

The Impact of Board Characteristics on R&D Intensity: The Case of Chinese Machinery Industry

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Abstract: With the acceleration of technology development, enterprises must increase R&D investment to obtain competitive advantage. Well-designed corporate governance structure can reduce the agency cost, and may solve the problem of insufficient R&D investment. Taking 182 A-share listed companies in Chinese machinery industry as sample, this paper investigates the impact of board characteristics on firms' R&D intensity. The results show that the CEO and board chair duality, the size of the board of directors, and the number of board meetings have no significant impacts on R&D intensity, while the proportion of independent directors and the shareholding proportion of the board of directors have significant positive impacts on R&D intensity.

Keywords: R&D intensity; board characteristics; corporate governance structure;

I. Introduction

With the acceleration of technology development, firms must increase R&D investment to obtain competitive advantage. Although China's total R&D intensity has increased significantly in the last two decades, there is still a big gap compared with their counterparts. It is of great significance to investigate the factors affecting firms R&D intensity from theoretical perspective. This paper mainly studies the impact of board characteristics on R&D investment. Well-designed corporate governance structure can reduce the agency cost, and may solve the problem of insufficient R&D investment. The corporate governance system mainly includes the general meeting of shareholders, the board of directors, the board of supervisors and the management. Among them, the board of directors not only implements the decisions made by the general meeting of shareholders, but also supervises the behavior of managers, which plays a connecting role in the internal governance system. Therefore, the board characteristics will also affect the R&D intensity.

II. Theoretical background and research hypotheses

The board of directors is an organization established in accordance with Corporate Laws. The members of the board of directors are elected by the shareholders of the company. They act on behalf of the rights and interests of shareholders. Board of directors is mainly responsible for managing all business activities of the company and reporting their activities during this period at the general meeting of shareholders. In short, the responsibilities of board of directors are aiming to solve the agency problem caused by the separation of management right and ownership of listed companies, promote the consistency of employees' personal goals with that of the company, and greatly increase shareholders' rights and interests. The board members should include independent directors, directors and the chairman

of the board. China's Corporate Laws also have strict provisions on independent directors. The 2003 guidance pointed out that the number of independent directors should account for at least one third of the total number of boardmembers. In addition, the board of directors should hold at least two meetings every year to summarize the company's operating activities, and put forward effective solutions to improve the company's governance structure. It is also needed to improve the work enthusiasm of the directors by allowing them to hold a certain proportion of the company's shares, and make them pay more attention to the long-term development of the enterprise. Therefore, this paper will consider the board characteristics from the following four aspects: structural characteristics, behavioral characteristics, incentive characteristics, and control characteristics.

2.1 Structural characteristics of the board of directors and R&D intensity

The structural characteristics of the board of directors can be reflected by the size of the board of directors, and the proportion of different categories of directors.

Klein (1998)[1] found that the size of the board of directors plays a very important role in the supervision and control of the management. Scholars have two different views on the size of the board of directors and R&D intensity. Jensen(1993) [2] claimed that there is a negative correlation between the size of the board of directors and the supervision of directors and the implementation of long-term strategy, that is, there is a negative correlation with R&D intensity. He argued that the larger the size of the board of directors, the more difficult it is to coordinate and reach an agreement, therefore, it is impossible to make decisions efficiently. However, Adams and Mehran (2002)[3] found that the size of the board of directors increases, the effectiveness of monitoring also increases, which is conducive to give full play to the professional skills of directors, collect expert opinions from different perspectives in the process of innovation decision-making, make correct decisions and reduce enterprise risks .

In addition, independent directors play an important role in the board structure. Independent directors refer to unrelated external directors who only hold the position of independent director in the company and do not hold other positions. Independent director has no relationship with the company and its main shareholders and managers, which may hinder his independent and objective judgment. Independent directors have two characteristics: independence and professionalism, that is, independent directors are not affected by shareholders and managers in the board of directors, and have certain professional knowledge to a certain extent. Nowadays, more and more scholars realize that independent directors can provide knowledge to the board of directors and help the board of directors make objective and fair decisions with their professional knowledge and experience, which plays a balanced role in the board of directors to some extent, and is related to higher corporate value. It can be seen that independent directors should have some impact on R&D intensity. There are also two different views on the relationship between the proportion of independent directors and the company's R&D intensity. Some believe that, compared with internal directors, the proportion of external independent directors is positively related to the R&D intensity. The increase of the proportion of external independent directors in directors will reduce the agency cost, so there will be more funds for R&D. It is proposed that this is because the external independent directors do not participate in the company's operation activities, can more objectively and independently judge various major decisions made by the company, therefore more effectively supervise and control the managers to avoid managers' short-sighted behavior. Some scholars argued that internal directors have more detailed information about product innovation, which can more accurately predict and evaluate the economic benefits brought by R&D investment, so they can more actively promote the company's technological innovation activities. Due to the restriction of information disclosure, external directors are unable to fully understand

the company's economic situation and business activities, and can not be informed of the necessity of technological innovation. Therefore, we hypothesize that:

H1. The size of the board of directors has a positive impact on R&D intensity

H2. The proportion of independent directors has a positive impact on R&D intensity

2.2 Behavioral characteristics of board of directors and R & D intensity

The behavioral characteristics of the board of directors are mainly reflected in the number of board meetings. Board meetings are composed of regular meetings, interim meetings, ordinary meetings, and special meetings. According to the Corporate Law, the board of directors of a limited company should hold meetings at least twice a year, while the number of meetings of the board of directors of a limited liability company is determined by the articles of association without specific provisions. For listed companies, the board of directors shall hold regular meetings at least twice a year. There is no unified conclusion on the relationship between the number of board meetings and R&D intensity. In the previous literature, there are different views on the impact of the number of meetings on the efficiency of corporate governance. Nikos (1999)[4] found that there was a negative correlation between the number of board meetings and corporate governance efficiency. He believed that board meetings generally occurred after the decline of the company's stock price, and the company's operating performance was improved after the abnormal increase of the number of meetings. Some scholars believe that the increase in the number of meetings will enable the directors to express their opinions. Meanwhile, the directors have more time to communicate, can learn more about the company's business status and performance from the management, pay more attention to the company's long-term development and R&D investment. Therefore, we hypothesize that:

H3. The frequency of board meetings has a positive impact on R&D intensity.

2.3 Incentive characteristics of the board of directors and R&D intensity

The shareholding of board members is a main form of incentive to board members, which makes the interests of the company closely connected with personal interests. Therefore, it is generally believed that the higher the shareholding proportion of board members, the better the operation efficiency of the company. Murphy (1985) [5] found that when the directors hold more shares, the agency cost between shareholders and managers will be reduced, and directors or management authorities will more actively improve the company's operating efficiency, which can effectively reduce the moral risk of management. Therefore, the shareholding of board members will make them pay more attention to the operation activities of the company, actively put forward investment decisions conducive to the long-term development of the company, and reduce the possibility of earnings manipulation. Therefore, we hypothesize that:

H4. The shareholding ratio of the board of directors has a positive impact on R&D intensity

2.4 Control characteristics of the board of directors and R&D intensity

The control rights of the board of directors are mainly reflected by the concurrent appointment of senior management, that is, whether the chairman and the general manager are separated or integrated. Scholars have two different views. Francis and Smith (1995)[6] advocated that "separation of two positions" is conducive to corporate governance and development. Because the agency theory puts forward that people are naturally lazy and

opportunistic. In order to prevent "moral risk" and "adverse selection", the company needs to establish an effective supervision mechanism. The separation of two positions enhances the supervision of the management and helps to reduce the possibility of earnings manipulation by the general manager. The opposite view is to advocate the "integration of two positions". Scholars who support this view believe that the integration of two positions can reduce the transaction cost between listed companies and controlling shareholders to a certain extent, improve the supervision effect of the board of directors on the management. It can help directors more comprehensively grasp the operation status of the company, improve the efficiency of information communication and corporate governance, and thus help to improve the operation efficiency of enterprises performance. This paper holds that the integration of two positions strengthens the relationship between the board of directors and enables the company to obtain an optimal allocation of resources. In a highly uncertain environment, the integration of two positions enables managers to have more autonomy in innovation activities, make more efficient decisions to face the risks of market changes, and is conducive to the enterprise's technological innovation and R&D investment. Therefore, we hypothesize that:

H5. The integration of two positions has a positive impact on R & D intensity

III. Research methodology

3.1 Variable measurements

(1) Dependent variable

R&D intensity: R&D intensity is an important indicator used to measure an enterprise's R&D investment. There are three methods to measure R&D intensity: (1) the ratio of R&D investment to total assets, (2) the ratio of R&D investment to operating income, and (3) the ratio of R&D investment to firm's market value. This study uses the second measurement. The data of R&D investment can be obtained in the item "other cash paid related to operating activities" in the cash flow statement, and the data of operating income can be obtained in the income statement.

(2) Independent variable

This paper takes the size of the board of directors, the proportion of independent directors, the number of board meetings, the shareholding proportion of board members and the setting of two positions as independent variables.

The size of the board of directors: the size of the board of directors refers to the total number of the board of directors of a company in a certain year, reflecting the characteristics of the company's organizational structure.

The proportion of independent directors: the proportion of independent directors, measured by the ratio of the number of independent directors to the total number of directors, which reflects the characteristics of personnel structure.

