

Collective Collaboration vs. Individual Pursuit: Digital Transformation and New-Quality Productive Forces in Enterprises from the Perspective of the Peer Effect



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Abstract: In the digital economy era, digital transformation serves as a crucial driver of enterprises' high-quality development. This study examines Chinese listed companies and develops an enterprise new quality productive forces index based on three dimensions: new quality laborers, new quality labor materials, and new quality labor objects. Through text analysis, the research assesses enterprise digital transformation and investigates its impact on new quality productive forces and transmission mechanisms. The findings demonstrate that digital transformation significantly enhances enterprises' new quality productive forces, a conclusion that remains robust after endogeneity concerns are addressed and multiple robustness tests are conducted. With respect to transmission mechanisms, digital transformation facilitates financing empowerment, labor empowerment, and quality empowerment, thereby alleviating financing constraints, optimizing labor resource structures, and enhancing innovation quality to promote enterprises' new quality productive forces. Heterogeneity analyses indicate that digital transformation has stronger positive effects on new quality productive forces among state-owned enterprises, nonlarge enterprises, organizations with high debt financing costs, and those with low information disclosure. Additional analysis reveals that enterprise digital transformation has peer effects and that the peer effect of digital transformation significantly enhances enterprises' new quality productive forces. This research broadens the microlevel understanding of new quality productive forces and provides policy recommendations for the governmental promotion of new quality productive force initiatives.

Keywords: digital transformation, new quality productive forces of enterprises, peer effect, quality of innovation, text analysis

1. Introduction

The report to the 20th National Congress of the Communist Party of China explicitly emphasized that “high-quality development is the primary task of building a modern socialist country in all respects” and “accelerate the implementation of the innovation-driven development strategy”. On January 31, 2024, while presiding over the first collective study of the Political Bureau of the Central Committee of the Communist Party of China, Chinese president Xi Jinping emphasized that “developing new quality productive forces is an inherent requirement and important focal point for promoting high-quality development. We must continue to advance innovation and promote the

accelerated development of new quality productive forces.” With the emergence of a new round of scientific and technological revolutions and industrial transformation, new quality productive forces—which represent the direction of advanced productive forces—have become critical drivers for advancing Chinese-style modernization and high-quality economic development through “innovation-driven” and “quality-oriented” approaches (Zhou & He, 2024; Chao & Wang, 2024). As primary drivers of scientific and technological innovation and industrial advancement, enterprises play a vital role in key areas where new quality productive forces materialize—strategic emerging industries and future industries. To promote new quality productive forces, leveraging enterprises'

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principal role in scientific and technological innovation is essential. Under the goal of achieving high-quality development, enterprises must increase their new quality productive forces development through increased research and development (R&D) investment in new technologies, processes, and materials to strengthen their independent innovation capabilities. The current literature on enterprises' new quality productive forces focuses primarily on theoretical discussions, with limited empirical analysis. This paper aims to provide a practical foundation for accelerating the development of new quality productive forces in enterprises by establishing a scientific and reasonable indicator system for measuring their development level.

With the widespread application of new-generation information technologies such as cloud computing, big data, and artificial intelligence, numerous enterprises have undergone digital transformation to varying degrees. It can promote financial performance through channels such as improving human capital efficiency and reducing carbon emission intensity and stock price crash risk by enhancing technological innovation capabilities (Shang et al., 2023; Wu et al., 2022). Currently, the digital transformation of enterprises in China is still in its initial stage. Small and medium-sized enterprises (SMEs) lag behind large enterprises in terms of digitalization and face challenges such as insufficient digital thinking, weak foundations, and transformation barriers (Shi et al., 2021). Industrial digitalization and fiscal expenditures on science and technology can drive enterprises' digital transformation (Wu et al., 2021). In this context, as a crucial driver of enterprises' high-quality development, can digital transformation promote the development of new quality productive forces? What is the underlying mechanism? On the basis of these questions, this paper integrates digital transformation and enterprises' new quality productive forces into a unified analytical framework, exploring the mechanism through which digital transformation empowers enterprises' new quality productive forces and the corresponding implementation paths. It further analyzes the impact of the peer effects of digital transformation on enterprises' new quality productive forces.

Given the current environment of heightened global economic uncertainty and accelerated technological advancement, the enhancement of enterprises' new quality productive forces through digital transformation has become central to academic and policy discussions. China's selection as

the research subject stems from its position as both the world's largest developing nation with a substantial market and its ongoing transition from "high-speed growth" to "high-quality development". This distinctive combination of a "superlarge transforming economy and a differentiated policy laboratory" presents an ideal context for examining how digital transformation influences enterprises' new quality productive forces, particularly given the current research gap regarding digital transformation in large developing nations. This paper makes three distinct contributions to the literature. First, using micro-level data from Chinese listed enterprises, we construct a three-dimensional development index for enterprises' new quality productive forces, which enriches the micro-level empirical research on new quality productive forces. Second, the study examines the impact of digital transformation on enterprises' new quality productive forces through multiple dimensions, analyzing both its overall effect and specific mechanisms of financing empowerment, labor empowerment, and quality empowerment, thus expanding the theoretical understanding of the microeffects of digital transformation. Third, by incorporating peer effects into the analytical framework, this research investigates how these effects influence enterprises' new quality productive forces, addresses the digital transformation paradox and provides policy guidance for the governmental support of enterprise development.

