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Empirical Analysis of Executive Capital, Innovation, and Risk-Taking in A-Share Tech Firms

Jun Zhang [1], Jing Wang [2], Chuleerat Kongruang [3*]

[1] *School of Accountancy and Finance, Walailak University, Nakhon Si Thammarat, 80160, Thailand.*

[2] *Personal Finance Department, Bank of China, Nan Ning, Guangxi, 530022, China.*

[3] *GSCR, School of Accountancy and Finance, Walailak University, Nakhon Si Thammarat, 80160, Thailand.*

Abstract

This research aims to explore the impact of executive human capital (SMHC) on the performance of Chinese A-share technology listed companies, with a focus on the mediating roles of technological innovation and risk-taking. Using 13,733 data points from 2,796 A-share technology listed companies from 2014 to 2022 sourced from the CSMAR Database, the OLS regression method was employed for analysis. The research findings indicate that SMHC, including its stock, flow, and investment, significantly improves enterprise performance. Among them, investment has the most significant impact, enhancing both economic benefits and market value. Moreover, technological innovation and risk-taking play mediating roles, with positive and significant coefficients. This research enriches the understanding of the relationship between SMHC, technological innovation, risk-taking, and enterprise performance, providing new insights for enterprises to optimize their human capital management and enhance competitiveness.

Keywords:

Executive Human Capital;
Enterprise Performance;
Technological Innovation; Risk-Taking;
A-Share Technology Listed Companies.

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1- Introduction

In the context of rapid global economic development and cut-throat competition, a plethora of studies have shed light on the essential elements for enterprise sustainability. Ganapathy et al. (2019) [1] demonstrated that the senior management team, through the utilization of its human capital, occupies a central position in strategic decision-making. Zahra et al. (1995) [2] reported that technological innovation acts as a crucial propeller for enterprise growth, enabling companies to remain competitive in a rapidly evolving market environment. Additionally, Settembre-Blundo et al. (2021) [3] emphasized that risk-taking, along with the senior management team's human capital and technological innovation, is highly important to enterprises. Although risk-taking helps enterprises seize opportunities in the face of challenges, this study focuses predominantly on the latter two factors. These elements collectively influence enterprise performance, underscoring their importance in ensuring long-term business prosperity.

This research centers on the technology-listed companies in China's A-share market. Anchored in human capital structure theory and drawing on the work of Li et al. (2024) [4], which highlights the role of technological innovation in the relationship between human capital and enterprise performance, this study takes technological innovation as a key mediating variable. The purpose is to dissect the mechanism by which it improves enterprise performance.

* **CONTACT**: chuleerat.ko@wu.ac.th

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Despite the existing body of research on the impact of executive capital on enterprise performance, notable voids still exist. Wang et al. (2012) [5] noted that the understanding of internal mechanisms remains inadequate. For example, previous research has focused mainly on the direct relationship between executive human capital and enterprise performance but has paid less attention to the complex interaction mechanisms among different components of executive human capital, technological innovation, and risk-taking. Additionally, the moderating effects of external factors, such as industry policies and market competition intensity, on these relationships have not been thoroughly explored.

To bridge these gaps, this study adopts a multidimensional approach. First, it will conduct an in-depth analysis of the dimensions and composition of executive capital in A-share technology listed companies. Second, by using a large-scale panel dataset from 2014–2022 and applying advanced statistical methods such as structural equation modeling, the correlations between human capital dimensions and enterprise performance can be explored with technological innovation as a mediator. Third, various external factors are incorporated as moderators in the model to comprehensively study their impact on enterprise operational performance.

Theoretically, this study enriches executive human capital theory. As Wu et al. (2022) [6] called for a more comprehensive understanding of the factors influencing enterprise performance, this research contributes by expanding the analytical framework. Practically, the research results can offer practical guidance for enterprises. As proposed by Berman et al. (2016) [7], it can assist enterprises in optimizing their senior management teams, stimulating innovation investment, and promoting industry-wide development.

2- Literature Review and Hypotheses

2-1- Interaction Mechanism between Executive Human Capital and Technological Innovation

The interplay between top management team (TMT) human capital and technological innovation has been extensively examined in recent studies. Research indicates that the depth and breadth of managerial knowledge significantly enhance firms' innovation output by enabling the integration of internal and external knowledge resources [8, 9]. This aligns with the theoretical foundation of absorptive capacity, which posits that accumulated managerial expertise facilitates the identification and assimilation of external technological knowledge [10]. Furthermore, TMT composition and mobility have been identified as critical drivers of organizational innovation climates. For example, diversified executive experiences can disrupt cognitive rigidity and stimulate creative problem solving [11].

From a strategic perspective, executive human capital is recognized as a core component of firms' innovation capabilities. Executive capital includes human capital stock, human capital flow, and human capital investment. Specifically, managers' professional knowledge serves as a pivotal resource for coordinating complex innovation projects [12]. Empirical studies further corroborate these mechanisms. For example, cross-functional expertise within TMTs has been shown to improve firms' ability to capture technological trends and align R&D investments with market demands. Additionally, targeted investments in executive development programs—such as academic exchanges—enhance strategic foresight and foster innovation-oriented decision-making. A notable case is the electric vehicle industry, where companies leveraging external executives with cross-sector expertise achieved breakthroughs in core battery technologies through knowledge recombination.

However, existing frameworks often overlook the dynamic interactions between executive human capital and contextual factors (e.g., industry volatility). Recent findings suggest that technological knowledge has a positive effect on executive human capital and that internal executive rotations, when combined with external hires, create synergistic effects that revitalize innovation pipelines [12]. This underscores the need for a more nuanced understanding of how temporal and structural dimensions of human capital management interact with innovation outcomes.

On the basis of this foundation, the following hypotheses are proposed:

H2a: Human capital stock has a positive effect on enterprise performance through the mediating variable of technological innovation.

H2b: Human capital flow has a positive effect on enterprise performance through the mediating variable of technological innovation.

H2c: Human capital investment has a positive effect on enterprise performance through the mediating variable of technological innovation.

