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Can digital technology innovation enhance the corporate profitability?

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ABSTRACT
Digital technology is driving a new wave of transformation, improving quality, efficiency, and business upgrading. Using data from A-share listed companies on the Shanghai and Shenzhen stock exchanges (2010–2022), this paper identifies digital patents through text analysis to measure digital innovation and employs regression models to examine its impact on corporate profitability. Key findings include: (1) Digital innovation significantly enhances profitability, a result robust across sensitivity tests. (2) The impact is stronger in highly competitive, private, high-tech, large, and eastern firms but weaker or negligible in smaller, state-owned, low-tech, and less competitive firms in central and western regions. (3) Mediation analysis shows that digital innovation boosts profitability by improving efficiency and scale, though cost-effectiveness is limited in early stages. (4) Moderation analysis suggests that stronger government and corporate governance further enhance its benefits. These insights offer a new perspective on digital technology's role in profitability and inform policy decisions.

KEYWORDS
Digital technology innovation; digital transformation; enterprises; market profitability

JEL CLASSIFICATION
D22; D24

I. Introduction

The wave of digitalization is reshaping the global economy, making the digital economy a key driver of international competition. According to the International Data Corporation (IDC), the global digital economy reached approximately $15 trillion in 2022, accounting for over 15% of global GDP. This figure is expected to exceed $23 trillion by 2025, reaching nearly 20% of GDP (Huateng et al. 2021). China's digital economy has also grown rapidly, becoming a major force in driving economic expansion.

In this context, emerging technologies such as the Internet, big data, Adobe Illustrator (AI), and the Internet of Things (IoT) are transforming industries. Enterprises are increasing investments in digital innovation to gain a competitive edge (Luo et al. 2023). China's 14th Five-Year Plan and 2035 Long-Term Vision emphasize the deep integration of digital technologies with the real economy to promote industrial upgrading, foster new industries, and develop innovative business models. At the macro level, digital technologies are reshaping global industries, generating new business models, and stimulating economic growth while bringing substantial social and economic benefits (Boons et al. 2013).

In China, digital innovation enhances both international competitiveness and economic resilience. At the micro level, it optimizes business operations, improving product design, production processes, and organizational structures. Automation, AI, and big data analytics enable firms to respond more accurately to market demands and improve productivity (Gaglio, Kraemer-Mbula, and Lorenz 2022). However, challenges such as high R&D costs, rapid technological advancements, and uncertain market demand pose risks to digital innovation (K. Li et al. 2020). These challenges raise critical questions about how digital innovation enhances corporate profitability and the mechanisms that drive this process.

Existing research focuses on several key aspects of digital technology innovation. First, scholars generally define digital technology as the use of computing and communication technologies for information collection, processing, storage, and transmission. Its core characteristics – informatization, intelligence, networking, and integration –

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drive its widespread application across industries (Javaid et al. 2022). Second, in terms of measurement, studies employ patent analysis, text mining, and survey data. However, the lack of a unified classification standard may lead to errors in identifying innovations, requiring further validation of measurement methods (D. Wang, Liao, and Wang 2024). Third, digital technology innovation can be classified into product innovation, process innovation, business model innovation, and management innovation. Product innovation focuses on developing new products, process innovation enhances production efficiency, business model innovation explores new ways to create value, and management innovation involves changes in organizational structure and managerial practices (Ancillai et al. 2023). Fourth, the economic effects of digital innovation are reflected in improved production efficiency, industrial transformation, employment structure changes, and economic growth (M. Chen et al. 2021). Finally, key influencing factors include firms' R&D investment, technological capabilities, market environment, and policy support. R&D investment and technological capabilities are critical, while market conditions and policies provide external support for innovation (Fang and Liu 2024; Liu et al. 2020).

Profitability is central to corporate operations, and analysing its determinants helps firms optimize decision-making and enhance competitiveness (Lin, Wu, and Song 2023). Early studies focused primarily on financial indicators, while later research examined internal and external factors affecting profitability and its sustainability (Ferris, Hanousek, and Tresl 2021). Internal factors include management efficiency, cost control, and technological innovation, while external factors encompass macroeconomic conditions, market competition, and government policies (Etienne Fabian et al. 2024; Kharlamov and Parry 2020). In recent years, corporate social responsibility (CSR) has been closely linked to profitability. Engaging in CSR not only enhances corporate image and brand reputation but also strengthens employee cohesion and consumer trust, ultimately improving profitability (X. Chen, Guo, and Shangguan 2022). Additionally, scholars have explored the relationship between profitability and digital transformation (Romero and Mammadov 2024; J. Wang and Bai 2024), offering theoretical support for this study.

Despite significant research progress on digital technology innovation and corporate profitability, a systematic framework linking the two remains lacking. Studies directly examining how digital innovation impacts profitability are limited. Additionally, inconsistencies in measurement methods have resulted in varying conclusions across studies.

To address this gap, this paper applies text analysis to patent application documents from listed companies to identify digital patents and constructs a measure of corporate digital technology innovation. Operating profit is used as a key indicator of profitability to systematically analyse the relationship between digital technology innovation and corporate profitability, as well as the underlying mechanisms.