2. Theoretical Analysis and Research Hypotheses

2.1 The impact of digital transformation on enterprises' new quality productive forces

Through dynamic capabilities theory, Zhang & Long (2022) demonstrated that digital transformation significantly enhances enterprises' innovation performance. First, increased enterprise digitalization promotes innovation investment, output, and efficiency while fostering innovation momentum through reduced operational costs and enhanced organizational management innovation (Peng & Tao, 2022; An & Wen, 2022). Second, during digital transformation, enterprises establish unified data platforms that integrate data resources across business operations, creating comprehensive data systems. Finally, digital transformation creates additional innovation opportunities through new technologies and applications, enabling enterprises to develop products and services that better address market demand. Furthermore, it facilitates internal knowledge sharing and dissemination, fostering employee innovation awareness and driving

enterprise development. Building on the preceding theoretical analysis, we develop the following testable research hypothesis:

H1: Digital transformation helps improve enterprises' new quality productive forces.

2.2 Mechanisms of the impact of digital transformation on enterprises' new quality productive forces

Digital transformation empowers the development of new quality productive forces through three primary mechanisms at the enterprise level: financing empowerment through alleviating financing constraints; labor empowerment by facilitating high-quality and highly educated labor matching and improving the labor resource structure; and quality empowerment through optimized production factor resource allocation and enhanced innovation quality. The following analysis examines these mechanisms in detail.

First, with respect to financing empowerment, digital transformation effectively reduces enterprises' financing constraints, thereby enhancing new quality productive forces. Digital transformation improves information transparency through technologies such as big data and cloud computing, enabling real-time information sharing and providing investors with comprehensive insights into their operational status. Additionally, digital transformation expands financing opportunities through emerging digital financial platforms, characterized by low entry barriers and enhanced flexibility. This transformation enables enterprises to access broader financing channels while reducing associated costs.

Second, concerning labor empowerment, digital transformation increases the demand for highly educated and high-quality labor, optimizing the labor resource structure and facilitating labor transformation and upgrading. Digital transformation necessitates changes in production, management, and services, requiring corresponding adjustments in the labor resource structure. Highly educated personnel typically demonstrate superior learning and innovation capabilities, adapting more readily to automated, intelligent, and data-driven work environments. Moreover, scientific and technological innovation forms the foundation of enterprises' new quality productive forces. Highly educated personnel contribute to enterprise competitiveness through their specialized knowledge and skills. Digital transformation enhances the labor income share by increasing the demand for high-skilled, highly educated workers through human capital structure optimization (Xiao et al., 2022). These skilled

professionals drive continuous innovation through technological R&D and product development.

Finally, digital transformation enhances enterprise innovation quality, thereby improving new quality productive forces. Patent innovation quality represents a crucial element of enterprise core competitiveness. First, enhanced patent innovation quality stimulates enterprise innovation vitality, driving continuous technological and product R&D. Through technological advantages, enterprises can expand their market share and increase profitability, converting innovation potential into new quality productive forces. Additionally, high-quality patent innovation elevates product technical sophistication and value-added components, strengthening market competitiveness and brand positioning while meeting market requirements. Digital transformation provides robust data support for R&D innovation initiatives. This data-driven decision-making approach enhances R&D project success rates, leading to increased high-quality patent output. Furthermore, digital transformation facilitates cross-disciplinary innovation within enterprises. By eliminating departmental silos, it enables seamless collaboration across research, development, design, production, and sales functions, creating synergies that enhance innovation efficiency and quality. Thus, digital transformation addresses innovation challenges by improving enterprises' innovation quality and absorption-transformation capabilities (Zhuo & Chen, 2023).

On the basis of the above analysis, this paper proposes the following research hypothesis:

H2: Digital transformation promotes the development of enterprises' new quality productive forces through financing empowerment, labor empowerment, and quality empowerment.

2.3 The impact of peer effects in digital transformation on enterprises' new quality productive forces

Digital transformation, as a critical means of enhancing competitiveness and achieving high-quality development, encompasses both internal technological advancement and process optimization, as well as interenterprise learning and imitation, known as the "peer effect". Peer effects represent a common phenomenon in corporate behavior, contributing to enterprise value enhancement, although their impact varies between the manufacturing and service sectors (Cheng & Huang, 2023). In digital transformation, peer effects manifest through enterprises advancing transformation collectively via mutual learning, imitation, and

communication. These effects are evident in the exemplary role of successfully transformed leading enterprises. Additionally, through collaboration and resource sharing, enterprises can reduce transformation costs and improve efficiency. The manufacturing sector has significant industry-level and regional peer effects on digital transformation, promoting both ambidextrous innovation and supply chain stability (Wu & Cui, 2024; Du et al., 2023). Peer effects facilitate access to current technical information and successful case studies, accelerating technological innovation and enhancing product competitiveness. Moreover, technological exchanges among peer enterprises enable the rapid adoption of new technologies, generating market opportunities through mutual cooperation. Peer effects also allow enterprises to leverage successful experiences, optimize management processes, improve operational efficiency, and drive high-quality development (Huo et al., 2023). Consequently, peer effects in digital transformation accelerate technological innovation, enhance management efficiency, expand market share, and improve new quality productive forces. Drawing on these preceding observations, we propose the following research hypothesis:

H3: Peer effects in digital transformation promote the development of enterprises' new quality productive forces.

