

# Ownership Concentration, CEO's Technical Background and Enterprise Innovation

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*Abstract:* - From the perspective of enterprise innovation, this paper studies whether companies with higher ownership concentration are willing to hire a technology CEO. This paper studies the relationship between ownership concentration, CEO's technical background, and enterprise innovation by taking private listed companies on small and medium-sized boards in Shenzhen Stock Market from 2011 to 2019 as research samples. The results show that CEO's technical background promotes enterprise innovation. However, enterprises with higher ownership concentration are more willing to hire a non-technology CEO. Ownership concentration not only directly hinders enterprise innovation, but also indirectly hinders enterprise innovation by hindering the selection and recruitment of technical CEOs. Further research shows that under the condition of shareholding, technology CEOs significantly promote enterprise innovation, while under the condition of non-shareholding, technology CEOs have no significant impact on enterprise innovation. Without serving as chairmen, technical CEOs significantly promotes enterprise innovation, while serving as chairmen, technical CEOs have no significant impact on enterprise innovation. However, in the samples with high ownership concentration, there are significantly more companies where CEO serves as chairman and significantly fewer companies where CEO holds shares, which indicates that companies with high ownership concentration do not actively implement innovation incentive measures for CEOs. This study provides an important basis for Chinese private small and medium-sized enterprises to make innovative decisions in major shareholder governance and general manager selection.

*Key-Words:* - Private listed companies; Ownership concentration; Technical CEOs; Enterprise innovation

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## 1 Introduction

Enterprise innovation is an important means to enhance the core competitiveness of small and medium-sized enterprises and a powerful driving force to promote the high-quality development of the national economy. As two key figures of enterprise innovation, the influence of major shareholders and general managers on enterprise innovation cannot be ignored. In recent years, foreign technology companies have successively appointed technical talents to CEO positions. For example, in 2014, Microsoft appointed Satya Nadella with technical background as its new CEO. In 2015, Google named product chief Sundar Pichai as its new CEO; In April 2020, IBM named engineer Arvind Koshner as its new CEO; In February 2021, Intel named technology veteran Pat Gelsinger as its new CEO. However, from 2011 to 2019, the number of CEOs with technical backgrounds in domestic private small and medium-sized listed companies declined year by year. Under

the background of the urgent improvement of technical innovation ability, why the small and medium-sized private listed companies in China are more and more reluctant to hire technical CEOs with technical backgrounds? Are technology CEOs hindering enterprise innovation? If not, then why are enterprises unwilling to hire a technology CEO? Is it because of a dominant share structure? The motivation behind this paper is to find out the reason behind this phenomenon.

The contribution of this paper is to study major shareholders, technology CEOs, and corporate innovation together. Most of the existing literature only studies the influence of shareholders on enterprise innovation, or the influence of managers on enterprise innovation, and there is a lack of integration of managers, shareholders, and enterprise innovation. First, this paper chooses the CEO group of small and medium-sized enterprises to study the relationship between technology CEOs and enterprise innovation. As for the relationship between technology CEOs and enterprise

innovation, most literatures think that the relationship is positive, [1], [2]. While a few literatures think that the relationship is not significant, [3]. The research conclusions are not uniform, and the research objects are concentrated in high-tech industries. The kinds of literature focus on the technical backgrounds of executive teams, rather than specific types of executives, such as CEOs. Second, this paper studies the relationship between ownership concentration and enterprise innovation. As for the relationship between ownership concentration and enterprise innovation, the conclusions include a positive correlation, [4], a negative correlation, [5], and an inverted U-shape correlation, [6]. The research conclusions are not uniform yet. Thirdly, this paper studies the relationship between the shareholding ratio of the largest shareholder and the selection and employment of technology CEOs, as well as the mediating effect of technology CEOs between ownership concentration and enterprise innovation, which has not been studied in the previous literature.

However, Chinese enterprises generally face two kinds of agency problems, that is, the agency problem between major shareholders and minor shareholders, and the agency problem between shareholders and managers. Under the background of imperfect company law, large shareholders will interfere in the selection of general managers and appoint acquaintances and relatives as senior executives. Therefore, it is crucial to integrate major shareholders, general managers, and enterprise innovation into a research framework to improve the level of enterprise innovation. Therefore, this paper takes the private non-financial listed companies in the SME board from 2011 to 2019 as the research object and studies the relationship between the three. This study helps to explain the objective phenomenon that the average technical background of CEOs of private listed companies on small and medium-sized boards has declined year by year in the past 10 years. This study is also helpful to explain the micro-mechanism of ownership concentration affecting enterprise innovation and enrich the theoretical research of enterprise innovation.

## 2 Theoretical Analysis and Research Hypothesis

### 2.1 CEO with a Technical Background and Enterprise Innovation

The high-level echelon theory, first proposed by Hambrick & Mason in 1984, holds that managers are bounded rationality, unable to fully understand the development of things, and can only make decisions based on their own experience and cognition, [7]. As the most important manager of an enterprise, the technological experience and cognition of CEOs will have a positive impact on enterprise innovation, which is reflected in the strong driving force of technological CEOs to carry out enterprise innovation activities and reduce the risk of enterprise innovation.

