STUDY ON THE IMPACT OF INTERNAL AND EXTERNAL GOVERNANCE CHARACTERISTICS ON CORPORATE R&D INVESTMENT-BASED ON CHINA GEM LISTED COMPANIES

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SUMMARY

Researching how different aspects of corporate governance affect R&D spending is both theoretically and practically relevant. Businesses in the high technology sector have been in the spotlight recently due to their status as icons of innovation. Modern Chinese high-tech businesses face intense competition in order to stay afloat and grow. One way they are adapting to this environment is by focusing their efforts on improving their own competitiveness through in-house innovation. Yet, domestic and international academics have given little attention to the connection between company internal and external governance and R&D investment activities, leading them to contradictory findings. The influence of internal and external governance on businesses is too complicated, with both good and negative consequences, and the impact route of corporate governance on enterprises cannot be reduced to a single variable for measurement. For this reason, it is important to investigate the following questions in the context of China's current economic transition: i. does corporate governance affect corporate R&D investment? ii. what the inner mechanism is behind the impact of corporate internal and external governance on R&D investment activities? iii. what is the relationship between corporate internal governance and R&D investment activities? This paper proposes relevant assumptions after summarising and analysing the research conclusions of other scholars and sorts out missing data based on the data of the annual reports of China GEM manufacturing listed companies from 2011 to 2020 in order to measure the specific impact of corporate governance and industry competition on enterprise R&D investment and the regulatory role of industry competition on the relationship between corporate governance and R&D investment. The author conducts an optimistic analysis and draws the following conclusions: First, from an external perspective, the intensity of industry competition has a major impact on the R&D investment decisions of firms, and vice versa. Second, from within the corporation, state-holding enterprises have greater leeway to invest in research and development than non-holding enterprises do, and the merger of the chairman and general manager roles can boost R&D spending. The third point is that the link between state-holding, position combination, and R&D investment will not be regulated by industry competition.

KEY WORDS: Corporate governance, Competitiveness, Innovation, High-tech enterprises, R&D investment, Regulatory effect

1. INTRODUCTION

Market competition is heating up as a result of the unrelenting development of science and technology. Simultaneously, China's manner of economic growth is shifting, however subtly. The old labor-intensive, capital-dependent, and resource-dependent model is giving way to a new, innovation-driven model in China. The "innovation-driven development strategy" was elevated to national status at the 18th National Congress in 2012. "Innovation is the greatest driving force to propel growth," the 19th National Congress said in 2017. From that point on, innovation has been central to China's modernization efforts.

In order to stay ahead of the competition and increase sales, businesses must regularly introduce new features and improvements to their products and services. Accounting data, such as R&D spending, is currently used to evaluate businesses' innovativeness. Because of the voluntary disclosure of R&D spending by Chinese listed companies before to 2007, China has comparatively little theoretical study on R&D spending. However, since 2007 when new accounting standards were implemented, listed firms have been obligated to disclose their R&D spending and have developed related disclosure standards, which are now beginning to bear fruit. That's why it makes more sense now than ever to investigate the corporation's R&D spending.

However, there are dangers associated with R&D innovation. Businesses should give careful consideration to a wide range of external issues before deciding on an R&D innovation strategy, with industry competition being the most crucial of these. One of the most significant groups of factors that can influence R&D expenditure are those

internal to businesses. However, academic studies from different countries tend to zero in on a single component, and rarely examine the impact of numerous factors acting in concert (Sreedhhar Bhukya K, 2024). Furthermore, the factors that affect industry competition outside the organization and the elements that affect corporate governance inside the enterprise are considered by fewer academics (P. Brundavani, 2024). This article uses the idea of technological innovation and information asymmetry to examine the impact of regulatory effect of industry competition degree on the relationship between corporate governance and R&D expenditure inside businesses.

This paper has two main goals: first, from a developmental standpoint, it hopes to lay a certain foundation for other scholars to conduct theoretical research and provide new ideas for existing research; second, for the actual operation and management of enterprises, it hopes that enterprises will be able to formulate more scientific R&D investment strategies according to their own characteristics in order to improve the efficiency of R&D investment.

2. LITERATURE REVIEW

Globalization of economic trade and increased competitiveness in the marketplace necessitate ongoing research and development innovation on the part of businesses. Companies with a greater degree of industry concentration are in a better position to invest in research and development according to the idea put forth by Schumpeter in 1942. On the other hand, Schumpeter's perspective is at odds with Arrow's (1959). Under conditions of ideal competition, he discovered, businesses were more likely to invest in R&D innovations. After researching Arrow's perspective in depth, Holmes (2012) concluded that monopolistic firms' loss aversion is to blame for the market's lack of support for research, development, and innovation. To reflect business success, Vithessonthi and Racela (2016) chose non-financial enterprises listed on the New York Stock Exchange and the Nasdaq Stock Market. According to their findings, businesses who invest in R&D are better prepared to compete in today's cutthroat markets.

Research and development (R&D) efforts impact business growth and shape the way companies move forward. Investors and executives view it as critically important because of this. Based on their empirical study of European businesses, Ricardo et al. (2019) concluded that firms with different corporate governance styles invest in R&D at varying levels. The principal-agent theory predicts that a company's general manager will act in a short-sighted manner if the board of directors and the general manager are separate entities, but that this behaviour will be more in line with the company's long-term interests and the intensity of its R&D investments if the two roles are combined.