The findings show that digital technology innovation significantly enhances corporate profitability, with stronger effects in highly competitive industries, high-tech sectors, private enterprises, large firms, and companies in eastern China. Mechanism tests indicate that digital technology innovation primarily improves profitability by increasing production efficiency and expanding firm size. Further analysis suggests that enhancing government governance efficiency and strengthening corporate governance incentives can amplify the positive impact of digital technology innovation on profitability.

This paper makes three main contributions: First, it enriches research on the impact of digital innovation on corporate profitability, providing insights for policymakers and business leaders. Second, it identifies three key pathways – cost reduction, efficiency improvement, and business expansion – through which digital innovation drives corporate growth, offering practical guidance for resource allocation. Third, it highlights the critical role of government and corporate governance in maximizing digital innovation's benefits, emphasizing the need for coordinated efforts between public and private sectors to achieve sustainable development. This research offers valuable theoretical and practical insights for enterprises undergoing digital transformation, contributing to a deeper understanding of how digital innovation fosters high-quality economic growth.

The rest of this paper is structured as follows: Section 2 presents the mechanism analysis and research hypotheses; Section 3 introduces the empirical research design; Section 4 presents the main empirical results and analysis; Section 5 provides further discussion; and Section 6 concludes with policy implications.

II. Mechanism analysis and research hypotheses

The direct impact on corporate profitability

In recent years, the global digital economy has expanded rapidly, with China experiencing significant growth. However, China faces imbalances between technology development and application due to weak foundational technologies and the need for key breakthroughs (Feng et al. 2022). These challenges stem from the high demands of digital innovation, long investment cycles, and uncertainties, deterring enterprises due to high costs, risks, and entry barriers. Despite these obstacles, digital innovation presents immense opportunities for corporate transformation, enhancing market competitiveness and profitability.

Digital technology innovation drives the shift from static to dynamic organizations, improving management efficiency and adaptability (Ghosh et al. 2022). Real-time data exchange and process automation enable firms to respond flexibly to market changes, breaking traditional hierarchies in favour of customer- and business-centric structures. An innovation-driven culture empowers employees as 'intrapreneurs', fostering creativity and competitiveness. Additionally, new business models and products enhance market performance in dynamic environments (Paiola and Gebauer 2020).

Furthermore, digital innovation supports intelligent transformation. Big data and AI optimize decision-making and operations. Data analytics improve decision accuracy, while AI-driven automation boosts efficiency and product quality, enabling cost reduction and resource optimization (F. Zhang, Yang, and Zhu 2023).

Finally, digital innovation strengthens competitive advantages. On one hand, technological advancements accelerate product development and market responsiveness. On the other, optimized production processes reduce costs and enhance profitability. Strategically, digital technology enhances adaptability, enabling firms to acquire, reorganize, and utilize resources effectively (Day 2011). By leveraging data analytics and machine learning, firms can sustain continuous innovation, maintain cost advantages, and drive long-term growth.

Based on this, the following hypothesis is proposed.

H1: Digital technology innovation can effectively improve corporate market profitability.

The indirect impact on corporate profitability

According to the production function theory, high efficiency leads to high output, and increased output enhances corporate profitability (Sealey Jr and Lindley 1977). As a key representation of productivity, digitalization, through the application of digital technologies, frees workers from low-end repetitive tasks, enabling them to focus on higher-value activities such as research and development and marketing, thereby improving productivity and product quality. At the same time, digital technologies significantly enhance a company's profit-generating capacity and exhibit notable output effects. Furthermore, as a new production factor, the application of digital technologies reduces the cost of information acquisition and optimizes the allocation of resources such as capital, technology, talent, and other inputs, significantly improving the efficiency of manufacturing, logistics, and sales processes, thereby increasing economic benefits. Digital innovation also improves the efficiency of resource allocation within companies (P. Chen 2022), optimizing production and management practices and promoting the rational allocation of production factors. The resulting technological innovation effect shifts enterprises from a factor-driven model to a technology-driven one, facilitating high-quality development and enhancing market profitability.

Based on this, the following hypothesis is proposed.

H2: Digital technology innovation can enhance corporate market profitability by improving production efficiency.

At the same time, a firm's costs can also significantly impact its market profitability. Mature digital innovations offer substantial cost advantages by reducing management, transaction, and innovation costs (Qinqin et al. 2023). However, according to Schumpeter's 'creative destruction' theory and the technology innovation lifecycle theory, early-stage innovations often incur higher costs than benefits (Rahimnia and Molavi 2021). On one hand, leveraging data, information, and the internet improves information transfer efficiency, enabling firms to respond quickly to market demand while reducing search costs. Big data analytics enhance product-market alignment, refine customer targeting, and optimize marketing strategies, thus increasing sales and lowering management costs (Barbosa-Povoa and Pinto 2020). Additionally, compared to traditional infrastructure, digital technologies require lower investment in physical assets, reduce human capital demands, and offer greater sustainability, effectively cutting innovation costs. On the other hand, Schumpeter's theory states that innovation progresses through stages – R&D, early market introduction, and maturity. In initial phases, high costs prevail, but as technology matures and market demand stabilizes, returns gradually increase (Dao, Langella, and Carbo 2011). Digital technology innovation, as an advanced integration of existing technologies, follows this trajectory, reinforcing its role as a driver of cost-efficient and sustainable growth.