First, technical CEOs have a higher drive for technological innovation. Internal motivation is the source of power to ensure the vitality of enterprise innovation. The innovation drive of technical CEOs comes from their high cognition of innovation activities, their ability to overcome the short-sightedness of management, and their self-worth realization needs. First, technical CEOs have a high awareness of enterprise innovation, because executives tend to internalize work experience into cognitive ability, thus affecting the formulation and implementation of corporate decisions, [8]. The technical work experience of CEOs enables them to have a relatively comprehensive understanding of the process of enterprise R&D, deeply realize the importance of financial support for enterprise R&D, and are more willing to invest in product or technological innovation, [9]. Second, technical CEOs can overcome the short-sightedness of management, because short-sighted management is common in listed companies due to internal and external pressures, which prevents management from engaging in high-risk innovative activities, [10]. Technical CEOs often have invention experience and relatively high technological innovation ability. To a certain extent, the inventor background of senior executives can curb the short-sightedness of corporate management, which is conducive to increasing the long-term technological innovation investment of enterprises, [11]. On the other hand, high-ability managers pay more attention to reputation and can get higher salaries, so they have weaker motivation to maximize their interests through rent-seeking behavior, [12], [13], [14]. Third, technology CEOs need self-realization. According to Maslow's five-level demand theory, CEOs in top management positions need to

maximize their skills. So they are more likely to focus on technological innovation and transform their technological talents into new products through innovative activities.

Second, technological CEOs can reduce the risk of innovation. The specific reasons are as follows. First, the innovation opportunities found by technical CEOs are more valuable. As technical experts in this field, technical executives have deep professional knowledge, a deeper understanding and grasp of the technological frontier, and a strong sensitivity to the development direction of the industry and the technological innovation frontier, so they can provide efficient guidance and suggestions for enterprise innovation, and can explore more valuable innovation opportunities, [15]. Second, enterprises with technical CEOs can provide positive signals to the market and provide financial guarantees for innovative activities. Studies have found that academic CEOs can inhibit enterprise R&D manipulation and thus improve enterprise innovation efficiency, [16]. Therefore, appointing a technology CEO can send a signal to the market that the company is serious about technology, increase investor confidence, and thus obtain more financial support. Third, technical CEOs can integrate innovation resources more effectively. Executive social networks promote enterprise innovation through obtaining information advantage, obtaining a capital advantage, and reducing risk levels, [17]. There are many resources within the social network, and the technical relationship network formed by technical CEOs can establish the “intangible innovation research network”, bring technical social resources to the enterprise, which is conducive to the enterprise obtaining innovation information, timely adjusting innovation deviation, and solve innovation problems.

So this paper proposes hypothesis 1: CEOs with technical backgrounds promote enterprise innovation.

## **2.2 Ownership Concentration and Enterprise Innovation**

Shareholders are often divided into major shareholders and minority shareholders due to their different shareholding ratios. The shareholding ratio is a symbol of shareholders’ decision-making power and cash flow right. The higher the shareholding ratio is, the higher the concentration of decision-making power and cash flow right. Major shareholders have higher shareholding, greater decision-making power, and cash flow power, so

they have a greater probability of abuse of power. In the context of “one share, one right” in China, small and medium-sized innovative private enterprises adopt an equity-dominated governance structure, and the shares are mostly held by the founders, [18]. A dominant share is not conducive to access to innovation funds, and is not conducive to the independence of innovation decisions, for the companies. Therefore, ownership concentration may negatively affect enterprise innovation.

First of all, a dominant share is not conducive to access to innovation funds. The specific reasons are as follows. First, major shareholders have “hollowing out” behavior. Johnson et al. first put forward the idea that major shareholders “hollow out” the company. In the case of equity concentration, to obtain private interests, large shareholders will occupy the resources of listed companies using tunnels, [19]. There are various ways for major shareholders to hollow out listed companies, including related transactions, fund occupation, and cash dividend policy, [20]. A large number of studies have found that the higher the degree of ownership concentration is, the stronger the motivation and ability of major shareholders to hollow out listed companies [21], [22]. The hollowing behavior of major shareholders encroached on the limited resources of the company and restricted the cash flow to enterprise innovation. Second, the high uncertainty of innovation makes major shareholders have no investment intention. The high uncertainty of innovation activities is reflected in high investment, high risk, long cycle, and easy to imitate. New products from research and development to marketization, not only need enterprises to invest a lot of human resources and material resources, but also face the risk of failure and free rider effect at any time. In an environment where intellectual property protection is weak, the innovation achievements of enterprises are more likely to be modeled. Due to the high shareholding ratio, if the innovation investment fails, the major shareholders will face greater losses. Therefore, major shareholders prefer stable management and are not willing to invest in innovation.

