

# An analysis method of enterprise digital transformation effect based on investor data of public companies

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**Abstract:** In the context of the trend of Digital transformation of enterprises, this paper empirically examines the differences in the impact of founders and strategic investment controllers on Digital transformation of enterprises, taking private listed companies from 2007 to 2020 as research samples. The research results indicate that the founding controller is beneficial for listed companies to actively promote the digital process of the enterprise; However, both financial and industrial investment controllers will inhibit the Digital transformation of enterprises, and the inhibitory effect of financial investment controllers is stronger. Digital finance and control rights further strengthen the above regression results. Individual controllers, vertical industry controllers and professional financial investment controllers are conducive to the Digital transformation of enterprises. The mechanism research shows that the company's innovation input and output, and information transparency play a mediating role between the controller heterogeneity and the enterprise's Digital transformation. The research results of this paper enrich the research perspective and content of the relationship between corporate controllers and Digital transformation, and have certain reference significance for enterprises to improve corporate governance and actively promote Digital transformation.

**Keywords:** Digital transformation of enterprises, Digital finance, Management of enterprise innovation, Big data

## 1. Introduction

Recently, with the popularization of digital technology, society and enterprises are facing rapid and thorough changes. At the macro level, the widespread application of digital technology in various fields has formed the current "digital trend", leading to profound changes in the entire social economy. At the micro level, digital technology is fundamentally changing the company's operating model, forcing enterprises to rethink how to use Digital transformation to maintain competitive advantage. According to the survey results of Internet data center (IDC), 67% of the top 1000 enterprises in the world regard Digital transformation as their core development strategy. However, from 2019 to 2020, about 70% of Digital transformation failed to meet expectations[1].

The "Digital transformation Partnership Action" initiative issued by the National Development and Reform Commission in May 2020 pointed out that we should focus on driving small, medium-sized and micro enterprises, accelerate the creation of digital enterprises, build digital industrial chains, foster digital ecology, and support high-quality economic development. Therefore, taking into account China's national conditions, actively promoting enterprise transformation and upgrading, and achieving high-quality development of the manufacturing industry through digital innovation are of great significance to the national economy. However, the internal Digital transformation of the enterprise is like a "black box", and its influencing factors, transmission mechanism and economic consequences

still need to be further explored in theory and practice. In recent years, the Digital transformation, as a new driving force to improve the economy in the digital economy era, has received extensive attention from scholars. Most of the existing literature focuses on the economic consequences of Digital transformation, such as the impact of Digital transformation on enterprise performance, enterprise resilience and Total factor productivity. In contrast, there is a lack of research on the drivers of enterprise Digital transformation[2]. In particular, based on the high-level echelon theory, the psychological cognition of the enterprise's top management team, such as risk orientation and thinking mode, will affect the company's strategic decision-making, so the heterogeneity of managers will also have a differential impact on the promotion of the enterprise's Digital transformation process. Founders, as the earliest initiators of a company, are significantly different from non-founders in terms of their connections with the company, management experience, and risk orientation. With the increasingly fierce competition for control in the capital market, a large number of founders of private enterprises have lost their control position, and instead, various types of strategic investment controllers have emerged[3]. These strategic investment controllers have different merger and acquisition purposes and development tendencies, including financial investment controllers who obtain short-term high returns, as well as industrial investment controllers who integrate and upgrade with existing industries. Obviously, Controllers with multiple goals have significant differences in corporate strategy, corporate governance, investment and financing behavior, and digital innovation, which will determine the future development process and sustainable growth ability of the enterprise. Therefore, considering and understanding the role of founder has strong theoretical and practical significance for many development strategies of enterprises in the context of the diversity of the roles of controllers in China's capital market. However, reviewing existing literature, there is a lack of research papers on the diversity of controller roles, which far lags behind the time requirements of capital market development[4-6].

Therefore, this paper conducts a text analysis of the "Management Discussion and Analysis" section of the annual report of listed companies to obtain data to measure the Digital transformation of enterprises, and manually collates the identity information of the founders and final controllers of enterprises to compare. It attempts to explore the different impacts that different types of final controllers may have on the Digital transformation of enterprises from the perspective of the heterogeneity between founders and investors, In order to provide some Empirical evidence for enterprises to successfully achieve Digital transformation.

The possible contributions of this paper are mainly reflected in: (1) The existing research focusing on the ultimate controller mainly considers the property right attribute, while this paper has subdivided the research of the founding controller, financial investment controller and industrial investment controller on the Digital transformation of the enterprise based on the differences of the controllers who have obtained control for different merger and acquisition purposes, enriching the relevant research of the enterprise controller; (2) In the context of the rapid development of the digital economy, studying the impact of enterprise controllers on the Digital transformation of enterprises can analyze the attitude differences, promotion process and influencing factors of micro subject behavior in the digital economy, which is conducive to improving the theoretical research related to the digital economy from a micro perspective; (3) The test of the regulatory effect of digital finance and control, the further analysis of the heterogeneity of the three types of controllers, and the investigation of the theoretical mechanism reveal the influence and difference of controllers on Digital transformation in a more detailed and comprehensive way. These studies have certain reference value for enterprises to actively promote the process of Digital transformation to maintain and consolidate competitive advantages, relevant departments to formulate preferential policies, and promote high-quality development of enterprises and society.

## **2. Research and hypotheses**

### ***2.1. Controller heterogeneity and corporate digital transformation***

Digital transformation does not simply use digital technology, but completely change and replace the original operation mode, and apply digital technology in every link and department of the enterprise. Although digital transformation is only an overall architecture for enterprises, micro individuals play an important role in the completion of digital transformation as the foundation of the whole enterprise. And each individual has many differences, such as different outlook on life, values, world view and wealth, so different individuals will have different impacts on all aspects of the enterprise. Especially for key individuals, different differences have a deeper impact on enterprises, such as CEO's experience,

self-confidence, power and personality. In recent years, it has attracted extensive research interest of scholars. The key individuals in an enterprise include not only the CEO, but also the ultimate controller, through his connection with the external environment and the ability to effectively allocate internal resources, thus formulating corporate strategies to help the enterprise guide the long-term development direction, clarify the development goals, point out the development points, determine the development capabilities needed by the enterprise, and help solve the development problems of the enterprise. To achieve rapid, healthy and sustainable development of the enterprise, it also has a decisive position and influence in the enterprise. Research on entrepreneurial enterprises shows that the decisions of founding controllers play a key role in influencing the core strategic decisions of enterprises, and this influence will still exist for a long time after their departure. As a cognitive framework, the identity of founders not only affects their own views on things and related behaviors, but also affects the overall strategic direction and action results of enterprises more generally[7-9].

Founders develop and grow together with enterprises. In this process, founders usually have a high sense of organizational belonging to the enterprise and are closely related to the enterprise, thus paying more attention to the long-term development of the enterprise. The goal of socioemotional wealth generated during the establishment and development of enterprises has also become the main starting point for founders to implement major strategies and risk-taking decisions. Moreover, as founders have accumulated rich experience and knowledge in corporate entrepreneurship and management, they are often better at discovering and seizing opportunities and are risk-takers. In fact, digitalization itself can be regarded as a kind of entrepreneurial process, and personal entrepreneurial orientation including adventure, innovation and initiative is the key driving factor for the implementation of enterprise digital strategy and digital transformation. Therefore, in a digital environment full of uncertainty and complexity, risk-oriented founding controllers are more likely to adopt the digital transformation process that ADAPTS to the trend of The Times[10].

