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Human capital accumulation, technological progress, and corporate financialization

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ABSTRACT

This study selects data from listed companies between 2008 and 2022 as the research sample, delving into the interrelationships among human capital accumulation, technological progress, and corporate financialization. The empirical results indicate the following: First, human capital accumulation promotes corporate financialization. Second, technological progress also facilitates the process of corporate financialization. Moreover, technological progress serves as a mediating factor in the relationship between human capital accumulation and corporate financialization. Additionally, the impact of human capital accumulation on corporate financialization shows no significant difference between state-owned enterprises (SOEs) and private enterprises (PEs). Similarly, the effect of technological progress on corporate financialization does not exhibit notable differences between SOEs and PEs. Finally, the influence of human capital accumulation on corporate financialization demonstrates a scale threshold effect.

1. Introduction

In the context of today's global economic integration and increasingly intense market competition, how enterprises maintain sustained competitiveness and achieve sustainable development has become a focal point for both academia and practitioners. With the advent of the knowledge economy era, human capital, as a core element driving enterprise innovation and development, has become increasingly prominent in importance (Huang et al., 2024). Simultaneously, technological progress, as the engine of economic growth, not only directly enhances enterprises' production efficiency and product quality but also profoundly transforms their operational models and market competition landscapes. Against this backdrop, financialization of enterprises, as a significant strategic choice, has gradually become an essential means for optimizing resource allocation and enhancing market value. Enterprise financialization refers to the process by which enterprises invest in financial products or engage in financial market activities to achieve capital appreciation and risk management, a process and outcome deeply influenced by human capital accumulation and technological progress (Liu & He, 2023). Therefore, an in-depth exploration of the interrelationships among human capital accumulation, technological progress, and enterprise financialization is of significant theoretical and practical value for understanding enterprise behavior, optimizing resource allocation, and promoting high-quality economic development.

In recent years, research on human capital accumulation, technological progress, and enterprise financialization has flourished, yielding a wealth of findings. Regarding human capital accumulation, scholars generally agree that a high-quality talent pool is the

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source of enterprise innovation, capable of driving technological upgrades and product iterations, thereby enhancing the capacity and effectiveness of enterprise financialization (Chen & Sun, 2023). Concerning technological progress, studies have indicated that technological advancements not only directly improve production efficiency and reduce operational costs but also create new business models and market opportunities, providing a broad space for enterprise financialization (Wang & Hu, 2023). However, research on how human capital accumulation and technological progress synergistically influence enterprise financialization remains insufficient. Existing studies often focus on the impact of a single factor on enterprise financialization, lacking in-depth exploration of the interaction mechanisms among human capital accumulation, technological progress, and enterprise financialization. Moreover, there is limited research on the differential performance of enterprises with different ownership structures (e.g., SOEs versus PEs) in the financialization process, as well as the threshold effect of enterprise scale on the impact of human capital accumulation on financialization.

Although existing research has laid a crucial foundation for understanding the relationship among human capital accumulation, technological progress, and enterprise financialization, several gaps remain. First, there is a lack of in-depth analysis of the internal mechanisms by which human capital accumulation and technological progress jointly influence enterprise financialization. Second, insufficient attention has been paid to the heterogeneous performance of enterprises with different ownership structures in the financialization process. Finally, there is a lack of empirical research on the threshold effect of enterprise scale on the impact of human capital accumulation on financialization. To address these research gaps, this paper aims to reveal the interrelationships and internal mechanisms among human capital accumulation, technological progress, and enterprise financialization through an in-depth analysis of data from listed companies between 2008 and 2022. The specific research objectives include: exploring the direct impact of human capital accumulation and technological progress on enterprise financialization; analyzing the mediating role of technological progress in the relationship between human capital accumulation and enterprise financialization; comparing the heterogeneous performance of enterprises with different ownership structures in the financialization process; and investigating the threshold effect of enterprise scale on the impact of human capital accumulation on financialization.