Secondly, a dominant share is not conducive to the independence of innovation investment decisions. The specific reasons are as follows. First, the independence of innovation decision-making of the board of directors decreases. At present, the main form of the governance structure of listed companies is “one layer three meetings”, which include shareholders’ meetings, boards of directors, supervisory boards, and senior management, the

core of which is the board of directors. The members of the board of directors who are elected by the general meeting of shareholders decide on the company's business plan and investment plan. The general meeting of shareholders is composed of all shareholders and is the highest authority of the company, exercising decision-making and supervision power on behalf of all shareholders. Due to the high proportion of shareholding, major shareholders have larger voting power in the general meeting of shareholders, and even one vote determines the result. The members of the board of directors elected by the general meeting of shareholders reflect the will of major shareholders, and the board of directors is likely to become the dominant voice of major shareholders and cannot play its core role in corporate governance, [23]. Which greatly reduces the independence of innovation decision-making of the board of directors decreases. Second, major shareholders hold the power to make decisions on important matters. The separation of ownership rights and control rights gives birth to the corporate governance mechanism, but because of the scarcity of capital, and the matching of responsibility and right, the phenomenon of excessive centralization of major shareholders in our country has always existed, resulting in the fact that the ownership rights and control rights of companies are not separated in essence. A single major shareholder holds the largest ownership of the company, the right to nominate and appoint executives, and the right to make investment decisions. Small shareholders have difficulty challenging large shareholders because of their low shareholding ratio. The majority shareholder essentially controls the company. Although listed companies have established corporate governance mechanisms in accordance with regulatory requirements, whether this mechanism can operate smoothly depends entirely on the will of major shareholders. The over-centralized major shareholders, limited by their vision and risk aversion preference, would rather the company develop slowly than delegate power, resulting in the company falling into the "major shareholder trap" and difficult to carry out innovative activities. The research found that a high degree of ownership concentration means a high degree of risk concentration, [24], leading to major shareholders using their control rights to intervene in high-risk investment decisions and refusing to invest in R&D innovation projects with large amounts, long-cycle, and uncertain returns, [25]. Under the condition of high ownership

concentration, the opinions of various stakeholders are often represented by major shareholders, and it is difficult to express their interest demands, which makes it difficult to realize the scientific nature and independence of innovation investment decisions.

So this paper puts forward hypothesis 2: ownership concentration inhibits enterprise innovation.

### **2.3 Ownership Concentration and Technical CEOs**

Currently, the manager market in China is not perfect, and the executive turnover rate is low, [26], which indirectly reflects that companies prefer to select senior executives from within rather than directly recruit from outside. Compared with enterprises that parachute management talents from the outside, enterprises that train management talents internally can establish a more effective innovation incentive mechanism, better motivate executives to improve the efficiency of asset use, and promote the improvement of enterprise innovation ability, [27]. But whether trained internally or parachuted from the outside, the common characteristic of technical CEOs is a past or present technical background. Based on theories such as the self-interest protection of major shareholders, the influence of Chinese relationship culture, and the transmission of negative signals, it is speculated that enterprises under the control of major shareholders are less likely to hire executives with technical backgrounds.

First, large shareholders have a stronger incentive to resist technical managers. The separation of ownership and management makes the agency problem of shareholders and managers always exist, that is, the first kind of agency problem. According to the hypothesis of economic man, shareholders, and managers have inconsistent interests. Managers may take advantage of information advantages and management rights to maximize their interests rather than the interests of shareholders. Appointing technical personnel as technical executives may increase the degree of information asymmetry between shareholders and managers and make the agency conflict between them more serious. Compared with non-technical CEOs, technical CEOs have a deeper understanding of the implementation of innovation investment plans and have more opportunities to maximize their interests. To reduce supervision costs, shareholders, especially major shareholders, may intervene in the decision of the board of directors to select CEOs and reduce the selection of technical CEOs.

Secondly, the influence of relationship culture in China. The influence of culture on corporate governance is just as important as the system, but more deep-rooted and hidden. In the case of a low level of social trust, influenced by the traditional culture of “cronyism” in China, the board of directors is more inclined to choose relatively familiar personnel when hiring general managers. The “one-share dominance” of corporate ownership structure in China is one of the root causes of the formation of the nepotism board culture, [28]. Companies with strong boards of directors often choose candidates with similar characteristics to the board of directors as the new CEOs, [29]. The research finds that only private enterprises with high operational risks are more willing to recruit senior executives from outside to supplement management talent due to their greater demand for management talent, [30]. That means hiring a CEO from outside sends a signal that the company is riskier. Most private listed companies prefer to select CEOs from within the company. Technical internal members have relatively weak interpersonal skills, and it is difficult to form a familiar relationship with the board members who decide the appointment and removal of the general manager. As a result, boards are much less likely to hire a technical CEO.