It is more and more common for strategic investors to act as the ultimate controllers of enterprises. Generally speaking, there is no "special emotional connection" between strategic investors and enterprises with non-economic interests, so they rarely take the initiative to play the role of "supervisor" in enterprises, and even "conniving" the short-term agency behavior of management. Digital transformation is closely related to business model transformation, which is a long-term strategic decision of enterprises. Therefore, compared with founders, strategic investors will inhibit the improvement of enterprises' digital level to a certain extent because they do not have the unique "long-term orientation" of founders. For the various types of strategic investors, more and more scholars have paid attention to the impact of the heterogeneity of institutional investors on the heterogeneity of enterprises in recent years. Therefore, considering that some of the strategic investor-based controllers of listed companies have founded companies and may be heterogeneous, this paper divides the investor-based ultimate controllers into industrial investors and financial investors according to whether the non-founder corporate controllers have their own start-up entities. On the one hand, compared with financial investors, industrial investors can bring advanced technology resources, high-quality cooperation opportunities and other non-financial convenience to enterprises, and bring more benefits to the digital transformation of enterprises; On the other hand, different from financial investors, the strategic intention of industrial investors makes them hold shares for a longer period of time, have a higher willingness to supervise the company, and are more likely to enhance managers' attention to long-term investment and digitalization. However, financial investors tend to be professional investment institutions, pursuing the maximization of short-term interests, and will not pay attention to the long-term development prospects of enterprises in the future, but will avoid high-risk corporate digital transformation behaviors. Based on the above analysis, compared with strategic investors, founder ultimate controllers will actively promote the digital transformation process of enterprises due to their long-term orientation with risk-taking tendency. At the same time, compared with industrial investors, financial investment controllers have a stronger inhibitory effect on improving the digital level and promoting the digital transformation of enterprises. Based on this, this paper puts forward Hypothesis 1 and Hypothesis 2:

Compared with strategic investors, founding controllers will be conducive to enterprises' digital transformation (H1); Compared with industrial investors, financial investment controllers have a stronger inhibitory effect on corporate digital transformation (H2).

## ***2.2. Moderating effect of digital finance***

As a strategic layout of enterprises, digital transformation is affected by many factors, such as internal and external factors. Generally, the level of digital finance development in a region will affect

the attitude and decision-making results of enterprises on digital transformation to a certain extent, and then affect the relationship between enterprise controllers and digital transformation. On the one hand, the development of digital finance is conducive to the establishment of an inclusive financial system, broaden the breadth of financial resources, enrich the financing channels of enterprises, reduce the financing transaction costs of enterprises, and provide long-term financial support for the digital transformation of enterprises. On the other hand, in the era of digitalization and informatization, based on digital technology, digital financial institutions can collect and analyze diversified and valuable data at a lower cost, so as to form the information effect of digital finance, alleviate the information asymmetry between enterprises, and promote the opening and sharing of financial resources among different enterprise subjects. And improve the efficiency of capital utilization. However, the inclusiveness and convenience of digital finance also provide enterprises with more diversified short-term financial investment opportunities, which to some extent promotes enterprises to "move from real to virtual" and hinders the digital transformation of enterprises. At this time, the heterogeneity of corporate controllers will make digital finance have different impacts on controllers and digital transformation. Specifically, due to the long-term development orientation of founding controllers, the financing advantage under the development of digital finance will further enhance the role of founders in promoting the digital transformation of enterprises. However, driven by short-term interests, strategic investors may pay more attention to the convenience of using financial assets to speculate under the development of digital finance. Moreover, compared with industrial investors, financial investors pursue the maximization of short-term interests and will use digital finance more to expand short-term investment. Therefore, the development of digital finance will "intensify" the short-term behavior of strategic investors, thus enhancing their inhibitory effect on the digital transformation of enterprises, and has a stronger negative moderating effect on financial investors. Based on this, this paper puts forward hypothesis 3:

Digital finance will further strengthen the relationship between controller heterogeneity and corporate digital transformation (H3).

### ***2.3. Moderating effect of control rights***

The control advantage enjoyed by the controller in the enterprise has a non-negligible impact on the strategic and operational decisions of the enterprise. The increase of the control right is bound to have an impact on the relevant decisions and behaviors of the enterprise, and then has an impact on the connection between the enterprise controller and the digital transformation. Theoretically, the ultimate controller of the enterprise exerts influence on the major decisions of the enterprise through its control advantage, and the greater the control right is, the greater the influence it can exert on the enterprise. With the increase of control rights, the interests of founders and enterprises are further aligned, and the sense of organizational identity and belonging of enterprises are higher, which will try to consolidate the competitive advantage of enterprises and realize the long-term development of enterprises. In addition, the increase of control rights often makes the founding controllers have greater decision-making autonomy, which is more conducive to the founders to "put into practice" the development blueprint of the enterprise, pay more attention to the digital technology innovation that is conducive to the long-term development of the enterprise, and actively promote the process of digital transformation of the enterprise. In addition, as mentioned above, the inhibitory effects of industrial and financial investment controllers on corporate digital transformation are significantly different, so the impact of increased control on the relationship between investor-based controllers and corporate digital transformation may also be different. Different from financial investors, industrial investors may control enterprises for the purpose of industrial integration, rather than using control rights to seek personal gains. Therefore, the increase of control power does not have a substantial impact on their investment preference. Financial investment controllers, as transactional investors, tend to take advantage of information and obtain capital returns, and even regard financial objectives as the only investment objectives, rather than actively play their governance role. With the increase of their control rights, they will be motivated to maximize private interests, and use the advantage of control rights to divert corporate resources to short-term investment, thus inhibiting the digital transformation of enterprises. Based on this, Hypothesis 4 is put forward:

The increase of control rights will strengthen the relationship between controller heterogeneity and enterprise digital transformation (H4)

### 3. Research design

#### 3.1. Data source and sample selection

The research sample of this paper is 4,681 private listed companies in non-financial industries from 2007 to 2020, and the following samples are excluded: (1) companies that belong to special disposition (ST) and delisting warning (\* ST); (2) The company whose basic data is missing; (3) the company is insolvent, that is, the company with a debt-to-assets ratio greater than 1; (4) Companies with no ultimate controller and no access to founder information; (5) Companies with valid sample data less than 5 years old. The result was 1776 companies, with a total of 15,942 sample observations. The relevant financial data mainly comes from the CSMAR database, the digital transformation data comes from the annual reports of listed companies, and the information of founders and investors is manually sorted out.

#### 3.2. Model construction

In order to verify whether the three types of final controllers, namely founders, industrial investors and financial investors, have different impacts on enterprises' digital transformation, this paper constructs the following basic regression model (1) :

$$\text{Digital}_{it} = \beta_0 + \beta_1 \text{Char}_{it} + \gamma \text{Controls}_{it} + \varepsilon_{it} \quad (1)$$

$$\text{Digital}_{it} = \beta_0 + \beta_1 \text{Char}_{it} + \beta_2 \text{Char}_{it} \times \text{Regu}_{it} + \beta_3 \text{Regu}_{it} + \gamma \text{Controls}_{it} + \varepsilon_{it} \quad (2)$$

Where: subscript *i* is enterprise; *t* is the year; The variable Digital is the explained variable, representing the digitalization level of the enterprise; The variable Char refers to the three types of ultimate controllers studied in this paper: the Founder controller, the Industry controller and the Finance controller. Regu stands for digital financial level (Index) and control level (Cont), Controls are the control variables listed in the variable definition table;  $\beta$  and  $\gamma$  are regression coefficients.  $\varepsilon$  is the random disturbance term.