Based on this, the following hypothesis is proposed.

H3: Mature digital technology innovations can enhance a firm's market profitability through cost effects, but in the early stages, their cost investments will still outweigh the benefits.

Moreover, digital technology innovation in enterprises generates scale effects. Early adopters of advanced digital technologies can quickly introduce competitive products and services, meeting consumer needs and expanding market share (Walsh, Kirchhoff, and Newbert 2002). By leveraging big data analytics and AI, firms can accurately predict market trends and consumer preferences, optimizing market strategies and product development. This first-mover advantage, combined with patent protection, prevents easy replication, securing long-term market leadership and generating excess profits.

As market share grows, scale effects intensify – larger firms achieve greater returns from digitalization (Kohtamäki et al. 2020). Companies with higher market shares build stronger brand influence, attracting more consumers and reinforcing a growth cycle. Beyond domestic expansion, digital technology also facilitates global market entry through e-commerce and digital marketing, increasing sales and market reach. This global expansion diversifies revenue streams, enhances competitiveness, and strengthens long-term profitability.

Based on this, the following hypothesis is proposed.

H4: Digital technology innovation can enhance corporate market profitability through scale effects.

III. Empirical research design

Model construction

To examine the impact of digital technology innovation on corporate profitability while effectively controlling for unobservable heterogeneity and eliminating estimation biases caused by time-invariant, unobserved characteristics across different firms, thereby ensuring more reliable results, this paper constructs the following fixed effects model for the baseline regression test:

$$lnyylr_{it} = \beta_0 + \beta_1 \mathrm{lndigtech}_{it} + \beta_2 \mathrm{control}_{it} + u_i + \gamma_t + \varepsilon_{it} \quad (1)$$

In the equation, i represents the enterprise, t represents time, $lnyylr_{it}$ represents corporate profitability, $lndigtech_{it}$ is the core explanatory variable representing firm-level digital technology innovation, $\mathrm{control}_{it}$ refers to the relevant control variables, u_i represents the firm fixed effects, γ_t represents the time fixed effects, and ε_{it} represents the error term.

Additionally, this paper applies clustered robust standard error at the firm level.

To examine the underlying mechanisms, this paper adopts the mediation effect test method, investigating how digital technology innovation affects corporate profitability through cost effects, production efficiency, and scale effects. The mediation effect models are set as follows:

$$MV_{it} = \varphi_0 + \varphi_1 \text{lndigtech}_{it} + \omega \text{control}_{it} + u_i + \gamma_t + \varepsilon_{it} \tag{2}$$

Where, MV represents the mediator variable, and the rest of the variables are defined as previously described.

Data sources and processing

The data for this study comes from two sources: patent data from the WinGo Financial Text Data Platform and company data from the CSMAR database. The sample includes A-share listed companies from the Shanghai and Shenzhen Stock Exchanges (2010–2022). The data processing steps include: (1) excluding Special Treatment companies and those delisted; (2) removing erroneous records; (3) excluding financial companies; (4) excluding companies with total assets less than liabilities; (5) excluding companies listed for less than a year. After processing 36,678 annual observations remain, with continuous variables winsorized at the 1% and 99% levels to reduce outliers.

Variable definitions

Core explanatory variable — digital technology innovation

Most research on digital technology innovation is theoretical, with limited empirical studies. To advance the field, measuring firm-level digital innovation is crucial. Existing studies often use patent text data, identifying digital patents through the number of patent applications (Hain et al. 2022). Some focus on patent analysis related to AI technologies (Miric, Jia, and Huang 2023). This paper conducts keyword analysis on patents' abstracts and claims from listed companies, using keywords related to 'underlying technology' and 'technology application'. The annual number of digital patent applications is calculated, represented by the variable lndigtech.

Dependent variable — corporate market profitability

The dependent variable in this paper is corporate market profitability, a key indicator of a company's growth potential. Commonly, Return on Assets (ROA) is used to measure profitability, calculated as ROA = EBIT/Total Assets, reflecting the ability to generate profits from assets (Alarussi and Gao 2023). Some studies use factor analysis to create a composite profitability index, while others define profitability as Operating Revenue/Operating Costs (Istan et al. 2021). Based on these methods, this paper measures market profitability using the logarithm of operating profits (lnyylr).

Control variables

This study selects a series of control variables, including firm age (Age), Tobin's Q (TobinQ), intangible asset ratio (Intass), leverage ratio (Lev), current ratio (Car), proportion of independent directors (Dirratio), ownership concentration of the largest shareholder (OwnCon1), ownership concentration of the second to tenth largest shareholders (OwnCon2), price-to-earnings ratio (PE), and board size (Sowncon), to account for the potential impact of other factors on the robustness of empirical results. The specific calculations and descriptive statistics of these indicators are presented in Appendix A.

Intermediary variables

(1) Cost Effect: The cost effect of a firm includes total cost, management cost, transaction cost, and research and development (R&D) cost. Total cost is the logarithm of a firm's operating costs, while management cost is the ratio of management expenses to operating income. Transaction cost is represented by the ratio of sales expenses to operating income. R&D cost is the ratio of R&D expenses to operating income. These measures are adapted from Alarussi and Gao (2023) and Istan et al. (2021). (2) Production Efficiency Effect: Total factor productivity (TFP) represents the overall efficiency with which various input factors are transformed into final output during the production process, offering a comprehensive measure of

a firm's production efficiency. This study uses firm-level TFP, calculated using the LP, OLS, and FE methods (Lin and Zhang 2023). (3) Scale Effect: The scale effect is measured by the asset size of the firm. Specifically, the natural logarithm of the firm's total assets (Size) is used as an indicator of firm size.