So this paper proposes hypothesis 3: Companies with a higher concentration of ownership are more likely to hire non-technical CEOs.

#### **2.4 The Mediating Effect of Technical CEOs in the Relationship between Ownership Concentration and Enterprise Innovation**

The two major agency problems in corporate governance are agency conflict between shareholders and managers, and agency conflict between major shareholders and minority shareholders. The common core of these two problems is the major shareholder. On the one hand, major shareholders should prevent the inaction and benefit theft of outsiders (managers), and on the other hand, they should exercise important decision-making power on behalf of insiders (minority shareholders). The articles of association of the company stipulate that the general meeting of shareholders shall decide on the overall plan of innovation investment, the board of directors shall decide on the action plan of innovation investment and the appointment of the management, and the management shall organize the implementation of the innovation investment plan. Previous studies have found that the company’s attributes have a

greater impact on enterprise innovation than the managers’ attributes, which may be because the company’s attributes directly affect enterprise innovation and indirectly affect enterprise innovation through managers. The attributes of enterprises are often the embodiment of the willpower of major shareholders. Therefore, this paper speculates that the influence of major shareholders on enterprise innovation is not entirely direct.

So this paper puts forward hypothesis 4: The controlling majority shareholders may indirectly affect enterprise innovation by influencing the selection and recruitment of technical CEOs.

### **3 Empirical Research Design**

#### **3.1 Sample Selection and Data Sources**

The initial research samples of this paper are all the private listed companies on the small and medium-sized boards in Shenzhen Stock Market from 2011 to 2019, which are excluded according to the following criteria: (1) Listed companies in the financial industry; (2) ST and \*ST companies during the sample period; (3) The absence of management information and corporate financial data; (4) Companies with an asset-liability ratio greater than 1; (5) The IPO companies of that year. After screening, the final study sample size was 3476 company observations. The sample period begins in 2011 to eliminate the impact of the 2008 financial crisis on corporate innovation and ends in 2019 to eliminate the impact of the COVID-19 pandemic on corporate innovation. The technical background data of the CEO in this paper are obtained after manual sorting according to the executive resumes in the CSMAR database, and other financial data are from the CSMAR database. To eliminate the influence of extreme values, a boxplot was used to detect whether outliers existed in all continuous variables, and a 1% tail reduction was carried out. The data analysis software used in this paper is Stata13.1.

#### **3.2 Design of Main Variables**

##### **(1) Ownership concentration (Top1)**

Referring to Chen and Chen’s research, the shareholding concentration variable is measured by the proportion of the largest shareholder, [31]. This index can reflect the decision-making ability and control degree of major shareholders in the enterprise and is a symbol of the power of discourse.

(2) CEO’s technical background (Tech)

Referring to Zhang’s research, if the CEO has the career background, professional background, and academic background related to the main business of the currently employed listed company, the CEO is considered to have the technical background, and the value is 1; otherwise, the value is 0, [32].

(3) Control variables

Referring to Yu and Li’s research, the control variables include enterprise Size (Size), operating performance (ROA), growth opportunity (TQ), net operating cash flow (OCF), listing years (Age), and debt level (Lev), [33]. In addition, this paper controls for annual and industry effects. See Table 1 for specific variable definitions. All control variables are indicated in the following model and table by the word “controls”.

Table 1. Definition and description of variables

Variable name	Symbol	Definition
Enterprise innovation	RD	Current innovation expenses/current operating income
Ownership concentration	Top1	The proportion of the largest shareholder
CEO’s technical background	Tech	The value is 1 if the CEO has a technical background (technical CEO); otherwise, it is 0(non-technical CEO).
Enterprise scale	Size	Ln (total assets at the beginning of the year)
Operating performance	ROA	Net profit of enterprise at the end of the year/annual average total assets
Growth opportunity	TQ	(Ending equity market value + ending total liabilities)/ending total assets
Net cash flow from operation	OCF	Net cash flow from operating activities at the end of the period/total assets at the beginning of the period
Market life	Age	Number of years the company has been public
Debt level	Lev	Total liabilities/total assets
Year dummy variable	Year	9 years of data, 8 dummy variables
Industry dummy variable	Ind	According to the industry classification standard of the 2012 edition of the China Securities Regulatory Commission, there are 15 industries and 14 dummy variables in total after excluding the financial industry.