3. Research Design

3.1 Sample selection and data sources

In this paper, Chinese A-share listed enterprises from 2011--2022 are used as the initial research sample, and the impact of digital transformation on enterprises' new quality productive forces is empirically analyzed through a two-way fixed effects model. The sample selection follows these criteria: (1) exclude specifically treated (ST, *ST) listed enterprises and those with significant missing data; (2) exclude financial and real estate industry samples; and (3) Winsorize all continuous variables at the 1% and 99% levels to minimize potential outlier effects. The core explanatory variable—enterprise digital transformation index—is derived primarily from analyzing listed enterprises' annual reports via Python's text analysis technology. Additional relevant data are sourced from the CSMAR database. All regressions employ clustered robust standard errors.

3.2 Variable definitions

3.2.1 Enterprises' new quality productive forces (*Nqp*)

Measuring enterprises' new quality productive force development level represents a central focus of this research. New quality productive forces fundamentally rely on scientific and technological innovation, with innovation-driven development at its core. The literature has developed indicator systems for new quality productive forces from both macro and micro perspectives. At the macro level, scholars have constructed new regional quality productivity indicator systems across three dimensions: new quality laborers, new quality labor materials, and new quality labor objects, drawing from labor factor theories (Han et al., 2024). At the micro level, Song et al. (2024) evaluated enterprises' new quality productive force development through a two-dimensional framework of the labor force and labor tools on the basis of the two-factor theory of labor.

New-quality productive forces exhibit distinct characteristics of disruptive innovation while embodying the contemporary attribute of greenization (Li, 2023). Based on existing studies, this paper incorporates the enterprise green transformation index and sustained green innovation level index to measure the development level of enterprises' new quality productive forces and construct a development index from three dimensions: new quality laborers, new quality labor materials, and new quality labor objects.

The new-quality labor dimension encompasses three subindicators: the proportion of R&D personnel salaries, the proportion of R&D personnel, and the proportion of highly educated personnel. The new quality labor materials dimension consists of four subindicators: the proportion of R&D depreciation and amortization, the proportion of R&D lease expenses, the proportion of direct R&D investment, and the proportion of intangible assets. The new quality labor objects dimension comprises four subindicators: the proportion of fixed assets, the proportion of manufacturing expenses, the green transformation index, and the sustained green innovation level index. The entropy method calculates the weights of each indicator to form the development index for enterprises' new quality productive forces.

3.2.2 Enterprise digital transformation (*Tdigital*)

Enterprise digital transformation represents a systematic process, and accurately measuring the degree of digital transformation at the microenterprise level presents specific challenges. In this paper, the Python text-analysis method is employed to assess the level of enterprise digital

transformation. The specific steps are as follows:

First, the Python crawler function is used to collect the annual reports of listed enterprises and extract the “Management Discussion and Analysis” section.

The classic literature on digital transformation (Wu et al., 2021) and important policy documents such as the “Special Action Plan for Digital Empowerment of Small Enterprises in China” establish a feature-word spectrum across five aspects: artificial intelligence technology, big data technology, cloud computing technology, blockchain technology, and digital technology application.

Finally, the above feature word map is integrated into the “Jieba” Chinese word segmentation library, machine learning methods are employed to search, match, and perform word frequency statistics on the “Management Discussion and Analysis (MD&A)” section, and the word frequencies are aggregated to establish an enterprise digital transformation index system.

3.2.3 Control variables

To increase research accuracy, this paper incorporates a series of control variables, including firm age (*Age*), management fees (*Mfee*), the institutional ownership ratio (*Institution*), firm size (*Size*), the shareholding ratio of the largest shareholder (*Top*), duality (*Duality*, i.e., whether the chairperson and general manager are the same person), audit opinion (*Opinion*), board size (*Board*), the proportion of independent directors (*Pind*), and return on equity (*Roe*).

3.3 Model specification and empirical strategy

To analyze the impact of digital transformation on enterprises' new quality productive forces, Equation (1) is used for empirical testing:

$$Nqp_{it} = \phi_0 + \phi_1 Tdigital_{it} + \sum_j \phi_j Controls_{it} + \sum Year + \sum Ind + \varepsilon_{it} \quad (1)$$

In the regression model, the dependent variable represents enterprises' new quality productive forces (*Nqp*), the core explanatory variable denotes enterprise digital transformation (*Tdigital*), *Controls* indicates a series of control variables, and ε represents the random error term. The regression equations employ statistics adjusted for clustered robust standard errors. Additionally, this paper controls for industry (*Ind*) and year (*Year*) dummy variables to capture fixed effects comprehensively.

To examine the mechanism through which digital transformation affects enterprises' new quality productive forces, this paper employs a mediating effect model and introduces three mediating variables:

financing constraints (*FC index*), labor resource structure (*Labor*), and innovation quality (*Iquality*). The investigation focuses on whether digital transformation influences the development of enterprises' new quality productive forces through three channels: alleviating financing constraints, optimizing the labor resource structure, and improving innovation quality. The models are constructed as follows:

$$Mechanism_{it} = \beta_0 + \beta_1 Tdigital_{it} + \sum_j \beta_j Controls_{it} + \sum Ind + \sum Year + \varepsilon_{it} \quad (2)$$

$$Nqp_{it} = \delta_0 + \delta_1 Tdigital_{it} + \delta_2 Mechanism_{it} + \sum_j \delta_j Controls_{it} + \sum Ind + \sum Year + \varepsilon_{it} \quad (3)$$

In Equation (2), *Mechanism_{it}* represents the mediating variables, comprising financing constraints (*FC index*), labor resource structure (*Labor*), and innovation quality (*Iquality*).

