

Enterprise New-Quality Productive Forces and the Improvement of Human Capital Level

Yilun Chen^a, Qiqi Song^b

School of Business, Liaoning University, Shenyang 110000, China;

^a15258745315@163.com, ^bqinianbanla@foxmail.com

Abstract. The world has gradually entered the era of digital economy, and in this context, vigorously enhancing the new-quality productive forces of enterprises has become an important path to promote the high-quality development of enterprises. Based on the data of A-share listed companies from 2014 to 2023, this paper studies the influence mechanism of enterprise new-quality productive forces on the level of human capital. The study finds that enterprise new-quality productive forces have a positive impact on the level of human capital, and this conclusion still holds after a series of robustness tests. Heterogeneity analysis shows that the promoting effect of enterprise new-quality productive forces on the level of human capital is more significant in central region enterprises, state-owned enterprises and non-competitive industries. Mechanism analysis indicates that enterprise new-quality productive forces promote the improvement of human capital level by strengthening the resource integration capacity of enterprises and increasing the level of knowledge diversification. The above results are highly consistent with the internal action mechanism of empowering the upgrading of enterprise human capital through new-quality productive forces. This paper has certain significance for developing enterprise new-quality productive forces and formulating strategies to improve the level of enterprise human capital.

Keywords: New Quality Productive Forces of Enterprises, Human Capital Level, Resource Integration Capability, Knowledge Diversification.

1. Introduction

With the fast growth of digital technologies and AI, enterprises gain empowerment yet face various uncertainties. Developing new-quality productive forces is vital for enterprises to tackle such challenges and realize high-quality development, which has also been stressed in national policies and official documents. Relevant data prove that enterprises driven by new-quality productive forces enjoy better profitability and greatly boost industrial growth. Thus, it is necessary to study the influencing effects of enterprises' new-quality productive forces to support their sound development and national economic high-quality growth.

Against the digital background, enterprise new-quality productivity enables firms to boost economic benefits through new technologies and approaches. Existing studies mostly discuss its influencing factors and economic effects. Scholars have verified its role in reducing corporate debt default risk, and identified multiple drivers including government digital governance, specialized credit development, and digital supply chain construction. On this basis, this study further investigates how enterprise new-quality productivity affects human capital upgrading.

Based on endogenous economic growth theory, technological progress and total factor productivity drive sustained economic growth. Digital technologies centering on data factors have reshaped economic operation logic and promoted overall upgrading of productivity and production modes. To develop new-quality productive forces, enterprises have growing demand for high-skilled human capital, thus increasing human capital investment and improving human capital quality. Previous studies also indicate that new-quality productive forces enhance corporate resource integration capacity; digital transformation alleviates financing constraints and strengthens enterprise innovation resilience, while deep AI application promotes diversified enterprise knowledge development, which optimizes knowledge allocation, improves R&D efficiency and sustains corporate competitive advantages. In addition, the growth of enterprise new-quality productive forces

improves workers' wage bargaining power, which directly reflects labor-capital income distribution and bilateral negotiation status.

This paper makes three main contributions. Firstly, it extends relevant research on enterprise new-quality productive forces. Prior studies mainly discuss its driving factors including technological innovation, financing alleviation, and institutional effects, while this study further explores its underlying mechanisms affecting corporate human capital. Secondly, it broadens the research boundary concerning the nexus between new-quality productive forces and human capital. Existing literature mostly analyzes how new-quality productive forces facilitate high-quality economic growth or optimize enterprise labor division, whereas this paper focuses on its influence on human capital upgrading to enrich relevant theoretical research. Thirdly, it verifies that sustained development of new-quality productive forces elevates enterprises' internal technical and managerial capabilities, fosters innovative environment and capacity, and thus helps attract high-end talents and strengthen corporate market competitiveness.

The remainder of this paper is structured as follows: Section 2 reviews existing literature; Section 3 presents research hypotheses and empirical design; Section 4 analyzes empirical results; Section 5 conducts further discussion; and Section 6 concludes the study.