Based on the aforementioned research gaps and objectives, this paper's contributions are mainly reflected in the following aspects: First, by constructing a comprehensive theoretical framework, this paper systematically analyzes for the first time the interaction mechanisms among human capital accumulation, technological progress, and enterprise financialization, filling a research gap in the relevant field. Second, using empirical research methods and leveraging extensive data from listed companies, this paper validates the promotional effects of human capital accumulation and technological progress on enterprise financialization, as well as the mediating effect of technological progress, providing robust empirical support for theoretical hypotheses. Third, by comparing the heterogeneous performance of state-owned and PEs in the financialization process, this paper reveals the significant influence of ownership structure on the pathways and outcomes of enterprise financialization, offering valuable insights for policymaking and enterprise management. Finally, this paper innovatively identifies the threshold effect of enterprise scale on the impact of human capital accumulation on financialization, indicating that once enterprise scale reaches a certain threshold, the promotional effect of human capital accumulation on financialization becomes significantly enhanced. This finding holds important value for guiding enterprises in optimizing resource allocation and achieving sustainable development.

2. Theoretical analysis and research hypotheses

The accumulation of human capital enhances workers' skill levels and overall quality, directly promoting enterprises' innovation capacity and competitiveness. During the process of financialization, enterprises not only require financial support but also need highly skilled talents to design and implement various financial instruments and financing plans (Tian & Sun, 2023). The improvement of human capital enables enterprises to better understand and utilize financial tools, thereby conducting financialization activities more effectively. At the same time, the accumulation of human capital contributes to the optimization of enterprises' incentive mechanisms (Wang et al., 2023). By offering equity incentives, funds, and other financialized tools, enterprises can stimulate employees' enthusiasm, initiative, and creativity. Such incentive mechanisms not only enhance employees' job satisfaction and loyalty but also further accelerate the financialization process of enterprises. As employees pursue the value of their personal human capital, they also pay greater attention to the financialization performance and long-term development of the enterprise (Paramati et al., 2021). Moreover, from a macroeconomic perspective, the accumulation of human capital is one of the key driving forces of economic growth. As human capital continues to improve, enterprises' production efficiency and technological levels will also increase significantly, thereby driving overall economic growth. This economic growth provides a more favorable market environment and more investment opportunities for enterprise financialization. Based on theoretical analysis, the first hypothesis is proposed.

H1. The accumulation of human capital promotes enterprise financialization.

Technological progress has significantly enhanced enterprises' capabilities in data processing and analysis. With the rapid development of big data, cloud computing, artificial intelligence, and other technologies, enterprises can more efficiently collect, organize, and analyze massive amounts of financial data, providing precise support for financial decision-making (Dowling & Lucey, 2023). This not only improves the scientific nature and timeliness of decisions but also enables enterprises to respond more flexibly to market changes, optimize the allocation of financial resources, and enhance the level of financialization. Additionally, technological progress drives innovation in financial products and services. Through the application of cutting-edge technologies such as blockchain and digital currencies, enterprises can develop more diversified and personalized financial products to meet various market demands (Mohsin et al., 2021). At the same time, technological progress reduces the cost of financial services and improves service efficiency, making the financialization process smoother and more efficient. Finally, technological progress enhances enterprises' risk

management capabilities (Banna et al., 2022). By using advanced risk management models and tools, enterprises can more accurately identify and assess financial risks and formulate effective risk response strategies. This not only helps ensure financial security but also provides a more robust foundation for enterprise financialization (Kong et al., 2021). Based on theoretical analysis, the second hypothesis is proposed.

H2. Technological progress enhances the level of enterprise financialization.

Technological progress provides strong momentum for the accumulation of human capital. With continuous advancements in technology, new knowledge and skills constantly emerge, requiring workers to continuously improve their competencies to adapt to market demands (Babar & Habib, 2021). As a result, education systems and vocational training have been significantly boosted, with the introduction of advanced teaching methods and technological tools improving the quality and efficiency of education, thereby accelerating the accumulation of human capital. This accumulation is reflected not only in the improvement of individual workers' skills but also in the optimization and upgrading of the entire labor market (Kara et al., 2021). Simultaneously, the accumulation of human capital provides a solid foundation for enterprise financialization. High-quality human capital implies stronger innovation capabilities and higher production efficiency, which strongly support enterprises in executing financialization activities (Venturini, 2022). Financialization requires enterprises to possess keen market insights and efficient decision-making capabilities, both of which rely heavily on human capital. Through the accumulation of human capital, enterprises can better understand and utilize financial tools, optimize resource allocation, and improve the level of financialization. Technological progress acts as a mediating factor, closely linking the accumulation of human capital with enterprise financialization. On the one hand, technological progress accelerates the speed and quality of human capital accumulation (Wen et al., 2022); on the other hand, human capital accumulation provides the necessary talent support and intellectual guarantees for enterprise financialization. This mutually reinforcing relationship enables enterprises to advance further and more steadily on the path of financialization. Based on theoretical analysis, the third hypothesis is proposed.