IV. Empirical results and analysis

Baseline regression results

The results show that in Column (1) of Table 1, without controlling for year and individual fixed effects, the regression coefficient of digital technology innovation (lndigtech) is significantly positive at the 1% significance level. In Column (2) of Table 1, after controlling for year fixed effects, it remains significantly positive. In Column (3) of Table 1, with both year and individual fixed effects, the coefficient is 0.251, still significant at the 1% level, confirming that digital innovation significantly boosts corporate profitability, validating Hypothesis 1.

Control variables show that Age, Car, Dirratio, OwnCon1, OwnCon2, and PE have positive coefficients, indicating that more experienced, liquid, and well-governed firms execute innovation more effectively. In contrast, Tobinq, Lev, and Sowncon have negative coefficients, suggesting that firms with lower market values, higher debt, and larger boards face challenges in digital innovation. The proportion of intangible assets has a negative but insignificant effect, suggesting quality matters more than volume.

Table 1. Baseline regression results.

Variable	(1)	(2)	(3)
lndigtech	0.416***	0.414***	0.251***
	(16.62)	(10.06)	(4.32)
Age	0.844***	0.959***	4.609***
	(10.49)	(6.04)	(7.23)
Tobinq	−0.474***	−0.451***	−0.187***
	(−17.58)	(−10.34)	(−4.50)
Intass	−0.513	−0.705	−1.945
	(−0.75)	(−0.60)	(−1.31)
Lev	−4.999***	−4.942***	−9.098***
	(−28.58)	(−17.72)	(−21.08)
Car	1.561***	1.613***	4.275***
	(8.88)	(5.59)	(9.39)
Dirratio	0.896**	0.714	1.971***
	(2.07)	(1.28)	(3.53)
OwnCon1	0.085***	0.084***	0.082***
	(36.42)	(21.84)	(10.95)
OwnCon2	0.059***	0.060***	0.067***
	(22.74)	(14.14)	(10.51)
PE	0.005***	0.005***	0.011***
	(21.52)	(15.57)	(28.61)
Sowncon	0.634***	0.466***	−0.864***
	(4.79)	(2.63)	(−4.54)
_cons	9.523***	9.571***	1.204
	(19.98)	(13.04)	(0.60)
N	36674	36674	36407
r2	0.096	0.111	0.395
Year Fixed Effects	No	YES	YES
Firm Fixed Effects	No	No	YES

*,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively, the value of t is in parentheses.

Mechanism test

The theoretical analysis presented earlier suggests that digital technology innovation can influence corporate market profitability through internal cost effects and production efficiency, as well as external scale effects and spillover effects. To verify this theory, this paper employs the mediation effect test method, examining the mechanism through which digital technology innovation affects corporate market profitability in four areas: production costs, production efficiency, firm size, and spatial spillover effects.

Mechanism test for cost effect

The theoretical analysis suggests that mature digital technology innovations can improve a firm's market profitability through cost effects. However, in the early stages, initial cost investments outweigh the benefits. To test this, the paper uses total cost, management cost, transaction cost, and R&D cost as indicators. Results in Table 2 show that the coefficients for digital technology innovation (lndigtech) are significantly positive across all cost indicators, implying that digital innovation does not immediately reduce enterprise costs. This could be due to

Table 2. Mechanism test: cost effect.

Variable	(1) Total Cost	(2) Management Cost	(3) Transaction Cost	(4) R&D Cost
lndigtech	1.554***	0.052***	0.045**	0.059***
	(0.431)	(0.012)	(0.019)	(0.017)
N	36407	36407	36407	36407
r2	0.855	0.887	0.922	0.409
Control Variables	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Firm Fixed Effects	YES	YES	YES	YES

*,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively, with standard errors clustered at the firm level shown in parentheses.

higher R&D, labour, and capital investments required in the early stages, which increase short-term costs. Additionally, the need for better management quality raises management costs. Despite these short-term cost increases, digital innovation enhances long-term development capabilities. Once mature, it can significantly boost market profitability, aligning with Qinqin et al. (2023)'s findings.

Mechanism test for production efficiency

According to the theoretical analysis, digital technology innovation can enhance corporate market profitability by improving production efficiency. To test this mechanism, this paper selects total factor productivity (TFP) as the variable and uses the LP method, OLS method, and FE method to calculate it. The test results are shown in Table 3, where the regression coefficients of digital technology innovation (lndigtech) are significantly positive, indicating that digital technology innovation can improve total factor productivity, thereby enhancing corporate market profitability.

Mechanism test for scale effect

The theoretical analysis suggests that digital technology innovation can enhance corporate market profitability by expanding the scale of the enterprise. To test this effect, this paper uses the natural logarithm of total assets (Size) as the mediator variable. The test results in Table 4 show that the regression coefficient of digital technology innovation (lndigtech) is 0.063, and it is significant at the 1% level, indicating that digital technology innovation significantly enhances market profitability by expanding the scale of the enterprise.