#### 3.3. Definition of key variables

##### 3.3.1. The Digital transformation of the dependent variable (Digital).

Based on the Digital glossary constructed by Yuan Chun et al. (2021), this paper analyzes the text of the "Management discussion and analysis" part of the corporate annual report, and constructs the variable digital to measure the degree of digitalization of the enterprise.

##### 3.3.2. The independent variable founding control people

Such as the definition of reference dechow, p (2012), according to the enterprise prospectus "founder" of the "publisher" and related description and search search engine to determine. If the company is founded by a team of founders, the member who has the largest share or holds a key position is deemed to be the founder. After the final controller of the enterprise is determined, the information of the Founder is compared with that of the founder of the enterprise. When the founder of the company is the final controller, the value of the founder is 1, and that of the non-founder controller (strategic investment controller) is 0. If the ultimate controller of the enterprise is not the founder, the non-founding controller is divided into Industry and Finance by further checking whether the controller owns a start-up entity through the Internet.

##### 3.3.3. Adjust the variable digital financial (Index)

In this paper, the method of reference Tang Song (2020), using the total provincial pratt & Whitney financial Index to measure area of Beijing university level of financial development, the number of words and the digital financial Index divided by 100 for research in this paper. Control rights (Cont), this paper adopts the control rights ratio of the ultimate controller to measure the size of the control rights.

##### 3.3.4. Control variables

Control variables refer to existing literature, selected the effect control heterogeneity factors associated with enterprise digital transformation as control variables. Such as company Size (Size), asset-liability ratio (Lev), Growth (Growth), enterprise value (Tq), cash holdings (Lev)(Table 1).

Table 1: Variable definition table

Categories	Variable symbols	Variable definition	Variable description
Explained variable	Digital	Digital transformation	The total frequency of words related to enterprise digitalization divided by the length of MD&A paragraphs in the annual report multiplied by 100
Explanatory variables	Founder	Founding controller	The value is 1 if the founder is the ultimate controller of the enterprise, and if 0 not
	Industry	Industry investment controller	If it is a non-founding controller and has a start-up entity industry, the value is 1; if it is not, it is 0
	Finance	Financial investment controller	If it is a non-founding controller and there is no start-up entity industry, the value is 1; if it is not, the value is 0
Moderating variable	Index	Digital Finance	Peking University Provincial Digital Financial Inclusion Index divided by 100
	Cont	Control rights	The ultimate controller controls the proportion of control of the listed company
Control variables	Size	Company size	Natural logarithm of the firm's total assets
	Lev	Asset-liability ratio	The ratio of corporate debt to average total assets
	Grow	Growth	The growth rate of a company's operating income
	Tq	Enterprise value	The ratio of the company's market value to the replacement value of its assets
	Cash	Cash on hand	Ratio of cash and cash equivalents balances to average total assets
	Roa	Return on assets	The ratio of net profit to average total assets
	First	Share holding Ratio of the largest share holder	Ratio of the number of shares held by the largest share holder to the total number of shares
	Audi	Audit opinion	Assign a value of 1 to 5 from standard unqualified opinion to unexpressible opinion
	Dual	Two in one	The value is 1 when the chairman of an enterprise concurrently serves as the general manager, and 0 otherwise
	Age	Age of business	Natural logarithm of the number of years from the year of establishment to 2020

### 3.4. Descriptive statistics and correlation analysis

Table 2: Descriptive statistics of variables.

Variables	Number of samples	Mean	Median	Standard deviation	Maximum	Minimum
Digital	15942	0.229	0.082	0.353	3.637	0
Founder	15942	0.724	1	0.447	1	0
Industry	15942	0.106	0	0.308	1	0
Finance	15942	0.170	0	0.375	1	0
Index	15942	2.177	2.267	0.852	3.777	0.183
Cont	15942	0.356	0.345	0.150	0.901	0.011
Size	15942	21.770	21.660	1.080	25.130	19.720
Lev	15942	0.375	0.363	0.195	0.844	0.043
Roa	15942	0.058	0.058	0.067	0.240	-0.259
Cash	15942	0.134	0.125	0.156	0.452	0.009
Tq	15942	2.160	1.731	1.321	8.600	0.921
Growth	15942	0.370	0.144	0.923	6.500	-0.639
First	15942	32.330	30.190	14.030	70.420	7.930
Age	15942	3.045	3.045	0.243	3.555	2.565
Audi	15942	4.922	5	0.438	5	1
Dual	15942	0.358	0	0.479	1	0

As can be seen from Table 2, from 2007 to 2020, the average Digital transformation (Digital) of enterprises is 0.229, much higher than the median of 0.082, indicating that the digital transformation gap among non-financial enterprises in China is large, and the digital transformation of most enterprises is below the average level. The mean value of the index of the founding controller is 0.724, and the median is 1, indicating again that most of the listed companies in the non-financial industry in China are still under the control of the company founder. At the same time, the mean value of financial investors (0.170) is larger than that of Industry investors (0.106), indicating that in the case of non-founder control, enterprises are mostly controlled by financial investors who do not own start-up entities. The maximum value, minimum value and standard deviation of the largest shareholder's shareholding ratio (First) are 70.420, 7.930 and 14.030, indicating that there are great differences in ownership concentration among different enterprises, and both concentration and dispersion of ownership exist in listed companies in China.

As can be seen from the correlation coefficient table of main variables in Table 3, the correlation coefficients of Founder and Digital are both significantly positive at the significance level of 1%. Preliminary results show that the originator controller will promote the digitalization level of enterprises to a certain extent. The correlation coefficient between the two types of strategic investors' controller (Finance, Industry) and Digital is negative, and it is significant at 1% level. This suggests that when a strategic investor eventually takes control of a company, it may hinder its digital transformation to some extent.

Table 3: Correlation numbers of main variables.

	Digital	Founder	Finance	Industry	Index	Cont
Digital	1					
Founder	0.132***	1				
Finance	-0.088***	-0.733***	1			
Industry	-0.088***	-0.559***	-0.156***	1		
Index	0.227***	0.060***	-0.013	-0.072***	1	
Cont	0.113***	0.141***	-0.146***	-0.034***	-0.026***	1

Note: \*\*\*, \*\* and \* indicate significance at the confidence levels of 1%, 5% and 10%, respectively.

## 4. Empirical Analysis and Results

### 4.1. Basic regression results

Columns (1) ~ (3) in Table 4 respectively show the regression results of founders, industrial controllers, financial investment controllers and enterprises' digital transformation. From the regression results, it can be seen that the regression coefficients of founding controllers and digital transformation of enterprises are significantly positive at the 1% level, while the regression coefficients of industrial investors and financial investors and digital transformation are significantly negative at the 1% and 5% levels, respectively. This suggests that founding controllers are more conducive to digitalization and thus actively promote digital transformation due to their long-term orientation and risk-taking tendencies, which are intrinsically motivated by their "special emotions", while financial and industrial investment controllers ultimately inhibit the digitalization of their companies. It is worth noting that numerically, the absolute values of regression coefficients and t-statistics of financial investment controllers are larger than those of industrial investment controllers, and the significant difference between the two is proved by the regression coefficients intergroup variability test, which indicates that financial investment controllers have stronger inhibitory effects on the digital transformation, and verifies the value orientation of the strategy of acquiring short-term financial goals by financial investment controllers.

The regression coefficients of company size, enterprise value, growth and enterprise digital transformation are all significantly positive at the 1% level, so enterprises with good growth can not only increase the value of the enterprise, but also grow the size of the company. The company size, enterprise value and growth of an enterprise are conducive to improving its digital transformation level and ultimately achieving the goal of maximizing enterprise value.