According to Francis and Smith's study on the intrinsic value of stock, businesses are more likely to engage in R&D innovation within their own walls when their significant shareholders have a say in the company's operations. State-owned businesses have less of an incentive to spend in research and development, hence they are less efficient than private businesses. As a result, enterprise innovation will benefit more from either a decrease in the percentage of state-owned shares or an increase in the percentage of non-state-owned shares (Brantley 1997). Li Zheng and Lu Yinhong (2014) draw different conclusions from the aforementioned researchers, finding that state-owned holding firms in China have a stronger innovative capacity and performance than non-state-owned holding enterprises.

Some academics have a firm grasp, based on extensive research, of the interplay between industry competitiveness and corporate governance's impact on businesses. They argue that the internal corporate governance mechanism can be partially replaced by the exterior market competition mechanism (Grossman, 1991; Chen H, 2014). Companies will be forced to adjust their R&D spending and corporate governance strategies in response to increased industry competitiveness (De Maere et al., 2014). Le (2006) and others' research shows that numerous external factors do not regulate the relationship between corporate governance and R&D investment, despite the fact that various corporate governance elements can considerably affect the R&D investment of firms. Corporate governance structures and industry competitiveness are complementary in shaping business decisions, according to research by Fu Chuanrui and colleagues (2018). Li Chang'e (2017) argued that the board's authority and R&D spending would not be influenced by the level of industry competition. No matter what happens in the world, according to Gong Lixin and Lv Xiaojun (2018), there will be no impact on R&D investment, corporate governance, or the effectiveness of R&D subsidies from regulations.Scholars represented by the Dang (2012) believe that the combination of the two positions will lead to a high degree of centralization, and eventually form a situation of "one word", which makes the original reasonable decision-making mechanism of enterprises virtually futile, and ultimately has a negative impact on R&D investment.

Xu Jinfa and Liu Yi (2002) found that when the two positions are separated, enterprises will make more efficient decisions, which is more conducive to R&D and innovation. After further research, other scholars found that the combination of the two roles does have a inhibiting effect on the R&D investment of enterprises. Liu Wei et al. (2007) conducted an empirical study on information technology enterprises and found that the concurrent appointment of the chairman as the general manager would inhibit the R&D investment of enterprises. On the contrary, scholars represented by Zhang Zongyi et al. (2007) believe that the integration of the two roles can significantly promote the R&D investment of enterprises. Their research shows that the integration of the two roles can make the general manager less constrained

when making decisions, so that the general manager can make adjustments more quickly and make R&D decisions more quickly when the market fluctuates. Enable enterprises to gain competitive advantages. He Pinglin (2019) et al. also found through research that based on the butler theory, the integration of the two roles can enable enterprises to make decisions more quickly and improve their performance and viability. Yang Songling et al. also found that the integration of the two roles can effectively promote the R&D investment of enterprises after empirical research on technology companies. Some domestic scholars have also studied other characteristics of corporate governance, such as the ability of directors to promote R&D investment if they hold positions in the unit of the controlling shareholder (Zhou Jie and Xue Youzhi 2008); There is no significant correlation between R&D investment intensity and the age of the chairman, and R&D investment intensity will decrease with the increase of the chairman's shareholding ratio (Zhao Hongjiang et al. 2008). R&D investment intensity increases with the increase of the proportion of male directors on the board of directors, but decreases with the increase of the board of directors' shareholding ratio and director compensation (Wu Jizhong and Miao Pengfei 2013).

Ping Xinqiao and Zhou Yiyi (2007) studied China's listed manufacturing companies from 2001 to 2005. They mainly studied the influence of three factors, namely market share, industry concentration and industry profit rate, on R&D investment of private enterprises (Swara Snehit Patil, 2024). The results showed that the relationship between industry competition and R&D investment was positive U-shaped. The two factors of market share and industry profit rate have an inverted U-shaped relationship with R&D investment. Nie Huihua et al. (2008) studied the data of industrial enterprises in China from 2001 to 2005, and used R&D investment intensity to represent innovation ability, the ratio of advertising expenses to operating income to represent marketing ability of enterprises, and the ratio of operating income of the top four manufacturers in the industry to total market income to represent the degree of industry competition. Empirical research is used to explore the relationship between the three, and the research results show that the innovation ability of enterprises and the degree of industry competition are in an inverted U-shaped structure, that is, appropriate industry competition can promote the R&D innovation of enterprises to a certain extent.

Lu Tong (2014) found that different industries have differences in all aspects, which are embodied in industry concentration and technology concentration, etc., which lead to significant differences in important decisions such as R&D and innovation made by different enterprises. At present, the high-tech industry has been widely concerned by the insiders. According to the study of Zhang Weiying et al. (2005), the development of high-tech industry is related to the fate of the country and the future of the nation, and is also an important guarantee for the implementation of sustainable development, and can also help the country gain advantages in international competition. Compared with other industries, high-tech industry has higher risks and needs more R&D investment to maintain its development, so efficiency and R&D are extremely important to it. Zhang Liying (2014) found through research that the R&D investment intensity of high-tech industry is far higher than that of other industries, and the development of high-tech industry is more dependent on R&D and innovation. Chi Guohua et al. (2016) believe that compared with the high-tech manufacturing industry, the scientific research strength of traditional industries is weak, labor-intensive and capital-dependent traditional industries are common forms, and their demand for technological innovation is low, so the investment intensity of intangible assets is small, and they mainly rely on fixed assets to ensure the development of enterprises.

