

Equity Incentives and Firm Innovation Efficiency: Moderating Role of Ownership Concentration

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Abstract. In order to cope with the new situation and new challenges facing China's economic development, the country proposes to accelerate industrial transformation and upgrading with innovation drive, and lead scientific and technological development with scientific and technological innovation. Manufacturing industry occupies an important share in the national economy, and how to improve the overall competitiveness of China's manufacturing industry and the innovation efficiency of enterprises has become a hot issue of general concern for all sectors of society. Based on innovation theory, principal-agent theory and two-factor incentive theory, this paper systematically investigates executive equity incentives, ownership concentration and innovation efficiency for China's manufacturing industry, and also tests the ownership concentration regulation effect in groups under the perspective of equity optimization. It is found that: (1) Executive equity incentives are significantly and positively related to innovation efficiency. (2) Ownership concentration is significantly and positively related to innovation efficiency. (3) The more significant the promotion effect of executive shareholding on innovation efficiency when the equity is relatively concentrated. This paper can provide a reference for Chinese manufacturing industry to establish a sound incentive mechanism and optimize equity policy.

Keywords: Ownership Concentration, Equity Incentives, Innovation Efficiency.

1. Introduction

The manufacturing industry occupies an important share of the national economy and is fundamental to the smooth and healthy development of China's economy and society. General Secretary Xi Jinping has publicly emphasized manufacturing technology, industry and scientific and technological innovation at different times and on different occasions, pointing out the importance of the innovation-driven strategy for the transformation and upgrading of the manufacturing industry. From the scale alone, China's manufacturing industry ranks first in the world, but there are still many shortcomings in "high precision", while the overall level of China's R&D and the world's advanced level there is still a certain gap between the manufacturing industry is large but not strong, the efficiency of enterprise scientific and technological innovation needs to be improved and other issues are more prominent. At the same time, China's economic development is also facing a new situation and new challenges. Compared with the double-digit economic growth rate in the past few years, China's GDP growth rate in recent years has shown a continuous slowdown trend, and the decline in growth rate has also brought some new contradictions and problems. In order to cope with the new situation of China's economic development, the "14th Five-Year Plan" clearly points out that we should insist on implementing the development concept of "innovation, coordination, green, openness, and sharing", and its primary goal is to accelerate industrial transformation and upgrading by innovation. From a macro point of view, China's industry is accelerating the transfer of the world, the new development pattern brings significant opportunities, China's manufacturing industry should be unswervingly to reform and innovation to promote the social economy; from a micro point of view, the innovation of the enterprise to bring the impetus for the development, in line with the principle of the interests of the supreme, the profit is the ultimate goal of the enterprise. The overall improvement of innovation efficiency can enhance the overall competitive strength of enterprises, thus realizing excess profits. Therefore, under the new economic normal, technological innovation is one of the key factors of economic development, and is the core of the manufacturing industry to survive.

Improving the innovation efficiency of manufacturing enterprises not only requires guidance and encouragement from the government at the macro level, but most importantly, it requires enterprises to truly realize the importance of improving their own innovation efficiency. The executives and key technical personnel of a company are the main participants in the innovation activities of the company, so how to improve the motivation of executives and core technical personnel to implement innovation activities has become a key issue. Equity incentives originated in the United States, where equity is granted to executives and employees in order to improve their work efficiency and thus strive for higher corporate earnings. Based on the principal-agent theory, enterprise executives, as decision makers and leaders of the enterprise, appropriate equity incentives can make the management form a community of interest with the enterprise, improve its emphasis on scientific and technological innovation, accelerate the implementation of innovation results, and is crucial to promoting enterprise innovation. In order to further improve the enterprise equity incentive policy mechanism, the China Securities Regulatory Commission has issued and implemented a series of laws and regulations, and at present equity incentives have been commonly used in domestic and foreign listed companies, and have become an essential and important reward policy for enterprises. In addition, equity incentives and reasonable equity structure is also closely linked, in recent years, many scholars around the equity structure of whether and through which factors affect corporate innovation to start the discussion, the conclusion shows that the degree of ownership concentration is not unrelated to the enterprise business management, equity mechanism, corporate performance and so on. For enterprises, the effectiveness and rationality of innovation policy cannot be separated from the scientific and effective enterprise innovation policy, and the implementation of scientific innovation mechanism depends on the rationality of equity structure. Therefore, this paper focuses on Chinese Shanghai and Shenzhen A-share listed companies in the manufacturing industry, takes corporate executives as the incentive object, and uses cross-sectional data between 2017-2021 to conduct an empirical study. Under the moderating perspective of ownership concentration, it explores how the equity incentive policy affects corporate innovation, with a view to improving the equity structure and accelerating corporate innovation efficiency.