H3. Technological progress plays a mediating role in the relationship between human capital accumulation and enterprise financialization.

SOEs (SOEs) have inherent advantages in the accumulation of human capital. Due to their close ties with the government and large financial institutions, SOEs have easier access to high-quality educational resources and vocational training opportunities (Murinde et al., 2022). This advantage enables SOEs to quickly integrate and utilize human capital during the financialization process, designing more sophisticated and efficient financial strategies to deepen financialization (Liu et al., 2023). In contrast, PEs face greater challenges in accumulating human capital. Due to financing constraints and competitive market pressures, PEs often find it difficult to bear the high costs of education and training. However, this does not mean that the financialization process of PEs is hindered. On the contrary, PEs rely more on internal cultivation and incentive mechanisms, utilizing flexible management models and innovative financial strategies to effectively leverage human capital and advance financialization rapidly.

At the same time, the market environment exerts different influences on the financialization of SOEs and PEs. SOEs usually operate in relatively stable market environments, and their financialization behavior is more influenced by policy guidance and strategic planning (Huang et al., 2022). In contrast, PEs face more complex and dynamic market environments, requiring them to capture market opportunities more sensitively and adjust financial strategies flexibly to adapt to changing market demands. Based on theoretical analysis, the fourth hypothesis is proposed.

H4. The impact of human capital accumulation on the financialization of SOEs and PEs exhibits heterogeneity.

SOEs and PEs also differ in their capacity for technological absorption and innovation. SOEs often have stronger financial resources and greater policy support, enabling them to adopt and apply new technologies more quickly, thereby advancing the financialization process (Zheng et al., 2024). In contrast, PEs have relatively weaker capabilities in technological absorption and innovation and may require more time and resources to adapt to and utilize new technologies, which can slow their financialization to some extent. Furthermore, technological progress impacts the financialization of SOEs and PEs differently in terms of market competition (Bawono, 2021). SOEs, typically occupying relatively stable market positions, are more influenced by policy guidance and internal strategic planning in their financialization behavior. PEs, on the other hand, face more intense market competition and need to use new technologies more flexibly to reduce costs, improve efficiency, and enhance competitiveness, thereby advancing financialization. Additionally, technological progress affects the financialization of SOEs and PEs differently in terms of financing channels and methods. SOEs, leveraging their background and strength, can more easily access financing channels such as bank loans and government subsidies, providing strong financial support for financialization. PEs, with relatively limited financing channels, may rely more on equity financing and venture capital, which increases the difficulty and risks of financialization to some extent (Zhang et al., 2022). Based on theoretical analysis, the fifth hypothesis is proposed.

H5. The impact of technological progress on the financialization of SOEs and PEs exhibits heterogeneity.

For small enterprises, although human capital accumulation can contribute to financialization, its effects are often limited due to factors such as resource constraints and low market influence. These enterprises may focus more on short-term survival and profitability, adopting a cautious approach to financialization investments and initiatives (Hsu et al., 2021). However, as enterprises grow in scale, their market influence, resource acquisition capabilities, and risk tolerance increase significantly. At this stage, the role of human capital accumulation becomes more prominent. Large enterprises, with more extensive talent reserves and more comprehensive training systems, can attract and retain high-quality employees. These employees not only enhance operational efficiency but also

provide innovative ideas and technical support for financialization (Ha & Ngoc, 2022). Furthermore, large enterprises often face more complex financial environments and higher risks during the financialization process, making the role of human capital accumulation even more critical. High-quality talents can more accurately analyze market dynamics, assess financial risks, and develop more scientific and rational financial strategies, ensuring the steady development of enterprises in the financialization process (Li et al., 2022). Based on theoretical analysis, the sixth hypothesis is proposed.