2. Literature Review

Research on Corporate New-Quality Productive Forces. Listed companies improve internal and external resource integration via technological innovation, factor innovation and organizational restructuring when developing new-quality productive forces. Factor combination efficiency, a core indicator of resource integration capacity, can be enhanced by new-quality productive forces, which also boosts total factor productivity and corporate operational efficiency through optimizing production processes and management modes (Zhang et al., 2025).

New-quality productive forces improve corporate operational efficiency from multiple aspects including resource allocation and technological innovation, strengthening firms' resilience and supporting their high-quality development. Existing studies indicate that such productivity affects internal wage disparity, employees' work efficiency and welfare, boosts corporate innovation performance, enhances enterprise investment value under relaxed market access, and improves overall operating performance (Cirillo V et al., 2017; Wang B et al., 2020; Wu Qiang et al., 2024; Chen Yizao et al., 2024; Yang Feihu et al., 2026).

New-quality productive forces strongly drive industrial and macroeconomic development, promoting industrial structure upgrading, strengthening industrial chain resilience and boosting total factor productivity to support high-quality economic development. Existing studies show they enhance enterprises' crisis resilience (Williams et al., 2017), that their focus on automation may disadvantage labor (Acemoglu D & Restrepo P, 2019), and that their core driver—technological innovation—helps enterprises reduce costs, optimize industrial chains and promote industrial structure upgrading (Xu Ziyao et al., 2024; Li Haixia et al., 2025).

Related Research on Human Capital Level. A large number of studies on corporate human capital have been conducted. Scholars adopt diverse measurement indicators, including individual knowledge, ability and health (Wang Yunbo et al., 2018), educational attainment (Faggian A & McCann P, 2008), as well as knowledge-based and experience-based human capital (Li Zibiao et al., 2020). Moreover, prior research mainly explores micro and macro drivers of corporate human capital upgrading.

At the micro level, technological application, digital transformation and foreign technology inflow replace routine work and match high-skill tasks, raising corporate demand for skilled labor and upgrading internal human capital structure. Studies have verified that computer technology favors high-skilled human capital (Autor et al., 2003), digital transformation improves overall human capital quality (Yami et al., 2020), imported advanced technologies upgrade labor skill structure (Liu

Chenyang et al., 2021), and digital development expands demand for skilled talents to optimize human capital allocation (Ye Yongwei et al., 2022).

At the macro level, tax incentives, improved financing and green transformation facilitate corporate human capital upgrading, whereas export controls and trade barriers restrain skilled labor allocation and human capital accumulation. Existing studies prove that preferential tax policies raise corporate demand for skilled workers, eased financing constraints optimize overall human capital quality, and green transformation upgrades labor skill structure through multiple channels. Nevertheless, foreign export restrictions have exerted long-term growing negative effects on enterprises' high-skilled labor proportion and human capital development (Liu Qiren et al., 2020; Fonseca et al., 2022; Li Bo et al., 2024; Zhou Shen et al., 2026).

In summary, prior studies have explored enterprise new-quality productive forces and human capital from multiple perspectives, confirming that new-quality productive forces improve corporate efficiency and industrial resilience via technological and organizational innovation, and identifying micro and macro drivers of human capital. Nevertheless, no consensus has been reached regarding how new-quality productive forces affect human capital. Moreover, few studies integrate knowledge diversity, resource integration capacity and labor wage bargaining power into intermediate mechanism analysis. Accordingly, this study provides valuable theoretical supplements.

3. Research Hypotheses and Empirical Design

Research Hypotheses. The core of new-quality productive forces is innovation-driven high-quality development, which influences corporate human capital via efficiency, technology and labor market channels. Firstly, digital technology, its core carrier, boosts corporate operational efficiency through optimized resource allocation and integration, supporting human capital value realization. Secondly, efficiency gains further stimulate technological innovation, knowledge production and network upgrading, facilitating corporate knowledge restructuring. Moreover, progress in AI patents expands intelligent technology application, promotes diversified corporate knowledge and optimizes innovation ecosystems (Li Yabing et al., 2022; Liu Xinxin et al., 2025). Finally, such development transmits to the labor market, expands employment and corporate labor demand, and ultimately strengthens workers' wage bargaining power (Xu Jiayun et al., 2023).