3.3 Model Construction

In order to test hypothesis 1, referring to Chen and Lian’s research, this paper builds model (1), [34]. The specific model is as follows. Fixed effects control the annual and industry effects of the enterprise.

$$RD_{it} = \beta_0 + \beta_1 Tech_{it} + \beta_2 Controls_{it} + fixed\_effects + \varepsilon_{it} \tag{1}$$

In order to test hypotheses 2, 3, and 4, referring to Fang, Wen, and Zhang’s research, this paper builds model (2) - (4), [35]. The establishment of the mediating effect of CEOs’ technical background needs to meet the following three conditions: (1) the regression coefficient of the equity concentration variable (Top1) on enterprise innovation variable (RD) reaches a significant level; (2) The regression coefficient of the equity concentration variable (Top1) on the intermediary variable CEO technical background (Tech) reached a significant level; (3) When equity concentration (Top1) and CEO technical background (Tech) are included in the regression at the same time, the coefficient of CEOs’ technical background (Tech), the intermediate variable, reached a significant level. If the coefficient of ownership concentration (Top1) is not significant, CEOs’ technology background (Tech) plays a complete mediating effect. When the coefficient of ownership concentration (Top1) is still significant, CEOs’ technology background (Tech) plays a part in the mediating effect. The following models are constructed respectively in this paper:

$$RD_{it} = \beta_0 + \beta_1 Top1_{it} + \beta_2 Controls_{it} + fixed\_effects + \varepsilon_{it} \tag{2}$$

$$Tech_{it} = \beta_0 + \beta_1 Top1_{it} + \beta_2 Controls_{it} + \sum Year + \sum Ind + \varepsilon_{it} \tag{3}$$

$$RD_{it} = \beta_0 + \beta_1 Top1_{it} + \beta_2 Tech_{it} + \beta_3 Controls_{it} + fixed\_effects + \varepsilon_{it} \tag{4}$$

4 Empirical Test and Result Analysis

4.1 Analysis of Descriptive Statistical Results

From Table 2, it can be seen that the average, maximum, and minimum levels of innovation input(RD) are 0.045, 0.211, and 0.000, indicating that there are great differences in the innovation

investment levels of small and medium-sized private enterprises in China. Among the 3476 observed values, 1151 of them had an innovation investment level above 0.045, accounting for 33.11%, which indicates that the innovation investment level of small and medium-sized private enterprises in China is generally low. There is a big difference between the maximum value of 0.698 and the minimum value of 0.041 of ownership concentration (Top1), which indicates that the shareholding ratio of the largest shareholder of small and medium-sized private enterprises is quite different. The average value of CEOs' technical background (Tech) is 0.421, which shows that the proportion of technology CEOs is low.

However, in the group with higher ownership concentration, the number of companies with technology CEOs is significantly less, which proves that companies with higher ownership concentration are not inclined to hire a technical CEO. In the group with higher ownership concentration, the number of companies with a CEO as the chairman is more, which preliminarily indicates that companies with higher ownership concentration are not willing to hire external CEOs, and are more inclined to concentrate decision-making power in the hands of shareholders' representative --chairman. In the group with a higher concentration of ownership, the number of companies in which the CEO holds equity is significantly less, which may indicate that a dominant company rarely uses equity incentive measures to motivate the CEO, because the major shareholders do not want the CEO to become a shareholder, to facilitate the major shareholders to infringe on the interests of minority shareholders.

Table 2. Descriptive statistics

Variables	Full sample					
	Mean	SD	P50	Min	Max	Obs
RD	0.045	0.036	0.036	0.000	0.211	3476
Top1	0.332	0.137	0.313	0.041	0.698	3476
Tech	0.421	0.494	0	0	1	3476
Size	21.847	0.878	21.760	20.202	24.319	3476
ROA	0.049	0.055	0.045	-0.169	0.212	3476
TQ	2.056	1.259	1.612	0.503	8.155	3476
OCF	0.048	0.064	0.046	-0.125	0.224	3476
Age	5.708	3.330	5	1	15	3476
Lev	0.357	0.173	0.347	0.008	0.879	3476

  

Vars	Grouped sample		
	Higher ownership concentration	Lower ownership concentration	Mean difference(t value)
Tech	0.386	0.450	3.813
CEO with shares	0.675	0.778	6.735
Dual	0.421	0.335	-5.219

#### 4.2 Analysis of Regression Results

This paper mainly adopts the fixed-effect regression model of panel data for empirical tests, and the specific regression results are shown in Table 3. According to Column 1 of Table 3, the regression coefficient of CEO technology background (Tech) is significantly positive at the 1% level, which indicates that CEO technology background promotes enterprise innovation, and hypothesis 1 is confirmed. According to Column 2 of Table 3, the regression coefficient of ownership concentration (Top1) is significantly negative at the 1% level, which indicates that ownership concentration inhibits enterprise innovation, and hypothesis 2 is confirmed. According to the third column of Table 3, the regression coefficient of ownership concentration (Top1) is significantly negative at the 1% level, which indicates that the higher the ownership concentration is, the less likely the enterprise is to hire technology CEOs. Hypothesis 3 is confirmed. According to the fourth column in Table 3, the regression coefficient of equity concentration (Top1) is significantly negative at the 1% level, and the regression coefficient of CEOs' technology background (Tech) is significantly positive at the 1% level, which indicates that CEOs' technology background (Tech) plays a partial mediating effect in the negative relationship between equity concentration (Top1) and enterprise innovation input (RD). Hypothesis 4 is confirmed.