The research in this paper contributes to the following two aspects. The first is the theoretical significance, most of the previous scholars focused on the relationship between equity incentives, ownership concentration and firm performance level of research, there are also many scholars on corporate profitability, asset structure and R&D situation on the impact of corporate innovation efficiency to discuss. Few studies directly focus on the impact of ownership concentration and executive equity incentives on corporate innovation efficiency, and this paper hopes to enrich the literature in this area. This paper combines the two perspectives of management and shareholders into one to further study the relationship between equity incentive effects, the size of shareholders' rights and corporate innovation efficiency, which can enrich the theoretical knowledge of equity incentives in manufacturing enterprises, improve the research framework of corporate innovation efficiency, provide references to optimize the corporate equity structure of the Chinese manufacturing industry in combination with its own characteristics, and provide theoretical basis for accelerating the reform of corporate innovation.

Second is the practical significance. Today's society has rapid economic development, the enterprise structure continues to innovate, fierce competition in all walks of life, the combination of enterprise technological innovation, equity incentives and equity structure is the inevitable trend of the development of the manufacturing industry. For the enterprise itself, this research can improve the efficiency of the implementation of equity incentive policy in manufacturing enterprises, optimize the allocation of enterprise resources, build their own advantages, and improve the corporate governance mechanism; for the country, it is conducive to promoting the further implementation of China's "innovation-driven development strategy", and accelerate the "supply-side reform" of manufacturing enterprises. For the state, it is conducive to promoting the further implementation of China's "innovation-driven development strategy" and accelerating the "supply-side reform" of

manufacturing enterprises, and it has certain practical significance for the Chinese government to improve the regulatory mechanism.

2. Literature References

2.1. Equity Incentives and Innovation Efficiency

In modern joint-stock enterprises, the separation of enterprise operation right and ownership right leads to the separation of enterprise innovation decision and innovation profit. When the benefits of innovation for the agent are not enough to compensate for the risks, corporate executives usually do not take the initiative to carry out innovation projects, resulting in a series of principal-agent problems. As a long-term incentive policy mechanism, equity incentive is a common way for modernized enterprises to strengthen corporate governance, through which the enterprise grants certain stocks, stock options, restricted shares, etc., to senior managers or important employees, and the incentivized party is substituted into the status of a shareholder and participates in the enterprise's decision-making, and the personal interests and the overall performance of the enterprise are integrated, and the executives share the profits of the company while operating the company and share some of the risks from shareholders, so as to achieve the goal of "sharing the risk". Bettis et al. [1] showed that the implementation of equity incentives for corporate executives can significantly promote corporate innovation, and Lin et al. [2] pointed out that when executive incentives are well implemented, the innovation efficiency of the enterprise is significantly improved based on the study of private enterprises. Cosh et al. [3] took British enterprises as a research sample and found that corporate innovation efficiency rises with the increase of CEO equity share. However, some scholars hold opposing views, Tien et al. [4] selected some listed companies in North America, and the study showed that no significant relationship was found between executive equity incentive policy and innovation investment, proposing that the attitude of executives towards corporate innovation depends only on personal preference. Equity incentives not only produce benefit convergence effect, but also some studies show that the trench effect is also inevitable. Panousi et al. [5] found that there is a turning point between executive incentives and corporate R&D, beyond which (e.g., granting too many stock options) may lead to executives' choice of short-term investment for the sake of risk avoidance, which will inhibit innovation efficiency. Xu et al. [6] explored the relationship between equity balance, executive shareholding and innovation efficiency in China's renewable energy industry, and the results show that equity balance is significantly positively correlated with innovation efficiency, and there is a nonlinear inverted U-shaped relationship between executive shareholding and innovation efficiency.

Domestic studies on the relationship between equity incentives and corporate innovation efficiency have reached mixed conclusions. Most scholars believe that equity incentives promote corporate innovation. Wang Cheng and Hao Haiyu [7] found that management equity incentives can significantly enhance innovation performance in line with the interest convergence hypothesis by conducting multiple regression analysis on panel data of Chinese private listed companies from 2004 to 2014. Mu Linjuan [8] for Chinese Shanghai and Shenzhen A-share listed companies in asset-light industries, found that the implementation of equity incentives for executives can positively promote R&D investment. Lu Guoqing [9] utilized the propensity score matching method and divided into experimental and control groups based on the implementation of equity incentives or not, and the results showed that the experimental group had a higher level of technological innovation. Wang Yan [10] and Zhou Simeng [11] argued that equity incentives are one of the most important ways to solve the agency problem, and the combination of personal interests with the overall interests of the enterprise can promote corporate innovation and improve corporate efficiency. Dong Ping and Zhou Xiaochun [12] suggested that employee equity incentives can also enhance long- and short-term corporate innovation performance. Chao Shenglin and Yin Zongcheng [13] found that equity incentives can negatively mitigate the inhibitory effect of management competence on corporate innovation. Deng Jiusheng and Luo Yiwen [14] constructed panel data based on GEM listed