To investigate the presence of peer effects in enterprise digital transformation and their influence on the development of enterprises' new quality productive forces, this study employs the peer effect model developed by Huo et al. (2023). The model specifications are as follows:

$$Tdigital_{it} = \alpha_0 + \alpha_1 Ieffect_{it} + \sum_j \alpha_j Controls_{it} + \sum Ind + \sum Year + \varepsilon_{it} \quad (4)$$

$$Tdigital_{it} = \rho_0 + \rho_1 Reffect_{it} + \sum_j \rho_j Controls_{it} + \sum Ind + \sum Year + \varepsilon_{it} \quad (5)$$

$$Nqp_{it} = c_0 + c_1 Ieffect_{it} + \sum_j c_j Controls_{it} + \sum Ind + \sum Year + \varepsilon_{it} \quad (6)$$

$$Nqp_{it} = d_0 + d_1 Reffect_{it} + \sum_j d_j Controls_{it} + \sum Ind + \sum Year + \varepsilon_{it} \quad (7)$$

In this model, *Ieffect* denotes the digital transformation level among industry peers, which is calculated as the mean value of the digital transformation levels of other enterprises within the same industry as the target enterprise. *The effect* represents the digital transformation level among regional peers, measured by the mean value of the digital transformation levels of other enterprises registered in the same province as the target enterprise.

4. Empirical Analysis

4.1 Descriptive statistics

Table 1 presents the descriptive statistical results of the main variables. The mean value of enterprises' new quality productive forces (*Nqp*) is 18.6182, with a standard deviation of 8.9018, indicating that substantial variation in new quality productive forces development levels across enterprises and considerable potential for improvement in China's

new quality productive forces. Analysis of the control variables reveals notable differences in enterprise attributes, with significant variation in firm size, the institutional ownership ratio, and other indicators.

This diverse sample coverage ensures effective control of research factors and strengthens the reliability of the empirical results. Additional variable details are provided in Table 1.

Table 1 Descriptive Statistics of the Variables

Variable	Variable Name	Observations	Mean	Standard Deviation
<i>Nqp</i>	enterprises' new quality productive forces	25696	18.6182	8.9018
<i>Tdigital</i>	enterprise digital transformation	25696	12.5711	27.9606
<i>Age</i>	firm age	25696	18.5719	5.5987
<i>Top</i>	shareholding ratio of the largest shareholder	25696	33.7154	14.7350
<i>Pind</i>	proportion of independent directors	25696	0.3755	0.0533
<i>Board</i>	board size	25696	2.1300	0.1980
<i>Duality</i>	whether the chairperson and general manager are the same person	25696	0.2670	0.4424
<i>Opinion</i>	audit opinion	25696	0.9673	0.1778
<i>Size</i>	firm size	25696	22.2888	1.2709
<i>Institution</i>	institutional ownership ratio	25696	44.7749	24.7033
<i>Roe</i>	return on equity	25696	0.0526	0.1512
<i>Mfee</i>	management fees	25696	0.0886	0.0722

4.2 Baseline regression test

This study employs a stepwise regression methodology to examine the relationship between digital transformation and enterprises' new quality productive forces, with the findings presented in Table 2. Column (1), which incorporates only year and industry fixed effects without control variables, reveals that the regression coefficient of digital transformation is 0.0373, demonstrating statistical significance at the 1% level. These findings suggest that enterprises implementing digital transformation demonstrate enhanced levels of new quality

productive forces on average.

Columns (2)–(4) display the regression results with the progressive inclusion of control variables. The regression coefficients of digital transformation (*Tdigital*) maintain statistical significance at the 1% level across all specifications, confirming the substantial positive influence of digital transformation on enterprises' new quality productive forces and its role in fostering high-quality enterprise development. These results demonstrate that digital transformation significantly enhances enterprises' new quality productive forces, providing robust support for research hypothesis H1.

Table 2 Baseline regression test

	(1)	(2)	(3)	(4)
	<i>Nqp</i>	<i>Nqp</i>	<i>Nqp</i>	<i>Nqp</i>
<i>Tdigital</i>	0.0373*** (0.0057)	0.0369*** (0.0057)	0.0361*** (0.0057)	0.0331*** (0.0055)
<i>Age</i>		-0.0691*** (0.0212)	-0.0747*** (0.0213)	-0.0882*** (0.0210)
<i>Top</i>		-0.0015 (0.0075)	-0.0020 (0.0075)	-0.0197** (0.0080)
<i>Pind</i>		0.5895 (1.6798)	7.3769*** (1.9526)	4.3110** (1.9365)
<i>Board</i>			3.4792*** (0.6475)	1.9388*** (0.6277)
<i>Duality</i>			-0.0393 (0.2065)	0.1718 (0.2041)
<i>Opinion</i>			0.4628 (0.3580)	0.8697** (0.3591)
<i>Size</i>				0.7780*** (0.1296)
<i>Institution</i>				0.0182*** (0.0047)
<i>Roe</i>				-0.6963 (0.4321)
<i>Mfee</i>				11.2739*** (1.8254)
<i>Industry FE</i>	YES	YES	YES	YES
<i>Year FE</i>	YES	YES	YES	YES
<i>R²</i>	0.357	0.359	0.364	0.378
<i>N</i>	26080	26071	25697	25696

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively; clustered robust standard errors are reported in parentheses, and the same applies below.