Yu Changhong and Bai Chen (2013) obtained the panel data of listed companies in China from 2006 to 2007 and conducted an empirical study on the impact of industry innovation competition degree on R&D investment. The study showed that when industry innovation competition degree was lower than a certain level, it would promote R&D investment. When the degree of innovation competition in the industry reaches a certain value, R&D investment will be inhibited. Based on the data of China's A-share manufacturing listed companies from 2014 to 2016, Huang Guoliang and Yang Guang (2018) drew A conclusion that the more concentrated the industry, the greater the R&D investment intensity. Lv Xinjun and Dai Chunxia (2016) also found that low industry competition is conducive to enterprises' improvement of R&D investment return rate. Chen Lin and Zhu Weiping (2011) selected the data disclosed by China's industrial listed companies from 2005 to 2006, used the proportion of state-owned enterprises in the industry to measure the degree of difficulty in entering the industry, and divided the sample data into two categories for regression. The research results showed that when state-owned enterprises accounted for a large proportion of the industry, the industry had certain administrative attributes (Srinivasa Sai Abhijit Challapalli, 2024). At this time, there is a U-shaped relationship between the degree of industry competition and the intensity of R&D investment of enterprises. Their research provides valuable ideas for domestic and foreign scholars to fully understand Schumpeter's theory.

Zeng Ping and Wu Yihong (2012) conducted an empirical study on Chinese GEM listed companies and found that R&D investment intensity varies with different industries, and the interaction between R&D investment and corporate governance risk is also different.

3. THEORETICAL ANALYSIS AND RESEARCH ASSUMPTION

When enterprises invest in R&D, they will be affected by external governance factors such as industry competition. In

particular, the competition in China's industry is extremely severe. Therefore, whether an enterprise has an advantage in the industry competition will be directly reflected in the financial statements. If the enterprise has good benefits and large R&D investment, it can basically be determined that it has a greater advantage in the competition; on the contrary, if the product loses its competitive advantage, then the enterprise's efficiency will be inevitably affected, and even the survival of the enterprise may be threatened. With the increasing concentration of the industry, enterprises will gradually increase their R&D expenditure. When the industry concentration reaches the monopoly level, enterprises carry out R&D innovation in order to maintain the monopoly position and monopoly profits, and monopoly enterprises have greater advantages in scale economy, risk sharing and other aspects, they have adequate financial support for their innovation and the risk is lower. This is consistent with Schumpeter's (1942) view in the theory of technological innovation: monopoly can promote enterprise innovation more than competition.

Therefore, assumption 1 can be proposed:

Assumption 1: If competition is high in an industry, fewer businesses will spend much on research and development.

Differences between China and other countries' corporate governance practises are an inevitability when examining China's listed corporations. The fundamental reason is that unlike in other nations, a high percentage of shares in Chinese listed companies are held by the state. While state-owned companies in China are required to make a profit like any other business, they are also tasked with fostering the nation's economic growth and bettering people's lives. Therefore, the government will have a certain inclination towards state-owned enterprises when formulating various policies to ensure the smooth operation of the national economy. This has resulted in state-owned enterprises having a strong administrative advantage in R&D investment and has reduced the short-sighted behaviour of leaders within state-owned enterprises, leading to an increase in R&D investment. You may call this a sub-type of equity structure theory. In conclusion, state-owned holding companies in China are the lifeblood of the national economy, and they will become increasingly active in R&D investment as a result of the inherent administrative advantages they enjoy.

Accordingly, we might postulate the following assumption 2:

Assumption 2: State holding can promote enterprises to invest in R&D.

One of the most important signs of healthy corporate governance is when the roles of chairman and general manager are kept separate. Integration of the two roles, as suggested by the principal-agent theory, has the potential to improve the efficiency of communication between the board of directors and management, as well as reduce the amount of time required to arrive at important decisions regarding the company's operations. In contrast to combining the two functions, separating them enables the company's management and governance to have access to a greater variety of resources and information, while simultaneously safeguarding the independence of the board of directors and eliminating the potentially harmful effect of insider control. The loss of the general manager's veto power, which occurs when the two roles are kept separate, can have adverse effects on the long-term growth of the company by discouraging investments in areas such as research and development. Researchers from a variety of countries have found that separating the two roles results in decreased productivity in the decision-making process of an enterprise and increases the costs associated with management. Because of this, there is a disincentive to spend money on research and development due to the division between the chairman and the general manager.

As a result, we are able to proceed with the following assumption 3:

Assumption 3: When a company's chairman and general manager are forbidden from coordinating their efforts, R&D budgets tend to shrink.