H6. The impact of human capital accumulation on enterprise financialization exhibits a scale threshold effect.

3. Variable description and model development

3.1. Data source

This study focuses on Chinese listed companies during the period from 2008 to 2022, with data sourced from the WIND database. During the data preprocessing stage, the study first excluded companies with incomplete information and decided to exclude firms in the financial industry from the analysis. To address the issue of missing data for certain non-critical variables, the study employed linear interpolation to appropriately fill in the gaps. To ensure the stability of data analysis and prevent extreme values from distorting the results, the study applied a 1 % winsorization to all continuous variables. Following this rigorous data screening and processing, the study ultimately obtained 28,597 valid sample observations.

3.2. Definition of variables

3.2.1. Dependent variable

Corporate financialization (*financialization*): The level of financialization of listed companies is measured by the ratio of financial assets to total corporate assets.

3.2.2. Independent variables

Human capital accumulation (*capital*): The level of human capital accumulation is measured by the proportion of employees with a postgraduate degree or higher relative to the total number of employees in the company.

Technological progress (*technological*): The study uses the logarithm of the number of patent applications filed by listed companies in a given year to measure technological progress.

3.2.3. Intermediary variable

Technological progress (*technological*): The logarithm of the number of patent applications filed by listed companies in a given year is also used to measure technological progress.

3.2.4. Control variables

Firm size (*size*), firm age (*age*), debt-to-asset ratio (*level*), ownership structure (*state*), shareholding ratio of the top 10 shareholders (*Top10*), board size (*board*), and total managerial compensation (*TMTPay*).

3.3. Model construction

To examine the impact of human capital accumulation and technological progress on corporate financialization, this paper establishes Model (1) and Model (2) for empirical analysis. Additionally, these two models are used to conduct subsample regression tests to verify the heterogeneity hypothesis.

$$financialization_{i,t} = \alpha_0 + \alpha_1 capital_{i,t} + \sum_{k=1}^{n} \alpha_k control_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{1}$$

$$financialization_{i,t} = \beta_0 + \beta_1 technological_{i,t} + \sum_{k=1}^{n} \beta_k control_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{2}$$

This study establishes Model (3) and Model (4) to test the mediating effect.

$$technological_{i,t} = \eta_0 + \eta_1 capital_{i,t} + \sum_{k=1}^{n} \eta_k control_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{3}$$

$$\begin{aligned} financialization_{i,t} = {} & \sigma_0 + \sigma_1 capital_{i,t} + \sigma_2 technological_{i,t} \\ & + \sum_{k=1}^{n} \sigma_k control_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \end{aligned} \tag{4}$$

This study establishes a threshold effect model to conduct a threshold effect test.

$$\begin{aligned} financialization_{i,t} = {} & \phi_0 + \phi_1 capital_{i,t} * I(size_{i,t} \le \gamma_1) + \phi_2 capital_{i,t} * I(\gamma_1 < size_{i,t} \le \gamma_2) \\ & \phi_3 capital_{i,t} * I(size_{i,t} > \gamma_3) + \sum_{k=1}^{n} \phi_k control_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \end{aligned} \tag{5}$$