Enterprise Size (Size), growth opportunity (TQ), and listing years (Age) are positively correlated with enterprise innovation. Because companies with larger scales, higher growth, and longer-lasting life have more economic strength and ability to invest in innovation. However, operating performance (ROA), net operating cash flow (OCF), and debt level (Lev) are negatively correlated with enterprise innovation. Because the source of enterprise innovation funds is not mainly dependent on their funds and external liabilities.

Table 3. Regression results

Variables	RD	RD	Tech	RD
	Model (1)	Model (2)	Model (3)	Model (4)
Top1		-0.015*** (-4.91)	-0.005*** (-2.67)	-0.015*** (-4.97)
Tech	0.146*** (2.71)			0.151*** (2.87)
Size	0.654*** (6.60)	0.651*** (6.38)	0.062* (1.73)	0.653*** (6.29)
ROA	-8.736*** (-8.07)	-8.630*** (-7.87)	0.095 (0.19)	-8.597*** (-7.82)
TQ	0.023 (1.02)	0.019 (0.86)	0.009 (0.37)	0.019 (0.86)
OCF	-0.942** (-2.30)	-1.000** (-2.29)	-0.781* (-1.96)	-1.018** (-2.35)
Age	0.028*** (2.76)	0.007 (0.65)	0.0131 (1.46)	0.010 (0.84)
Lev	-3.339*** (-4.96)	-3.273*** (-4.90)	-0.115 (-0.71)	-3.297*** (-4.90)
Ind	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
_cons	-8.412*** (-4.38)	-7.685*** (-3.71)	-0.610 (-0.79)	-7.806*** (-3.67)
N	3476	3476	3465	3476
F	147.70	236.32	—	771.92
R <sup>2</sup>	0.0929	0.0952	0.0375	0.0945

Note: \*, \*\*, and \*\*\* are significant at the level of 10%, 5%, and 1%, respectively. The square brackets below the regression coefficient are the T value or Z value, the same as below. In the fixed effects regression method, R<sup>2</sup> refers to within R-squared; in the probit regression method, R<sup>2</sup> refers to Pseudo R<sup>2</sup>; in the mixed OLS regression method, R<sup>2</sup> refers to R-squared. In the process of regression, Breusch & Pagan LM test and Hausman test were carried out in this paper, and a fixed effect model was adopted.

### 4.3 Endogeneity Test

There may be a problem of sample self-selection between the technical background of CEOs and

enterprise innovation, that is, enterprises with a high level of innovation investment may be inclined to hire technical CEOs. To solve the possible problem of sample self-selection, Heckman's two-stage method is adopted in this paper. In the first stage, the Logit model was used to estimate the probability of hiring technical CEOs, and the inverse Mills ratio (IMR) was calculated according to the estimated results. In the second stage, IMR was substituted into the original regression model as a control variable. Referring to Li and Liu's research, the instrumental variable adopts the proportion of technology-based CEOs of other enterprises in the same industry in the same year, [36]. The specific regression results are shown in Table 4. The regression results of the first stage (column 1 of Table 4) show that the regression coefficient of the instrumental variable IV\_Tech is significantly negative at the 1% level, which indicates that the instrumental variable IV\_Tech is highly correlated with the endogenous variable, and the instrumental variable is effective. The results of the second stage regression (column 2 of Table 4) show that the regression coefficient of IMR is not significant, and the technical background (Tech) of CEOs is significantly positive at the 1% level, which indicates that the result of hypothesis 1 is relatively robust.

Table 4. Results of the endogeneity test

Variables	Tech	RD
	The first stage	The second stage
IV_Tech	-5.935*** (-6.87)	
IMR		-0.022 (-0.13)
Tech		0.720*** (5.79)
Controls	YES	YES
Year	YES	YES
Ind	YES	YES
N	3434	3434
R <sup>2</sup>	0.0475	0.2921

Note: Regression results for control variables were consistent with expectations, the same as below.

### 4.4 Robustness Test

First, this paper remeasures the ownership concentration variable. To eliminate measurement bias, the Herfindale index (H1) is used to measure equity concentration, [37]. The specific regression results are shown in Table 5.



Second, this paper remeasures the technical background variables of CEOs. Considering that technological innovation requires the management to find innovation opportunities, integrate innovation resources, make innovation plans, and a series of complex activities that need a certain amount of time to complete. In other words, technological CEOs have a time lag effect on enterprise innovation. So the CEOs' technology background variable (Tech) is advanced one phase. The specific regression results are shown in Table 6.

Third, this paper remeasures the enterprise innovation variables. (1) To eliminate the industrial differences in enterprise innovation, the intensity of R&D investment adjusted by the annual and industrial mean is used to measure the enterprise innovation level. The specific regression results are shown in Table 7. (2) This paper remeasures the level of enterprise innovation from the aspect of innovation output. Based on the study of Chen et al.,  $\ln(\text{total patent applications} + 1)$  is used to measure enterprise innovation, [38]. The specific regression results are shown in Table 5, Table 6, Table 7, and Table 8 show that the results in this paper are robust.