Academics have found that ignoring the regulatory role that both external and internal governance play in the recent years while focusing solely on the influence of external governance on R&D investment or focusing one's attention solely on the impact of internal governance on R&D investment is incorrect. Unlike in the developed western nations, the Chinese government has actual control over the majority of companies trading on the Chinese stock market. When it comes to the innovation and growth of other SOEs in China, the state-owned holding enterprises play a crucial role as they continue to play a major role in the country's economic and social development. The state-owned holding companies in China also remain crucial to the country's military advancement. This is why state-owned enterprises (SOEs) are given priority by the government when it comes to enacting preferential policies and securing national funding for R&D. Considering the actual situation in China, although industry competition as an external governance mechanism may affect the internal governance mechanism, this assumption may not be applicable to the current situation of Chinese companies. Thus, this paper believes that industry competition will not affect the relationship between the state-owned holding of enterprises and R&D investment.

Therefore, assumption 4 can be proposed:

Assumption 4: The regulatory effect of industry competition on state-owned holding and R&D investment is not significant.

Friedman (1953) pointed out that when enterprises face fierce industrial competition, enterprise owners and managers do not need to worry about the agency problem of enterprises. Guadalupe and Pérez-González took "executives abuse their power for personal gain" as the explanatory variable of corporate governance and conducted empirical research on monopoly industries and competitive industries respectively. They also found that industry competition can indeed reduce the probability. In general, industry competition can affect the internal governance mechanism to a certain extent to reduce the agency problem of senior executives. Whether the two positions chairman and general manager are integrated or not, is an important indicator of the agency problem of senior executives should also be affected by industry competition to a certain extent. When the chairperson and chief operating officer are combined into one position, R&D spending increases, especially in highly concentrated industries.

Therefore, the following assumption 5 can be put forward:

Assumption 5: The association between chairman/general manager integration and R&D expenditure is positively regulated by the level of industry competition.

4. RESEARCH DESIGN

4.1 RELATED VARIABLE SETTING

4.1.1 Interpreted variable

The R&D intensity of businesses is the primary metric used in this paper to analyse their R&D spending. To be more precise, the formula is the ratio of annual R&D spending to annual operating income. This paper does not include data samples from years in which high-tech listed companies did not invest in R&D because such companies do not exist.

4.1.2 Explanatory variables

1. Degree of industry competition

In this research, we use the Huffindahl index (HHI) to evaluate levels of rivalry in the business sector. The precise method of calculation is as follows:

$$HHI = \sum Ci^2 \quad (1)$$

The ratio of a firm's annual operating profit to the entire industry's operating income is known as the "competitive intensity index" or "Ci."

According to the formula, the smaller the HHI, the higher the degree of industry competition, and the greater the competitive pressure of enterprises; on the contrary, the larger the HHI is, the higher the industry concentration is, indicating that the enterprise has an advantage in the industry.

2. Concurrency of Chairman and General Manager

This article examines the impact of the scenario presented in this paper on R&D investment by dividing the chairman and general manager roles into two distinct scenarios: one in which the chairman also serves in the capacity of general manager, and another in which these two positions are held by separate individuals. The real-world variable that we are interested in is represented by the dummy variable Dual. When the value is 1, it indicates that the chairman also serves as the general manager, whereas when the value is 0, it indicates that the two roles are kept separate from one another.

3. State holding

This paper categorises high-tech listed companies as either state-owned or privately held, with Owner serving as a proxy for the percentage of state-owned holding in each group. It's a fake one, so don't worry about it. If the holding is owned by the state, count it as 1; if it is privately held, count it as 0.

4.1.3 Control variables

1. Enterprise scale

Numerous economists have observed that a company's size has a significant bearing on the amount of resources it dedicates to R&D. There is a correlation between business size and R&D intensity, according to empirical studies, however the studies' conclusions vary. In this study, we utilise Size to describe the size of the business, with the natural logarithm of total assets serving as the metric for size.

2. Profitability

Business profitability is a popular metric for evaluating the success of a venture. In this study, we use the return on assets (ROA) as a proxy for the total assets yield to evaluate business profitability.

3. Financial leverage

Lev stands for the asset-liability ratio, which is used as a proxy variable for financial leverage in this paper. The formula is the total book value of liabilities divided by the entire book value of assets.

4. Industry

In this paper, we follow the Guidelines for Industry Classification of Listed Companies issued by the China Securities Regulatory Commission and classify businesses into three groups based on the technological content of their industries: high technology, medium technology, and low technology. We then use two dummy variables to indicate whether or not a business is in a high technology industry (High) or a low technology industry (Low), with 1 indicating High and 0 indicating Low.

5. Year

This article additionally controls the year in order to limit the effect of the macro climate on industry competition and corporate governance on R&D spending. The variable Year is used to denote this information. If the value is 1, then it is on the year; otherwise, the value is 0.

In Table 1 you can see the explaining elements, explanatory factors, and control variables that were considered for this paper.

4.2 SAMPLE SELECTION AND DATA SOURCE

This research uses the annual time series data of Companies Quoted in China's GEM manufacturing base from 2011 to 2020 as its starting point, then removes the samples that were missing from the original data study to arrive at its panel data, including 29 companies in 2011, 108 in 2012, 228 in 2014, 244 in 2015, and 274 in 2016. In this study, we use data from the CSMAR database to examine three types of variables: explanatory variables, explained variables, and control variables. All the data of the continuous variables related to the study were processed with 1% winsorization to ensure the stability of the results, as the extreme values of the related data could potentially skew the results otherwise. As a result, we switched to using Excel 2010 and Eviews 10.0 for our subsequent data aggregation and statistical analysis.