Stronger corporate resource integration capacity improves human capital via indirect empowerment, talent allocation optimization and management reform. Firstly, amid the growth of new-quality productive forces, innovative resources keep gathering, and efficient resource integration serves as a vital intermediary to convert input into output and unleash human capital efficiency (Wang Wenhua et al., 2014). Secondly, demand for disruptive innovation pushes enterprises to upgrade data-oriented advanced resource integration, which raises skill requirements for employees, eliminates low-skilled labor, and boosts demand for high-skilled and compound talents to optimize overall human capital structure (Huang Xueqin et al., 2024). Finally, upgraded resource integration further integrates with corporate employment systems, realizing systematic human capital empowerment and human resource management innovation (Li Zhaomin et al., 2025).

Corporate knowledge diversity expands employees' learning opportunities and skill development channels to facilitate human capital accumulation. Driven by new-quality productive forces, digital transformation and cross-border innovation motivate enterprises to break knowledge barriers, integrate heterogeneous resources and achieve diversified knowledge structure. As a core internal path, knowledge diversity supports employees' cross-domain learning and capability growth, which collectively upgrades overall corporate human capital and cultivates high-skilled talent teams matching new-quality productive forces (Yuan Zeming et al., 2024).

Higher labor wage bargaining power stimulates workers to invest more in human capital and realize reasonable value pricing, thus upgrading overall corporate human capital. Firstly, enhanced bargaining power driven by new-quality productive forces addresses undervaluation and misallocation of human capital in traditional labor markets, helps realize existing human capital value,

motivates human capital investment and achieves differentiated empowerment for different employee groups (Zhang Xiaopeng et al., 2021). Secondly, from the perspective of income expectations, it promotes incremental human capital accumulation beyond stock optimization, as higher expected returns encourage workers to conduct active self-improvement such as skill training (Jiang Zhuoyu et al., 2024). Accordingly, this study proposes Hypothesis H1:

H1: Enterprise new-quality productive forces positively improve corporate human capital level.

Empirical Analysis. To verify whether the new productive forces of enterprises promote the improvement of their human capital level, referring to the studies of Xiao Youzhi et al. (2024) and Wang Yuhao et al. (2024), the following regression model is set up:

$$HC_{i,t} = \alpha + \beta_1 NPRO_{i,t-1} + \sum_m \beta_m CV_{i,t-1} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (1)$$

HC denotes corporate human capital level. Following prior research (Yuan Zeming et al., 2024), it is measured by the proportion of employees with bachelor’s degrees or above, where a higher ratio indicates better human capital.

NPRO stands for enterprise new-quality productive forces. Most existing measurements construct comprehensive indicators from productivity components and development features. The two-dimensional measurement from labor and means of production (Wen Lei & Li Sifei, 2024) neglects labor objects and fails to reflect its innovation-driven, high-efficiency connotation. Thus, drawing on Li Xinru et al. (2024), this paper establishes an evaluation system covering new-quality laborers, labor objects and labor means (see Table 1), and calculates NPRO via the entropy weight method. This study mainly examines regression coefficient β ; a significantly positive β verifies that new-quality productive forces boost corporate human capital.

Table 1. Evaluation Index System of New Quality Productive Forces of Enterprises

First-level Indicators	Second-level Indicators	Third-level Indicators	Calculation Method
New Quality Laborers	Management Quality	Executives' Green Cognition	ln (frequency of green development keywords in annual report + 1)
		Management's Overseas Background	1 if executives have overseas background, 0 otherwise
New Quality Objects of Labor	Ecological Environment	Environmental Governance Score	E indicator of Huazheng ESG rating, 9 levels assigned 1~9 respectively
	Future Development	Fixed Asset Ratio	(Fixed assets/Total assets)×100
Capital Accumulation Rate		(Growth amount of owner's equity in the current year/Initial owner's equity)×100	
New Quality Means of Labor	Scientific and Technological Means of Labor	Innovation Level	ln (Number of granted patents + 1)
	Digital Means of Labor	Digitalization Degree	ln (frequency of digital keywords in annual report + 1)
		Intangible Asset Ratio	(Intangible assets/Total assets)×100
	Green Means of Labor	Green Technology Level	ln (Number of granted green patents + 1)
Green Patent Ratio		(Number of granted green patents/Number of granted patents)×100	

CV represents control variables, covering firm size, leverage, ROA, cash flow, equity concentration, listing age, firm age, Big4 audit, and asset turnover. This study also controls for year and industry fixed effects, and adopts firm-level clustered standard errors to alleviate cross-sectional correlation. Variable definitions are shown in Table 2.