4. Empirical results analysis

4.1. Descriptive statistical analysis

The average level of corporate financialization (*financialization*) is 0.0477, indicating that the proportion of financial assets to total assets is relatively low among the sampled firms. However, the maximum value reaches 0.4599, highlighting significant differences in financialization levels across companies. The average level of human capital accumulation (*capital*) is 0.0459, reflecting a low proportion of highly educated employees within the workforce of most firms. Nonetheless, in certain companies, this proportion reaches as high as 0.3300, demonstrating an uneven distribution of human capital across firms. The average value for technological innovation (*technological*) is 2.6950, with a large standard deviation (1.7902), suggesting considerable variation in firms' investments and outputs related to technological innovation. The average firm size (*size*) is 22.2460, indicating that the sampled companies generally possess substantial asset scales. The average logarithm of firm age (*age*) is 2.1724, implying that the sample includes a proportion of companies with long operational histories. The average financial leverage ratio (*level*) is 0.4298, which is at a moderate level, but the maximum value reaches 0.9264, signaling that some companies may face higher financial risks. Regarding ownership structure (*state*), state-owned and non-SOEs each account for approximately half of the sample. The average shareholding ratio of the top ten shareholders (*Top10*) is 0.5878. The average logarithm of board size (*board*) is 2.2477, indicating relatively stable board compositions among the sampled firms. The average logarithm of executive team compensation (*TMTPay*) is 15.4713, reflecting the market's recognition and incentives for executive talent (see Table 1).

4.2. Basic regression analysis

This study employs two regression methods to analyze the impact of human capital accumulation and technological progress on corporate financialization. According to the results in the first two columns of Table 2, regardless of whether individual effects and time effects are controlled, the coefficient of human capital accumulation (*capital*) is significantly positive, indicating that human capital accumulation can enhance the level of corporate financialization, thereby confirming Hypothesis 1. Based on the data in the third and fourth columns of Tables 2 and in both the non-fixed effects and fixed effects regression results, the coefficient of technological progress (*technological*) is also significantly positive, suggesting that technological progress can likewise significantly enhance the level of corporate financialization, thus confirming Hypothesis 2.

4.3. Mediation effect analysis

The results in Table 3 are derived based on the mediation effect model. According to the results in column (1), human capital accumulation (*capital*), as the core explanatory variable, has a coefficient of 0.4573, which is significant at the 5 % level. This finding strongly supports the positive effect of human capital accumulation in driving technological progress (*technological*) within firms. Based on the results in column (2), the coefficients for both human capital accumulation and technological progress are significantly positive, indicating that technological progress plays a mediating role in the relationship between human capital accumulation and corporate financialization. Hypothesis 3 is thus confirmed. Technological advancements drive the transformation of human capital accumulation into corporate financialization through two pathways. Firstly, technological innovation enhances production efficiency, reduces reliance on low-skilled labor, prompts enterprises to optimize their human capital structure, and redirects the saved costs into the financial sector. Secondly, technology-driven cost reduction boosts corporate profitability, providing a reserve of funds for financial investments.

4.4. Endogeneity test

Considering the potential endogeneity between human capital accumulation and corporate financialization, this paper employs the instrumental variable method to conduct an endogeneity test. Based on the test results in Table 4, the selected instrumental variable (*L. capital*) is shown to be an effective instrument. Furthermore, according to the results of the second stage, the fitted value of human

Table 1
Descriptive statistics.

VarName	Obs	Mean	SD	Min	Median	Max
financialization	28,597	0.0477	0.0841	0.0000	0.0117	0.4599
capital	28,597	0.0459	0.0584	0.0012	0.0247	0.3300
technological	28,597	2.6950	1.7902	0.0000	2.8332	7.1050
size	28,597	22.2460	1.3618	19.7166	22.0383	26.4335
age	28,597	2.1724	0.8377	0.1380	2.3421	3.3749
level	28,597	0.4298	0.2096	0.0553	0.4198	0.9264
state	28,597	0.4173	0.4931	0.0000	0.0000	1.0000
Top10	28,597	0.5878	0.1560	0.2295	0.5963	0.9106
board	28,597	2.2477	0.1758	1.7918	2.3026	2.7726
TMTPay	28,597	15.4713	0.7295	13.6171	15.4560	17.4425

Table 2
Basic regression analysis.