4.3 MODEL DESIGN

The five multiple regressions listed below are built in this study to positively test the hypothesis and confirm the hypotheses presented in Chapter 3.

$$RD = \beta_0 + \beta_1 HHI + \beta_2 ROA + \beta_3 Size + \beta_4 Lev + \beta_5 High + \beta_6 Low + \beta_7 Year + \varepsilon \quad (2)$$

$$RD = \beta_0 + \beta_1 Owner + \beta_2 ROA + \beta_3 Size + \beta_4 Lev + \beta_5 High + \beta_6 Low + \beta_7 Year + \varepsilon \quad (3)$$

$$RD = \beta_0 + \beta_1 Dual + \beta_2 ROA + \beta_3 Size + \beta_4 Lev + \beta_5 High + \beta_6 Low + \beta_7 Year + \varepsilon \quad (4)$$

$$RD = \beta_0 + \beta_1 HHI + \beta_2 Owner + \beta_3 HHI \times Owner + \beta_4 ROA + \beta_5 Size + \beta_6 Lev + \beta_7 High + \beta_8 Low + \beta_9 Year + \varepsilon \quad (5)$$

$$RD = \beta_0 + \beta_1 HHI + \beta_2 Dual + \beta_3 HHI \times Dual + \beta_4 ROA + \beta_5 Size + \beta_6 Lev + \beta_7 High + \beta_8 Low + \beta_9 Year + \varepsilon \quad (6)$$

Table 1. Variable definition table

Variable Properties	Influencing Factors	Variable Symbols	Meaning	Valuation Method
Explained variables	Research and development	R&D	R&D investment intensity	R&D expenditure / main business income
Explanatory variables	Industry conditions	HHI	Degree of industry competition	(intra-industry company turnover / total industry turnover) ^2
	Corporate governance	Dual	Concurrency of Chairman and General Manager	1 for concurrent, 0 for not concurrent
		Owner	Situation of state-owned holdings	1 for state-owned enterprises, 0 for non-State-owned enterprises
Control variable	Company size	Size	Asset size	Natural logarithm of total assets
	Profitability	ROA	Assets yield	Net profit / total assets
	Financial leverage	Lev	Asset-liability Ratio	Total Liabilities / Total Assets
	Industry	High	High Technology Industry	If the enterprise belongs to High, take 1, otherwise take 0
		Low	Low technology industry	If the enterprise belongs to Low, take 1, otherwise take 0
	Year	Year	Which year the enterprise on	1 represents it is on the year, and 0 represents not

Wherein, ε refers to random error, and other variables are defined in Table 1.

5. EMPIRICAL RESEARCH

5.1 DESCRIPTIVE ANALYSIS

For convenience of reading, Table 2 provides a summary of all model variables, with the exception of the dummy variables (1), (2), (3), (4), (5), and (6). We are able to draw the conclusion from the data that companies spend a median of 4.9900 hours and an average of 6.5341 hours annually on research and development activities. Because different companies place varying amounts of importance on R&D spending, there is a large gap between the median and the average. This gap can be attributed to the fact that companies. Research and development (R&D) could be worth as little as 0.0200 or as much as 72.7500. The disparity between the two figures suggests that listed companies in China's high-tech manufacturing sector place varying degrees of emphasis on R&D investment. This is suggested by the fact that the figures are not identical.

The HHI values that were discovered in the set of data fell within the range of 0.4588 to 0.0077, with 0.0212 serving as the mean and 0.0146 as the median. Listed companies in China's high-tech manufacturing industry have a tendency to have market shares that are lower than the industry average. This is indicated by the large difference between the average and the median, which further indicates that the industry conditions that are faced by the listed companies are quite different due to the large difference between the maximum and minimum values.

The descriptive statistics for the control factors yield a mean value of 21.1277 and a median value of 21.0282 for the variable known as size. As a result of the relatively narrow difference between the two, it is abundantly evident that the majority of the publicly traded high-tech manufacturers still have a significant amount of potential for expansion. Given that the values for the overall size of development among the listed firms range from 25.0257 to 18.7602, it is abundantly evident that there is no undisputed victor in this category. The average return on investment is 0.0624, while the median return on investment is 0.0626. Given that the two numbers differ by a margin that may be considered negligible at best, it appears reasonable to conclude that the majority of the companies that are listed are doing well financially. It is abundantly evident that there is a significant disparity in the levels of profitability among the organisations that are listed, with a maximum of 0.4315 and a minimum of –1.0288 respectively. The values for Lev range from 0.0110 to 1.6852, with a mean of 0.2797 and a median of 0.2515. These numbers suggest that the majority of listed companies rely on debt to maintain operations, and that the level of debt is currently within a reasonable range. However, as can be seen from the discrepancy between the maximum and minimum values, the prospects for listed businesses in China's high-tech manufacturing industry to get funding through external loans vary substantially.

5.2 CORRELATION TEST

This research uses the Pearson coefficient to check for associations between the various explanatory, explanandum, and control variables before moving on to a regression analysis of the link between industry competitiveness degree, corporate governance, and R&D spending. Details can be seen in Table 3.