The regression coefficient of return on assets and digital transformation of firms is significantly negative at the 1% level, i.e., it inhibits the degree of digital development of firms and is detrimental to the level of digitization.

The regression coefficient between audit opinion and digital transformation of enterprises is also significantly positive at the 1% level, and auditors' perceptions of and attitudes towards the results of the review play a role in facilitating the digital transformation of enterprises (Table 4).

Table 4: Regression results of controller type and enterprise digital transformation.

Variables	(1)	(2)	(3)	Variables	(1)	(2)	(3)
	Digital	Digital	Digital		Digital	Digital	Digital
Founder	0.043*** (4.728)			First	-0.001** (-2.532)	-0.001** (-2.354)	-0.001* (-1.840)
Finance		-0.033*** (-3.248)		Age	0.005 (0.300)	-0.006 (-0.358)	-0.011 (-0.643)
Industry			-0.027** (-2.443)	Audi	0.024*** (4.064)	0.024*** (4.007)	0.025*** (4.287)
Size	0.029*** (6.634)	0.027*** (6.221)	0.029*** (6.555)	Dual	0.001 (0.132)	0.003 (0.371)	0.002 (0.304)
Lev	-0.036 (-1.463)	-0.042* (-1.715)	-0.046* (-1.875)	Constant	-0.838*** (-6.539)	-0.732*** (-5.865)	-0.758*** (-6.113)
Roa	-0.241*** (-3.411)	-0.242*** (-3.433)	-0.236*** (-3.338)	Year/ Indu	Control	Control	Control
Cash	0.003** (2.190)	0.003** (2.213)	0.003** (2.140)	N	7464	7464	7462
Tq	0.016*** (4.687)	0.015*** (4.472)	0.014*** (4.232)	Adj-R2	0.519	0.519	0.518
Growth	0.017*** (4.258)	0.017*** (4.240)	0.016*** (3.983)	value	0.000***	0.000***	0.016**

#### 4.2. Moderating effect

Table 5 demonstrates the moderating effect of digital finance and control. From columns (1) to (4) of Table 5, the level of digital finance is significantly and positively related to digital transformation, suggesting that as the level of digital finance in a region increases, the degree of digital transformation of firms also increases. The regression coefficient of the interaction term of founding controllers and digital finance with firms' digital transformation is significantly positive at the 1% level, suggesting that the role of founding controllers in facilitating firms' digital transformation will be further enhanced when the level of digital finance development in the region where the firms are located is higher. The regression coefficients of the interaction terms of financial investment controllers and digital finance with firms' digital transformation are significantly negative, whereas the regression coefficients of the interaction terms of industrial investment controllers and digital finance with firms' digital transformation are negative but not significant, and the significant difference is proven by the regression coefficients' test of between-groups variability. This suggests that the development of digital finance can significantly enhance the inhibitory effect of financial investors on digital transformation to the detriment of corporate digital transformation, while the negative moderating effect on the relationship between industrial investors and digital transformation is not significant.

As seen from the regression results in columns (5) to (8) of Table 5, overall, an increase in control is generally accompanied by a significant increase in the firm's digital transformation; For founding controllers, along with increased control, founding controllers will further contribute to the enhancement of the digital transformation of the enterprise due to their long-term orientation and decision-making autonomy; For financial controllers, who usually focus on the short-term profitability of the enterprise, increased control tends to influence the "short-termization" of the enterprise's investment decisions and behaviors, further inhibiting the digital transformation of the enterprise; For industrial investment controllers, the regression coefficient of the interaction term and enterprise digital transformation is negative, but the value is small and insignificant, indicating that for industrial investors in the purpose of industrial integration, the increase of control does not have a substantial impact on enterprise digital transformation. This verifies Hypothesis 4 of this paper.



Table 5: Moderating effect of digital finance and control rights.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Index				Cont			
	Digital	Digital	Digital	Digital	Digital	Digital	Digital	Digital
Founder		-0.017 (-0.837)				0.005 (0.186)		
Finance			-0.013 (-0.268)				0.010 (0.323)	
Industry				-0.028*** (-4.635)				0.001 (0.027)
Regu	0.001*** (2.886)	0.001* (1.739)	0.001*** (3.316)	0.001*** (3.795)	0.001*** (3.536)	0.001 (-0.101)	0.001*** (2.712)	0.001** (2.515)
Founder×Regu		0.011*** (2.698)				0.001*** (3.899)		
Finance×Regu			-0.077*** (-3.104)				-0.002** (-1.999)	
Industry×Regu				-0.022 (-0.891)				-0.001 (-0.658)
Size	0.031*** (6.769)	0.031*** (6.784)	0.029*** (6.369)	0.031*** (6.750)	0.035*** (6.823)	0.036*** (6.884)	0.033*** (6.449)	0.034*** (6.662)
Lev	-0.041 (-1.604)	-0.040 (-1.578)	-0.039 (-1.538)	-0.045* (-1.815)	-0.071** (-2.455)	-0.068** (-2.355)	-0.072** (-2.467)	-0.079*** (-2.703)
Roa	-0.238*** (-3.312)	-0.237*** (-3.305)	-0.234*** (-3.254)	-0.230*** (-3.202)	-0.230*** (-2.945)	-0.231*** (-2.788)	-0.236*** (-2.861)	-0.230*** (-2.773)
Cash	0.003** (2.336)	0.003** (2.348)	0.003** (2.310)	0.003** (2.304)	0.002 (1.561)	0.002 (1.384)	0.002 (1.442)	0.002 (1.284)
Tq	0.016*** (4.485)	0.016*** (4.488)	0.015*** (4.380)	0.014*** (4.049)	0.014*** (3.548)	0.015*** (3.660)	0.014*** (3.538)	0.014*** (3.390)
Growth	0.017*** (4.040)	0.018*** (4.074)	0.018*** (4.070)	0.017*** (3.938)	0.017*** (4.241)	0.018*** (4.007)	0.019*** (4.051)	0.017*** (3.719)
First	-0.001** (-2.340)	-0.001** (-2.356)	-0.001** (-2.152)	-0.001* (-1.763)	-0.001*** (-3.235)	-0.001*** (-2.898)	-0.001*** (-3.064)	-0.001*** (-2.899)
Age	0.002 (0.105)	0.002 (0.136)	-0.005 (-0.296)	-0.010 (-0.589)	0.009 (0.222)	0.009 (0.445)	0.001 (0.033)	-0.009 (-0.428)
Audi	0.001 (0.538)	0.001 (0.589)	0.001 (0.285)	0.001 (0.186)	0.026*** (3.576)	0.026*** (3.511)	0.026*** (3.442)	0.026*** (3.577)
Dual	0.002 (0.279)	0.002 (0.258)	0.003 (0.365)	0.002 (0.345)	0.013 (1.447)	0.012 (1.469)	0.015* (1.776)	0.014* (1.757)
Constant	-0.715*** (-5.875)	-0.725*** (-5.944)	-0.675*** (-5.612)	-0.705*** (-5.934)	-0.869*** (-6.236)	-0.943*** (-6.186)	-0.862*** (-5.770)	-0.870*** (-5.847)
Year/Indu	Control	Control	Control	Control	Control	Control	Control	Control
N	7230	7230	7230	7228	5616	5616	5616	5614
Adj-R2	0.516	0.521	0.520	0.521	0.536	0.542	0.541	0.540

Note: \* \*\* and \*\*\* indicate significance at the confidence levels of 1%, 5% and 10%, respectively; Values in parentheses are t values.