4.3 Endogeneity test

The baseline regression analysis may exhibit endogeneity concerns arising from omitted variables or reverse causality. To address these potential issues, this study employs the instrumental variable (IV) methodology for model re-estimation. Following established practices and drawing from Zhao (2023), the first lag of enterprise digital transformation serves as an initial instrumental variable. Additionally, following the methods of Derenoncourt (2022) and Zhao et al. (2021), this study implements the Bartik instrumental variable as a second instrument for enterprise digital transformation. The construction of the Bartik instrumental variable follows Equation (8):

$$Bartik_{IV_{ijt}} = Tdigital_{j,t-1} * \frac{1}{n} \left(\sum_{j=1}^n Tdigital_{j,t} - \sum_{j=1}^n Tdigital_{j,t-1} \right) \tag{8}$$

The Bartik instrumental variable functions as a “predicted value” of enterprise digital transformation. The variable's construction reflects the inherent

inertia in digital transformation, where future “predicted values” depend on historical states, thus satisfying instrumental variable relevance requirements. Furthermore, the lagged difference of the digital transformation index maintains relative exogeneity to enterprises' new quality productive forces, ensuring that the Bartik instrumental variable fulfills both relevance and exogeneity conditions.

Table 3 presents the instrumental variable regression results. Columns (1) and (2) demonstrate that in the regressions of *Tdigital* on the instrumental variables *L.Tdigital* and *Bartik_Tdigital*, both coefficients are statistically significant at the 1% level, confirming their satisfaction with the relevance condition. The second-stage results in Columns (3) and (4) reveal that the regression coefficient of digital transformation (*Tdigital*) remains statistically significant at the 1% level. These findings indicate that digital transformation continues to increase enterprises' new quality productive forces after endogeneity concerns are addressed, providing

additional support for research hypothesis H1.

The Kleibergen–Paap rk LM statistics are significant at the 1% level for both instrumental variables, whereas the Cragg–Donald Wald F statistics exceed the Stock–Yogo weak instrument F

test critical values at the 10% significance level. These statistical indicators confirm the reliability of the selected instrumental variables and substantiate the robustness of the baseline findings.

Table 3 Endogeneity Test

	first stage		second stage	
	(1)	(2)	(3)	(4)
	<i>Tdigital</i>	<i>Tdigital</i>	<i>Nqp</i>	<i>Nqp</i>
<i>Tdigital</i>			0.0216*** (0.0038)	0.0402*** (0.0034)
<i>Bartik_Tdigital</i>	0.3575*** (0.0122)			
<i>L.Tdigital</i>		0.9103*** (0.0082)		
<i>Controls</i>	YES	YES	YES	YES
<i>Industry FE</i>	YES	YES	YES	YES
<i>Year FE</i>	YES	YES	YES	YES
<i>R²</i>	0.662	0.642	0.377	0.359
<i>N</i>	25635	21818	25635	21818

4.4 Robustness Test

4.4.1 Replacement of the dependent variable

Productivity represents the amount of production factors needed to generate a unit of product or service in a specified timeframe. Productivity improvements drive the advancement of productive forces. The essence of new quality productive forces centers on enhancing total factor productivity (*TFP*), which is fundamentally linked to new quality productive forces. Consequently, *in the robustness test*, *TFP* is employed as an alternative variable for enterprises' new quality productive forces. To measure enterprise *TFP*, this study utilizes two methods: the Levinsohn–Petrin (LP) approach and ordinary least squares (OLS), with the findings presented in Table 4. As indicated in Columns (1) and (2) of Table 4, irrespective of the measurement method, the regression coefficients for digital transformation (*Tdigital*) demonstrate significant positive values at the 1% significance level. These findings confirm that digital transformation positively influences the development of enterprises' new quality productive forces, supporting the main conclusions of this research.

4.4.2 Explanatory variable replacement

Variations in digital transformation measurement methods may influence the results. To further investigate the impact of digital

transformation on enterprises' new quality productive forces, this study adopts the methodology of Zhao et al. (2021) and develops an enterprise digital transformation index (*Rdigital*) by analyzing keyword frequency disclosures across four dimensions: digital technology application, internet business models, smart manufacturing, and modern information systems. The findings are presented in Table 4. The coefficient of *Rdigital* in Column (3) is significantly positive at the 1% level, which aligns with the baseline results.

4.4.3 Altering the sample study period

The “Internet Plus” initiative was incorporated into the Government Work Report in 2015, following which regions throughout China implemented “Internet Plus” execution plans to guide enterprise digital transformation through policy measures. Various enterprises responded to governmental directives by accelerating their digital transformation initiatives from 2015 onward. To strengthen the robustness of the results, this study adjusts the sample study period by analyzing data after 2015 and conducting new regression analyses. Column (4) of Table 4 demonstrates that digital transformation (*Tdigital*) continues to significantly increase enterprises' new quality productive forces after the sample period adjustment, which is consistent with the baseline regression results.