Table 3. Mechanism test: production efficiency.

Variable	(1) tfp_lp	(2) tfp_ols	(3) tfp_fe
lndigtech	0.017***	0.026***	0.029***
	(0.007)	(0.008)	(0.008)
N	36407	36407	36407
r2	0.780	0.797	0.800
Control Variables	YES	YES	YES
Year Fixed Effects	YES	YES	YES
Firm Fixed Effects	YES	YES	YES

*,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively, with standard errors clustered at the firm level shown in parentheses.

Table 4. Mechanism test: scale effect.

Variable	(1) Size
lndigtech	0.063***
	(0.008)
N	36407
r2	0.907
Control Variables	YES
Year Fixed Effects	YES
Firm Fixed Effects	YES

*,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively, with standard errors clustered at the firm level shown in parentheses.

Robustness and endogeneity test

To verify the robustness of the estimation results, this paper conducts robustness tests from several aspects, including the construction of core indicators, sample interval adjustment, removal of extreme samples, adjustments to estimation methods, and instrumental variable regression.

(1) Replacing the explanatory variable: Different methods of measuring digital technology innovation may yield different results, which could influence the estimation results in this paper. This paper adopts the method of Zhang and Chen (2023), measuring corporate digital technology innovation activities from the perspective of patent quality for the robustness test. Specifically, this paper only considers approved and effective patent applications, excluding those with the legal status of 'under review', 'rejected', or 'withdrawn', and reconstructs the digital technology innovation indicator based on the number of patent applications in the given year. The variable lndigcited represents the natural logarithm of this indicator. The results in Column (1) of Table 5 show that this variable is consistent with the baseline results.

(2) Replacing the dependent variable: Different methods of measuring corporate market profitability may also affect the estimation results. This paper uses Return on Assets (ROA) to measure corporate market profitability, calculated as 'Earnings Before Interest and Taxes (EBIT)/Total Assets'. The results in Column (2) of Table 5 show that this method is consistent with the baseline results.

Table 5. Robustness test.

Variable	(1) Replacing Explanatory Variable	(2) Replacing Dependent Variable	(3) Adding Lagged Term	(4) Removing Extreme Samples	(5) Stricter Fixed Effects	(6) Instrumental Variable Regression
Indigtech	0.301***	0.001***	0.483***	0.290***	0.243***	0.400**
	(4.73)	(2.66)	(7.84)	(3.33)	(4.18)	(−2.05)
Age	4.617***	0.042***	2.502***	1.718*	4.609***	1.664*
	(7.26)	(6.57)	(3.77)	(1.79)	(7.28)	(1.67)
Tobinq	−0.187***	0.001**	−0.004	0.158***	−0.198***	0.107
	(−4.50)	(2.35)	(−0.09)	(2.61)	(−4.83)	(1.64)
Intass	−1.944	−0.044***	−3.284**	−3.477	−1.776	−3.928
	(−1.31)	(−2.60)	(−2.09)	(−1.14)	(−1.20)	(−1.25)
Lev	−9.113***	−0.138***	−7.345***	−10.68***	−9.137***	−9.777***
	(−21.12)	(−26.45)	(−16.92)	(−13.24)	(−21.71)	(−12.27)
Car	4.277***	0.049***	2.406***	5.107***	4.223***	5.247***
	(9.40)	(10.02)	(5.34)	(5.80)	(9.33)	(6.06)
Dirratio	1.952***	0.012**	0.876	1.128	1.877***	1.181
	(3.50)	(2.17)	(1.53)	(1.20)	(3.36)	(1.35)
OwnCon1	0.082***	0.001***	0.061***	0.070***	0.084***	0.079***
	(10.94)	(11.74)	(8.13)	(4.88)	(11.34)	(5.44)
OwnCon2	0.067***	0.001***	0.047***	0.059***	0.069***	0.056***
	(10.46)	(9.71)	(7.37)	(5.00)	(10.97)	(4.92)
PE	0.011***	0.000***	−0.004***	0.010***	0.011***	0.010***
	(28.64)	(4.49)	(−9.33)	(14.72)	(28.71)	(14.71)
Sowncon	−0.865***	−0.011***	−1.390***	−0.449	−0.827***	−0.376
	(−4.54)	(−5.41)	(−6.94)	(−1.35)	(−4.37)	(−1.13)
_cons	1.238	−0.085***	11.049***	8.940***	1.098	
	(0.62)	(−4.25)	(5.23)	(2.86)	(0.55)	
N	36407	36407	31904	12512	36407	12335
r2	0.395	0.490	0.340	0.429	0.410	0.095
Control Variables	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	×Province	×Industry
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Kleibergen-Paaprk LM						203.929***
						(0.000)
CraggDonald Wald F						1563.509
						[194.95]

*,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively, the value of t is in parentheses.

(3) Adding a lagged term for corporate market profitability: Corporate market profitability may be serially correlated, meaning that the current year's profitability could be influenced by profits from previous years. Therefore, we include a lagged term for corporate market profitability in the new regression analysis. The results in Column (3) of Table 5 show that this adjustment is consistent with the baseline results.