5. Robustness tests and endogeneity issues

5.1. Robustness test

5.1.1. Exclude special years

The sample data of enterprises selected in this paper span from 2007 to 2020, among which several years are affected by unexpected events, such as the financial crisis in 2008, the European debt crisis in 2012 and the COVID-19 epidemic in 2022. Considering that the research results of this paper will be affected with a certain probability, Therefore, the sample data of 2008, 2012 and 2020 are removed to ensure the robustness of the calculation results, and then the basic regression model ① is applied. In the regression results of columns (1) - (3) of Table 6, the regression coefficient of founding controller and enterprise digital transformation is still significantly positive at the confidence level of 1%, while the regression coefficient of financial investment controller is significantly negative at the confidence level of 1%, and the regression coefficient of industrial investment controller is significantly negative at the confidence level of 5%. According to the T value between the three, the promotion effect of founders on corporate digital transformation is greater than the inhibitory effect of financial and

industrial investment controllers, which is basically consistent with the previous regression results, which again verifies the result that founding controllers will help enterprises realize digital transformation and the inhibitory effect of financial and investment controllers on corporate digital transformation is stronger than that of industrial investment controllers.

**5.1.2. Independent variables are lagged one and two periods**

Generally speaking, the ultimate controller of the enterprise needs a certain amount of time to complete the industrial digital transformation. Assuming that the required time is lagged by one period and two periods respectively, the main independent variables are lagged by one period and two periods respectively, and then put into the regression model (1). From the regression results in columns (4) - (9) of Table 6, it can be seen that the regression results of founders are still positive in the case of lagged one and two periods, and the regression results of financial investment controllers lagged one and two periods are still significantly negative at the confidence level of 1%. Although the absolute value of t is slightly reduced, the overall inhibitory results remain unchanged. The regression results of the industrial investment controllers lagged by one and two periods are negative at the confidence level of 5% and 10% respectively, which is roughly consistent with the previous regression results, indicating that the independent variables lagged by one and two periods will not significantly change the research results, and verify Hypothesis 1 and Hypothesis 2 of this paper.

*Table 6: Regression results after excluding special years and after one or two periods of lag.*

Variables	Eliminating special years			Lagged one period			Lag two periods		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Digital	Digital	Digital	Digital	Digital	Digital	Digital	Digital	Digital
Founder	0.043*** (4.728)			0.036*** (3.757)			0.037*** (3.574)		
Finance		-0.033*** (-3.248)			-0.027** (-2.337)			-0.029** (-2.513)	
Industry			-0.027** (-2.443)			-0.025** (-2.269)			-0.021* (-1.676)
Size	0.029*** (6.634)	0.027*** (6.221)	0.029*** (6.555)	0.029*** (6.244)	0.030*** (5.839)	0.027*** (5.924)	0.028*** (5.526)	0.029*** (6.215)	0.029*** (5.698)
Lev	-0.036 (-1.463)	-0.042* (-1.715)	-0.046* (-1.875)	-0.043* (-1.693)	-0.054* (-1.882)	-0.049* (-1.897)	-0.058** (-2.009)	-0.051** (-1.979)	-0.060** (-2.123)
Roa	-0.241 ***(-3.411)	-0.242*** (-3.433)	-0.236*** (-3.338)	-0.225*** (-3.066)	-0.233*** (-2.922)	-0.226*** (-3.077)	-0.234*** (-2.932)	-0.226*** (-3.072)	-0.236*** (-2.952)
Cash	0.003** (2.190)	0.003** (2.213)	0.003** (2.140)	0.002 (1.593)	0.003** (2.001)	0.002 (1.575)	0.003** (2.031)	0.002 (1.552)	0.003** (1.966)
Tq	0.016*** (4.687)	0.015*** (4.472)	0.014*** (4.232)	0.015*** (4.163)	0.013*** (3.333)	0.014*** (4.005)	0.012*** (3.229)	0.014*** (3.917)	0.012*** (3.141)
Growth	0.017*** (4.258)	0.017*** (4.240)	0.016*** (3.983)	0.020*** (4.860)	0.017*** (3.993)	0.020*** (4.828)	0.017*** (4.000)	0.019*** (4.702)	0.016*** (3.847)
First	-0.001** (-2.532)	-0.001** (-2.354)	-0.001* (-1.840)	-0.001** (-2.570)	-0.001** (-2.507)	-0.001** (-2.397)	-0.001** (-2.400)	-0.001** (-2.054)	-0.001** (-2.046)
Age	0.005 (0.300)	-0.006 (-0.358)	-0.011 (-0.643)	0.005 (0.276)	0.007 (0.346)	-0.006 (-0.333)	-0.004 (-0.206)	-0.008 (-0.445)	-0.009 (-0.441)
Audi	0.024*** (4.064)	0.024*** (4.007)	0.025*** (4.287)	0.026*** (4.109)	0.024*** (3.614)	0.026*** (4.081)	0.024*** (3.574)	0.027*** (4.270)	0.025*** (3.752)
Dual	0.001 (0.132)	0.003 (0.371)	0.002 (0.304)	0.002 (0.270)	0.007 (0.827)	0.003 (0.468)	0.008 (1.008)	0.003 (0.376)	0.007 (0.946)
Constant	-0.838*** (-6.539)	-0.732*** (-5.865)	-0.758*** (-6.113)	-0.825*** (-6.199)	-0.841*** (-5.655)	-0.734*** (-5.667)	-0.743*** (-5.144)	-0.763*** (-5.937)	-0.763*** (-5.315)
Year/Indu	Control	Control	Control	Control	Control	Control	Control	Control	Control
N	7464	7464	7462	7141	6160	7141	6160	7139	6159
Adj-R2	0.519	0.519	0.518	0.523	0.525	0.522	0.525	0.522	0.524

Note: \*\*\*, \*\* and \* indicate significance at the confidence levels of 1%, 5% and 10%, respectively; Values in parentheses are t values.

**5.2. Endogeneity problem**

Considering that the process of enterprise transformation to digital may be affected by some accidental factors, that is, there may be endogenous problems such as sample bias and reverse causality in the connection between the ultimate controller of the enterprise and enterprise transformation. On this basis, this paper uses two-stage least squares method and propensity score matching method to

bridge the error problem caused by sample bias. In the propensity score matching method, the nearest samples are matched in a ratio of 1 : 1, and then the matching results are repeated in the basic regression model (1). In the two-stage least square method, the instrumental variable of the main endogenous explanatory variable is obtained by selecting the average level of different types of controllers in the same industry in the same year. Since the average number of controller types in the same industry in the same year is related to the final controller situation of a single enterprise, it will not affect the enterprise's digital transformation in a large probability. It meets the requirements of correlation and exogeneity of instrumental variables. The two-stage least squares regression and propensity score matching regression results are shown in Table 7. The regression coefficients of the founding controller are significantly positive in the two-stage least squares regression and propensity score matching regression results, and the regression results of the financial investment controller are significantly negative at the confidence level of 1% in both cases. The regression results of financial investment controllers are significantly negative at the confidence level of 1%. Therefore, it can be concluded that after the endogeneity problem is alleviated, the positive impact of founders on corporate transformation can still be shown, while the industrial and financial investment controllers still show the inhibitory effect. At the same time, the above hypothesis 1 is verified again.

Table 7: Results of two-stage least squares regression and propensity score matching regression.