2-2- Interaction Mechanism between Executive Human Capital and Risk-Taking

Recent studies have focused on the role of executive human capital in risk decisions. Ingley et al. (2008) [13] highlighted that experienced executives with professional insights can balance risk and reward effectively. Zhang & Zhu (2024) [14] reported that targeted training, such as advanced financial knowledge programs, enhances executives' ability to assess and respond to risks scientifically. Pan et al. (2017) [15] noted that introducing executives with distinct risk

preferences reshaped risk culture, optimizing firms' risk strategies. High human capital allows executives to anticipate potential risks, design adaptive strategies, and balance safety with opportunities for high returns.

On the basis of these insights, the following hypotheses are proposed:

H3a: Human capital stock has a positive effect on enterprise performance through the mediating variable of risk-taking.

H3b: Human capital flow has a positive effect on enterprise performance through the mediating variable of risk-taking.

H3c: Human capital investment has a positive effect on enterprise performance through the mediating variable of risk-taking.

2-3- Mediating Role of Technological Innovation between Executive Human Capital and Enterprise Performance

Duan et al. (2022) [16] confirmed that knowledge diversity in TMTs enhances firms' capacities to absorb and re-innovate technologies, driving performance gains. Training in digital transformation equips managers to implement intelligent technologies, enhancing efficiency, reducing costs, and driving competitiveness. George et al. (2002) [17] noted that investments in academic exchanges stimulate product innovation and market expansion, creating new profit avenues. Moreover, Hu et al. (2024) [18] revealed that digital innovation training for TMTs strengthens firms' adaptability in dynamic markets.

Human capital flow also fosters technological innovation, indirectly boosting performance. Zhong et al. (2024) [19] reported that introducing external managers with technical expertise or rotating internal executives enhances cross-field knowledge integration and innovation. Ma et al. (2021) [20] demonstrated that TMT mobility increases functional diversity, enabling rapid technological responses and performance improvements.

On the basis of these findings, the following hypothesis is proposed:

H4a: Executive capital has a positive effect on enterprise performance through the mediating variable of technological innovation.

2-4- Mediating Role of Risk-Taking between Executive Human Capital and Enterprise Performance

Risk-taking serves as a critical bridge connecting top management team (TMT) human capital and enterprise performance, playing a pivotal role in the internal driving logic of firm development [21]. While traditional theories such as Markowitz's (1952) modern portfolio theory emphasize balancing risks and returns, recent studies highlight that TMTs with rich human capital enhance firms' ability to navigate uncertainties and strategically allocate resources [22]. Moreover, the Bounded Rationality Theory suggests that cognitive limitations may hinder decision-making; however, experienced top managers can mitigate these effects by leveraging their knowledge to assess risks accurately and make relatively optimal choices [23].

Empirical evidence supports this perspective, demonstrating that TMT characteristics significantly shape corporate risk-taking decisions [24]. The role of human capital in executive teams extends beyond cognitive skills to influence firms' risk posture and long-term performance. In particular, Hanushek et al. (2022) [25] reported that a firm's risk-taking culture is closely linked to the patience and strategic decision-making of its executives, reinforcing the connection between human capital and corporate outcomes. Furthermore, Atayah et al. (2022) [26] highlighted the mediating role of risk-taking in firms' financial stability, showing that firms with proactive risk management strategies tend to exhibit more sustainable performance.

Additionally, gender diversity within TMTs has been identified as a factor influencing corporate risk behavior. Studies indicate that diverse executive teams contribute to more balanced and cautious risk-taking approaches, ultimately leading to better financial performance [27]. This aligns with findings from García-Lopera et al. (2022) [28], who explored how different TMT compositions impact firm decision-making under uncertainty. Given these insights, understanding the nuanced effects of human capital on enterprise risk-taking remains crucial for future research.

H4b: Executive capital has a positive effect on enterprise performance through the mediating variable of risk-taking.

2-5- Interaction Mechanism between Executive Human Capital and Enterprise Performance

Executive human capital, as a core driver of firm development, is intricately linked to enterprise performance. Recent studies have shown that executive capital benefits from improved decision-making capabilities and resource allocation, leading to increased competitiveness [29]. The resource-based view suggests that unique managerial knowledge, skills, and experience constitute critical sources of competitive advantage, directly contributing to superior firm performance [30]. Similarly, empirical evidence indicates that technology-intensive firms, where executive human capital plays a central role, exhibit higher innovation and market expansion rates [31].

The upper echelons theory further highlights that TMT members' human capital characteristics, including education, industry expertise, and leadership skills, significantly influence strategic decision-making and corporate performance [32]. Studies have demonstrated that firms with highly skilled executives are more likely to engage in risk-taking behaviors that facilitate innovation and growth, reinforcing the importance of executive talent development [33]. Additionally, companies that sustain investments in executive human capital, particularly in the digital era, achieve greater adaptability and long-term performance gains [34]. This growing body of research underscores the vital role of human capital in driving enterprise success through informed strategic management, risk assessment, and technological adoption.

H1a: Human capital stock has a positive effect on enterprise performance.

H1b: Human capital flow has a positive effect on enterprise performance.

H1c: Human capital investment has a positive effect on enterprise performance.

2-6- Conceptual Framework

On the basis of the above literature review and conceptual framework diagram, the relationships among various variables are verified in Figure 1.