VARIABLES	(1)	(2)	(3)	(4)
	financialization	financialization	financialization	financialization
capital	0.1389***	0.1097***		
	(11.8249)	(8.1895)		
technological			0.0028***	0.0041***
			(7.7051)	(10.0871)
size	−0.0007	−0.0039***	0.0014*	−0.0015*
	(-0.9393)	(-4.4066)	(1.8584)	(-1.6753)
age	0.0285***	0.0246***	0.0292***	0.0247***
	(28.4167)	(16.4654)	(29.1327)	(16.5501)
level	−0.0649***	−0.0524***	−0.0688***	−0.0544***
	(-20.8665)	(-15.7217)	(-22.0875)	(-16.3191)
state	−0.0312***	−0.0309***	−0.0310***	−0.0315***
	(-10.7545)	(-9.7138)	(-10.8320)	(-11.0328)
Top10	−0.0094**	−0.0149***	−0.0080*	−0.0134***
	(-2.0976)	(-3.0821)	(-1.7781)	(-2.7884)
board	−0.0225***	−0.0028	−0.0243***	−0.0022
	(-6.6701)	(-0.7596)	(-7.1966)	(-0.5958)
TMTPay	0.0069***	−0.0012	0.0085***	−0.0008
	(7.4858)	(-1.1228)	(9.2577)	(-0.8172)
Constant	−0.0035	0.1198***	−0.0597***	0.0725***
	(-0.2249)	(6.1409)	(-3.7247)	(3.6622)
ID FE	NO	YES	NO	YES
Year FE	NO	YES	NO	YES
Observations	28,597	28,597	28,597	28,597
R-squared	0.3970	0.3233	0.3938	0.3245

Table 3
Mediation effect analysis.

VARIABLES	(1)	(2)
	technological	financialization
capital	0.4573**	0.1016***
	(2.1996)	(8.3473)
technological		0.0041***
		(10.2158)
size	−0.4705***	−0.0019**
	(-34.3365)	(-2.1521)
age	−0.0514**	0.0249***
	(-2.2126)	(16.6402)
level	0.2070***	−0.0533***
	(3.9988)	(-16.0068)
state	−0.0304***	−0.0311***
	(-9.2536)	(-10.2015)
Top10	0.1592**	−0.0155***
	(2.1291)	(-3.2254)
board	−0.1645***	−0.0021
	(-2.9057)	(-0.5738)
TMTPay	−0.0150	−0.0011
	(-0.9322)	(-1.0649)
Constant	9.1107***	0.0820***
	(30.1024)	(4.1389)
ID FE	YES	YES
Year FE	YES	YES
Observations	28,597	28,597
R-squared	0.3202	0.2269

capital accumulation (*capital*) remains significantly and positively correlated with corporate financialization.

4.5. Heterogeneity analysis

Table 5 presents the results of the impact of human capital accumulation on corporate financialization across different samples. From the results in column 3 of Tables 5 and it can be observed that the coefficient of human capital accumulation (*capital*) is significantly positive in all samples, including the full sample, the state-owned enterprise sample, and the private enterprise sample. Although the coefficient of human capital accumulation (*capital*) is larger in the state-owned enterprise sample, there is no significant

Table 4
Endogeneity test.

	(1)	(2)
	Phase one	Phase two
	capital	financialization
L.capital	0.9541*** (458.6515)	
capital		0.1568*** (16.6725)
Controlvariable	Yes	Yes
LM value (unidentifiable test)	22279.00	
First-stage F-value (weak instrument variable test)	2.1e+05	

difference between this coefficient and that in the private enterprise sample. This indicates that the impact of human capital (*capital*) accumulation on the financialization of SOEs and PEs does not differ significantly, and thus Hypothesis 4 is not supported. The insignificant difference in the impact of human capital accumulation on the financialization of SOEs and PEs primarily stems from two aspects: Firstly, the integration of governance mechanisms, as the establishment of modern corporate governance systems has enabled both types of enterprises to adopt market-oriented mechanisms for selecting and appointing personnel, thereby narrowing the gap in the efficiency of human capital allocation; Secondly, the unification of market environments, as SOEs and PEs now operate within the same talent competition market and financial landscape under factor marketization reforms, leading to a convergence in their capacity to translate human capital accumulation into financial investment capabilities.