companies and proposed that executive equity incentives are positively related to innovation efficiency and more significant in the case of higher government intervention. Consistent with foreign literature, domestic studies also suggest that equity incentives may inhibit corporate innovation. Yang Huihui et al. [15] used factor analysis and showed that executive equity incentives are significantly negatively related to corporate innovation when the ultimate controlling shareholders' two rights are separated. Huang Xinjian and You Shanshan [16] focused on Chinese A-share listed companies, explored whether and how equity incentive pacts affect corporate innovation through multiple models, and proposed that executive equity incentives reduce innovation inputs and innovation outputs. Ma Lili et al. [17] pointed out that the implementation of equity incentive policy for core employees can promote innovation efficiency, but for executives, incentives are not correlated with innovation. Some studies suggest that there may be a nonlinear relationship between equity incentives and firms' innovation efficiency. Zhu Desheng et al. [18] and Zhu Desheng et al. [19] find an inverted U-shaped relationship between executive shareholding and innovation efficiency. Cheng Cuifeng [20] and Wang Li [21] found that equity incentives drive R&D investment, while executive equity incentives have an inverted U-shaped relationship with innovation strategy. Shao Jianbing [22] conducted a study with a new perspective of dual innovation and showed that equity incentives are positively related to exploratory innovation and have an inverted U-shaped relationship with exploitative innovation in high-tech enterprises.

2.2. Ownership Concentration and Innovation Efficiency

Corporate governance structure influences the operation of corporate innovation activities in a subtle way. The relationship between ownership concentration and corporate innovation has been a hot topic in the field of corporate governance. Hosono [23] for the Japanese manufacturing industry, found that the proportion of majority shareholders' ownership is significantly positively correlated with R&D investment. Garcia et al. [24] suggested that the higher the degree of equity dispersion, the more dispersed the owner regulation is, and the less likely the self-interested behavior of management is to be detected thus leading to a decrease in innovation. Di Vito [25] showed that the innovation efficiency of firms decreases significantly when the equity is highly concentrated in the Canadian firms. Deng et al. [26] found that compared to the firms with many owners, the R&D-innovation conversion of the single-family SMEs tend to have higher R&D-to-innovation conversion ratios. Chen et al. [27], using panel data of 487 and 475 Chinese listed firms during the periods of 2004-2005 and 2005-2006, find that both diversity of equity types and ownership concentration improve innovation performance, but there is an upper limit to the latter's there is an upper limit to the enhancement effect. Minetti et al. [28] suggest that ownership concentration triggers conflict between majority and remaining minority shareholders, which inhibits firm innovation by reducing R&D efforts.

There exist three categories of mainstream conclusions about the relationship between ownership concentration and innovation in China: positive correlation, negative correlation and non-linear relationship. Based on the empirical evidence of Chinese private listed companies from 2004-2014, Wang Cheng and Hao Haiyu [7] showed that innovation performance is significantly positively correlated with ownership concentration, and that the relative ownership concentration is conducive to the owner's control of the overall direction of the enterprise, improves supervision, and reduces the risk of executives abandoning the overall interests of the company for the sake of their own self-interests. Jiang Weihua [29] found that when equity is highly concentrated, controlling shareholders are more inclined to the long-term interests of the company and pay more attention to corporate research and development. Yang Yahan [30] used ownership concentration as a control variable and whether the shareholding ratio of the top five shareholders exceeds 50% as the basis for distinguishing between tight and sparse enterprises, and proposed that equity-tight enterprises have a greater advantage in R&D investment. Zheng Yi [31] conducted a study on Chinese GEM enterprises and proposed that ownership concentration leads to the reduction of innovation investment. Zhang Yujuan et al. [32] found that ownership concentration inhibits firms' innovation efficiency to a certain extent,

while equity checks and balances can significantly promote firms to carry out more innovative activities. Similarly, Zhang Yujuan and Tang Xiangxi [33] based on the perspective of the nature of property rights showed that equity checks and balances promote innovation especially in state-owned enterprises, while ownership concentration inhibits innovation especially in private enterprises. Studies by Zhang Bo [34] and Yang Le [35] also found that ownership concentration inhibits corporate innovation. A few studies find that ownership concentration and corporate innovation are not purely linear, for example, Ning Qingqing [36] points out that there is an inverted U-shape between ownership concentration and innovation motivation and innovation output, and there is an upper limit to the incentive effect of ownership concentration, and excessive ownership concentration brings about an encroachment effect.

2.3. The Moderating Effect of Ownership Concentration

There is not much domestic and international literature that examines the relationship between incentive policies and firms' innovation efficiency under the moderating perspective of ownership concentration. Maury and Pajuste [37], using Finnish non-financial industry listed firms, find that the more balanced the equity structure of the largest shareholders, the better the innovation performance. Zulfiqar [38], centering on non-financial firms in China's Shanghai and Shenzhen A-shares that found that CEO compensation positively and significantly affects organizational innovation, and ownership concentration measured by the top five shareholders enhances this relationship. Cheng Cuifeng [20] based on Chinese manufacturing firms, found that ownership concentration is a negative moderating variable of executive equity incentives and innovation strategies. Guoyong [39] showed that equity incentive policies for management and core technical staff can subconsciously affect firms' innovation efficiency in a study of Chinese A-share listed manufacturing firms, and in addition the promotion effect of incentive policies on innovation efficiency is more significant in the group where ownership concentration is higher than the sample mean. On the contrary, Li Quan and Yang Kun [40] study on the data of listed financial institutions shows that the inhibitory effect of executive incentives on firms' innovative performance is more pronounced when equity is relatively concentrated.