(4) Removing extreme samples: Existing research finds that digital technology innovation patents are mainly concentrated in leading enterprises, and there is a significant gap in patent numbers between leading and follower firms. Therefore, we remove samples of firms with fewer than one digital technology patent application per year to control for the influence of extreme samples on the regression results. The results in Column (4) of Table 5 show that this adjustment is consistent with the baseline results.

(5) Adding interaction fixed effects for province and year: Provinces with higher levels of economic development generally have more advanced digital infrastructure, giving them an advantage in digital technology innovation. Based on this, we add interaction effects between province and year to control for province-level factors that change over time, thereby mitigating the influence of macroeconomic changes brought by digital economic development. The results in Column (5) of Table 5 show that this adjustment is consistent with the baseline results.

(6) Instrumental variable regression: There may be potential endogeneity in the relationship between digital technology innovation and corporate market profitability, so this paper uses instrumental variable (IV) regression

analysis. A firm's decision to innovate digitally is usually influenced by the average level of digital innovation in the industry, but the industry average for digital technology innovation does not directly affect the firm's market profitability. Based on this, we select the industry average digital technology innovation (excluding the firm itself) as the instrumental variable (Hanelt et al. 2021). We also further control for interaction fixed effects between industry and year. The regression results are shown in Column (6) of Table 5, indicating that the coefficient for digital technology innovation is significantly positive. The Kleibergen-Paaprk LM statistic is significant at the 1% level, and the Cragg-Donald Wald F statistic is greater than the critical value for the Stock-Yogo weak instrument identification test at the 10% significance level, indicating that the selected instrumental variable is reasonable and reliable. The baseline results are robust.

Heterogeneity test

Heterogeneity in industry competition intensity

The impact of digital technology innovation varies by competitive environment. Market competition stimulates innovation, particularly in digital applications, where creative destruction is more prominent, encouraging firms to adopt big data and information technology solutions. Research suggests that highly competitive industries see stronger effects from digital innovation on market value than less competitive sectors.

To test this, this study constructs a dummy variable for industry competition using the Herfindahl Index. Industries with index values below the annual median are classified as highly competitive (High = 1); others as less competitive (High = 0). Results in Table 6 show that in highly competitive industries, the digital innovation coefficient (lndigtech) is 0.303 (Column 1, significant at 1%), while in less competitive industries, it is 0.217 (Column 2, also significant at 1%). This confirms that digital innovation enhances market profitability across industries, but its effect is stronger in highly competitive sectors, aligning with M. Li et al. (2025).

Heterogeneity in the nature of corporate ownership

The impact of digital technology innovation on market value varies by corporate ownership. Private enterprises, focused on profit maximization, prioritize digital innovation to enhance market value, supported by efficient governance structures. In contrast, state-owned enterprises (SOEs) face additional strategic and social policy responsibilities, which diminish their focus on profit. Operationally, SOEs benefit from soft budget constraints and easier policy support, while private enterprises struggle with obtaining bank loans and policy benefits, placing greater pressure on them to leverage digital technology innovation for market value.

To test this, the study divides the sample into SOEs and private enterprises using data from the CSMAR database. A dummy variable (Soe) is used to distinguish ownership types: 1 for SOEs and 0 for private enterprises. Table 6, Column (3) shows that the regression coefficient for digital technology innovation (lndigtech) is not significant for

Table 6. Heterogeneity test.

	Industry competition intensity		Enterprise ownership structure		High-tech enterprise qualification	
Variable	(1) High competition intensity	(2) Low competition intensity	(3) State-owned enterprises	(4) Private enterprises	(5) High-tech enterprises	(6) Low-tech enterprises
lndigtech	0.303***	0.217***	0.168	0.264***	0.243***	0.248**
	(0.082)	(0.084)	(0.106)	(0.069)	(0.066)	(0.124)
N	17861	17545	12722	23627	20702	15608
r2	0.444	0.450	0.417	0.410	0.406	0.422
Control variable	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES

*,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively, with standard errors clustered at the firm level shown in parentheses.

SOEs, but is significantly positive for private enterprises (Column 4). This indicates that digital technology innovation has only a significant impact on the market profitability of private enterprises.

Heterogeneity in high-tech enterprise qualifications

High-tech enterprises are defined as domestic companies, registered for more than one year (excluding those in Hong Kong, Macau, and Taiwan), that continuously engage in research and development within the 'National Key Supported High-Tech Fields' in China, convert technological achievements into commercial applications, and operate based on these innovations while holding independent intellectual property rights. To obtain this qualification, companies must meet the requirements outlined in the relevant management regulations. As such, the status of being a high-tech enterprise may influence the relationship between digital technology innovation and market profitability. First, high-tech enterprises typically possess advantages in human capital and technological accumulation, which facilitates the transformation and application of digital technology innovations. Second, the high-tech enterprise qualification often comes with a range of tax incentives and financial subsidies. These policies help offset the costs of digital technology research and innovation activities, enabling companies to achieve higher economic returns from digital technology innovation, thereby enhancing their market profitability.