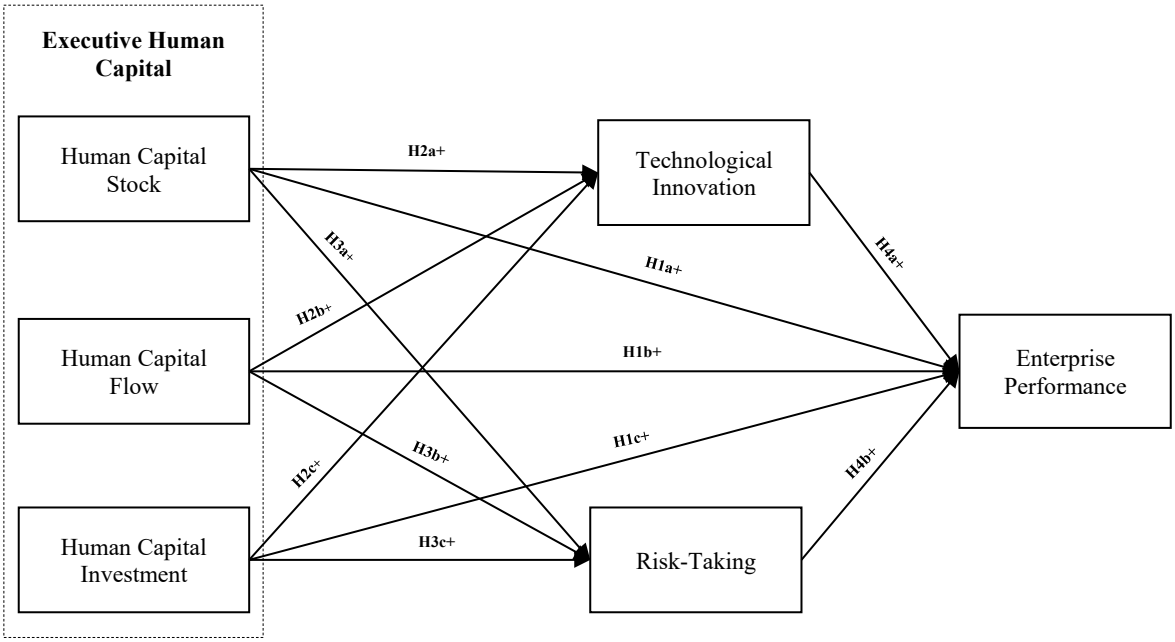

Figure 1. Conceptual Framework Diagram

3- Research Design

3-1- Research Methodology

This study analyzes how human capital affects enterprise performance via OLS regression to explore the impact and mechanisms, providing insights for human capital management strategies.

3-2- Empirical Research Design

This research selects the data of Chinese A-share technology listed companies from 2014--2022 as observation samples. In accordance with the research purpose and drawing on existing practices, this research screens the samples according to the following criteria: 1) exclude listed companies with a trading status of ST or *ST in the current year; 2) exclude observation samples with missing relevant data. Therefore, a total of 2,796 listed companies and 13,733 data points are selected as observation values for statistical analysis in this research.

4- Empirical Analysis

4-1- Variable Definition

To analyze the impact of executive capital on enterprise performance, this study selected technological innovation and risk-taking as mediating variables. From a theoretical and practical perspective, technological innovation is a key driver of enterprise development, and risk-taking influences enterprise decision-making and resource allocation.

Both have a significant effect on performance in the competitive environment of A-share technology listed companies. Although potential mediating factors such as organizational culture were considered, due to the practical situation with Chinese characteristics and the research objectives, other mediating variables were excluded from consideration. To effectively control for differences at the industry and company levels, the study selected key variables such as company size and financial leverage. These variables affect enterprise operations in multiple ways, thus influencing the relationship between executive capital and enterprise performance. Controlling these variables helps to accurately reveal the relationship between the two. The "investment" in executive human capital mainly includes human resource investment and knowledge capital investment. Human resource investment enhances executives' skills and promotes the optimization of enterprise operations, whereas knowledge capital investment strengthens executives' innovation capabilities, enabling enterprises to expand into new markets and ultimately enhancing market value and economic benefits.

The variable definitions are shown in Table 1.

Table 1. Variable definition and measurement

Variable Type	Variable Name	Variable Symbol	Variable Definition
Explained Variable	Enterprise Performance	TFP	Enterprise performance calculated by LP Method
Explanatory Variable	Human Capital Stock	HCS	The number of executives with a bachelor's degree or above/The number of executives
	Human Capital Flow	EDU	Assign a value of 1 to technical secondary school and below, 2 to junior college, 3 to undergraduate, 4 to master's degree, and 5 to doctoral degree. Then, take the average value of the above assignments.
	Human Capital Investment	HCI	Natural logarithm of the total compensation of the executive team
Mediating Variable	Technological Innovation	Patent	The number of enterprise patent applications, with logarithm taken.
	Risk-Taking	Risk	Standard deviation of return on total assets
Control Variable	Company Size	Size	Logarithm of total assets
	Financial Leverage	Lev	Total Liabilities/Total Assets
	Return on Total Assets	ROA	Net Profit/Total Assets
	Growth	Growth	Revenue Growth Rate
	Operating Cash Flow	OCF	Operating cash flow/Total assets
	Enterprise Establishment Years	Age	Ln(current year - establishment year + 1)
	Proportion of Independent Directors	Bind	Number of independent directors/Number of board members
	Ownership Concentration	Top10	Shareholding ratio of top ten shareholders/Total number of shares
	Management Shareholding Ratio	MSH	Number of shares held by executives/Total number of shares

4-2- Model Construction

To verify the impact of the stock of executive capital on enterprise performance, the following model is constructed for hypothesis testing:

$$TFP_{it} = \alpha_0 + \alpha_1 \times HCS_{it} + \alpha_2 \times Control_{it} + Ind + Year + \varepsilon_{it} \quad (1)$$

To verify the impact of human capital flow on enterprise performance, this research constructs the following model for hypothesis testing:

$$TFP_{it} = \alpha_0 + \alpha_1 \times EDU_{it} + \alpha_2 \times Control_{it} + Ind + Year + \varepsilon_{it} \quad (2)$$

To verify the impact of executive human resource investment on enterprise performance, this research constructs the following model for hypothesis testing:

$$TFP_{it} = \alpha_0 + \alpha_1 \times HCI_{it} + \alpha_2 \times Control_{it} + Ind + Year + \varepsilon_{it} \quad (3)$$

In terms of research methods, OLS regression analysis was used. Although alternative methods such as panel data models were also considered, the OLS method was found to be the most suitable method due to its simplicity and intuitiveness, as well as factors related to the data structure and research objectives of this study.

4-3- Empirical Results

(1) Descriptive statistics

Table 2 lists the descriptive statistics of the key variables.