In general, the conclusions of domestic and international studies on the relationship between equity incentives and innovation are not consistent, and even there are some widely differing views, the same way the conclusions of the research on the impact of ownership concentration on the innovation efficiency of enterprises are not the same. This may be due to the different research samples and research time period, in addition to the inconsistency of the scholars on the selection of proxy variables for innovation performance, innovation efficiency, can also explain the different conclusions. Current academic research generally focuses on how incentive policies and R&D investment, innovation performance, or factors such as equity structure and firm characteristics affect innovation efficiency. Few scholars have jointly studied ownership concentration, executive equity incentives and innovation efficiency. In this paper, we collect financial data and R&D input and output data from Chinese A-share manufacturing companies in Shanghai and Shenzhen during 2017-2021 to explore how equity incentive policies and corporate governance structure affect corporate innovation, and at the same time test the moderating effect of ownership concentration in groups.

3. Hypothesis Development

The separation of enterprise ownership and operation, the mismatch between the utility functions of shareholders' and managers' interests, the asymmetry of information between the two, and the lack of shareholders' supervision can lead to short-sighted behaviors of enterprise operators in decision-making. Innovation activity is a special kind of investment behavior, which has the characteristics of high risk, long cycle and uncertain return. The agent bears the risk of innovation, while the benefits of innovation are enjoyed by shareholders, and in case of failure, the agent's professional ability will be questioned. Therefore, when the benefits of innovation are not enough to make up for the risk,

based on the self-interested point of view of short-term interests and personal reputation, the management usually will not take the initiative to carry out innovative projects, or even give up the projects that can bring the long-term benefits to the enterprise. In addition, the lack of shareholder monitoring leads to the proliferation of management opportunism, blind spending, and self-interested behavior, all of which exacerbate principal-agent conflicts [41].

Based on Herzberg's two-factor incentive theory, equity incentive can be an effective long-term incentive mechanism. In addition, the "interest convergence hypothesis" shows that by granting certain shares, stock options, restricted shares, etc. to corporate executives, the incentives become shareholders, who will actively participate in the enterprise innovation decision-making, construct a community of interest, and better consider the long-term development of the enterprise [42]. Therefore, the enterprise can make the agent and the enterprise long-term profitability goals consistent by developing appropriate incentive policies [43], the close relationship between the agent's own interests and the overall interests of the enterprise, once the interests of the enterprise is damaged, the executives' own interests cannot be avoided. Ceccagnoli [44] found that, for every 1% increase in R&D expenditures, the Tobin's Q floats upward by 0.2%. Wang Cheng [7] and Lu Guoqing [9] showed that equity incentives can significantly improve the innovation efficiency and innovation performance of Chinese enterprises. Meanwhile, in recent years, China's equity incentive system has been gradually improved, and the shareholding ratio of executives in listed companies has been increasing year by year, and their innovation strength and competitiveness are also increasing. On account of above analysis, this paper puts forward hypothesis 1:

H1: Executive equity incentives are positively related to firms' innovation efficiency.

When the equity is more dispersed, the ownership and operation rights are completely separated, the individual shareholders have little influence on the enterprise's operation decision-making, the shareholders' supervision of the operator is not targeted, and the supervision is insufficient, which will easily lead to conflict of interest and increase the agency cost. The more dispersed the shareholding, the more small and medium-sized shareholders "free-rider" mentality, the relative weakening of the binding force of the shareholding, the management of the phenomenon of infringement of the interests of small and medium-sized shareholders is also more prevalent. Based on the assumption of economic man, professional managers choose projects based on the idea of "no merit but no fault", and tend to make risk-averse behaviors, which in the long run will lead to inefficient corporate innovation and make it difficult to meet the industry standard. According to the principal-agent theory, a reasonable equity structure can solve the agency problem and reduce the agency cost. Ownership concentration makes shareholders' control more centralized, reduces the degree of information asymmetry, converges the personal interests of large shareholders with the overall interests of the enterprise, increases the degree of concern for the long-term value of the enterprise, and improves the efficiency of shareholders' supervision and the efficiency of resource allocation. Relatively concentrated enterprise innovation decision-making is more decisive, the research and development investment in innovation projects tends to increase, the implementation of the project is more effective, while the concentration of control brought about by the concentration of shareholding can make the major shareholders to choose the outstanding agents more in line with the concept of enterprise innovation and development, and to promote the sustained and healthy development of the enterprise. On account of above analysis, this paper puts forward hypothesis 2:

H2: Ownership concentration is positively related to firms' innovation efficiency.