Table 2. Variable Definition and Construction

Variable Symbol	Variable Name	Variable Construction Description
Size	Enterprise Size	Total assets at the end of the year
Lev	Asset-Liability Ratio	Ratio of total liabilities to total assets
ROA	Return on Total Assets	Ratio of net profit to average total assets
CashFlow	Cash Flow Ratio	Ratio of net cash flow from operating activities to total assets at the end of the period
Top3	Equity Concentration - Shareholding Ratio of Top 3 Shareholders	Sum of shareholding ratios of top 3 shareholders
ListAge	Listing Years	Natural logarithm of the difference between the current year and the company's listing year
FirmAge	Establishment Years	Natural logarithm of the difference between the current year and the company's establishment year
Big4	Audit Institution	1 if the enterprise is audited by the Big Four accounting firms, 0 otherwise
ATO	Total Asset Turnover	Ratio of operating income to average total assets

Data Sources. This study selects A-share listed companies from 2014 to 2023 as the research sample, with all data sourced from the CSMAR database. The sample is processed by excluding financial firms and ST/*ST listed firms, removing observations with missing variables, and winsorizing all continuous variables at the 1% level to eliminate outliers.

Descriptive Statistics. Descriptive statistics of major variables are reported in Table 3. The mean value of corporate human capital is 4.234 with a large standard deviation of 6.394, suggesting prominent disparities in human capital allocation across firms, which may stem from differences in corporate life cycle and strategies. The average ROA is merely 0.0396 with a minimum of -0.216, revealing great profitability divergence and losses in some firms. Besides, large standard deviations are also observed in new-quality productive forces, indicating obvious inter-firm differences in both core variables.

Table 3. Descriptive Analysis Table

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Size	22,493	22.140	1.151	20.140	25.760
Lev	22,493	0.389	0.190	0.059	0.859
ROA	22,493	0.040	0.061	-0.216	0.189
CashFlow	22,493	0.051	0.065	-0.133	0.231
Top3	22,493	0.479	0.148	0.173	0.835
ListAge	22,493	1.886	0.909	0.000	3.332
FirmAge	22,493	2.963	0.291	2.197	3.584
Big4	22,493	0.042	0.201	0.000	1.000
ATO	22,493	0.580	0.317	0.109	1.932
NPRO	22,493	0.140	0.068	0.029	0.363
HC	22,493	4.234	6.394	0.000	35.640

4. Empirical Results and Analysis

Benchmark Regression Analysis. Table 4 presents the benchmark regression results. Four regression models are set with or without control variables and fixed effects. The core coefficient of new-quality productive forces is significantly positive at the 1% level in all specifications. After incorporating full controls and fixed effects, its coefficient remains significantly positive. This demonstrates that enterprise new-quality productive forces markedly promote human capital upgrading, which validates Hypothesis H1.

Table 4. Baseline Regression Analysis Results

	(1)	(2)	(3)	(4)
VARIABLES	HC	HC	HC	HC
NPRO	11.627***	6.586***	9.603***	4.723***
	(11.655)	(6.419)	(9.440)	(4.616)
Size			0.937***	0.882***
			(7.953)	(7.570)
Lev			-5.046***	-4.271***
			(-7.572)	(-7.225)
ROA			1.584	2.331*
			(1.098)	(1.705)
ATO			-2.856***	-1.770***
			(-10.472)	(-6.376)
CashFlow			-9.239***	-7.822***
			(-8.643)	(-7.803)
ListAge			-0.688***	-0.218*
			(-5.142)	(-1.703)
FirmAge			-0.936***	-1.618***
			(-2.620)	(-4.469)
Big4			2.652***	2.239***
			(4.767)	(4.513)
Top3			-4.062***	-1.726**
			(-5.094)	(-2.288)
Constant	2.610***	0.731	-7.930***	-9.546***
	(17.457)	(1.197)	(-3.306)	(-3.678)
Observations	22,493	22,493	22,493	22,493
R-squared	0.015	0.197	0.093	0.240
Industry FE	NO	YES	NO	YES
Year FE	NO	YES	NO	YES

Robustness Test. Benchmark regression confirms that new-quality productive forces advance corporate human capital. Multiple robustness tests are further conducted to ensure result reliability.