Table 2. Descriptive Statistics

Variables	N	Mean	Median	Std. Dev	Minimum	MaITimum
TFP	13733	8.132	8.076	0.877	6.101	11.231
HCS	13733	0.844	1	0.219	0	1
EDU	13733	3.311	3.333	0.557	1	5
HCI	13733	15.419	15.394	0.661	13.699	17.51
Size	13733	21.915	21.792	1.026	19.782	27.377
Lev	13733	0.377	0.365	0.187	0.055	0.95
ROA	13733	0.036	0.041	0.074	-0.372	0.207
Growth	13733	0.176	0.122	0.375	-0.622	2.473
OCF	13733	0.049	0.047	0.065	-0.172	0.25
Age	13733	2.938	2.944	0.283	1.792	4.205
Bind	13733	0.379	0.364	0.053	0.333	0.571
Top10	13733	0.574	0.582	0.142	0.234	0.912
MSH	13733	0.202	0.144	0.204	0	0.701

Table 2 lists the descriptive statistics of the key variables. The mean is 8.132, the maximum is 11.231, and the minimum is 6.101, indicating that there are large differences in enterprise performance among different enterprises. The mean HCS is 0.844, indicating that the proportion of people with a bachelor's degree or above on the executive team accounts for more than 80% of the sample. The mean EDU is 3.311, and the flow of executive capital has reached the level of a bachelor's degree or above. The mean HCI is 15.419, and the standard deviation is 0.661, which also shows that there are differences in executive compensation among different enterprises.

(2) Correlation analysis

Table 3 reports on the Pearson correlation coefficient matrix. This research reveals that the correlation coefficient between HCS and the “dependent variable” is 0.104 and is significantly positively correlated at the 1% level; the correlation coefficient between EDU and the “dependent variable” is 0.145 and is significantly positively correlated at the 1% level; and the correlation coefficient between HCI and the “dependent variable” is 0.481 and is significantly positively correlated at the 1% level. Moreover, there are significant correlations with other control variables. Therefore, it is still necessary to further test the impact of executive capital on enterprise performance via regression analysis.

Table 3. Correlation Analysis

	TFP	HCS	EDU	HCI	Size	Lev	ROA	Growth	OCF	Age	Bind	Top10	MSH
TFP	1												
HCS	0.104***	1											
EDU	0.145***	0.775***	1										
HCI	0.481***	0.141***	0.204***	1									
Size	0.791***	0.105***	0.171***	0.502***	1								
Lev	0.425***	0.054***	0.062***	0.098***	0.441***	1							
ROA	0.150***	-0.055***	-0.042***	0.183***	0.037***	-0.377***	1						
Growth	0.180***	0.00500	0.023***	0.066***	0.087***	0.035***	0.285***	1					
OCF	0.104***	-0.038***	-0.023***	0.171***	0.048***	-0.202***	0.412***	0.036***	1				
Age	0.149***	0.027***	0.000	0.147***	0.153***	0.094***	-0.036***	-0.104***	0.037***	1			
Bind	-0.064***	0.00200	-0.00800	-0.107***	-0.059***	-0.00500	-0.048***	-0.025***	-0.015*	-0.021**	1		
Top10	-0.0100	-0.126***	-0.109***	-0.0140	-0.070***	-0.152***	0.248***	0.096***	0.126***	-0.142***	0.039***	1	
MSH	-0.222***	-0.137***	-0.145***	-0.092***	-0.308***	-0.230***	0.146***	0.055***	0.022**	-0.158***	0.075***	0.263***	1

Note: ***p<0.01, **p<0.05, *p<0.1

4-4- Multiple Regression Analysis

(1) Human capital stock and enterprise performance

This research uses the stepwise regression method to empirically test the relationship between the human capital stock and enterprise performance. The results are shown in Table 4.

Table 4. Human capital stock and enterprise performance

	(1)	(2)
	TFP	
HCS	0.392***	0.080***
	(11.66)	(4.15)
Size		0.592***
		(121.51)
Lev		0.857***
		(30.39)
ROA		1.979***
		(27.89)
Growth		0.146***
		(12.29)
OCF		0.579***
		(8.03)
Age		0.086***
		(5.39)
Bind		-0.360***
		(-4.65)
Top10		0.201***
		(6.41)
MSH		0.00100
		(0.06)
Cons	7.605***	-5.677***
	(64.56)	(-43.20)
Ind	YES	YES
Year	YES	YES
N	13733	13733
Adj-R2	0.0690	0.701

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

Column (1) shows that the coefficient of HCS is 0.392 and is significant at the 1% level. Finally, after controlling for all control variables, the coefficient of HCS is 0.080 and is significant at the 1% level. In conclusion, the above results indicate that the human capital stock significantly improves enterprise performance. Therefore, H1a is established.

(2) Human capital flow and enterprise performance

This research uses the stepwise regression method to empirically test the relationship between human capital flow and enterprise performance. The results are shown in Table 5.

Table 5. Human capital flow and enterprise performance

	(1)	(2)
	TFP	
EDU	0.218***	0.017**
	(16.59)	(2.19)
Size		0.592***
		(120.50)
Lev		0.856***
		(30.34)
ROA		1.977***
		(27.85)
Growth		0.146***
		(12.30)
OCF		0.577***
		(8.00)
Age		0.086***
		(5.44)
Bind		-0.357***
		(-4.61)
Top10		0.195***
		(6.24)
MSH		-0.00300
		(-0.15)
Cons	7.171***	-5.674***
	(58.51)	(-43.03)
Ind	YES	YES
Year	YES	YES
N	13733	13733
Adj-R2	0.0780	0.701

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

Column (1) shows that the coefficient of EDU is 0.218 and is significant at the 1% level. Finally, after controlling for all control variables, the coefficient of EDU is 0.017 and is significant at the 1% level. In conclusion, the above results indicate that human capital flow significantly improves enterprise performance. Therefore, H1b is supported.

(3) Human capital investment and enterprise performance

This research uses the stepwise regression method to empirically test the relationship between human capital investment and enterprise performance. The results are shown in Table 6.

Column (1) shows that the coefficient of HCI is 0.654 and is significant at the 1% level. Finally, after this research further controls for all control variables, the coefficient of HCI is 0.105 and is significant at the 1% level. In conclusion,

the above results indicate that human capital investment significantly improves enterprise performance. Therefore, H1c is established.