Corporate governance structure can indirectly affect innovation policy and innovation behavior through the intermediary of management [45]. Ownership concentration intuitively reflects the distribution of shareholdings in a joint-stock company, which can measure whether the corporate governance structure is stable and explain the operation of the enterprise and the level of corporate innovation, however, the degree of enthusiasm of major shareholders for investment in corporate innovation strategy cannot be directly refracted to the R&D inputs and outputs, but rather in the indirect moderating effect of executive equity incentives on the play of corporate innovation strategy and innovation efficiency. As the actual controller of the enterprise, the proportion of shares held by

the major shareholders determines the quality of the enterprise's supervisory mechanism to play a role, which will inevitably affect the incentive effect of executives [46]. When the ownership concentration is low, the majority shareholder's supervision of the agent is not targeted, and the supervision cost is high; small and medium-sized shareholders are not willing to supervise, the supervision effect is not strong, and the equity constraints become weaker. In this case, the implementation of the equity incentive policy does not maximize the utility, and may even increase the cost of the enterprise. When ownership concentration is high, the majority shareholder holds most of the shares of the enterprise, in order to protect their own interests, will increase the supervision of the management, have the willingness and ability to participate in business decision-making, to curb the phenomenon of executive opportunism. At this time, the implementation of equity incentives for management is bound to stimulate their work enthusiasm, make them pay more attention to the enterprise's overall R&D decision-making and long-term business performance, reduce R&D risks, improve the profit conversion rate of innovative projects, and enhance innovation vitality and core competitiveness. On account of above analysis, this paper puts forward hypothesis 3:

H3: Ownership concentration positively moderates the promotional effect of executive equity incentives on innovation efficiency.

4. Research Design

4.1. Sample Selection and Data Sources

The overall number of manufacturing enterprises accounts for a large proportion of the whole industry, the financial data is rich and real and credible; innovation activities and manufacturing enterprises are inseparable, new products and new technologies can often bring far-reaching benefits to manufacturing enterprises; in addition, the manufacturing industry centrally reflects the core competitiveness of a country, which is fundamental to the smooth and healthy development of China's economy and society. Based on this the empirical part of this paper selects Chinese Shanghai and Shenzhen listed companies in the manufacturing industry that have implemented equity incentive policies in 2017-2021.

Innovation inputs, innovation outputs and related financial data are obtained from CSMAR database, and some missing values are supplemented by Juchao database and annual reports of enterprises. Preliminary data processing was conducted in Excel in advance to exclude ST class samples, missing data samples, and samples that did not implement equity incentive policies ($MSR=0$), and variables were subjected to upper and lower 1% shrinkage to weaken the effect of extreme values, and finally 4,744 sample observations were selected. The empirical analysis is conducted entirely through Stata16 software.

4.2. Variable Definition

Dependent Variable: Innovation Efficiency (IE), usually defined as the ratio of innovation output to innovation input. The innovation output of an enterprise generally consists of the sales revenue of new products, new processes, the number of patents, etc. The sales revenue of new products is more intuitive and can be directly measured in monetary terms, however, it is not easy to measure the value of new processes and new technologies. For an enterprise's new technology, the enterprise through the application of this new technology can achieve improved production efficiency or product quality to reduce the enterprise's production costs or increase the effect of business income, so ultimately to the implementation of the enterprise's profit index. Net profit is the net income received by shareholders from capital investment, EBIT is the sum of net profit, interest expense and income tax expense. Based on this, this paper argues that EBIT can reflect the full economic benefits brought by the enterprise's R&D investment, and the change value derived from the enterprise's EBIT in year t minus EBIT in year $t-1$ is used to measure the enterprise's innovation output [18]. In addition, because the transformation of inputs and outputs of innovative resources requires a certain amount of time, there is a certain lag, and the transformation cycle is generally 1-3 years [47], so this paper uses the

R&D inputs in year t-2 to measure the innovation inputs of enterprises. The formula for innovation efficiency is shown below:

$$IE_t = (EBIT_t - EBIT_{t-1}) / R\&D_{t-2}. \quad (1)$$

Independent Variable: Executive equity incentives (MSR) is measured using the ratio of the number of shares held by executives at the end of the accounting period to the total number of shares in the company; and ownership concentration (CRI) is measured using the percentage of shares held by the largest shareholder. The formulas are shown below:

$$MSR = \text{Number of shares held by executives} / \text{Total number of shares}. \quad (2)$$

$$CRI = \text{Number of shares held by the largest shareholder} / \text{Total number of shares}. \quad (3)$$

Control Variable: Return on assets (ROA) reflects the profitability and asset utilization efficiency of the enterprise. Asset liability ratio (LEV) is an important indicator of the long-term solvency and financial status of the enterprise. In addition, this paper also selects company size (Size), net profit growth rate (Growth), cash flow (CASH), board size (Board), independent director size (Indep), separation of powers (Sep) and year virtual variables (Year).

4.3. Model Building

For hypothesis 1, we establish model (3) to test the relationship between executive equity incentives and innovation efficiency; for hypothesis 2, we establish model (4) to test the effect of ownership concentration on innovation efficiency. For hypothesis 3, also using model (3), the sample is divided into two groups according to the criterion that ownership concentration is higher (or lower) than the average, and regressed separately to analyze its moderating effect.

$$IE_{i,t} = \beta_0 + \beta_1 MSR_i + \beta_2 ROA_i + \beta_3 LEV_i + \beta_4 Size_i + \beta_5 Rrow_i + \beta_6 Cash_i + \beta_7 Board_i + \beta_8 Indep_i + \beta_9 SEP_i + \beta_{10} Year_i + \varepsilon_i \quad (3)$$

$$IE_{i,t} = \beta_0 + \beta_1 CRI_i + \beta_2 ROA_i + \beta_3 LEV_i + \beta_4 Size_i + \beta_5 Rrow_i + \beta_6 Cash_i + \beta_7 Board_i + \beta_8 Indep_i + \beta_9 SEP_i + \beta_{10} Year_i + \varepsilon_i \quad (4)$$