To validate the above hypothesis, this study constructs a binary variable, Hightech, to group the sample based on whether the firms have obtained the high-tech enterprise qualification. Firms with high-tech enterprise status are assigned a value of 1 (Hightech = 1), while those without the qualification are assigned a value of 0 (Hightech = 0). The results in columns (5) and (6) of Table 6 show that, within high-tech enterprises, digital technology innovation has a significantly positive impact on improving market profitability, which is consistent with the theoretical expectations outlined earlier. However, the effect of digital technology innovation on enhancing market profitability is more pronounced in the Low-tech enterprises group. This may be due to the fact that low-tech enterprises typically rely on traditional production models and lower levels of technology, which results in fewer technological barriers and competitive advantages.

Heterogeneity of enterprise size

The impact of digital technology innovation on market profitability may vary significantly across enterprises of different sizes. Compared to small and medium-sized enterprises (SMEs), large enterprises benefit from greater data resources and financial capacity, enabling them to drive stronger innovation outcomes (Maroufkhani et al. 2020). This suggests that larger firms may experience greater profitability gains from digital innovation. However, SMEs, despite resource constraints, rely more on digital innovation to compete and gain market recognition. Successful innovation can significantly boost their market value by attracting investor attention. To examine these differences, this study constructs a dummy variable 'Scale' to classify firms: those with total assets above the industry median are large enterprises (Scale = 1), while others are SMEs (Scale = 0). Results in Table 7 show that the digital innovation coefficient (lndigtech) for large enterprises is 0.233 (Column 1), while for SMEs, it is 0.142 (Column 2). This confirms that

Table 7. Heterogeneity test.

Variable	Enterprise size heterogeneity				Enterprise regional heterogeneity		
	(1) Large enterprises	(2) SMEs	(3) Large enterprises	(4) SMEs	(5) Eastern region enterprises	(6) Western region enterprises	(7) Central region enterprises
lndigtech	0.233***	0.142*	0.247**	0.137	0.227***	0.315	0.331
	(0.082)	(0.086)	(0.123)	(0.094)	(0.069)	(0.176)	(0.179)
N	18018	17934	23109	12843	25148	4809	3785
r2	0.425	0.439	0.647	0.732	0.416	0.543	0.569
Control variable	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES

*,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively, with standard errors clustered at the firm level shown in parentheses.

digital innovation has a stronger impact on large enterprises' market value than on SMEs.

To verify the robustness of the results, we further refer to the 'Measures for the Classification of Large, Medium, Small, and Micro Enterprises' (2017) issued by the National Bureau of Statistics of China. The sample firms are categorized based on their annual and industry median sizes, with firms above the median classified as large enterprises and those below the median classified as medium and small enterprises. A robustness test is conducted on the above conclusions, and the results are presented in columns (3) and (4) of Table 7. The coefficient for large enterprises is significantly positive, while the coefficient for medium and small enterprises is not significant, indicating the robustness of the previous results.

Regional heterogeneity of enterprises

China's eastern, central, and western regions exhibit significant economic disparities. The eastern region, benefiting from favourable geography and abundant resources, leads in development, whereas the western region, with complex terrain, sparse population, and poor transportation, lags behind. These differences also affect digital technology innovation's impact on corporate profitability. Enterprises in the eastern region have superior data resources and innovation capacity, leading to higher returns from digital innovation. In contrast, firms in the central and western regions face higher costs, longer profitability cycles, and weaker effects. To verify these regional differences, this study constructs dummy variables for regions (East, West, Mid). Results in Table 7 show that the eastern region's digital innovation coefficient (0.227) is significant at the 1% level (Column 5), while coefficients for central and western firms (Columns 6 & 7) are not significant. This indicates that digital technology innovation has a significant impact on the market profitability of firms in the eastern region, while it does not have a significant effect on firms in the central and western regions.

V. Further analysis

A well-balanced government-market relationship is essential for economic stability. As a key production factor, digital technology drives market growth, while government governance efficiency ensures its sustained impact. Incorporating governance efficiency into the digital economy framework optimizes resource allocation, boosting corporate profitability by balancing regulatory oversight and market flexibility. Internally, upper echelon theory suggests that corporate decision-making relies heavily on senior management, particularly board members' expertise. Those with digital technology backgrounds significantly influence intellectual property (IP) development, fostering digital innovation and transformation. This study examines how government governance efficiency (GV) and internal governance (IG) moderate the impact of digital innovation on profitability. GV follows Zhao (2024), using the Digital Government Development Index to define G5, G10, and G15 dummy variables, while IG is measured by the proportion of board members with digital expertise (Zhong and Feng 2024). Regression results (Table 8) show that digital innovation and GV significantly enhance profitability, with the strongest effect in top five provinces, while digital

Table 8. Moderation effect estimation results.

Variable	(1) G5	(2) G10	(3) G15	(4) Internal governance dynamics
lndigtech	0.298***	0.13***	0.401***	0.394***
	(0.0539)	(0.034)	(0.008)	(0.03)
lndigtech* gv	0.633***	0.062***	0.038***	
	(0.081)	(0.006)	(0.007)	
lndigtech* ig				0.158**
				(0.071)
_cons	0.599***	0.669***	0.737***	2.145***
	(0.063)	(0.031)	(0.028)	(0.021)
N	36407	36407	36407	36407
r2	0.553	0.527	0.548	0.712
Control variable	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES

*,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively, with standard errors clustered at the firm level shown in parentheses.

innovation and IG also positively impact profitability, highlighting internal governance's critical role.