This study also employs a subsample regression approach to examine whether technological progress has heterogeneous effects on the financialization of SOEs (SOEs) and PEs. The results of the subsample regression are presented in Table 6. In all three columns of results in Table 6, the coefficients for technological progress (*technological*) are significantly positive. Moreover, there is no notable difference in the coefficients for technological progress (*technological*) between the SOE sample and the private enterprise sample, indicating that the impact of technological progress on the financialization of SOEs and PEs does not exhibit significant differences. Therefore, Hypothesis 5 is not supported. The insignificant difference in the impact of technological progress on the financialization of SOEs and PEs primarily stems from two aspects: Firstly, the convergence of technological application effects, as advanced technologies such as large models are widely adopted by both types of enterprises, leading to increasingly similar outcomes in enhancing operational efficiency and optimizing customer service; Secondly, the unification of market feedback, as SOEs and PEs now operate within the same talent competition landscape and financial environment under factor marketization reforms, resulting in a growing equilibrium in their capacity to translate technological advancements into financial investment capabilities.

4.6. Threshold effect analysis

Table 6 lists the specific threshold values determined by the threshold tests in this study, while Table 7 presents the results of the threshold effect tests. Based on the data in Table 7, this study finds that the single-threshold model and the double-threshold model are supported at the 1 % and 5 % significance levels, respectively. The test results indicate that adopting the double-threshold effect regression model in this study is appropriate.

Table 5
Heterogeneity analysis (1).

VARIABLES	(1)	(2)	(3)
	Full sample	SOEs	PEs
capital	0.1097***	0.1270***	0.1036***
	(8.1895)	(7.9989)	(4.8865)
size	−0.0039***	0.0016	−0.0101***
	(-4.4066)	(1.3928)	(-7.6273)
age	0.0246***	0.0160***	0.0239***
	(16.4654)	(7.2996)	(11.2396)
level	−0.0524***	−0.0421***	−0.0631***
	(-15.7217)	(-9.7127)	(-13.0335)
Top10	−0.0149***	−0.0065	−0.0101
	(-3.0821)	(-1.0098)	(-1.4522)
board	−0.0028	0.0030	−0.0112**
	(-0.7596)	(0.6684)	(-2.0332)
TMTPay	−0.0012	−0.0005	−0.0033**
	(-1.1228)	(-0.3812)	(-2.0302)
Constant	0.1198***	−0.0207	0.2948***
	(6.1409)	(-0.8340)	(10.0657)
ID FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	28,597	11,934	16,663
R-squared	0.3233	0.3910	0.3533

Table 6
Heterogeneity analysis (2).

VARIABLES	(1)	(2)	(3)
	Full sample	SOEs	PEs
technological	0.0041***	0.0043***	0.0033***
	(10.0871)	(8.5876)	(5.3705)
size	−0.0015*	0.0042***	−0.0082***
	(-1.6753)	(3.7341)	(-6.0556)
age	0.0247***	0.0165***	0.0245***
	(16.5501)	(7.5312)	(11.5126)
level	−0.0544***	−0.0438***	−0.0652***
	(-16.3191)	(-10.1141)	(-13.4796)
Top10	−0.0134***	−0.0029	−0.0112
	(-2.7884)	(-0.4487)	(-1.6182)
board	−0.0022	0.0036	−0.0107*
	(-0.5958)	(0.8156)	(-1.9314)
TMTPay	−0.0008	0.0000	−0.0029*
	(-0.8172)	(0.0061)	(-1.7757)
Constant	0.0725***	−0.0790***	0.2581***
	(3.6622)	(-3.1590)	(8.6229)
ID FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	28,597	11,934	16,663
R-squared	0.3245	0.3918	0.3536

According to the results in Table 7 , the double threshold values in this paper are 20.2365 and 25.2744, respectively. Table 8 presents the regression results of the double threshold effect. When the firm size is less than 20.2365, the coefficient of human capital accumulation (*capital*) is 0.1207. Although it is positive, it is not statistically significant, indicating that the impact of human capital accumulation on corporate financialization is not significant when firm size is relatively small. When the firm size is between 20.2365 and 25.2744, the coefficient of human capital accumulation (*capital*) is 0.1500, which is significant at the 1 % level. When the firm size exceeds 25.2744, the coefficient of human capital accumulation (*capital*) further increases to 0.3761, which is also significant at the 1 % level. This suggests that the impact of human capital accumulation on corporate financialization varies with firm size, thereby confirming Hypothesis 6 (see Table 9).