5. Empirical Results and Analysis

5.1. Descriptive Statistical Analysis

Table 1 shows the results of descriptive statistical analysis of IE, MSR, CRI and each control variable. In 4744 samples, the average value of IE is 7.468, the maximum value is 198.2, and the minimum value is -18.48, which shows that the innovation efficiency presents a large difference among listed companies in China's manufacturing industry, and the overall view of the manufacturing industry is that each unit of innovation input is converted into an average of 7.468 times of innovation output, and the innovation efficiency is generally low, and the enterprises should optimize the use of resources to improve the R&D and innovation success rate, improve innovation output and innovation performance. In addition, this paper takes into account that equity incentive policy is an indispensable part for enterprises, and the degree of its implementation reflects the soundness or otherwise of the enterprise's incentive system, so this paper excludes sample enterprises that do not implement equity incentive policy (MSR=0) in the previous data processing. According to Table 1, it can be found that the mean value of MSR is only 12.60%, indicating that the strength of equity incentives in China's manufacturing industry is generally not high; the maximum and minimum values are 77.90% and 0.0050%, respectively, which indicates that the implementation of equity incentives in China's listed companies in the manufacturing industry, implementation of the strength of the policy varies widely, there are large differences. the mean value of CRI is 32.40%, the minimum and maximum values are 4.146% and 80.99%, indicating that the ownership concentration in China's manufacturing industry is generally high, but there are large differences in ownership concentration among enterprises, which is not unrelated to the number of shareholders, the nature of property rights, and the stage of enterprise development.

Table 1. Descriptive Statistics of Variables

Variable	Observations	Mean	Median	Min	Max
IE	4,744	7.468	16.89	-18.48	198.2
MSR	4,744	0.126	0.162	5.00e-05	0.779
CRI	4,744	32.40	13.10	4.146	80.99
ROA	4,744	0.0552	0.0551	-0.297	0.466
LEV	4,744	0.355	0.171	0.00906	0.916
Size	4,744	16.73	1.033	14.34	21.37
Grow	4,744	-0.0860	11.02	-680.2	131.3
Cash	4,744	0.0505	0.0631	-0.317	0.488
Board	4,744	8.335	1.544	4	18
Indep	4,744	0.377	0.0550	0.333	0.800
Sep	4,744	4.094	7.120	-0.0116	49.40

5.2. Correlation Analysis

In order to preliminarily test the relationship between corporate innovation efficiency and executive equity incentives as well as ownership concentration, this paper conducts a correlation coefficient test. According to the correlation analysis in Table 2, it can be seen that the coefficients of IE and MSR are positive but not significant, considering that the correlation analysis is to measure the relationship between the two variables, while the regression analysis is to synthesize the effects of all the variables in the model on the dependent variable, so the difference in regression coefficients between the ordinary correlation analysis and the regression analysis is understandable, and the relationship between the two should be based on the regression analysis. The coefficients of IE and CRI are significantly positive at the 1% level. IE and CRI are significantly positive at 1% level, which preliminarily verifies hypothesis 2. Except for Indep, there is a significant relationship between innovation efficiency and each control variable, which indicates that the control variables are appropriately selected

Table 2. Descriptive Statistics of Variables

Variable	IE	MSR	CRI	ROA	LEV	Size	Grow	CASH	Board	Indep	Sep
IE	1										
MSR	0.0150	1									
CRI	0.099***	0.120***	1								
ROA	0.291***	0.132***	0.186***	1							
LEV	0.059***	-0.165***	-0.052***	-0.299***	1						
Size	0.209***	-0.280***	0.00200	0.00200	0.520***	1					
Grow	0.087***	0.0190	0.029**	0.204***	-0.0230	0.0240	1				
Cash	0.167***	0	0.120***	0.474***	-0.156***	0.056***	0.042***	1			
Board	0.081***	-0.154***	-0.089***	0.0230	0.101***	0.256***	-0.0110	0.051***	1		
Indep	-0.00200	0.123***	0.095***	-0.0150	-0.0100	-0.068***	-0.00400	-0.0130	-0.573***	1	
Sep	0.038***	-0.272***	0.183***	0.061***	0.089***	0.165***	0.00100	0.102***	0.068***	-0.062***	1