Table 6. Human capital investment and enterprise performance

	(1)	(2)
	TFP	
HCI	0.654***	0.105***
	(64.35)	(13.40)
Size		0.558***
		(100.93)
Lev		0.883***
		(31.41)
ROA		1.875***
		(26.45)
Growth		0.146***
		(12.37)
OCF		0.487***
		(6.77)
Age		0.087***
		(5.53)
Bind		-0.246***
		(-3.18)
Top10		0.199***
		(6.42)
MSH		-0.0210
		(-0.94)
Cons	-1.847***	-6.494***
	(-10.14)	(-44.80)
Ind	YES	YES
Year	YES	YES
N	13733	13733
Adj-R2	0.278	0.705

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

4-5- Robustness Test

(1) Lagged regression

The impact of human capital on enterprises is lagging and long-term. At the same time, higher enterprise performance in the current period will bring abundant resources to enterprises, which will help increase human capital investment. Therefore, there may be a problem of mutual causation in this research. In view of this, this research conducts lagged regression, that is, exploring the impact of current human capital on enterprise performance in the next period. The relevant results are shown in Table 7.

Table 7. Lagged regression

	(1)	(2)	(3)
		TFPit+1	
HCS	0.078***		
	(3.36)		
EDU		0.022**	
		(2.40)	
HCI			0.115***
			(12.07)
Size	0.584***	0.583***	0.545***
	(97.82)	(96.92)	(80.34)
Lev	0.821***	0.821***	0.849***
	(23.97)	(23.97)	(24.88)
ROA	2.056***	2.054***	1.928***
	(24.07)	(24.05)	(22.57)
Growth	0.241***	0.241***	0.242***
	(16.93)	(16.92)	(17.13)
OCF	0.389***	0.388***	0.278***
	(4.42)	(4.40)	(3.16)
Age	0.041**	0.042**	0.041**
	(2.15)	(2.22)	(2.20)
Bind	-0.382***	-0.380***	-0.266***
	(-4.13)	(-4.10)	(-2.88)
Top10	0.264***	0.263***	0.299***
	(7.00)	(6.98)	(7.98)
MSH	0.0280	0.0250	0.00500
	(1.08)	(0.95)	(0.18)
Cons	-5.224***	-5.234***	-6.102***
	(-33.33)	(-33.28)	(-35.35)
Ind	YES	YES	YES
Year	YES	YES	YES
N	10782	10782	10782
Adj-R2	0.663	0.663	0.667

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

(2) Changing the explained variable

In the main test, enterprise performance calculated via the LP method is used to measure enterprise performance. In the robustness test, this research further uses enterprise performance calculated by the GMM model to measure enterprise performance (TFP-GMM). The relevant results are shown in Table 8.

Table 8. Changing the explained variable

	(1)	(2)	(3)
	TFP-GMM		
HCS	0.107***		
	(5.25)		
EDU		0.025***	
		(3.05)	
HCI			0.063***
			(7.60)
Size	0.322***	0.321***	0.302***
	(62.84)	(62.25)	(51.70)
Lev	0.661***	0.661***	0.675***
	(22.35)	(22.32)	(22.77)
ROA	1.877***	1.874***	1.804***
	(25.29)	(25.23)	(24.18)
Growth	0.171***	0.171***	0.172***
	(13.75)	(13.74)	(13.83)
OCF	0.026	0.022	-0.035
	(0.34)	(0.30)	(-0.46)
Age	0.009	0.011	0.010
	(0.53)	(0.64)	(0.61)
Bind	-0.280***	-0.276***	-0.213***
	(-3.44)	(-3.39)	(-2.60)
Top10	0.126***	0.124***	0.140***
	(3.82)	(3.75)	(4.25)
MSH	0.034	0.028	0.013
	(1.48)	(1.20)	(0.57)
Cons	-2.101***	-2.105***	-2.578***
	(-15.38)	(-15.36)	(-16.96)
Ind	YES	YES	YES
Year	YES	YES	YES
N	13733	13733	13733
Adj-R2	0.473	0.472	0.474

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

(3) Eliminating the impact of the COVID-19 pandemic

The COVID-19 pandemic significantly has had a negative effect on enterprise supply chain management and enterprise financing and has negatively affected enterprise performance. Therefore, to eliminate the impact of the COVID-19 pandemic on the results of this research, in the robustness test, this research further eliminates the impact of the COVID-19 pandemic period from 2020-2021.

As shown in Tables 4 to 9, column (2) presents the final results. There is no obvious difference between the research conclusions and the research conclusions in Tables 4 to 6, indicating that the conclusions of this research are robust.

Table 9. Eliminating the impact of the COVID-19 pandemic

	(1)	(2)	(3)
		TFP	
HCS	0.080***		
	(3.54)		
EDU		0.021**	
		(2.35)	
HCI			0.103***
			(11.13)
Size	0.589***	0.588***	0.555***
	(101.82)	(100.90)	(84.43)
Lev	0.847***	0.847***	0.873***
	(25.51)	(25.50)	(26.38)
ROA	1.991***	1.989***	1.875***
	(23.67)	(23.63)	(22.26)
Growth	0.142***	0.142***	0.145***
	(10.24)	(10.26)	(10.54)
OCF	0.725***	0.722***	0.629***
	(8.61)	(8.57)	(7.48)
Age	0.081***	0.082***	0.082***
	(4.37)	(4.43)	(4.49)
Bind	-0.378***	-0.374***	-0.272***
	(-4.14)	(-4.10)	(-2.98)
Top10	0.263***	0.263***	0.296***
	(7.13)	(7.11)	(8.03)
MSH	0.0120	0.00800	-0.0100
	(0.45)	(0.29)	(-0.40)
Cons	-5.561***	-5.567***	-6.363***
	(-36.62)	(-36.54)	(-37.83)
Ind	YES	YES	YES
Year	YES	YES	YES
N	10004	10004	10004
Adj-R2	0.701	0.701	0.704

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

In summary, since the three sub-Hypotheses H1a, H1b, and H1c are all established simultaneously and are robust, H1 is established.