The Pearson correlation coefficient among the table variables shows that the absolute value is generally less than 0.4, There is not significant cointegration relationship between these variables because the correlation coefficients between the explanatory factors and the control variable are all less than 0.4, and multiple linear regression analysis can be performed on them. In addition, the HHI, Dual, Owner, and R&D all have positive correlation coefficients, which lends preliminary support to the paper's hypothesised relationship between the integration of the chairman and general manager and an increase in R&D investment intensity.

5.3 REGRESSION RESULT ANALYSIS

5.3.1 Impact of Industry Competition on R&D Investment

Model significance and regression results are presented in Table 4. (2). The VIF of the model was computed prior to doing the regression analysis, and the multicollinearity

Table 2. Descriptive statistics of variables

	N	Average	Median	Maximum	Minimum	SD
R&D	2796	6.5341	4.9900	72.7500	0.0200	5.5766
HHI	2796	0.0212	0.0146	0.4588	0.0077	0.0329
Size	2796	21.1277	21.0282	25.0257	18.7602	0.7760
ROA	2796	0.0624	0.0626	0.4315	–1.0288	0.0779
Lev	2796	0.2797	0.2515	1.6852	0.0110	0.1676

Table 3. Correlation test

	R&D	HHI	Dual	Owner	Size	ROA	Lev	High	Low
R&D	1								
HHI	0.0541***	1							
Dual	0.0534***	–0.0013	1						
Owner	0.0411**	–0.0283	–0.1899***	1					
Size	–0.0632***	–0.1590***	–0.1198***	0.0475**	1				
ROA	–0.1832***	0.0302	0.0354*	–0.0097	–0.1221***	1			
Lev	–0.1736***	–0.1145***	–0.0309	–0.0190	0.4370***	–0.2248***	1		
High	0.1500***	–0.2988***	0.0309	0.0262	0.1392***	–0.0792***	0.0559***	1	
Low	–0.1406***	0.3059***	–0.0426**	–0.0207	–0.1341***	0.0745***	–0.0610***	–0.9732***	1

Note: * * *, * *, * are statistically significant at the 1%, 5%, and 10% levels of assurance, respectively.

Table 4. Regression analysis of industry competition on R&D investment

	Coef	Std. Err.	t	P>t
HHI	14.4149***	3.2014	4.5027	0.0000
Size	–0.0270	0.1446	–0.1870	0.8516
ROA	–15.9071***	1.3153	–12.0938	0.0000
Lev	–7.3698***	0.6749	–10.9199	0.0000
High	2.4857***	0.9266	2.6827	0.0073
Low	0.4680	0.9369	0.4995	0.6175
Year	Controlled			
Obs	2796			

Note: * * *, * *, * are statistically significant at the 1%, 5%, and 10% levels of assurance, respectively.

was not severe because the mean value of the VIF did not exceed 10. According to Table 4, a positive correlation of 14.4149 exists between the degree of industrial competition (HHI) and the intensity of R&D spending. And at the 1% level of significance, it shows that the more intense the competition in an industry, the less money businesses are willing to put into R&D. That's in line with the findings of the study by Muhammad (2020) et al., and it's the same thing as Assumption 1 up there. It has been theorised by Schumpeter that when an industry is highly competitive, businesses reduce their R&D spending. The level of competition in the market today makes it difficult for businesses to justify spending money on research and development. Companies that enjoy a monopoly in their industry not only have a higher need for R&D, but also are better equipped to handle the inevitable setbacks that accompany such endeavours. This means that monopoly firms are uniquely positioned to conduct cutting-edge scientific study.

5.3.2 Impact of corporate governance on R&D investment

The regression results and significance level for model (3) are shown in Table 5. The VIF of the model was also determined prior to doing the regression analysis. Multicollinearity was not severe because the mean VIF was under 10. The empirical findings show that there is a significant positive correlation between the state holding status and the intensity of enterprise R&D investment in model (3) at the 10% level (r = 0.8052), which basically confirms the correctness of Assumption 2. This suggests that the state's administrative prowess in R&D innovation is put to use when an enterprise is in its hands, which lessens the likelihood of short-sighted behaviour on the part of enterprise managers and boosts R&D investment.

Table 6 displays the regression results and levels of significance for model (4), which examines the impact of the chairman being the general manager on R&D investment (4). The VIF of the model was again estimated prior to the regression analysis, and the mean value was less than 10, indicating that the multicollinearity was not severe. The table shows that the regression coefficient between the two integrated positions and R&D investment is 0.5627, which is statistically significant at the 1% level. Assumption 3, which argues that combining two positions can boost R&D investment activities, is supported by the regression results. This indicates that when the two positions are combined, the manager is more motivated to defend the interests of the company out of a sense of responsibility and accomplishment, and this in turn contributes to the R&D investment of the company.Huang Qinghua (2017) et al also believe that the integration of the two roles is conducive to the conduct of R&D investment in enterprises.

Table 5. Regression analysis of state holding on R&D investment

	Coef	Std. Err.	t	P>t
Owner	0.8052*	0.4640	1.7351	0.0828
Size	–0.1008	0.1447	–0.6971	0.4858
ROA	–15.9819***	1.3193	–12.1143	0.0000
Lev	–7.4828***	0.6766	–11.0586	0.0000
High	2.4379***	0.9297	2.6224	0.0088
Low	0.7246	0.9378	0.7727	0.4398
Year	Controlled			
Obs	2796			

Note: * * *, * *, * are statistically significant at the 1%, 5%, and 10% levels of assurance, respectively.