Table 5. The regression result of remeasurement of ownership concentration

Variables	RD	Tech	RD
	Model (2)	Model (3)	Model (4)
H1	-2.127*** (-5.08)	-0.405 (-1.76)	-2.157*** (-5.23)
Tech			0.150** (2.73)
Controls	YES	YES	YES
Year	YES	YES	YES
Ind	YES	YES	YES
N	3469	3458	3469
F	764.37	—	411.77
R <sup>2</sup>	0.0946	0.0364	0.0952

Table 6. Regression results of CEO's technical background being advanced by one period

Variables	RD	RD	Tech	RD
	Model(1)	Model(2)	Model(3)	Model(4)
Tech	0.202** (2.49)			0.206** (2.57)
Top1		-0.015*** (-4.91)	-0.009** (-2.74)	-0.015*** (-6.37)
Controls	YES	YES	YES	YES
Year	YES	YES	YES	YES
Ind	YES	YES	YES	YES
N	2337	3476	2313	2337
F	252.01	771.92	—	252.86
R <sup>2</sup>	0.0758	0.0945	0.0392	0.0780

Table 7. Regression results after eliminating innovation industry differences

Variables	RD	RD	Tech	RD
	Model (1)	Model (2)	Model (3)	Model (4)
Tech	0.001*** (2.71)			0.002*** (2.87)
Top1		- 0.0002*** (-4.91)	- 0.007*** (-2.68)	- 0.0002*** (-4.97)
Controls	YES	YES	YES	YES
Year	YES	YES	YES	YES
Ind	YES	YES	YES	YES
N	3476	3476	3465	3476
F	147.70	771.92	—	236.32
R <sup>2</sup>	0.0929	0.0945	0.0376	0.0952

Table 8. Regression results of enterprise innovation measured by the number of patent applications

Variables	Patents	Patents	Tech	Patents
	Model (1)	Model (2)	Model (3)	Model (4)
Top1		-0.006*** (-3.75)	-0.005** (-2.67)	-0.006*** (-3.68)
Tech	0.095* (2.23)			0.088** (2.09)
Controls	YES	YES	YES	YES
Year	YES	YES	YES	YES
Ind	YES	YES	YES	YES
N	3476	3476	3465	3476
R <sup>2</sup>	0.0257	0.0279	0.0375	0.0291

## 5 Further Analysis

The regression results above show that the technical background of the CEO promotes firm innovation.

This part further studies how to better play the role of CEOs' technology background in promoting enterprise innovation. This paper mainly considers the factors such as the shareholding of the CEO and the combination of the managing director and chairman.

### 5.1 Whether the CEOs Hold Shares or Not

There is a common overlap between shareholders and managers in family enterprises. The data in this paper shows that the shareholding ratio of CEOs is 73.96%. Management shareholding can effectively alleviate the first kind of agency problem so that the interests of management and shareholders converge. CEOs holding shares have the dual identities of shareholders and managers, so they will reduce short-sighted behaviors, give play to the sense of ownership and increase innovation input. The samples are grouped according to whether the CEO holds shares. When the CEOs hold shares of the in-service company, the variable value is 1; otherwise, it is 0. According to the grouping regression results in Table 9, under the condition of shareholding, the technical background of CEOs is significantly positively correlated with innovation input, while under the condition of non-shareholding, the technical background of CEOs is not significantly positively correlated with innovation input. This indicates that equity incentives play a positive role in motivating technical CEOs to increase R&D intensity.

### 5.2 Whether the CEO also Serves as the Chairman

Most small and medium-sized private enterprises are family enterprises, and it is common to combine the chairman and general manager. The data in this paper shows that 37.50% of the sample of small and medium-sized private enterprises combine the chairman and general manager. On the one hand, the two-in-one leadership structure of the board of directors weakens the supervisory function and decision-making independence of the board of directors, which provides convenient conditions for the general manager to pursue his interests. On the other hand, it distracts the technical CEOs' energy to concentrate on technology. As a result, the appointment of a technology CEO as chairman may reduce investment in innovation.

If the position of chairman and general manager shall be assumed by one person, the value is 1; otherwise, the value is 0. According to the grouping regression results in Table 9, the technical background of CEOs is significantly positively

correlated with enterprise innovation input under the condition of non-integration of two jobs, while the technical background of CEOs is not significantly positively correlated with enterprise innovation input under the condition of integration of two jobs. This indicates that the non-dual board governance structure is conducive to the increase of innovation investment for technology CEOs.