4-6- Mechanism Analysis

(I) Mechanistic analysis of the impact of the human capital stock on enterprise performance

To verify the mechanism of the impact of human capital stock on enterprise performance, this research constructs the following mediation effect model for hypothesis testing, where mediation represents the mediation variable. This research takes technological innovation (patent) and risk as mediation variables.

$$TFP_{it} = \alpha_0 + \alpha_1 \times HCS_{it} + \alpha_2 \times Control_{it} + ind + year + \varepsilon_{it} \quad (4)$$

$$Mediation_{it} = \gamma_0 + \gamma_1 \times HCS_{it} + \gamma_2 \times Control_{it} + ind + year + \varepsilon_{it} \quad (5)$$

$$TFP_{it} = \delta_0 + \delta_1 \times HCS_{it} + \delta_2 \times Median_{it} + \delta_3 \times Control_{it} + ind + year + \varepsilon_{it} \quad (6)$$

1. Technological innovation mechanism of the impact of the human capital stock on enterprise performance

This research uses the number of enterprise patent applications and takes the logarithm as a proxy variable for technological innovation (Patent), constructs a mediation effect model for testing, and the data results are shown in Table 10:

Table 10. Technological Innovation Mechanism of the Impact of Human Capital Stock on Enterprise Performance

	(1)	(2)	(3)
	TFP	**Patent**	**TFP**
HCS	0.080***	0.341***	0.067***
	(4.15)	(7.44)	(3.49)
Patent			0.038***
			(10.54)
Size	0.591***	0.661***	0.566***
	(121.42)	(57.40)	(104.81)
Lev	0.848***	0.186***	0.841***
	(30.11)	(2.79)	(29.97)
ROA	1.979***	1.218***	1.933***
	(28.02)	(7.30)	(27.43)
Growth	0.152***	-0.067**	0.154***
	(12.80)	(-2.39)	(13.06)
OCF	0.571***	0.245	0.562***
	(7.93)	(1.44)	(7.83)
Age	0.080***	-0.0220	0.081***
	(5.06)	(-0.60)	(5.13)
Bind	-0.387***	-0.376**	-0.373***
	(-5.00)	(-2.05)	(-4.83)
Top10	0.244***	0.0590	0.242***
	(7.81)	(0.79)	(7.77)
MSH	0.0300	0.437***	0.0140
	(1.38)	(8.45)	(0.62)
Cons	-5.603***	-12.756***	-5.119***
	(-43.11)	(-41.51)	(-37.27)
Ind	YES	YES	YES
Year	YES	YES	YES
N	13733	13733	13733
Adj-R^2	0.702	0.357	0.704

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

2. Risk-Taking Mechanism Analysis of the Impact of the Human Capital Stock on Enterprise Performance

This research uses the standard deviation of the return on total assets of listed companies adjusted by the industry average from year t - 2 to year t to measure risk-taking and constructs a mediation effect model for testing; the data results are shown in the following table:

Table 11. Risk-Taking Mechanism of the Impact of Human Capital Stock on Enterprise Performance

	(1)	(2)	(3)
	TFP	Risk	TFP
HCS	0.080***	0.007***	0.076***
	(4.15)	(3.76)	(3.94)
Risk			0.568***
			(6.58)
Size	0.591***	-0.004***	0.594***
	(121.42)	(-9.07)	(121.76)
Lev	0.848***	-0.00100	0.848***
	(30.11)	(-0.21)	(30.17)
ROA	1.979***	-0.340***	2.173***
	(28.02)	(-48.70)	(28.44)
Growth	0.152***	0.008***	0.147***
	(12.80)	(6.94)	(12.40)
OCF	0.571***	0.092***	0.519***
	(7.93)	(12.98)	(7.17)
Age	0.080***	-0.00100	0.081***
	(5.06)	(-0.78)	(5.11)
Bind	-0.387***	0.032***	-0.405***
	(-5.00)	(4.12)	(-5.23)
Top10	0.244***	-0.013***	0.252***
	(7.81)	(-4.06)	(8.05)
MSH	0.0300	-0.008***	0.0350
	(1.38)	(-3.81)	(1.59)
Cons	-5.603***	0.159***	-5.694***
	(-43.11)	(12.41)	(-43.63)
Ind	YES	YES	YES
Year	YES	YES	YES
N	13733	13733	13733
Adj-R^2	0.702	0.309	0.703

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

(II) Mechanistic analysis of the impact of human capital flow on enterprise performance

To verify the mechanism of the impact of human capital flow on enterprise performance, this research constructs the following mediation effect model for hypothesis testing, where mediation represents the mediation variable. This research takes technological innovation (patent) and risk-taking as mediation variables.

$$TFP_{it} = \alpha_0 + \alpha_1 \times EDU_{it} + \alpha_2 \times Control_{it} + ind + year + \varepsilon_{it} \quad (7)$$

$$Mediation_{it} = \gamma_0 + \gamma_1 \times EDU_{it} + \gamma_2 \times Control_{it} + ind + year + \varepsilon_{it} \quad (8)$$

$$TFP_{it} = \delta_0 + \delta_1 \times EDU_{it} + \delta_2 \times Median_{it} + \delta_3 \times Control_{it} + ind + year + \varepsilon_{it} \quad (9)$$

1. Mechanism Analysis Based on Technological Innovation

This research uses the number of enterprise patent applications, takes the logarithm as a proxy variable of technological innovation (Patent), and constructs a mediation effect model for testing. The data results are shown in Table 12.

Table 12. Technological Innovation Mechanism of the Impact of Human capital flow on Enterprise Performance

	(1)	(2)	(3)
	TFP	**Patent**	**TFP**
EDU	0.019**	0.157***	0.013*
	(2.48)	(8.75)	(1.68)
Patent			0.039***
			(9.69)
Size	0.591***	0.669***	0.565***
	(109.54)	(53.31)	(93.75)
Lev	0.848***	0.190***	0.840***
	(24.61)	(2.72)	(24.43)
ROA	1.977***	1.224***	1.929***
	(18.13)	(6.70)	(17.84)
Growth	0.152***	-0.073**	0.155***
	(9.46)	(-2.38)	(9.67)
OCF	0.569***	0.248	0.559***
	(6.41)	(1.35)	(6.30)
Age	0.081***	-0.00700	0.081***
	(5.02)	(-0.20)	(5.06)
Bind	-0.384***	-0.349*	-0.371***
	(-4.92)	(-1.85)	(-4.77)
Top10	0.243***	0.0900	0.239***
	(7.62)	(1.18)	(7.56)
MSH	0.0250	0.443***	0.00800
	(1.21)	(8.63)	(0.38)
Cons	-5.607***	-13.263***	-5.086***
	(-40.55)	(-40.59)	(-34.26)
Ind	YES	YES	YES
Year	YES	YES	YES
N	13733	13733	13733
Adj-R^2	0.701	0.363	0.704

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

2. Mechanism Analysis Based on Risk-taking

This research uses the standard deviation of the return on total assets of listed companies adjusted by the industry average from year t - 2 to year t to measure risk-taking and constructs a mediation effect model for testing. The data results are shown in Table 13.