Table 4 Robustness test

	(1)	(2)	(3)	(4)
	<i>TFP LP</i>	<i>TFP OLS</i>	<i>Nqp</i>	<i>Nqp</i>
<i>Tdigital</i>	0.0023*** (0.0004)	0.0012*** (0.0003)		0.0274*** (0.0056)
<i>Rdigital</i>			0.0107*** (0.0025)	
<i>Controls</i>	YES	YES	YES	YES
<i>Industry FE</i>	YES	YES	YES	YES
<i>Year FE</i>	YES	YES	YES	YES
<i>R²</i>	0.794	0.881	0.376	0.307
<i>N</i>	25337	25337	25337	18601

4.5 Mechanistic test

The results of the theoretical analysis presented earlier suggest that digital transformation provides enterprises with financing empowerment, labor empowerment, and quality empowerment capabilities. This paper employs a mediation effect test to examine the mechanisms through which digital transformation influences enterprises' new quality productive forces, focusing on three aspects: alleviating financing constraints, optimizing the labor resource structure, and enhancing innovation quality.

4.5.1 Financing empowerment mechanism

To assess enterprise financing constraints, this paper adopts the methods of Han & Yu (2024) and Xiao et al. (2024), utilizing the FC index to measure financing constraints—where higher FC index values indicate more severe financing constraints. The mechanism test results are presented in Table 5. Columns (1) and (2) present the financing empowerment mechanism. The regression coefficient of digital transformation (*Tdigital*) on the mediating variable (*FC index*) shows a significant negative correlation, demonstrating that digital transformation substantially reduces enterprises' financing constraints. Column (2) reveals that both the regression coefficients of digital transformation (*Tdigital*) and financing constraints (*FC index*) on new quality productive forces are significant at the 1% level, with the FC index coefficient showing a significant negative correlation. These findings indicate that financing constraints serve as partial mediators, significantly impacting enterprises' new quality productive force development. These findings confirm that digital transformation functions as a financing empowerment tool, enhancing enterprises' new quality productive forces by reducing financing

constraints.

4.5.2 Labor empowerment mechanism

Previous analysis indicates that enterprise digital transformation necessitates high-skill and high-quality talent, potentially driving enterprises to optimize their labor resource structure and recruit innovative employees, thereby enhancing new-quality productive force development. To validate this labor empowerment mechanism, this paper references the literature (Zhao, 2023; Xiao et al., 2022) and analyzes employee structural data from listed companies, characterizing the labor resource structure through educational attainment levels. The variable *Labor* represents the ratio of employees holding master's degrees or higher to the total workforce.

Column (3) of Table 5 shows that the regression coefficient of enterprise digital transformation (*Tdigital*) is significantly positive at the 1% level. These findings demonstrate that digital transformation significantly increases the proportion of highly educated and high-quality talent, encouraging enterprises to increase employee skill levels and optimize their labor resource structure. Column (4) indicates that both the digital transformation (*Tdigital*) and the mediating variable (*Labor*) regression coefficients are significantly positive, confirming the mediating effect of the labor resource structure between digital transformation and enterprises' new quality productive forces. These results demonstrate that digital transformation enhances new quality productive forces by optimizing the labor resource structure through increased recruitment of highly educated and high-quality talent.

4.5.3 Quality empowerment mechanism

The results of the theoretical analysis suggest

that digital transformation enhances enterprise innovation quality, thereby improving new quality productive forces through quality empowerment. Innovation quality is measured with reference to the study by Bradley et al. (2017), which uses the number of non-self-citations of listed companies' patents^[26]. Innovation quality (*Iquality*) is defined as the natural logarithm of (the total number of nonself citations to patents applied for by the enterprise in the subsequent year plus 1). In general, the greater the number of nonself citations a company's applied patents receive, the greater the quality of its innovation. Columns (5) and (6) of Table 5 present the results for the innovation quality empowerment

mechanism. The regression coefficient of digital transformation (*Tdigital*) on innovation quality (*Iquality*) is significantly positively correlated at the 1% level, indicating that digital transformation enhances enterprise innovation quality. Additionally, both digital transformation (*Tdigital*) and innovation quality (*Iquality*) demonstrate significantly positive regression coefficients on enterprises' new quality productive forces (*Nqp*), confirming the significant mediating effect of enterprise innovation quality. These findings confirm that digital transformation operates through a quality empowerment mechanism, enhancing new quality productive forces by improving enterprise innovation quality.

Table 5 Mechanism Test: Financing Empowerment, Labor Empowerment, and Quality Empowerment

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>FC</i>	<i>Nqp</i>	<i>Labor</i>	<i>Nqp</i>	<i>Iquality</i>	<i>Nqp</i>
<i>Tdigital</i>	-0.0002** (0.0001)	0.0412*** (0.0051)	0.0002*** (0.0000)	0.0168*** (0.0037)	0.0057*** (0.0008)	0.0242*** (0.0054)
<i>FC</i>		-1.7784*** (0.4632)				
<i>Labor</i>				83.1643*** (1.6690)		
<i>Iquality</i>						1.3312*** (0.1011)
<i>Controls</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>
<i>Industry FE</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>
<i>Year FE</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>
<i>R²</i>	0.871	0.802	0.216	0.604	0.494	0.425
<i>N</i>	24863	24863	25696	25696	20438	20438

5. Further Analysis

5.1 Heterogeneity test of the impact of digital transformation on enterprises' new quality productive forces

Given that the development levels of new quality productive forces vary among enterprises with different attributes, this study conducts a heterogeneity test across four dimensions, i.e., property rights attributes, size attributes, debt financing costs, and information disclosure levels, to examine the differential effects of digital transformation on enterprises' new quality productive forces.