Table 9. Regression results of further analysis

Variables	Whether the CEO owns shares		Whether the CEO also serves as chairman	
	NO	YES	NO	YES
Tech	0.199 (1.35)	0.174*** (3.06)	0.228** (2.28)	0.068 (0.62)
Controls	YES	YES	YES	YES
Year	YES	YES	YES	YES
Ind	YES	YES	YES	YES
N	905	2571	2162	1297
R <sup>2</sup>	0.1001	0.0907	0.0862	0.1042

## 6 Research Conclusions and Policy Recommendations

### 6.1 Research Conclusions

It is worth thinking about how to develop the positive factors, overcome the negative factors, and obtain the excess profit of innovation for small and medium-sized enterprises. This paper takes the panel data of non-financial small and medium-sized private listed companies in the Shenzhen Stock Market from 2011 to 2019 as samples. Starting from two key figures, major shareholders and technical CEOs, through theoretical reasoning and empirical analysis, this paper finds out their roles in enterprise innovation. It is found that the controlling shareholder not only directly inhibits enterprise innovation, but also indirectly inhibits enterprise innovation by influencing the selection of technology CEOs. Further research shows that technical CEOs can significantly promote enterprise innovation under the condition that CEO holds shares or does not concurrently serve as chairman.

These conclusions are consistent with the history and culture of China, the development of the capital market, and the characteristics of small and medium-sized enterprises. First of all, Chinese enterprises are influenced by traditional culture, and the idea of moderation occupies the mainstream. They do not like to take risks and do not like to be the first to try. As a relatively vulnerable group, the

owners of small and medium-sized enterprises are more reluctant to participate in risky activities, such as innovation. Second, in China, the capital market started late and is not perfect. The major shareholders use the advantage of equity to interfere excessively in the decision-making of the board of directors and influence the selection of managers. Third, small and medium-sized enterprises have a poor ability to resist risks, and their business goal is mainly to maximize short-term profits. For the sake of enterprise survival, major shareholders are unwilling to hire a technology CEO with high salaries to enhance the long-term value of enterprises. However, the competitiveness of stocks and products of small and medium-sized companies is weak, and it is difficult for them to grow if they are excessively conservative in management. Small and medium-sized enterprises should hire a technical CEO, improve product quality, and quickly occupy the market, just like Apple company. They should attach importance to products and innovation from the beginning, and achieve the goal of quickly occupying the market.

The research conclusions of this paper may not apply to foreign SMEs, because there are great differences in traditional culture, capital market development, and economic level. These conclusions of this paper also do not apply to China's state-owned enterprises, which are subject to government interference in major decisions.

## 6.2 Policy Recommendations

According to the research conclusions of this paper, this paper puts forward the following suggestions to improve the innovation level of small and medium-sized private enterprises in China.

Regarding major shareholder governance, the suggestions are as follows. First, enterprises can cultivate a group of major shareholders with innovative consciousness. The urgent task is to cultivate a group of rational major shareholders with innovative consciousness. These entrepreneurs can lead team members to actively invest in innovation, form a culture of enterprise innovation inside and outside the company, and influence the behavior of employees imperceptibly so that all employees can make efforts towards innovation. Major shareholders of enterprises should have a sense of the overall situation and take the initiative to assume the social responsibility of rejuvenating the country through innovation, instead of blindly pursuing profit maximization. They should not excessively interfere in the decision-making of various departments of the enterprise but should trust and

appropriately authorize all departments. Second, enterprises can give play the supervisory role of Party members over major shareholders. The standard, sound, and independent three-tier governance structure can promote the cooperation and supervision of various departments and maintain the normal and efficient operation of the company. But the independence of the three-tier institutions is vulnerable to interference by major shareholders. Therefore, Party members can be appointed to supervise the major shareholders of the enterprise, encourage the controlling shareholders to rationally allocate limited enterprise resources to the production field, focus on the innovation ability of the enterprise, and make the capital increase in the production.

Regarding manager selection, the suggestions are as follows. First, enterprises can improve the employment mechanism of technical executives. As the world's largest developing country, China has yet to complete its legal system, market-oriented system, and modern enterprise management system, and corporate governance is still immature and at a relatively low level. It is common for management to speculate and short-sighted behaviors that harm shareholders and the long-term development of enterprises. The short-sighted behaviors of managers who pay more attention to short-term profits rather than the long-term development of enterprises lead to increased distrust of managers by shareholders, which seriously affects innovation activities. The introduction of external or internal technical CEOs can effectively improve the diversity of the management, reduce the short-sightedness of the enterprise management, and facilitate the management to take strategic decisions in line with the long-term development of the enterprise. Second, enterprises can improve equity incentive measures for technical CEOs. This paper finds that equity incentives can significantly promote technical CEOs to increase innovation investment. The key to improving the technological innovation level of enterprises is to motivate the technical staff to give full play to their intelligence. The technical CEO is the leader in implementing enterprise technology innovation activities. The implementation of equity incentive measures for technical CEOs can not only give full play to the leading role of technical CEOs but also convey to the market the signal that enterprises are actively engaged in technology, which is conducive to access to innovation resources and improve the innovation level of enterprises.

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