5. Conclusions

This article, based on data from listed companies between 2008 and 2022, delves into the interrelationships among human capital accumulation, technological progress, and corporate financialization, arriving at the following conclusions: human capital accumulation significantly promotes corporate financialization. This conclusion underscores the central role of human capital in advancing the process of corporate financialization. Similarly, technological progress also exerts a positive driving effect on corporate financialization. With continuous advancements in technology, firms are able to leverage more sophisticated financial tools and techniques for market operations and risk management, thereby enhancing returns on financial investments. Furthermore, technological progress serves as a mediating factor in the relationship between human capital accumulation and corporate financialization. This indicates that human capital accumulation promotes corporate financialization through its facilitation of technological progress. This finding unveils the transmission mechanism among the three factors, offering a new perspective for understanding the deeper causes of corporate financialization. Additionally, the study finds no significant difference in the impact of human capital accumulation on the financialization of SOEs versus PEs. This conclusion challenges the misconception of inherent differences in the financialization processes of enterprises with varying ownership structures, emphasizing the universal role of human capital in driving corporate financialization. Moreover, the influence of human capital accumulation on corporate financialization exhibits a scale threshold effect. That is, as the scale of an enterprise expands, the promoting effect of human capital accumulation on corporate financialization becomes increasingly pronounced. This finding highlights the importance of enterprise scale in advancing corporate financialization, providing strong support for large enterprises in formulating relevant strategies.

Enterprises should prioritize the synergy between human capital and technological advancement to optimize financial resource allocation. First, increase investments in research and development and employee training to improve human capital quality, thereby reducing excessive reliance on financial investments through innovation-driven strategies. Second, leverage technological progress to streamline production processes, reduce costs, and channel resources toward the real economy. Third, adopt differentiated financialization strategies based on firm size, with smaller enterprises remaining vigilant about risks arising from scale threshold effects to avoid blind expansion of financial investments. Fourth, both SOEs and PEs should modernize corporate governance systems, enhance human capital and technological efficiency through market-oriented mechanisms, and balance financialization with core business operations.

Future research could further explore the following directions: First, refine the analysis of corporate ownership attributes to examine the specific differences and mechanisms in financialization paths between SOEs and PEs. Second, introduce dynamic panel models or instrumental variable approaches to address potential endogeneity issues and enhance the robustness of conclusions. Third,

Table 7
Threshold value results.

model	Threshold	Lower	Upper
Th-1	20.2365	20.1081	22.6981
Th-21	20.2365	20.1081	20.3356
Th-22	25.2744	24.9742	25.6023
Th-3	21.4853	21.3381	21.5261

Table 8
Threshold effect test results.

Threshold	RSS	MSE	Fstat	Prob	Crit10	Crit5	Crit1
Single	53.6828	0.0026	57.2725	0.0033	28.6292	36.1813	52.7971
Double	53.532	0.0026	53.4814	0.0124	25.9614	33.3848	54.9132
Triple	53.4968	0.0026	13.4128	0.5833	52.034	71.3488	118.722

Table 9
Regression results of the double threshold effect.

	(1)
	financialization
capital(size≤20.2365)	0.1207
	(1.1895)
capital(20.2365<size≤25.2744)	0.1500***
	(3.3723)
capital(size>25.2744)	0.3761***
	(3.4497)
size	−0.0007
	(-0.3333)
age	0.0358***
	(10.4290)
level	−0.0512***
	(-6.4489)
Top10	−0.0097
	(-0.8261)
board	−0.0011
	(-0.1515)
TMTPay	−0.0001
	(-0.0447)
_cons	−0.0092
	(-0.2211)
r^2	0.3841
F	35.5602

investigate the moderating effects of external environments (e.g., industrial policies, financial regulations) on the human capital-technological advancement-financialization nexus. Fourth, expand to cross-country samples to compare the heterogeneity of corporate financialization drivers under different institutional contexts.

Author contributions

Zixuan Dong: Conceptualization, Methodology, Writing-Original Draft, Mohd Faiq Abd Aziz: Data Collection, Data Analysis, Writing – Review & Editing Yan Wang: Data Collection, Project Administration, Visualization.

Declaration of interest statement

The authors declare that there are no conflicts of interest associated with this study.

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