Replacement of the measurement of the dependent variable. To mitigate single-indicator bias, this paper adopts the R&D personnel ratio as an alternative human capital proxy for robustness testing. As shown in Table 5, after controlling for relevant variables and fixed effects, the core coefficient remains significantly positive at the 1% level, further validating the baseline findings.

Table 5. Replacement of Explained Variable Results

VARIABLES	(1) HC2	(2) HC2	(3) HC2	(4) HC2
NPRO	41.014*** (15.744)	20.760*** (9.516)	45.456*** (17.888)	25.862*** (11.756)
Size			-0.523** (-2.437)	-0.602*** (-3.109)
Lev			-12.894*** (-10.336)	-8.547*** (-8.040)
ROA			-2.137 (-0.866)	3.617* (1.676)
ATO			-4.039*** (-7.808)	-2.142*** (-4.245)
CashFlow			-18.898*** (-8.529)	-13.649*** (-6.998)
ListAge			-1.691*** (-6.856)	-0.077 (-0.374)
FirmAge			0.181 (0.264)	-3.484*** (-5.215)
Big4			2.402** (2.434)	1.878** (2.261)
Top3			-16.564*** (-11.779)	-7.069*** (-5.812)
Constant	10.814*** (32.430)	-12.103*** (-9.791)	40.655*** (9.211)	19.614*** (4.434)
Observations	22,493	22,493	22,493	22,493
R-squared	0.040	0.399	0.153	0.436
Industry FE	NO	YES	NO	YES
Year FE	NO	YES	NO	YES

Propensity Score Matching. This paper employs PSM to identify the causal link between new-quality productive forces and human capital. Taking firm characteristics as matching covariates, it conducts 1:1 nearest neighbor matching, dividing samples into treatment and control groups by the median of core variables. As shown in Table 6, NPRO remains significantly positive across matching settings, confirming the robustness of the findings.

Table 6. Propensity Score Matching Table

VARIABLES	(1) HC	(2) HC	(3) HC	(4) HC
NPRO	13.884*** (13.743)	13.844*** (13.444)	12.271*** (12.069)	6.678*** (6.319)
Size			0.986*** (8.150)	0.888*** (7.442)
Lev			-5.010*** (-7.662)	-4.232*** (-7.300)
ROA			1.154 (0.798)	1.896 (1.381)
ATO			-2.703*** (-9.237)	-1.639*** (-5.505)
CashFlow			-9.142*** (-7.978)	-7.547*** (-7.064)
ListAge			-0.615*** (-4.698)	-0.157 (-1.249)
FirmAge			-0.945*** (-2.667)	-1.611*** (-4.441)
Big4			2.614*** (4.299)	2.213*** (4.191)
Top3			-3.867*** (-4.965)	-1.750** (-2.349)
Constant	2.270*** (16.495)	1.296*** (8.048)	-9.659*** (-3.879)	-9.974*** (-3.804)
Observations	17,216	17,216	17,216	17,216
R-squared	0.019	0.031	0.094	0.243
Industry FE	NO	YES	NO	YES
Year FE	NO	YES	NO	YES

Replacing the Sample Interval. Given the exogenous shock of the 2020 COVID-19 pandemic may distort the causal relationship and empirical results, this study excludes 2020 samples for re-estimation. As presented in Table 8, after controlling for relevant variables and fixed effects, the core coefficient remains significantly positive at the 1% level with no substantial changes. Hence, the main conclusion is not affected by pandemic outliers and presents strong robustness.