Variables	Two-stage least squares regression			Propensity score matching regression		
	(1)	(2)	(3)	(4)	(5)	(6)
	Digital	Digital	Digital	Digital	Digital	Digital
Founder	0.629*** (14.875)			0.029** (2.333)		
Finance		-0.802*** (-13.568)			-0.037*** (-2.696)	
Industry			-0.193* (-1.717)			-0.029** (-2.079)
Size	0.056*** (8.935)	0.030*** (4.761)	0.852 (1.148)	0.010 (1.186)	0.001 (0.134)	0.041*** (4.502)
Lev	-0.017 (-0.468)	-0.077** (-2.108)	2.812 (1.010)	0.028 (0.631)	0.120** (2.523)	-0.043 (-0.857)
Roa	-0.740*** (-7.065)	-0.894*** (-8.151)	3.633 (0.858)	-0.150 (-1.094)	0.097 (0.654)	139 (0.883)
Cash	0.005** (2.239)	0.006*** (2.744)	-0.030 (-0.731)	0.004 (1.584)	-0.003 (-1.086)	0.001 (0.401)
Tq	0.062*** (14.792)	0.061*** (14.002)	174 (1.355)	0.007 (1.311)	0.004 (0.639)	0.009 (1.421)
Growth	0.061*** (10.679)	0.064*** (10.488)	118 (1.184)	0.008 (1.095)	0.002 (0.324)	-0.003 (-0.506)
First	-0.005*** (-13.601)	-0.006*** (-13.983)	0.002 (0.337)	0.001 (-0.570)	-0.001** (-1.996)	0.001 (-0.800)
Age	0.227*** (6.839)	120*** (4.018)	4.973 (1.080)	-0.005 (-0.170)	-0.136*** (-3.815)	-0.015 (-0.418)
Audi	0.011 (0.807)	0.009 (0.639)	-0.084 (-0.423)	0.035** (2.285)	0.018 (1.267)	0.017 (1.164)
Dual	-0.003 (-0.256)	0.021* (1.889)	-0.803 (-1.048)	-0.006 (-0.453)	0.001 (0.065)	0.005 (0.293)
Constant	-2.104*** (-9.626)	-0.558*** (-3.181)	-32.434 (-1.111)	-0.442* (-1.825)	0.280 (1.119)	-0.935*** (-3.644)
Year/ Indu	Control	Control	Control	Control	Control	Control
N	7464	7464	7462	1808	1559	1025
Adj-R2	0.325	0.187	0.122	0.522	0.484	0.553

Note: \*\*\*, \*\* and \* indicate significance at the confidence levels of 1%, 5% and 10%, respectively; Values in parentheses are t values.

## 6. Further inquiry and mechanism study

### 6.1. Heterogeneity analysis of their

#### 6.1.1. Heterogeneity Analysis of Founding Controllers

Collective cognition is fundamentally different from individual cognition or a collection of

individual cognition, and thus founders and the founding team may have different perceptions and outcomes of digital transformation. Individual founders make faster decisions, have a clearer direction, and as owners have the motivation and power to effectively supervise the firm's management, mitigate information asymmetry and agency problems associated with R&D, and ultimately have a positive impact on the firm's R&D intensity and productivity. In contrast, because of the large number of founder team members and their different experiences and expertise, there are often different opinions and uneven distribution of their respective interests, and thus founder team control of the firm will lead to high coordination costs, slow decision-making, low willingness to monitor the firm's R&D and high agency costs, which will have a negative impact on the digital transformation. Accordingly, this paper predicts that it will be more favourable to the digitalisation of the firm if the founders alone control the firm. To this end, the founding controllers are further divided into two scenarios: sole founders and founder teams, and regression analyses are conducted separately.

From the regression results in Table 8(1) and (2), when the founder-controller is a sole founder, the regression coefficients are significantly positive and the return on assets is higher, while the regression coefficients in the case of a team of founders are positive but not significant and the return on assets is lower. This suggests that the control of a firm by a sole founder is more conducive to the process of digital transformation than the control of a team of founders.

### **6.1.2. Heterogeneity analysis of industrial investors' controllers**

Industrial investors control listed companies for various purposes, such as industrial integration, optimisation of shareholding structure, enhancement of corporate image, strengthening of core competitiveness, scale synergy and diversification of investment, etc., which have different consequences and governance effects on the digital transformation of enterprises. Therefore, according to the differences in the strategic purposes of enterprise development, according to whether the listed company and its start-up entity belong to the same industry, upstream and downstream of the industrial chain and cross-industry integration, industrial investors are classified into horizontal integration, vertical integration and diversification integration in order. For horizontal integration, it refers to the integration between the same industry, the scale effect and synergistic resource advantages, which can provide a certain resource base for the enterprise's digital technological innovation, but due to the horizontal integration of the enterprise's purpose is to make more use of the scale advantage to achieve growth in corporate performance or acquisition of competitors to grow the scale of the enterprise, rather than to improve technological innovation and digital transformation to achieve long-term sustainable development, coupled with the integration of enterprises in the same industry. This, coupled with the risks and costs associated with the integration of companies in the same industry, can largely offset this resource advantage. As a result, it is difficult for such horizontal integration to effectively drive the development of digital transformation. Vertical integration, on the other hand, can make the links between enterprises in the supply chain closer, better division of labour and collaboration between various departments, reduce their communication costs, enhance the synergy of interests between enterprises by improving the enterprise industry chain and value chain, and reduce the transaction costs between enterprises. Therefore, such industrial complementarity and collaboration can generate a high return on investment, which in turn is conducive to the improvement of enterprise digital technology innovation and digitalisation. Diversification and integration can stimulate creativity and integrate multiple advantages, and industrial investors often look at the development prospects of the industry in which the target company is located, and then "use" listed companies to enter the market quickly and avoid market entry barriers. However, due to the cross-industry mergers and acquisitions compared to the same industry for its higher risk, will produce a large number of management costs, coordination costs and unknown industry competition barriers and other reasons, the need for higher capital turnover, higher financial leverage, these will increase the solvency of the enterprise to weaken the risk of fluctuations in the external environment to cope with the ability to be difficult to effectively and successfully implement the diversification of the integration is bound to impede the listed companies to a certain extent. The improvement of digital level and the effective promotion of digital transformation. Based on this, this paper divides the sample enterprises of industrial investment controllers into three types: horizontal integration, vertical integration and diversification integration, and conducts regression analyses respectively.

The regression results are shown in columns (3) to (5) of Table 8. The regression coefficients between industrial investment controllers and digital transformation of enterprises are positive but not significant in the case of horizontal integration, while the regression coefficients between vertical industrial investment controllers and digital transformation of enterprises are significantly positive, and the regression coefficients between diversified integration and digital transformation of enterprises are

significantly negative. This suggests that supply chain synergies generated by vertical integration will benefit the digitalisation of enterprises to a certain extent, while horizontal integration will hardly contribute significantly to the digitalisation of enterprises, and diversification will significantly inhibit the digitalisation of enterprises.

### **6.1.3. Analysis of the heterogeneity of financial investment controllers**

Although financial investors do not have their own initial entity enterprises, when financial investors ultimately control the enterprise, the level of their investment specialisation or not largely affects the enterprise digital transformation process. Financial investors are profit-oriented, through certain investment behaviours to achieve economic returns, and in the appropriate actual cash, more focused on short-term profits, and do not care about the long-term development of the enterprise. Generally speaking, professional venture capital firms due to its professional investment personnel, more cases of background tend to invest in the market with a broad vision, more inclined to the pursuit of high-risk, high-yield investment and financing projects, conducive to the development of enterprise innovation, and as a strategic investor in venture capital, there are incentives to promote the exchange of complementary resources between the enterprises under its control, to maximise profits. In addition, unlike general entities, venture capital firms can not only provide financial investment, plan investment portfolios, and optimise risk-return ratios for enterprises, but also attract more resources and technicians for them, so as to make them seize market opportunities and enhance their innovation and digitalisation capabilities. As a result, the ultimate control of financial investors over enterprises through professional venture capital firms is more conducive to the enhancement of enterprises' digitalisation level. Therefore, the division of venture capital and non-venture capital is based on a regression analysis by reviewing the equity structure chain of enterprises and dividing financial investment controllers into two types of professional and non-professional financial investors.