1. Heterogeneity in property rights attributes. The impact of digital transformation on enterprises' new quality productive forces may vary because of differences in property rights attributes. Private enterprises prioritize profit maximization, resulting in more focused business objectives; conversely, state-owned enterprises (SOEs) pursue multiple goals, balancing profit generation with broader social

responsibilities. This analysis divides the full sample into state-owned enterprises (SOE=1) and nonstate-owned enterprises (SOE=0). As illustrated

in Columns (1) and (2) of Table 6, digital transformation has a more pronounced effect on state-owned enterprises' new quality productive forces. This enhanced effect may stem from SOEs' access to stable funding sources and financing channels. During digital transformation initiatives, these enterprises possess relatively abundant capital and talent resources while benefiting from increased government support. These advantages enable comprehensive digital transformation implementation and superior enhancement of new quality productive force levels.

2. Heterogeneity in Size Attributes. The influence of digital transformation on new quality productive forces varies widely across different enterprise sizes. Using median grouping, this study categorizes the full sample into large enterprises (Size=1) and nonlarge enterprises (Size=0). As

demonstrated in Columns (3) and (4) of Table 6, the regression coefficients of digital transformation on new quality productive forces for large and nonlarge enterprises are 0.0250 and 0.0378, respectively—both statistically significant at the 1% level. Digital transformation has a stronger effect on the new quality productive forces of nonlarge enterprises. This heightened effect may arise from nonlarge enterprises' greater imperative to achieve market catch-up through digital transformation. When nonlarge enterprises establish suitable conditions for digital transformation, they often attract increased capital market attention, initiating a cascade effect that enhances new quality productive forces.

3. Heterogeneity in Debt Financing Costs. The effectiveness of digital transformation varies according to enterprises' debt financing costs. Debt financing cost levels influence both enterprises' financing decisions and their investment in new quality productive forces. Moreover, excessive debt financing costs may lead to underinvestment in talent acquisition and development because of debt repayment pressure, ultimately affecting the development of new quality productive forces. In this analysis, a debt financing cost variable (Debt, calculated as the ratio of debt expenses to total debt) is constructed, and the sample is separated into high debt financing cost (Debt=1) and low debt financing cost (Debt=0) groups. Columns (5) and (6) of Table 6 reveal larger regression coefficients for digital transformation in the high debt financing cost group, suggesting enhanced effectiveness in developing new quality productive forces. This occurs because enterprises with high debt financing costs typically face substantial financial pressure: digital transformation reduces operational costs through advanced information technology, expands financing channels, and alleviates funding constraints. Through

digital platforms, these enterprises establish stronger investor connections, attracting additional financial support and promoting new-quality productive forces development. Conversely, enterprises with low debt financing costs often possess stable funding sources and sufficient capital, potentially reducing their digital transformation motivation.

4. Heterogeneity in Information Disclosure Levels. The impact of digital transformation on enterprises' new quality productive forces varies on the basis of information disclosure levels. Enhanced information disclosure enables stakeholders to better understand enterprise development, facilitating capital and talent attraction for technological innovation. Additionally, high information disclosure helps enterprises establish positive brand images, demonstrate integrity and responsibility, and gain competitive advantages, further promoting new quality productive forces improvements. This study employs Kim and Verrecchia's (2001) methodology to measure information disclosure levels, categorizing enterprises into high information disclosure (KV=1) and low information disclosure (KV=0) groups.

As shown in Columns (7) and (8) of Table 6, digital transformation has a more substantial positive effect on new quality productive forces among enterprises with low information disclosure. This enhanced effect may occur because digital transformation effectively reduces information asymmetry and principal-agent costs (Xie et al., 2021), addressing financing challenges caused by insufficient information disclosure—providing crucial support when needed. For enterprises with high information disclosure, the marginal effect of digital transformation on reducing information asymmetry decreases, resulting in relatively weaker new quality productive forces promotion.

Table 6 Heterogeneity impact analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	state-owne d	non-state-owne d	large	nonlarg e	high debt financin g costs	low debt financin g costs	low informatio n disclosure	high informatio n disclosure
	<i>Nqp</i>	<i>Nqp</i>	<i>Nqp</i>	<i>Nqp</i>	<i>Nqp</i>	<i>Nqp</i>	<i>Nqp</i>	<i>Nqp</i>
<i>Tdigital</i>	0.0690***	0.0266***	0.0250** *	0.0378** *	0.0382** *	0.0289** *	0.0362***	0.0286***
	(0.0146)	(0.0053)	(0.0089)	(0.0064)	(0.0072)	(0.0066)	(0.0070)	(0.0057)
<i>Control s</i>	YES	YES	YES	YES	YES	YES	YES	YES
<i>Industr y FE</i>	YES	YES	YES	YES	YES	YES	YES	YES
<i>Year FE</i>	YES	YES	YES	YES	YES	YES	YES	YES
<i>R²</i>	0.405	0.404	0.391	0.397	0.384	0.400	0.364	0.373
<i>N</i>	9933	15759	12809	12883	12042	12086	12289	12268