Table 7. Replacement of Sample Interval Table

VARIABLES	(1) HC	(2) HC	(3) HC	(4) HC
NPRO	12.147*** (10.950)	6.828*** (6.122)	9.982*** (8.850)	4.861*** (4.423)
Size			1.057*** (8.135)	0.967*** (7.522)
Lev			-6.130*** (-8.086)	-5.146*** (-7.831)
ROA			-0.307 (-0.214)	0.970 (0.721)
ATO			-2.501*** (-9.119)	-1.437*** (-5.268)
CashFlow			-10.784*** (-9.064)	-9.080*** (-7.989)
ListAge			-0.790*** (-5.439)	-0.269* (-1.955)
FirmAge			-1.092*** (-2.795)	-1.877*** (-4.570)
Big4			2.871*** (4.401)	2.485*** (4.154)
Top3			-4.173*** (-4.623)	-1.707** (-1.976)
Constant	2.620*** (16.642)	0.638 (1.042)	-9.483*** (-3.736)	-10.403*** (-3.738)
Observations	20,007	20,007	20,007	20,007
R-squared	0.014	0.184	0.089	0.227
Industry FE	NO	YES	NO	YES
Year FE	NO	YES	NO	YES

Endogeneity Test. To address endogeneity including reverse causality and omitted variables, this paper applies the 2SLS instrumental variable method. The industry-average NPRO is selected as the instrumental variable, which satisfies both exogeneity and correlation due to industry spillover effects. As shown in Table 7, after mitigating endogeneity, the core coefficient remains significantly positive at the 1% level. The first-stage regression results confirm a valid instrumental variable with no weak instrument issues, further solidifying the reliability of the core conclusion.

Table 8. Instrumental Variable Regression Results Table

VARIABLES	(1) NPRO	(2) HC
iv	0.967*** (16.769)	
Size	0.014*** (13.489)	0.481*** (3.687)
Lev	0.011** (2.011)	-6.263*** (-8.077)
ROA	-0.012 (-1.272)	1.658 (1.193)
ATO	-0.002 (-0.637)	-2.227*** (-8.014)
CashFlow	0.022** (2.342)	-10.658*** (-9.129)
ListAge	-0.002* (-1.888)	-0.403*** (-2.794)
FirmAge	-0.008** (-2.473)	-1.757*** (-3.858)
Big4	0.006 (1.590)	2.870*** (4.251)
Top3	-0.021*** (-3.313)	-2.579*** (-2.770)
NPRO		42.897*** (10.281)
Constant	-0.280*** (-10.989)	-1.628 (-0.625)
Observations	22,493	22,493
Industry FE	YES	YES
Year FE	YES	YES

5. Further Analysis

Heterogeneity Analysis. Regional Heterogeneity. Regional economic imbalance may trigger heterogeneous impacts of new-quality productive forces on human capital. The eastern region features mature marketization, limiting the marginal promotion effect of such productivity. By contrast, the central and western regions are in industrial catch-up and policy dividend periods, with strong demand for technological innovation and higher sensitivity to external empowerment, delivering more pronounced marginal effects. Accordingly, the promotion of new-quality productive forces on human capital is hypothesized to be stronger in central and western China than in eastern China.

Classifying samples into eastern, central and western regions per official standards, this study conducts grouped regressions (Table 9). New-quality productive forces show a significant positive effect on human capital across all three regions, proving its universal promotion effect. However, its coefficients in central and western areas are larger than that in eastern China. This marginal difference arises from the high existing human capital stock in the east with diminishing returns, while central and western regions are in industrial upgrading, yielding more prominent promotional effects.

Table 9. Regional Heterogeneity Analysis

VARIABLES	(1) HC	(2) HC	(3) HC
NPRO	3.681*** (2.716)	7.798*** (3.151)	7.106*** (3.140)
Size	1.199*** (7.219)	0.455 (1.343)	0.245 (1.322)
Lev	-5.792*** (-6.937)	-1.901 (-1.414)	-3.292** (-2.418)
ROA	-0.004 (-0.002)	4.873** (2.020)	4.490* (1.718)
ATO	-1.680*** (-5.316)	-1.332*** (-2.776)	-0.533 (-0.413)
CashFlow	-7.806*** (-5.884)	-7.486*** (-2.900)	-8.721*** (-3.033)
ListAge	-0.530*** (-3.089)	0.260 (0.761)	-0.066 (-0.221)
FirmAge	-2.069*** (-4.240)	-0.439 (-0.371)	-1.797** (-2.024)
Big4	2.696*** (3.514)	0.805 (0.685)	2.459* (1.752)
Top3	-2.389** (-2.213)	2.543 (1.050)	-2.323 (-1.484)
Constant	-14.582*** (-4.117)	-6.094 (-0.794)	3.272 (0.702)
Observations	16,659	3,400	2,434
R-squared	0.237	0.268	0.263
Industry FE	YES	YES	YES
Year FE	YES	YES	YES