The regression results are shown in columns (6) and (7) of Table 8, where the regression coefficients of professional financial investment controllers and digital transformation of enterprises are significantly positive, while the regression coefficients of non-professional financial investment controllers and digital transformation of enterprises are significantly negative. This suggests that professional financial investment controllers will be more conducive to the digitalisation of enterprises than non-professional financial investment controllers.

## **6.2. Ediation effects test**

The long-term development orientation and the governance effect are the two major aspects that distinguish founders from strategic investors. Therefore, founders who ultimately control their firms will increase long-term investments in R&D due to their long-term development orientation, mitigate agency problems and improve information transparency due to governance effects, and ultimately drive digital transformation, while the opposite is true for strategic investors.

### **6.2.1. The mediation effect of R&D inputs and outputs under long-term development orientation**

Digital transformation relies on technological means, and it is beneficial for enterprises to innovate their processes and accelerate their business model innovation through digital technology, so as to facilitate the process of digital transformation in an orderly manner. Regarding the relationship between founders and firms' innovation performance, most scholars tend to believe that founders have a positive effect on firms' innovation. On the one hand, the high-risk, time-consuming and uncertain nature of innovation often requires firms to be more tolerant of risks and challenges. Founders are usually creative, independent thinkers and innovative problem-solvers, and risk-takers, i.e. their propensity to take risks is compatible with the high-risk nature of innovation. On the other hand, compared with other owners, founder shareholders have certain advantages in terms of their willingness and ability to supervise the R&D process, coupled with their deep understanding of the company's business model, which not only reduces the R&D agency costs, but also improves the intensity and productivity of R&D. Strategic investors usually pay more attention to the company's business model. Strategic investors, on the other hand, are usually more concerned about the short-term performance of firms, thus inhibiting the inputs and outputs of innovations with longer cycles. Based on this, this paper predicts that founding controllers will push forward the digital transformation of firms by increasing their R&D inputs and outputs, while industrial and financial investors will hinder the digital transformation of firms by reducing their R&D inputs and outputs. In this paper, R&D investment is measured by the ratio of R&D investment to operating revenue of listed companies, and R&D output is measured by the number of patent applications filed by listed companies.

The results of the mediation effects of R&D inputs and outputs are shown in Table 8-9, from which the regression results show that the regression coefficients between the founding controller and R&D inputs and outputs are significantly positive, while the regression coefficients between the financial and industrial investment controllers and R&D inputs and outputs are both significantly negative. This suggests that R&D inputs and outputs play a mediating role between the ultimate controllers and the digital transformation of the enterprises, i.e., the founding controllers will promote the digital transformation of the enterprises by increasing R&D inputs and outputs, while the financial and industrial investment controllers will inhibit the digital transformation of the enterprises by decreasing R&D inputs and outputs.

Table 8: Regression results of controller heterogeneity analysis.

variant	Sole founder	Founder's Team	Horizontal integration	Vertical integration	Diversification and integration	Professional financial investors	Nonprofessional financial investors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Digital	Digital	Digital	Digital	Digital	Digital	Digital
Founder	0.046*** (4.095)	0.039 (1.625)					
Industry			0.025 (0.987)	0.019** (2.168)	-0.113*** (-3.680)		
Finance						0.053*** (3.247)	-0.257*** (5.016)
Size	0.029*** (5.199)	0.028*** (3.804)	0.074*** (4.918)	0.072*** (4.541)	0.074*** (4.857)	-0.319** (-2.402)	-0.026** (-2.399)
Lev	-0.004 (-0.137)	-0.065* (-1.794)	-0.007 (-0.076)	0.008 (0.095)	0.033 (0.357)	0.672* (2.004)	0.161*** (3.061)
Roa	-0.216** (-2.336)	-0.263** (-2.225)	-0.038 (-0.192)	-0.059 (-0.292)	-0.026 (-0.128)	1.669 (0.596)	0.248 (1.481)
Cash	0.002 (1.057)	0.004* (1.833)	0.003 (0.839)	0.003 (0.936)	0.002 (0.769)	-0.003 (-0.089)	0.001 (0.544)
Tq	0.012*** (3.087)	0.025*** (4.547)	0.044*** (3.578)	0.044*** (3.595)	0.043*** (3.516)	0.027*** (3.592)	-0.004** (-3.643)
Growth	0.013*** (2.860)	0.022*** (2.763)	-0.009 (-1.434)	-0.009 (-1.439)	-0.007 (-1.171)	0.094* (1.933)	0.012* (1.893)
First	-0.001** (-2.083)	0.001 (-1.014)	-0.006*** (-4.929)	-0.006*** (-5.000)	-0.007*** (-4.858)	-0.034** (-2.372)	-0.003*** (-3.896)
Age	0.006 (0.299)	-0.005 (-0.207)	0.025 (0.298)	0.031 (0.387)	0.016 (0.213)	-1.058** (-2.388)	-0.181*** (-3.860)
Audi	0.027*** (2.738)	0.013 (0.744)	-0.005 (-0.224)	-0.007 (-0.293)	-0.007 (-0.329)	0.001*** (3.976)	0.011*** (3.741)
Dual	0.001 (-0.045)	-0.004 (-0.344)	0.019 (0.665)	0.023 (0.777)	0.017 (0.569)	0.176* (1.898)	-0.019 (-1.000)
Constant	-0.835*** (-5.385)	-0.781*** (-2.933)	-1.516*** (-2.782)	-1.484*** (-2.648)	-1.400*** (-2.702)	10.358*** (5.003)	1.060*** (3.644)
Year/Indu	Control	Control	Control	Control	Control	Control	Control
N	4118	3346	487	546	688	1650	1022
Adj-R2	0.525	0.529	0.128	0.128	0.147	0.592	0.515

Note: \*\*\*, \*\*, \* indicate significant at the 1 per cent, 5 per cent and 10 per cent confidence levels, respectively; t-values are in parentheses.

Table 9: Results of the mediation effect test of R&D inputs and outputs.

variant	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Input	Digital	Input	Digital	Input	Digital	Output	Digital	Output	Digital	Output	Digital
Founder	0.603*** (6.142)	0.024** (2.217)					0.596*** (20.785)	0.031*** (3.343)				
Finance			-0.538*** (-5.101)	-0.015 (-1.156)					-0.545*** (-18.784)	-0.023** (-2.210)		
Industry					-0.377** (-2.514)	-0.026* (-1.653)					-0.220*** (-5.869)	-0.021* (-1.863)
Input		0.013***		0.013***		0.013***		0.017***		0.018***		0.019***