Table 13. Risk-Taking Mechanism of the Impact of Human capital flow on Enterprise Performance

	(1)	(2)	(3)
	TFP	**Risk**	**TFP**
EDU	0.019**	0.003***	0.017**
	(2.43)	(3.77)	(2.22)
Risk			0.573***
			(6.64)
Size	0.591***	-0.004***	0.594***
	(120.36)	(-9.26)	(120.70)
Lev	0.848***	0	0.848***
	(30.08)	(-0.15)	(30.13)
ROA	1.977***	-0.340***	2.172***
	(27.98)	(-48.68)	(28.42)
Growth	0.152***	0.008***	0.147***
	(12.79)	(6.90)	(12.40)
OCF	0.569***	0.092***	0.516***
	(7.89)	(12.96)	(7.12)
Age	0.081***	-0.00100	0.082***
	(5.14)	(-0.64)	(5.18)
Bind	-0.384***	0.032***	-0.402***
	(-4.96)	(4.14)	(-5.20)
Top10	0.243***	-0.012***	0.250***
	(7.75)	(-3.98)	(7.98)
MSH	0.0250	-0.008***	0.0300
	(1.16)	(-3.85)	(1.38)
Cons	-5.607***	0.157***	-5.697***
	(-42.98)	(12.19)	(-43.51)
Ind	YES	YES	YES
Year	YES	YES	YES
N	13733	13733	13733
Adj-R^2	0.701	0.309	0.702

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

(III) Mechanistic Analysis of the Impact of Human Capital Investment on Enterprise Performance

To verify the mechanism of the impact of human capital investment on enterprise performance, this research constructs the following mediation effect model for hypothesis testing, where mediation represents the mediation variable. This research takes technological innovation (patent) and risk-taking as mediation variables.

$$\mathrm{TFP}_{it} = \alpha_0 + \alpha_1 \times \mathrm{HCI}_{it} + \alpha_2 \times \mathrm{Control}_{it} + \mathrm{ind} + \mathrm{year} + \varepsilon_{it} \quad (10)$$

$$\mathrm{Mediation}_{it} = \gamma_0 + \gamma_1 \times \mathrm{HCI}_{it} + \gamma_2 \times \mathrm{Control}_{it} + \mathrm{ind} + \mathrm{year} + \varepsilon_{it} \quad (11)$$

$$\mathrm{TFP}_{it} = \delta_0 + \delta_1 \times \mathrm{HCI}_{it} + \delta_2 \times \mathrm{Median}_{it} + \delta_3 \times \mathrm{Control}_{it} + \mathrm{ind} + \mathrm{year} + \varepsilon_{it} \quad (12)$$

1. Mechanism Analysis Based on Technological Innovation

This research uses the number of enterprise patent applications, takes the logarithm as a proxy variable for technological innovation (Patent), and constructs a mediation effect model for testing. The data results are as follows:

Table 14. Technological Innovation Mechanism of the Impact of Human Capital Investment on Enterprise Performance

	(1)	(2)	(3)
	TFP	Patent	TFP
HCI	0.111***	0.281***	0.102***
	(14.11)	(14.93)	(12.84)
Patent			0.034***
			(9.48)
Size	0.555***	0.588***	0.535***
	(100.34)	(44.61)	(90.69)
Lev	0.875***	0.243***	0.867***
	(31.20)	(3.64)	(30.99)
ROA	1.860***	0.901***	1.830***
	(26.35)	(5.36)	(25.98)
Growth	0.152***	-0.068**	0.155***
	(12.93)	(-2.43)	(13.16)
OCF	0.471***	-0.00800	0.471***
	(6.54)	(-0.04)	(6.57)
Age	0.082***	-0.0130	0.083***
	(5.26)	(-0.36)	(5.31)
Bind	-0.274***	-0.0630	-0.272***
	(-3.55)	(-0.34)	(-3.53)
Top10	0.280***	0.147**	0.275***
	(8.97)	(1.98)	(8.84)
MSH	0.00700	0.365***	-0.00500
	(0.32)	(7.08)	(-0.25)
Cons	-6.477***	-15.281***	-5.959***
	(-45.02)	(-44.58)	(-38.83)
Ind	YES	YES	YES
Year	YES	YES	YES
N	13733	13733	13733
Adj-R^2	0.706	0.370	0.708

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

2. Mechanism Analysis Based on Risk-taking

This research uses the standard deviation of the return on total assets of listed companies adjusted by the industry average from year t - 2 to year t to measure risk-taking and constructs a mediation effect model for testing. The data results are shown in Table 15.

Table 15. Risk-Taking Mechanism of the Impact of Human Capital Investment on Enterprise Performance

	(1)	(2)	(3)
	TFP	Risk	TFP
HCI	0.111***	0.004***	0.109***
	(14.11)	(5.30)	(13.83)
Risk			0.525***
			(6.12)
Size	0.555***	-0.006***	0.558***
	(100.34)	(-10.26)	(100.63)
Lev	0.875***	0.000	0.875***
	(31.20)	(0.11)	(31.24)
ROA	1.860***	-0.345***	2.042***
	(26.35)	(-49.12)	(26.70)
Growth	0.152***	0.008***	0.148***
	(12.93)	(6.99)	(12.56)
OCF	0.471***	0.089***	0.424***
	(6.54)	(12.37)	(5.87)
Age	0.082***	-0.00100	0.083***
	(5.26)	(-0.72)	(5.31)
Bind	-0.274***	0.036***	-0.293***
	(-3.55)	(4.68)	(-3.79)
Top10	0.280***	-0.012***	0.286***
	(8.97)	(-3.76)	(9.18)
MSH	0.007	-0.010***	0.012
	(0.32)	(-4.48)	(0.56)
Cons	-6.477***	0.128***	-6.544***
	(-45.02)	(8.95)	(-45.41)
Ind	YES	YES	YES
Year	YES	YES	YES
N	13733	13733	13733
Adj-R^2	0.706	0.310	0.706

Note: *** indicates p<0.01, ** indicates p<0.05, and * indicates p<0.1. The numbers in parentheses from columns (1) to (4) are t values.