Enterprise Nature. This paper divides samples into state-owned (SOEs) and non-state-owned enterprises (non-SOEs) for ownership heterogeneity analysis. As a key institutional factor, ownership shapes financing constraints: SOEs enjoy looser financing conditions thanks to implicit government guarantees. Restricted by capital pressure, operational risks and short-term profit orientation, non-SOEs lack sufficient incentives for human capital investment. Accordingly, new-quality productive forces exert a stronger promotional effect on human capital upgrading in SOEs than in non-SOEs.

Samples are grouped into SOEs and non-SOEs for regression (Table 10). The coefficients of new-quality productive forces are significantly positive for both groups at the 1% level, indicating its universal promotion effect on human capital. Notably, the promotional effect is markedly stronger in SOEs, which validates the ownership heterogeneity hypothesis.

Table 10. Enterprise Nature Analysis Table

VARIABLES	(1) HC	(2) HC
NPRO	15.361*** (10.390)	5.311*** (4.753)
Size	0.327*** (3.167)	0.832*** (5.436)
Lev	-2.400*** (-3.587)	-5.916*** (-7.700)
ROA	16.100*** (6.977)	-1.180 (-0.852)
ATO	-2.261*** (-8.080)	-1.570*** (-5.973)
CashFlow	-19.038*** (-10.614)	-5.681*** (-4.947)
ListAge	-2.097*** (-12.087)	-0.842*** (-6.243)
FirmAge	-0.030 (-0.072)	-2.120*** (-4.916)
Big4	0.511 (1.237)	3.980*** (4.383)
Top3	2.352*** (3.023)	-5.417*** (-6.130)
Constant	3.242 (1.418)	-4.468 (-1.395)
Observations	5,474	17,019
R-squared	0.113	0.243
Industry FE	YES	YES
Year FE	YES	YES

Competitive Industries. Firms in competitive industries tend to prioritize market expansion and cost reduction via digital transformation over human capital investment. By contrast, non-competitive industries face weaker market competition and feature stronger technical complementarity. Thus, new-quality productive forces better drive skill advancement and human capital improvement in non-competitive sectors.

Referring to existing studies, this paper classifies firms into competitive and non-competitive industries. Grouped regression results (Table 11) show that new-quality productive forces significantly boost human capital in both industries at the 1% level. Nevertheless, the promoting coefficient is larger in non-competitive industries, confirming the industry competition heterogeneity hypothesis.

Table 11. Competitive Industry Analysis Table

	(1)	(2)
VARIABLES	HC	HC
NPRO	4.011***	8.032***
	(3.083)	(4.314)
Size	1.027***	0.594**
	(6.887)	(2.206)
Lev	-5.208***	-3.795***
	(-6.947)	(-2.866)
ROA	1.367	-2.030
	(0.939)	(-0.702)
ATO	-1.797***	-0.618
	(-5.795)	(-1.057)
CashFlow	-8.162***	-6.441***
	(-6.751)	(-2.780)
ListAge	-0.418***	0.260
	(-2.759)	(0.792)
FirmAge	-2.054***	-0.800
	(-4.401)	(-0.962)
Big4	3.420***	0.103
	(4.319)	(0.170)
Top3	-2.546***	2.596
	(-2.627)	(1.408)
Constant	-10.251***	-10.229
	(-3.235)	(-1.628)
Observations	18,726	3,767
R-squared	0.239	0.190
Industry FE	YES	YES
Year FE	YES	YES

Mechanism Analysis. This paper selects resource integration capacity, knowledge diversification and workers’ bargaining power as mechanism variables to explore the transmission paths. Two-step tests verify that new-quality productive forces elevate human capital through three channels. First, it optimizes resource allocation, curbs inefficient investment and reduces resource mismatch to support human capital cultivation. Second, digital and intelligent technologies strengthen resource integration and factor coordination to raise human capital output. Third, it breaks industrial knowledge boundaries to facilitate cross-field knowledge integration and diversification. Lastly, technological progress raises the demand for high-skilled labor, enhancing employees’ wage bargaining power.