5.2 The impact of peer effects in digital transformation on enterprises' new quality productive forces

Enterprise digital transformation decisions are influenced by both internal resource endowments and external stakeholders, particularly peer groups. Social interactions within interconnected peer groups, encompassing competition, imitation, and pressure, directly influence enterprises' digital transformation motivations and behaviors (Chen et al., 2021). Additionally, industry peer groups with similar business scopes and regional peer groups sharing common external business environments serve as valuable references for target enterprises' digital transformation decisions. Within these clusters, group members generate spillover effects on target enterprises through technological transfer and infrastructure sharing, facilitating digital transformation initiatives. While the relationship between peer effects in digital transformation and enterprises' new quality productive forces merits investigation, the current research has not thoroughly examined this connection. This study initially evaluates the presence of peer effects in enterprise digital transformation via Formulas (4) and (5) and then analyzes their impact on new quality productive forces via Formulas (6) and (7). Table 7 presents the findings. Column (1) reveals that the regression coefficient of digital transformation by industry peer

enterprises (*Ieffect*) on target enterprises' digital transformation is 0.5327, which is statistically significant at the 1% level. Similarly, Column (2) shows that the regression coefficient of digital

transformation by regional peer enterprises (*Reffect*) is 0.1572, which is also significant at the 1% level. These results conclusively demonstrate significant peer effects in both industry and regional enterprise digital transformation, indicating that enhanced digital transformation among peer enterprises motivates target enterprises to pursue similar initiatives. Columns (3) and (4) indicate that the regression coefficients of industry and regional peer effects on target enterprises' new quality productive forces are 0.1694 and 0.1086, respectively, both of which are significant at the 1% level. These findings substantiate that peer effects in digital transformation significantly increase enterprises' new quality productive forces.

Table 7 Test of the Relationship between Peer Effects in Digital Transformation and Enterprises' New Quality Productive Forces

	(1)	(2)	(3)	(4)
	<i>Tdigital</i>	<i>Tdigital</i>	<i>Nqp</i>	<i>Nqp</i>
<i>Ieffect</i>	0.5327*** (0.0633)		0.1694*** (0.0131)	
<i>Reffect</i>		0.1572*** (0.0599)		0.1086*** (0.0195)
<i>Controls</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>
<i>Industry FE</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>
<i>Year FE</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>	<i>YES</i>
<i>R²</i>	0.433	0.423	0.382	0.377
<i>N</i>	25633	25696	25662	25725

6. Conclusions and Implications

Enterprise digital transformation serves as a powerful driver for the emergence and growth of new quality productive forces. Using A-share listed firms from 2011 to 2022 as the empirical sample, this paper develops an evaluation index for enterprise new quality productive forces from three aspects: new-quality laborers, new-quality labor materials, and new-quality labor objects. Employing text analysis techniques, the study measures firms' digital transformation intensity and then explores its effects on new quality productive forces, together with the relevant mechanisms and heterogeneous determinants. From the standpoint of peer effects, it further analyzes how digital transformation spillovers among peers are related to enterprises' new quality productive forces. The empirical results show that digital transformation markedly promotes enterprises' new quality productive forces, and this conclusion remains valid after accounting for endogeneity and passing a range of robustness checks. Mechanism tests suggest that the enhancement operates through three main pathways: easing financing constraints, improving the allocation of labor resources, and raising innovation quality. These results highlight the financing, labor, and quality empowerment roles of digital transformation within firms. Heterogeneity analysis shows that the positive effect is more pronounced in state-owned enterprises, nonlarge enterprises, firms facing higher debt financing costs, and enterprises with lower levels of information disclosure. Additional evidence indicates that enterprise digital transformation generates notable industry and regional peer effects, which in turn

significantly strengthen firms' new quality productive forces. On the basis of the above research conclusions, this paper has the following implications:

First, enterprises' awareness of digital transformation should increase, and its implementation should be systematically advanced. Governments should introduce relevant policies and financial support measures to encourage enterprises to increase their investment in digital transformation. For enterprises that achieve notable results in digital transformation, governments can provide incentives such as tax breaks to mitigate their costs and risks.

Second, regulatory and evaluation mechanisms for enterprise digital transformation should be established to ensure high-quality development. Governments should establish standards and evaluation systems for digital transformation, regularly assess the progress and effectiveness of enterprises' digital transformation, and provide recommendations for improvement and optimization.

Third, leverage the peer effects of enterprise digital transformation to increase enterprises' new quality productive forces. Governments can establish industry exchange platforms for digital transformation, cultivate digital transformation benchmarks within regional or industrial contexts, and develop digital industry innovation alliances. These initiatives facilitate information sharing among enterprises and maximize the positive effects of digital transformation peer effects on new quality productive forces development.

Fourth, enterprises should be guided toward high-quality development, and the endogenous

drivers of new quality productive forces should be activated. The analysis demonstrates that alleviating financing constraints, optimizing the labor resource structure, and improving innovation quality significantly increase enterprises' new quality productive forces. Therefore, governments should foster an equitable financial ecosystem, encouraging financial institutions to develop customized, low-cost financing services. They should guide enterprises to prioritize digital transformation talent cultivation and recruitment. By establishing industry-academia-research exchange platforms and enhancing scientific and technological achievement transformation, governments can support enterprises in improving their patent products' innovative quality. These efforts collectively drive the enhancement of enterprises' new quality productive forces.

Conflict of Interest

The authors declare that they have no conflicts of interest to this work.

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