4-7- Summary of Study Hypothesis Test Results

The results of the hypothesis tests on the relationships among executive capital, technological innovation, risk-taking, and enterprise performance are shown in Table 16.

4-8- Empirical Results Analysis

The analysis confirms that executive human capital positively impacts enterprise performance (H1), with education providing theoretical foundations, professional skills ensuring sound decision-making (H1a), and experience enhancing problem-solving abilities. Moreover, the flow and investment of executive human capital, such as recruitment, training, and internal transfers, significantly improve performance (H1c), enabling adaptability, innovation, and alignment with market dynamics. Enterprises must prioritize diverse and high-quality executive human capital to maintain competitiveness and achieve long-term growth. Technological innovation mediates the relationship between executive capital and enterprise performance (H2). Executives transform their knowledge and skills into R&D output through strategic planning, resource allocation, and team leadership, boosting technological advancements and market competitiveness (H2b). Flow and investment in human capital bring new ideas and improve innovation capabilities

(H2a, H2c). Risk-taking, while context dependent, influences how executives utilize their human capital, especially in strategic decisions and resource allocation (H3, H3a, H3b, H3c). Although it can mediate specific scenarios, risk-taking is not universally applicable as a central link between executive human capital and enterprise performance. Both factors highlight the dynamic interplay of human capital with enterprise strategies for sustained success (H4).

Table 16. Summary of study hypothesis test results

Hypothesis	Result
H1：The executive human capital has a positive impact on enterprise performance.	Support
H1a：The human capital stock has a positive impact on enterprise performance.	Support
H1b：The human capital flow has a positive impact on enterprise performance.	Support
H1c：Human capital investment has a positive impact on enterprise performance.	Support
H2：The executive human capital has a positive impact on enterprise performance through the mediating variable of technological innovation.	Support
H2a：The human capital stock has a positive impact on enterprise performance with technological innovation as the mediating variable.	Support
H2b：The human capital flow has a positive impact on enterprise performance with technological innovation as the mediating variable.	Support
H2c：Human capital investment has a positive impact on enterprise performance with risk-taking as the mediating variable and technological innovation as the mediating variable.	Support
H3：The executive human capital has a positive impact on enterprise performance through the mediating variable of risk-taking.	Support
H3a：The human capital stock has a positive impact on enterprise performance with risk-taking as the mediating variable.	Support
H3b：The human capital flow has a positive impact on enterprise performance with risk-taking as the mediating variable.	Support
H3c：Human capital investment has a positive impact on enterprise performance with risk-taking as the mediating variable.	Support
H4a：Executive human capital (human capital stock, human capital flow, human capital investment) has a positive impact on enterprise performance with technological innovation as the mediating variable.	Support
H4b：Executive human capital (human capital stock, human capital flow, human capital investment) has a positive impact on enterprise performance with risk-taking as the mediating variable.	Support

5- Conclusion

This research focuses on Chinese A-share technology listed companies and deeply explores the relationships among executive human capital, technological innovation, risk-taking, and enterprise performance. The empirical results show that the stock, flow, and investment of executive capital all have a significant positive effect on enterprise performance. Technological innovation and risk-taking play crucial mediating roles in this relationship. Technological innovation promotes enterprise technological upgrades and product improvements, amplifying the positive effect of executive capital on enterprise performance. Risk-taking influences the flow and investment of executive human capital, enhances enterprise decision-making and innovation capabilities, and thus promotes the improvement of enterprise performance.

Compared with previous studies, this research has unique value. Although previous studies recognized the promoting effect of executive capital on enterprise performance, they did not analyze the impact mechanism in depth and seldom considered the mediating effects of technological innovation and risk-taking simultaneously. This research constructs a multiple regression model to comprehensively verify the mediating roles of technological innovation and risk-taking, clearly revealing the specific paths through which various dimensions of executive capital affect enterprise performance. For example, research has shown that executive capital investment has a significant effect on enterprise performance and has an indirect effect through technological innovation and risk-taking. This achievement enriches and improves the relevant theoretical system, compensating for the deficiencies of previous studies. In practice, enterprises can optimize the construction of executive teams, increase investment in technological innovation, and reasonably control the level of risk-taking on the basis of the conclusions of this research to effectively improve enterprise performance and provide strong support for the sustainable development of enterprises.

5-1- Recommendations and the Significance of this Research

This research highlights that enterprises should prioritize increased investment in technological innovation, focusing on R&D team development, external collaboration, and robust evaluation mechanisms to enhance competitiveness and growth. Optimizing the risk-taking structure of the executive team, with a balance of innovation and caution, ensures stable decision-making and mitigates excessive risk. Additionally, implementing comprehensive incentive mechanisms, including competitive compensation, equity plans, and performance evaluations, can unleash the full potential of the executive team.

This research can provide suggestions and countermeasures for the construction of executive capital models in Chinese A-share technology listed companies and for the optimization of enterprise performance. The relevant optimization suggestions can be extended to other enterprises in China and can also serve as a reference for enterprises in Western countries and around the world. Therefore, it has strong theoretical value and practical significance.

6- Declarations

6-1- Author Contributions

Conceptualization, J.Z. and C.K.; methodology, J.Z. and C.K.; software, J.Z. and J.W.; validation, J.Z., J.W., and C.K.; formal analysis, J.Z.; investigation, J.Z. and J.W.; resources, CK.; data curation, C.K. and J.W.; writing—original draft preparation, J.Z.; writing—review and editing, C.K.; visualization, J.Z. and J.W.; supervision, C.K.; project administration, J.Z. All authors have read and agreed to the published version of the manuscript.

6-2- Data Availability Statement

The data presented in this study are available in the article.

6-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

6-4- Institutional Review Board Statement

Not applicable.

6-5- Informed Consent Statement

Not applicable.

6-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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