Referring to relevant literature, this study constructs an investment model to estimate corporate reasonable investment and uses positive residuals to measure over-investment. The result shows that new-quality productive forces significantly inhibit over-investment. Taking total factor productivity residuals as the proxy for resource integration capability, relevant regression presents a significantly positive coefficient, indicating new-quality productive forces strengthen resource integration. Additionally, workers’ wage bargaining power is measured following prior research via the Nash bargaining model.

$$\phi = \frac{\varepsilon^M \theta^L - \varepsilon^L \theta^M}{\varepsilon^M - \varepsilon^L \theta^M} \quad (2)$$

θ denotes factor income share and ε represents factor output elasticity. A higher value indicates stronger employee bargaining power and labor income ratio. Regression results show new-quality productive forces exert no significant effect on workers’ bargaining power, invalidating this

mediating path. Knowledge diversification is further measured via the Teachman entropy index based on existing literature.

$$\text{Knowledge Diversification} = \sum_{i=1}^n p_i \ln p_i \tag{3}$$

Where p_i refers to the proportion of category- i patents in total patents; a higher index indicates greater knowledge diversification. As shown in Table 12, new-quality productive forces have a significantly positive coefficient, markedly facilitating corporate knowledge diversification.

Table 12. Mechanism Analysis Table

	(1)	(2)	(3)	(4)
VARIABLES	Overinvest	RC	Nego	KD
NPRO	-0.064**	0.144***	-0.017	1.994***
	(-1.991)	(7.708)	(-1.584)	(9.731)
Size	0.034***	-0.021***	-0.018***	0.497***
	(9.145)	(-10.076)	(-10.443)	(22.563)
Lev	0.055***	0.102***	0.156***	-0.119
	(4.666)	(10.559)	(26.526)	(-1.535)
ROA	-0.038*	0.042**	0.735***	-0.088
	(-1.714)	(2.086)	(36.210)	(-0.657)
ATO	-0.028***	-0.131***	-0.028***	0.233***
	(-3.461)	(-24.615)	(-6.444)	(4.925)
CashFlow	0.271***	-0.436***	0.020	-0.365***
	(6.395)	(-21.870)	(1.237)	(-2.645)
ListAge	-0.003	-0.013***	0.000	-0.044***
	(-0.747)	(-4.349)	(0.095)	(-2.721)
FirmAge	-0.018**	-0.007	-0.009***	0.077*
	(-2.033)	(-1.139)	(-2.875)	(1.669)
Big4	0.020	-0.020*	0.002	0.017
	(0.805)	(-1.934)	(0.364)	(0.179)
Top3	0.041	-0.087***	0.006	0.062
	(1.611)	(-7.312)	(0.859)	(0.652)
Constant	-0.650***	2.009***	1.669***	-10.636***
	(-7.940)	(45.500)	(46.475)	(-21.652)
Observations	15,970	20,736	20,755	21,468
R-squared	0.036	0.345	0.356	0.410
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

6. Conclusion

Against the backdrop of widespread digital and AI applications, new-quality productive forces underpin high-quality economic and corporate development. Using 2014–2023 A-share listed firm data, this paper empirically explores its influence on human capital. The main conclusions are: first, new-quality productive forces significantly boost corporate human capital; second, this promotional effect is more pronounced in central regions, state-owned enterprises and non-competitive industries, via strengthening resource integration and knowledge diversification. Accordingly, targeted policy suggestions are proposed to advance high-quality human capital development.

Three policy implications are proposed. First, governments should offer policy support to foster new-quality productive forces, while enterprises take such forces as the core driver to optimize human capital structure. Second, accelerate the allocation of key factors including digital technology, improve vocational training and industry-university cooperation, and strengthen internal learning and

incentive systems to enhance employee quality. Third, adopt differentiated strategies: tilt support toward non-state-owned and small-and-medium enterprises to narrow the human capital gap, and optimize internal talent mechanisms to consolidate the empowerment effect of new-quality productive forces.

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