Table 6. Regression analysis of the concurrency of chairman and general manager on the R&D investment

	Coef	Std. Err.	t	P>t
Dual	0.5627***	0.2030	2.7717	0.0056
Size	–0.0369	0.1454	–0.2541	0.7994
ROA	–16.1117***	1.3186	–12.2186	0.0000
Lev	–7.5872***	0.6757	–11.2293	0.0000
High	2.5769***	0.9294	2.7728	0.0056
Low	0.8928	0.9382	0.9517	0.3413
Year	Controlled			
Obs	2796			

Note: * * *, * *, * are statistically significant at the 1%, 5%, and 10% levels of assurance, respectively.

5.3.3 Regulatory effect of industry competition on the relationship between corporate governance and R&D investment

This section explores how industrial competitiveness affects regulation, with an emphasis on the connection between state-owned holding, two-position integration, and R&D spending. Moreover, the effect of industry competitiveness on regulations is analysed here as well. The level of R&D spending is strongly correlated with the strength of the relationship between external and internal governance, as demonstrated by the research of Sharma (1981) on regulatory factors. This points to the existence of either a mixed regulatory/non-regulatory influence or a pure regulatory/non-regulatory effect. When there is no substantial interaction between the two governance techniques and external governance is significantly related to R&D expenditure, we observe a homogeneous regulatory effect. When internal governance has no regulatory effect, this happens.

Table 7. lays out the ways in which market competition has impacted the legal structure that links government ownership to R&D expenditures

	Coef	Std. Err.	t	P>t
HHI	14.2993***	3.2077	4.4578	0.0000
Owner	0.1821	0.7647	0.2382	0.8117
HHI*Owner	38.5907	35.3230	1.0925	0.2747
Size	–0.0346	0.1449	–0.2387	0.8113
ROA	–15.8817***	1.3148	–12.0792	0.0000
Lev	–7.3305***	0.6755	–10.8522	0.0000
High	2.4488***	0.9264	2.6435	0.0083
Low	0.4270	0.9367	0.4558	0.6485
Year	Controlled			
Obs	2796			

Note: * * *, * *, * are statistically significant at the 1%, 5%, and 10% levels of assurance, respectively.

Table 8. Regulatory effect of industry competition on the relationship between the concurrent role of chairman and general manager and R&D investment

	Coef	Std. Err.	t	P>t
HHI	18.0086***	4.5548	3.9538	0.0001
Dual	0.7059***	0.2396	2.9468	0.0032
HHI* Dual	–6.6731	6.0532	–1.1024	0.2704
Size	0.0211	0.1455	0.1449	0.8848
ROA	–15.9620***	1.3150	–12.1387	0.0000
Lev	–7.3924***	0.6748	–10.9547	0.0000
High	2.6021***	0.9262	2.8094	0.0050
Low	0.6080	0.9371	0.6488	0.5165
Year	Controlled			
Obs	2796			

Note: * * *, * *, * are statistically significant at the 1%, 5%, and 10% levels of assurance, respectively.

The outcomes of our regression analysis, along with their respective levels of model significance, are presented in Table 7. (5). The VIF of the model was also determined prior to doing the regression analysis. Multicollinearity was not severe because the mean VIF was under 10. The cross term coefficient (HHI * Owner) of state-owned holdings and the intensity of R&D investment is 38.5907, but not statistically significant, as shown by the regression results between industry competition degree and HHI. In addition, there is a positive correlation between the level of competition in an industry and the level of R&D investment (r = 14.2993), confirming that, contrary to Assumption 4, the level of competition in an industry does not act as a

regulatory factor in the correlation between state-owned holdings and R&D investment. This demonstrates the impossibility of using industry rivalry as an external governance mechanism to change the intrinsic connection between stocks and R&D spending.

In Table 8 we see the model (6) significance level and the regression results. The VIF of the model was also determined prior to doing the regression analysis. Multicollinearity was not severe because the mean VIF was under 10. Integration of the two roles, the cross item coefficient of industry competition (HHI * Dual), and R&D investment intensity have a non-significant regression coefficient of –6.6731. There is no moderating effect of industry competition on the correlation between integrated position and R&D investment, as measured by the correlation coefficient of 18.0086, which is positive. The fifth assumption has not been checked. This demonstrates that the industry competition as an external governance mode has no effect on the relationship between the integration of two roles and R&D investment when the enterprise is engaged in fierce industry competition. This finding indicates that industry competition will have no effect on the influence of directors' power over R&D investment.

5.4 ROBUSTNESS TEST

In the previous multiple regression analysis, this paper verified the relationship between industry competition, internal governance and R&D investment intensity. This work has revised the benchmark against which industry rivalry is measured, and it has used the results of a new empirical investigation to verify or refute the validity of its earlier findings.