The number of board meetings: the number of meetings of the board of directors is expressed by the total number of annual meetings of the board of directors.

The shareholding proportion of board members: the shareholding ratio of board members is expressed by the proportion of shares held by board members in the total shares of the company.

The CEO and board chair duality: if the chairman and the general manager are in one, The CEO and board chair duality is set to equal to 1, otherwise 0.

(3) Control variables.

Capital structure: measured by the company's asset liability ratio.

Asset: the company's asset size is measured by the natural logarithm of the total assets of the current year.

3.2 Samples

The data of this paper mainly comes from Guotai'an database, and a small part comes from Sina Finance.

SPSS16 is used for data processing. This paper selects the data of 192 listed companies in Chinese machinery manufacturing industry in 2019 as samples. The reason for choosing the machinery industry as the research context is that it can be regarded as one of the engines for China's economic development. At the same time, the manufacturing products of the machinery industry rely on high and new technology. Compared with other industries, the R&D intensity in machinery industry will be relatively high and representative. When selecting samples, there are the following selection principles:

- (1) the listed companies with incomplete data is excluded
- (2) ST company is eliminated
- (3) only select the listed companies that issued A-shares

According to the above screening data, we choose 182 listed companies as our samples.

IV. Empirical analysis

4.1 Descriptive statistics

The descriptive statistics of all variables are shown in Table 1.

Table 1 Descriptive statistics.

Variable	Min	Max	Mean	Standard deviation
R&D intensity	0.027	0.464	0.086	0.046
SZ(The size of the board of directors)	3	10	7.365	1.423
IN(The proportion of independent directors)	0.247	0.460	0.287	0.045
MT(The number of board meetings)	2	10	7.472	1.563
DU(The CEO and board chair duality)	0	1	0.324	0.398
SH(The shareholding proportion of board members)	0	0.784	0.257	0.216
AS(Asset)	14.347	22.146	16.390	2.112
LV(Capital structure)	0.031	1.212	0.278	0.129

4.2 Regression analysis

In order to test the above hypotheses, this paper constructs the following model:

$$R\&D\ intensity = \alpha_0 + \alpha_1 SZ + \alpha_2 IN + \alpha_3 MT + \alpha_4 SH + \alpha_5 DU + \alpha_6 AS + \alpha_7 LV$$

It can be seen from Table 2 that the proportion of independent directors (IN) and the shareholding ratio of directors (SH) have a positive impact on R&D intensity at the significant level of 0.05. However, the duality of chairman and general manager (DU), the number of meetings of the board of directors (MT) and the size of directors (SZ) have no significant impacts on R&D intensity.

Table 2 Regression analysis results

	Standardize Coefficients		
	α	t	P
Constant		2.345	0.001
DU	-0.056	-0.980	0.248
MT	0.122	1.624	0.217
IN	0.165	3.127	0.021
SH	0.346	3.126	0.005
SZ	0.214	1.239	0.218
AS	-0.249	-3.158	0.191
LV	0.036	0.864	0.248

V. Conclusion

We empirically investigate and analyze the data of 182 listed companies from China's machinery industry, and the main findings are as follows:

For the machinery manufacturing industry, the size of the board of directors, the number of meetings and the duality of chairman and general manager do not significantly impact the R&D intensity. The proportion of independent directors has a significant positive impact on the R & D intensity, which confirmed hypothesis 2. The shareholding proportion of the board of directors also has a positive impact on the R&D intensity. Hypothesis 4 is verified.

The size of the board of directors, the number of meetings and the duality of chairman and general manager have no significant impact on R&D intensity. The reason why the number of board meetings has no significant impact on R&D intensity may be that most meetings in China only pay attention to form rather than content. The large number of meetings does not mean that directors can effectively solve the problems of corporate governance. In addition, the duality of chairman and general manager may not be effective, mainly because the phenomenon of insider control has been formed within the company, and this phenomenon exists for a long time, which makes the board of directors lack sufficient and effective supervision mechanism for the management, so that the governance structure of the board of directors cannot play a critical role.

The proportion of independent directors has a significant positive impact on R&D investments because the increase of independent directors enhances the professionalism and independence of the board of directors, which is conducive to maintaining the objectivity and fairness of the board of directors, which plays a more positive role in the supervision mechanism of the board of directors and R&D investment. Therefore, the company should better supervise the management by increasing the proportion of independent directors. At the same time, it should also hire external directors to enable more people with professional experience to join the board of directors, put forward suggestions on the strategic decision-making of directors, and enhance the efficiency of the board of directors.

The shareholding ratio of board members has a positive impact on R&D intensity. Directors should pay more attention to major decisions affecting the future development of the company, and provide greater support to R&D investment and innovation. Therefore, the company should increase the shareholding ratio of board members.

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