*** p<0.01, ** p<0.05, * p<0.1

5.3. Regression Analysis

5.3.1 Multivariate Regression

Table 3 column (1) shows the regression analysis of executive equity incentives and innovation efficiency. From the regression results, it can be seen that model (1) is significant at the 1% level, and model (1) is valid. The regression coefficient of MSR is significantly positive at the 5% level, which indicates that granting a certain amount of shares to corporate executives can have a positive impact on the innovation efficiency of enterprises, and hypothesis 1 is valid. While the proportion of executive shareholding increases, the personal interests are linked to the overall interests of the company and the relationship is getting closer, the short-sighted behavior of the management is curbed, and it pays more attention to the long-term performance of the enterprise, and it is more inclined to realize the growth of the enterprise's operating performance by increasing innovation investment and improving innovation efficiency. Therefore, executive equity incentives will have a positive impact on corporate innovation efficiency, supporting H1. Among the control variables selected in this paper, the coefficients of return on assets, gearing ratio, company size, net profit

growth rate, cash flow, board of directors' size and independent directors' size are all significantly positive, and the control variables are properly selected; only the coefficient of Sep is negative and does not pass the test of significance, which indicates that the correlation between the difference between the control right of the actual controller of the enterprise and the ownership right and the innovation efficiency in the model (1) is relatively weak, and that the difference in the degree of the two rights does not make the innovation efficiency of the enterprise. The difference in the degree of separation of the two powers will not make a significant difference in the innovation efficiency of enterprises.

Table 3 column (2) shows the regression analysis of ownership concentration and innovation efficiency. From the regression results, it can be seen that model (2) is significant at the 1% level, and model (2) is valid. The regression coefficient of CRI is significantly positive at the 1% level, which indicates that ownership concentration can further enhance the R&D investment and innovation ability of enterprises, supporting H2. The increase of the proportion of shares held by the first largest shareholder strengthens the binding force of shareholders on corporate executives, the degree of information asymmetry is reduced, the efficiency of shareholder supervision is improved, the innovation decision-making is more decisive, the innovation investment tends to increase, and the level of corporate innovation is improved. The coefficients of the selected control variables, such as return on assets, gearing ratio, company size, net profit growth rate, cash flow, board of directors' size, independent directors' size, and indicators, are all significantly positive; the coefficients of Sep in model (2) are significantly negative at the 10% level, indicating that the separation of controlling shareholders' two powers encroach upon the innovation efficiency of the enterprise and inhibit the innovation ability of the enterprise, which further verifies that the concentration of shareholding has a positive impact on innovation.

Table 3. Multivariate Regression Results

Variable	(1) IE	(2) IE
MSR	3.962** (2.56)	
CRI		0.066*** (3.65)
ROA	87.392*** (17.07)	86.849*** (17.02)
LEV	6.152*** (3.65)	6.300*** (3.75)
Size	2.874*** (10.18)	2.726*** (9.87)
Grow	0.035* (1.67)	0.035* (1.67)
Cash	7.915* (1.90)	7.168* (1.72)
Board	0.547*** (2.91)	0.567*** (3.02)
Indep	11.883** (2.32)	11.602** (2.27)
Sep	-0.018 (-0.54)	-0.061* (-1.84)
Constant	-57.145*** (-11.58)	-56.271*** (-11.63)
Year	control	control
N	4,744	4,744
F	57.09	57.70
AdjR2	0.1333	0.1345

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.3.2 Grouped Regression

Based on the above regression results, this paper is divided into two corresponding groups according to the criterion that ownership concentration is higher (or lower) than the sample mean: the relatively dispersed equity group (2605 samples) and the relatively concentrated equity group (2139 samples), which are controlled and regressed individually, and the results are presented in columns (2) and (3) of Table 4. For executive equity incentives, in the relatively decentralized equity group, the MSR and IE regression coefficient is 0.707 and insignificant. In the relatively concentrated group, MSR and IE are significantly and positively correlated at the 1% level, while their regression coefficients increase compared to the total sample, indicating that ownership concentration positively moderates the promotional effect of executive equity incentives on innovation efficiency, i.e., the promotional effect of equity incentives becomes more pronounced when equity is relatively concentrated. This is because, when equity is relatively concentrated, large shareholders hold most of the shares of the enterprise, have the willingness and ability to participate in the enterprise's business decision-making, and can quickly reflect to the enterprise's overall R&D and innovation activities and long-term business performance after capturing the favorable market signals; executive equity incentives are not only a long-term incentive, but also a recognition and praise of the management's work, which can stimulate their work motivation and the team's sense of responsibility, and Further accelerate the R&D results and improve the core competitiveness of the enterprise, supporting H3.

Table 4. Grouped Regression Results

Variable	(1) IE	(2) IE	(3) IE
MSR	3.962** (2.56)	0.707 (0.31)	8.520*** (4.00)
ROA	87.392*** (17.07)	74.367*** (14.22)	91.897*** (9.22)
LEV	6.152*** (3.65)	4.763*** (2.77)	7.840** (2.51)
Size	2.874*** (10.18)	2.107*** (7.01)	3.559*** (7.07)
Grow	0.035* (1.67)	0.026 (1.51)	0.328*** (2.92)
Cash	7.915* (1.90)	-1.056 (-0.25)	13.192* (1.70)
Board	0.547*** (2.91)	0.182 (0.98)	1.467*** (3.98)
Indep	11.883** (2.32)	6.215 (1.16)	21.851** (2.37)
Sep	-0.018 (-0.54)	0.044 (1.05)	-0.118** (-2.23)
Constant	-57.145*** (-11.58)	-39.063*** (-7.37)	-79.384*** (-9.15)
Year	control	control	control
N	4,744	2,605	2,139
F	57.09***	31.06***	28.28***
AdjR2	0.1333	0.1305	0.1423