VI. Conclusion and implications

Conclusion

Digital technology is driving a new wave of transformation, enabling firms to enhance quality, efficiency, and achieve sustainable upgrading. Scholars widely recognize its role in promoting socioeconomic development. This paper argues that digital innovation generates cost and scale effects, improving production efficiency and profitability. Using data from Shanghai and Shenzhen A-share listed firms (2010–2022), we applied text analysis to identify digital patents, measuring firms' digital innovation levels. A regression model was employed to examine its impact on profitability, underlying mechanisms, and heterogeneity. The key findings include: (1) Digital innovation significantly enhances corporate profitability, a result confirmed through robustness checks such as alternative key metrics, lagged variables, outlier exclusion, interaction fixed effects, and instrumental variable regressions. (2) Heterogeneity analysis reveals stronger profitability effects in high-competition industries, private firms, high-tech sectors, large enterprises, and firms in eastern regions, while effects are weaker for SMEs, SOEs, low-tech sectors, and firms in central and western regions. (3) Mechanism analysis shows that digital innovation boosts profitability by enhancing total factor productivity and market share expansion, though its early-stage cost-effectiveness is limited. (4) Strengthening government governance and internal corporate governance further amplifies the positive impact of digital innovation on profitability.

Implications

Based on the above conclusions, this paper proposes the following policy recommendations:

(1) Enhance the government's guiding role. Given the positive impact of digital technology innovation on corporate profitability, the government should implement policies that foster a conducive environment for digital development and integration into production, management, and organizational processes. Establishing special funds and tax incentives can alleviate financial constraints, reducing the tax burden and increasing enterprises' willingness to invest in digital R&D.

(2) Tailored industry-specific support policies. Since digital innovation affects enterprises differently, industry-specific policies are essential to optimize resource allocation. For SMEs, the government should provide financial aid, technical support, and market expansion assistance to ease growth challenges. Private enterprises require flexible market access and innovation incentives to enhance competitiveness. In highly competitive industries, subsidies and innovation rewards can boost market leadership, while in low-tech sectors and underdeveloped regions, technical training and support can facilitate digital transformation, improving efficiency and competitiveness.

(3) Promote digital innovation for efficiency, cost reduction, and scaling. Digital innovation enhances production efficiency, cost savings, and scalability, key drivers of profitability. The government should establish technology trading platforms and information-sharing networks to improve access to cutting-edge digital solutions. Encouraging collaboration between universities, research institutions, and businesses can accelerate the industrialization of innovations, shortening adoption cycles. Enterprises should leverage big data, AI, and IoT to optimize supply chains, reduce waste, and enhance profitability through targeted marketing strategies.

(4) Improve governance efficiency. In regions with lower governance efficiency, building digital governance systems can enhance public service accessibility and effectiveness. By optimizing the business environment and resource allocation, the government can amplify digital technology's role in boosting corporate profitability. Supporting enterprises in internal digital governance will also drive more efficient transformations, further improving profitability.

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Author contributions

Debin Ma: Conceptualization; Methodology; Software; Validation; Visualization; Roles/Writing – original draft; Writing – review & editing.
Yanyun Wang: Data curation; Software.
Xiaoyu Zhang: Formal analysis.
Ziyi Wang: Supervision; Project administration.

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Appendix A

This paper selects a series of control variables (Controls) to account for the potential influence of other factors on the robustness of the empirical results, specifically including:(1) Firm Age (Age), represented by the natural logarithm of the company's years since establishment;(2) Tobin's Q (TobinQ), represented by the ratio of a company's market value to the replacement cost of its assets;(3) Intangible Asset Ratio (Intass), represented by the ratio of intangible assets to total assets;(4) Leverage Ratio (Lev), represented by the ratio of total liabilities to total assets;(5) Current Ratio (Car), represented by the ratio of current assets to total assets;(6) Independent Director Ratio (Dirratio), represented by the ratio of independent directors to the total number of directors;(7) Ownership Concentration 1 (OwnCon1), represented by the ratio of the largest shareholder's holdings to total shares;(8) Ownership Concentration 2 (OwnCon2), represented by the sum of the holdings of the second to the tenth largest shareholders as a proportion of total shares;(9) Price-Earnings Ratio (PE), represented by the proportion of net profit to operating revenue;(10) Board Size (Sowncon), represented by the natural logarithm of the number of board members. The descriptive statistical results of the data are shown in Table A1.

Table A1. Descriptive statistics.

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Indigtech	36,678	0.721	1.198	0	4.990
Inyylr	36,678	16.54	6.144	0	22.93
Tobinq	36,678	1.957	1.369	0	8.939
Lev	36,677	0.428	0.213	0.053	0.958
Intass	36,674	0.047	0.052	0	0.334
Car	36,677	0.575	0.205	0.095	0.958
OwnCon1	36,678	34.79	15.04	8.770	75.25
OwnCon2	36,675	24.68	13.33	2.330	57.12
Dirratio	36,678	0.382	0.072	0.250	0.600
PE	36,678	64.51	118.8	0	842.0
Sowncon	36,678	2.277	0.255	1.386	3.434
Age	36,678	2.838	0.370	1.609	3.497