core Explanatory Variable.

The core explanatory variable selected in this study is FT. Following the methodological approach proposed by Huang Lei et al. (2023)<sup>[19]</sup>.

### 3.2.3 Control Variables.

Drawing on the existing literature, this study selects the following control variables: (1) Firm size (denoted as size). (2) Debt-to-asset ratio (denoted as lev). (3) Return on assets (denoted as ROA). (4) Cash flow ratio (denoted as cashflow). (5) Revenue growth rate (denoted as growth). (6) Largest shareholder's ownership ratio (denoted as top1). (7) Tobin's Q ratio (denoted as tobinQ).

## 4 Benchmark Regression

Table 1 reports the results of the benchmark regression analysis that examines the relationship between FT and EGTFP. As shown in Table 1, the regression coefficient of the core explanatory variable—FT—is significantly positive at conventional statistical significance levels across all regression specifications. This result strongly supports Research Hypothesis H proposed in this study.

**Table 1.** Benchmark Regression Results.

VARIABLES	(1) GTFP	(2) GTFP	(3) GTFP
FT	0.0004*** (2.702)	0.0006*** (3.689)	0.0008*** (4.382)
Size		0.0011*** (4.274)	0.0014*** (4.722)
Lev		0.0032*** (2.808)	0.0027** (2.178)
ROA		-0.0129*** (-5.095)	-0.0150*** (-5.110)
Cashflow			0.0057***

VARIABLES	(1)	(2)	(3)
			(3.003)
Growth			-0.0004
			(-1.048)
Top1			-0.0084***
			(-4.793)
TobinQ			0.0003**
			(2.112)
Constant	1.0076***	0.9843***	0.9798***
	(2,212.527)	(174.142)	(152.475)
Observations	43,874	38,548	35,621
R-squared	0.982	0.981	0.982
firm FE	Yes	Yes	Yes
year FE	Yes	Yes	Yes

## 5 Conclusions

Key finding of this study is FT development exerts a significantly positive enabling effect on EGTFP. Based on the aforementioned research findings of this study, the following practical and theoretical insights are derived: At the governmental level: A national-level special plan for the green-oriented development of FT should be formulated. This plan should explicitly define the strategic positioning, phased objectives, and implementation pathways of FT in improving EGTFP. Meanwhile, it should strengthen the systematic integration and policy coordination between this plan and national-level strategies—including the “dual carbon” goals (carbon peaking and carbon neutrality goals) and the Digital China initiative. To mitigate regional development imbalances in the enabling effect of FT: Targeted regional support policies should be implemented, with specific measures as follows: For central regions: Prioritize increasing investment in new-type infrastructure—including 5G networks, data centers, and green computing infrastructure—to strengthen the foundation for FT application. Meanwhile, promote the in-depth integration between digital financial platforms and local green project databases, thereby addressing the “central dip” phenomenon in the enabling effect of FT; For cities with stringent environmental regulations or transportation hub attributes: Introduce innovative policy instruments—including “digital green credit interest subsidies” and “carbon accounts + blockchain-based certification”—to enhance the application of FT in green fields. Simultaneously, establish “green digital technology application demonstration zones” in these cities, aiming to fully exploit the synergistic amplification effect between environmental regulation/location advantages and the enabling effect of FT.

At the corporate level: Technology-intensive enterprises should proactively establish a “green technology + digital finance” dual-engine driving model—where “digital finance” primarily refers to FT development oriented toward green fields. Specifically, these enterprises should integrate core technologies—including AI, the IoT, and blockchain—to build an integrated digital platform covering the entire chain of “green

design → clean production → carbon footprint management → green financing”. This platform should not only realize the visualization, quantification, and capitalization of green performance indicators but also proactively explore blockchain-based solutions—such as green asset tokenization and carbon derivatives trading facilitation—to expand the application scenarios of FT in green transformation. Enterprises should strengthen the standardization and traceability of green information disclosure. Specifically, they should regularly publish key green indicators—including carbon footprints, green patents, and ESG performance—and leverage blockchain technology to ensure the immutability and auditability of disclosed data. This will lay a solid data foundation for the precise identification, dynamic evaluation, and efficient empowerment of FT development.

At the financial institution level: Strengthen the innovation of green financial products oriented toward FT development. Specifically, actively develop two categories of products: “Green credit” and “carbon derivatives” supported by big data-driven intelligent risk control; “Green bonds” and “ESG asset management products” leveraging blockchain technology. Explore pricing mechanisms that link environmental benefits to credit interest rates and insurance premiums. This will help comprehensively enhance financial institutions’ capabilities in identifying, pricing, and managing risks related to green assets—thereby laying a foundation for FT to efficiently allocate financial resources to green projects.