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

5.4. Robust Test

The robustness test is conducted by replacing the explanatory variables. Drawing on the practice of existing scholars, to ensure the reliability of the research findings, ownership concentration replaces CRI (the proportion of shares held by the largest shareholder) with CRI2 (proportion of shares held by the first three shareholders), and other control variables remain unchanged, and the regression results are shown in Table 5. According to columns (1) and (2), MSR remains significantly positively correlated with IE and CRI2 with IE. According to column (3), in the relatively dispersed equity group, the regression coefficient of MSR with IE is 1.213 and insignificant. According to column (4), in the relatively concentrated equity group, the regression coefficient of MSR with IE is 9.961 and significantly positive at the 1% level. The results are generally consistent with the above regression findings and confirm the previous hypotheses.

Table 5. Robust Test Results

Variable	(1) IE	(2) IE	(3) IE	(4) IE
MSR	3.962** (2.56)		1.213 (0.60)	9.961*** (3.50)
CRI2		0.064*** (3.72)		
ROA	87.392*** (17.07)	86.747*** (17.00)	80.650*** (12.52)	86.172*** (10.09)
LEV	6.152*** (3.65)	6.425*** (3.82)	5.566*** (2.64)	7.520*** (2.85)
Size	2.874*** (10.18)	2.768*** (10.01)	2.278*** (6.14)	3.344*** (7.87)
Grow	0.035* (1.67)	0.035* (1.65)	0.034* (1.77)	0.264* (1.81)
Cash	7.915* (1.90)	7.051* (1.69)	1.623 (0.31)	13.334** (2.01)
Board	0.547*** (2.91)	0.561*** (2.99)	0.262 (1.19)	1.174*** (3.68)
Indep	11.883** (2.32)	11.415** (2.23)	5.178 (0.80)	21.130*** (2.64)
Sep	-0.018 (-0.54)	-0.055* (-1.66)	0.014 (0.29)	-0.070 (-1.46)
Constant	-57.145*** (-11.58)	-57.745*** (-11.79)	-43.046*** (-6.67)	-72.767*** (-9.72)
Year	control	control	control	control
N	4,744	4,744	2,379	2,365
F	57.09***	57.74***	26.40***	31.45***
AdjR2	0.1333	0.1346	0.1267	0.1434

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6. Summary

At present, executive equity incentives have been widely noticed and generally implemented, becoming an important system of incentives for listed companies. For enterprises, in addition to equity incentives, the effectiveness and rationality of innovation policies depend on the scientific and effective enterprise innovation system, and the implementation of scientific innovation mechanism depends on the rationality of the equity structure, and the ownership concentration has far-reaching

impacts on the improvement of the corporate governance mechanism and company performance. This paper focuses on China's manufacturing industry, takes listed companies that have implemented equity incentive policy in 2017-2021 as the research object, introduces the moderating variable of ownership concentration, and conducts a systematic research on executive equity incentives and innovation efficiency under the brand-new perspective of equity optimization. The conclusions are as follows: (1) The strength of executive equity incentives in Chinese manufacturing listed companies is generally low, and the incentive intensity is significantly positively correlated with the innovation efficiency, i.e., a certain amount of shares or stock options can be granted to corporate executives to realize the convergence of interests, so as to achieve the goal of bringing into play the management's motivation to innovate and enhancing the overall level of innovation and competition in the enterprise. (2) Ownership concentration is significantly positively related to innovation efficiency, and the concentration of control brought by ownership concentration can reduce the level of information asymmetry, improve the efficiency of shareholders' supervision and the efficiency of resource allocation, and further enhance the R&D and innovation ability of enterprises. (3) Ownership concentration has a positive moderating effect, the more obvious the promotion effect of executive equity incentives on innovation efficiency when equity is relatively concentrated.

Based on the research conclusions, this paper puts forward the following suggestions: (1) From the perspective of enterprise strategy, enterprises should optimize the use of resources and rapidly realize resource conversion. The management should also improve their professional skills, strengthen personnel training and the introduction of professional skills, improve the success rate of R&D and innovation, and accelerate the enterprise to enter a new innovation cycle. (2) From the perspective of corporate policy, enterprises should establish a sound incentive mechanism for executives, continuously promote equity incentive policy, promote the convergence of interests between executives and shareholders, and reduce the short-sighted behavior of management, so as to optimize the allocation of corporate resources. (3) From the perspective of corporate governance, enterprises should further improve the shareholding structure to avoid excessive dispersion of shareholdings and reduce the opportunistic behavior of management. (4) From the perspective of social supervision, government departments should further establish sound innovation policies. Executive benefits (on-the-job consumption, equity changes, non-monetary incentives, etc.) cannot be accurately obtained, and untimely and inaccurate corporate disclosure can jeopardize the legitimate rights and interests of corporate investors. Regulators should improve the disclosure mechanism, as well as lead the innovation strategy of enterprises and adjust the innovation policy according to regional characteristics in a timely manner.

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