		(9.437)		(9.510)		(9.587)		(6.687)		(7.061)		(7.348)
Size	0.297*** (6.638)	0.025*** (4.844)	0.273*** (6.078)	0.024*** (4.653)	0.281*** (6.338)	0.025*** (4.857)	0.265*** (16.590)	0.025*** (5.485)	0.237*** (14.800)	0.023*** (5.180)	0.253*** (15.688)	0.024*** (5.406)
Lev	- 6.179*** (-23.483)	0.061** (2.181)	-6.232*** (-23.771)	0.059** (2.080)	-6.214*** (-23.711)	0.060** (2.129)	-0.095 (-1.372)	-0.035 (-1.441)	-0.139** (-2.008)	-0.040 (-1.627)	-0.228*** (-3.260)	-0.042* (-1.729)
Roa	- 11.132** * (-12.633)	-0.111 (-1.424)	-11.126*** (-12.613)	-0.112 (-1.436)	- 10.970*** (-12.424)	-0.104 (-1.344)	2.031*** (9.682)	-0.293*** (-4.167)	2.090*** (9.897)	-0.297*** (-4.210)	2.190*** (10.255)	-0.294*** (-4.164)
Cash	0.052*** (3.834)	0.003** (2.513)	0.053*** (3.904)	0.004** (2.549)	0.052*** (3.806)	0.003** (2.467)	-0.007 ** (-2.085)	0.003** (2.428)	-0.007 ** (-2.127)	0.003** (2.452)	-0.007** (-2.186)	0.003** (2.405)
Tq	0.572*** (13.456)	0.010*** (2.625)	0.563*** (13.246)	0.009** (2.496)	0.558*** (13.119)	0.009** (2.447)	0.031*** (3.200)	0.016*** (4.568)	0.020** (2.053)	0.015*** (4.412)	0.016 (1.600)	0.014*** (4.249)
Growth	0.282*** (4.828)	0.020*** (3.452)	0.280*** (4.772)	0.019*** (3.394)	0.272*** (4.622)	0.019*** (3.358)	-0.043*** (-4.100)	0.018*** (4.564)	-0.043*** (-3.989)	0.018*** (4.562)	-0.058*** (-5.375)	0.018*** (4.385)
First	- 0.015*** (-6.113)	0.001 (-1.566)	-0.014*** (-5.899)	0.001 (-1.406)	-0.012*** (-5.234)	0.001 (-1.252)	0.001 (0.282)	-0.001** (-2.426)	0.001 (0.497)	-0.001** (-2.262)	0.003*** (3.147)	-0.001* (-1.911)

Continued from table 9

variant	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Input	Digital	Input	Digital	Input	Digital	Output	Digital	Output	Digital	Output	Digital
Age	- 0.783*** (-5.121)	0.023 (1.159)	-0.897*** (-6.091)	0.017 (0.851)	-0.960*** (-6.521)	0.017 (0.904)	-0.190*** (-3.806)	0.009 (0.516)	-0.338*** (-6.887)	0.001 (0.035)	-0.474*** (-9.714)	-0.002 (-0.107)
Audi	-0.066 (-0.709)	0.037*** (4.176)	-0.060 (-0.650)	0.038*** (4.180)	-0.050 (-0.533)	0.037*** (4.222)	0.004 (0.245)	0.024*** (4.095)	0.004 (0.251)	0.025*** (4.054)	0.023 (1.315)	0.025*** (4.262)
Dual	0.443*** (6.126)	-0.004 (-0.584)	0.460*** (6.341)	-0.004 (-0.490)	0.448*** (6.188)	-0.004 (-0.550)	-0.050** (-2.156)	0.001 (0.212)	-0.027 (-1.171)	0.003 (0.391)	-0.029 (-1.223)	0.002 (0.334)
Constant	5.042*** (2.112)	-1.007*** (-6.678)	6.154*** (2.604)	-0.957*** (-6.408)	6.165*** (2.611)	-0.968*** (-6.607)	-5.523*** (-13.543)	-0.741*** (-5.724)	-4.108*** (-10.089)	-0.660*** (-5.271)	-4.270*** (-10.513)	-0.679*** (-5.474)
Year/Indu	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
N	12268	6399	12268	6399	12264	6397	15070	7464	15070	7464	15066	7462
Adj-R2	0.418	0.530	0.418	0.530	0.417	0.530	0.302	0.523	0.296	0.522	0.283	0.522

Note: \*\*\*, \*\*, \* indicate significant at the 1 per cent, 5 per cent and 10 per cent confidence levels, respectively; t-values are in parentheses.

### 6.2.2. Testing the mediating effect of information transparency under governance effects

Information asymmetry within the enterprise hinders effective communication in the digital economy, which in practice has led to problems such as information inefficiency; however, governance mechanisms play an important role in utilising digital technology and alleviating information asymmetry. As mentioned above, founders will actively participate in the management or supervision of the enterprise due to the convergence of interests, which can alleviate the information asymmetry of the enterprise to a certain extent, and thus promote the digital transformation of the enterprise. However, for strategic investors, information asymmetry provides them with a unique opportunity to make quick profits in the short term, leading to more short-term opportunistic behaviours and thus hindering the digital transformation of the enterprise. Accordingly, founding controllers will promote digital transformation by increasing the transparency of corporate information, while industrial and financial investors will inhibit digital transformation by increasing the asymmetry of corporate information. Therefore, the information asymmetry of a firm is measured as the sum of the absolute value of the firm's manipulative accruals over the last three years. As a larger value of this indicator indicates a lower level of information transparency, this indicator is treated negatively in this paper for ease of understanding and analysis.

## 7. Conclusion

Based on the relevant data of non-financial listed companies in China from 2007 to 2020, this paper empirically studies the difference and mechanism of the impact of founding controllers and strategic investment controllers of listed companies on Digital transformation. At the same time, the moderating role of digital finance and control rights was further examined. The empirical analysis finds that, first of all, in terms of the type of controller, compared with strategic investors, founder control will be more conducive to the improvement of enterprise digital level and the advancement of Digital transformation process. Among strategic investment controllers, financial investment controllers have a stronger inhibitory effect. Moreover, these research conclusions remain unchanged after considering endogeneity and robustness analysis. Secondly, by further subdividing the heterogeneity of the controllers, it is found that the individual founders among the founding controllers have a more significant role in promoting Digital transformation than the team founders; Horizontal integration of

industrial investors is difficult to significantly improve the digital level of enterprises, while vertical integration can significantly promote the digital level of enterprises, and diversified integration can significantly inhibit the Digital transformation of enterprises; Compared to non professional financial investors, professional financial investors will be beneficial for improving the digital level of enterprises. Finally, in terms of the impact path, the founding controller promotes the improvement of the digital level of the enterprise by enhancing its information transparency and increasing its R&D investment and output, while the strategic investment controller does the opposite.

Digital transformation is conducive to improving the operational efficiency of enterprises, which is crucial to the sustainable development of enterprises and the economic growth of the country. For enterprises, first of all, we should focus on the ownership of corporate control and the nature of the controller, strengthen the control position of the founding controller, prevent dilution of control rights and the loss of control status of external mergers and acquisitions, and affect the improvement of enterprise innovation investment and Digital transformation; Secondly, in the selection of M&A enterprise controllers, more consideration should be given to the entry of industrial investors who have industrial integration and long-term development with the enterprise, so as to avoid controlling the enterprise as an institutional investor with short-term financial returns, affecting the Digital transformation of the enterprise and the sustainable growth of the enterprise. Finally, no matter who controls the corporate control, enterprises should constantly improve the corporate governance structure, strengthen supervision over controlling shareholders, actively promote the process of Digital transformation, and maintain competitive advantages to achieve sustainable development. For the government regulatory authorities, first of all, they should focus on the supervision of companies controlled by financial investors in the transfer of control rights, pay attention to whether the information disclosure of such companies is timely, accurate and fair, and prevent listed companies from becoming a Pay-to-play tool for financial investors and executives to conspire, affecting the digital innovation and sustainable development of enterprises; Secondly, relevant government departments can adopt corresponding preferential policies to reduce the cost of Digital transformation of enterprises and actively promote the realization of Digital transformation of enterprises and high-quality economic development.

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