## References

1. Liu G, Yang N, Zang R. Research on the Carbon Emission Reduction Effect of the Synergy Between FinTech and Green Finance: From the Perspective of “Technology Empowerment and Institutional Drive” [J]. *Modern Finance and Economics-Journal*,2025,45(10):77-93.
2. Hu J, Yu Lu, Liu Y. The Incentive Effect of Fintech on Enterprise Green Transformation: Based on the Dual Empowerment Perspective of Digitization and Green Governance[J]. *Modern Finance and Economics-Journal*,2024,44(06):93-109.
3. Fang H, Xie H, Zhao Q. Establishment of Big Data Comprehensive Pilot Area, Data Element Enabling Effect and Green Transformation of Enterprises[J]. *World Economy Study*, 2024, (11):93-107+137.
4. Zhang Q, Ye Y. Artificial Intelligence and Green Total Factor Energy Efficiency against the Background of Coordinated Regional Development[J]. *Journal of Nantong University*, 2025,41(13):179-183.
5. Zhuang L, Zhou H. Research on Evolutionary Game of Innovation and Application of Financial Science and Technology[J]. *Financial Theory and Practice*, 2020, (07):42-50.
6. Xu Y, Fan Y, Liu S. The Green Finance Effect of Digital Inclusive Finance-Evidence and Mechanism for Promoting Green Technology Innovation[J]. *The World of Survey and Research*,1-13.
7. Sun Y. Study on Green Technology Innovation Effect of Fiscal Vertical Imbalance: Based on an Analysis of Provincial Panel Data[J]. *Journal of Northeastern University (Social Science)*,1-12[2025-11-05].
8. Li Z. The Impact of Digital Economy on Green Technology Innovation of Enterprises-Mediation Effect Based on Financing Costs and Carbon Emission Reduction Constraints[J]. *Statistics and Decision*, 2025, (20):29-34.

9. Liu R, Gao Z, Zhang W. How the Introduction of Strategic Investors Promotes High-Quality Corporate Development-Based on the Perspective of Technology Resource Allocation and Agency Costs[J]. *Journal of Wuhan Textile University*,2025, (16):29-37.
10. Cui L, Sun W, Huang M. Research on the impact of new energy demonstration city construction on green total factor productivity of enterprises-Empirical analysis based on A-share listed companies[J]. *Journal of Guangxi University of Finance and Economics*, 2023,36(01):92-104.
11. Sheng X, Chen W, Tang D, et al. Impact of Digital Finance on Manufacturing Technology Innovation: Fixed-Effects and Panel-Threshold Approaches[J]. *Sustainability*, 2023, 15(14): 11476.
12. Okanda T L, Zhang J, Sarfo P A, et al. Exploring the Nexus between Debt Financing and Firm Performance: A Robustness Analysis Using Instrumental Variables[J]. *International Journal of Advanced Engineering Research and Science*, 2025, 12(02).
13. Fang C, Cheng J, Zhu Y, et al. Green total factor productivity of extractive industries in China: An explanation from technology heterogeneity[J]. *Resources Policy*, 2021, 70: 101933.
14. Hu W, Li X. Financial technology development and green total factor productivity[J]. *Sustainability*, 2023, 15(13): 10309.
15. Lyu Y, Ji Z, Zhang X, et al. Can Fintech alleviate the financing constraints of enterprises? — Evidence from the Chinese securities Market[J]. *Sustainability*, 2023, 15(5): 3876.
16. Liu J, Zhang Y, Kuang J. Fintech development and green innovation: Evidence from China[J]. *Energy Policy*, 2023, 183: 113827.
17. Okere K I, Dimnwobi S K, Fasanya I O. Pathways to environmental sustainability: exploring the role of FinTech, natural resources and globalization in North Africa[J]. *International Journal of Sustainable Development & World Ecology*, 2025, 32(4): 446-464.
18. Huang L, Huang S, Yang C. The Impact and Role Mechanism of Fintech on Green Credit-Base on the Perspective of Fintech in Commercial Banks[J]. *Journal of Financial Development Research*, 2023, (07):73-82.
19. Huang Q, Liu M, Hu J. Trade Openness, Environmental Regulation and Green Total Factor Productivity-Based on the Empirical Test of the Yangtze River Economic Belt[J]. *Journal of Southwest University*,2021,43(07):118-129.

**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.