In this article, the level of competition in the sector in which the companies operate is quantified using the Herfindahl index. This research re-verifies the connection between industry competitiveness and internal governance and R&D investment by using a substitute variable of the Herfindahl index (HHI): the total of the market shares of the top 10 firms in the industry (the industry concentration, or CR10). Regress the experimental data using models (2), (5), and (6), and check to see if the new findings are in line with the old ones after each change is made to the experimental setup.

From Table 9, Table 10 and Table 11, we can see that after replacing the HHI with CR10, the industry concentration ratio has a significant positive correlation with the R&D at the level of 1%. The interaction coefficient between industry concentration and state-owned holding on R&D investment is positive, but not significant, and industry concentration is significantly positively correlated with R&D investment intensity. The interaction coefficient of industry concentration and the concurrency of two positions on R&D investment is negative, but not significant, and the

Table 9. Concentration in a few sectors' effect on R&D spending, tabulated

	Coef	Std. Err.	t	P>t
CR10	4.6184***	0.9083	5.0847	0.0000
Size	–0.0181	0.1444	–0.1255	0.9002
ROA	–15.8160***	1.3144	–12.0332	0.0000
Lev	–7.4047***	0.6737	–10.9910	0.0000
High	2.6225***	0.9261	2.8318	0.0047
Low	0.5271	0.9349	0.5638	0.5730
Year	Controlled			
Obs	2796			

Note: * * *, * *, * are statistically significant at the 1%, 5%, and 10% levels of assurance, respectively.

Table 10. Regulatory effect of industry concentration on the relationship between state holding and R&D investment

	Coef	Std. Err.	t	P>t
CR10	4.5446***	0.9152	4.9658	0.0000
Owner	–0.5301	1.8132	–0.2924	0.7700
CR10* Owner	4.7573	6.1495	0.7736	0.4392
Szie	–0.0287***	0.1447	–0.1983	0.8428
ROA	–15.7920***	1.3140	–12.0181	0.0000
Lev	–7.3640	0.6744	–10.9191	0.0000
High	2.5837***	0.9260	2.7901	0.0053
Low	0.4918	0.9348	0.5261	0.5989
Year	Controlled			
Obs	2796			

Note: * * *, * *, * are statistically significant at the 1%, 5%, and 10% levels of assurance, respectively.

Table 11. Regulatory effect of industry concentration on the relationship between the position concurrency and R&D investment

	Coef	Std. Err.	t	P>t
CR10	4.9159***	1.1513	4.2699	0.0000
Dual	0.7630	0.5456	1.3985	0.1621
CR10* Dual	–0.6278	1.7240	–0.3642	0.7158
Size	0.0318	0.1454	0.2186	0.8270
ROA	–15.9089***	1.3139	–12.1085	0.0000
Lev	–7.4487***	0.6736	–11.0586	0.0000
High	2.7316***	0.9258	2.9505	0.0032
Low	0.6701	0.9352	0.7166	0.4737
Year	Controlled			
Obs	2796			

Note: * * *, * *, * are statistically significant at the 1%, 5%, and 10% levels of assurance, respectively.

industry concentration is significantly positively correlated with the intensity of R&D investment. After replacing the new measurement method, the results of using CR10 and HHI to represent the degree of industry competition are basically consistent. We can basically confirm that the results of robustness test are basically consistent with the previous regression results. The results show that the conclusions of this study are robust.

6. RESEARCH CONCLUSIONS AND SUGGESTIONS

6.1 RESEARCH CONCLUSION

The analysis and research presented in this study lead to the following conclusions:

In the first place, companies are hesitant to invest in R&D because of the intense rivalry in their sector. Companies are less likely to invest in R&D when they have not reached a critical mass in the market and are therefore unable to establish monopoly.

Second, a stake held by the state can help Chinese businesses invest more in research and development. State-owned corporations, which are the backbone of any nation's economy, are safer bets than private businesses because they receive more government backing. This means that state-owned businesses have a greater budget for research and development than private businesses.

Third, the company's investment in R&D will suffer as a result of the split between the chairman and the general manager. To better think about the company's long-term development, avoid the short-sighted attitude that "He who is not in a particular position has nothing to do with plans for administration of its duties," and increase research and development activities to better compete, it is beneficial for the chairman to also serve as the company's general manager.

Fourth, the correlation between good corporate management and R&D spending is not governed by the level of rivalry in a given industry. Even against the backdrop of the imperfections in the Chinese governance structure, this will not change the correlation between the composition of the equity or the merger of two positions and R&D spending. It also suggests, at least in part, that in the current Chinese market climate, companies are investing in R&D more to cater to the needs of high-tech businesses than to make equivalent investments based on market conditions.

6.2 RELEVANT SUGGESTIONS

Based on the research conclusion, the following suggestions are put forward:

Businesses, first and foremost, ought to prioritize good corporate governance. Companies in China can no longer rely on external governance mechanisms like competition to influence their decision-making; instead, they must rely on internal governance mechanisms like constantly upgrading internal controls to limit the agency behavior of senior executives.

Second, from a policy standpoint, the government should monitor industry competition closely, fully implement macroeconomic regulation, and keep industry competition at a level that encourages businesses to invest in research and development.

Third, while investing in businesses across different industries, investors should approach it with a somewhat different mindset. If investors want to make a smart investment in a monopoly-holding corporation, for instance, they should study the company's spending on research and development and how it has affected the market.

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