Board Governance, Financing Constraints and Technological Innovation: Empirical Evidence from Parent Companies of Enterprise Groups

Jun Zhou, Jinxiao Yang*

School of Economics, Wuhan University of Technology, Wuhan, China
Email: *y25687777@163.com

Abstract

Based on the sample of A-share group listed companies and their parent companies from 2015 to 2019, this paper empirically analyzes the relationship among board governance, financing constraints and technological innovation using the intermediary effect model. The results show that improving the board governance level of the parent company can significantly improve the innovation capability of enterprise groups. The financing constraint plays a partial intermediary role in the relationship between the board governance of the parent company and technological innovation, that is to say, the improvement of the board governance of the parent company can effectively alleviate the financing constraint problem faced by enterprise groups to a certain extent, and then enhance the group's technological innovation ability. Therefore, in order to improve the technological innovation ability of enterprise groups, enterprise groups should further optimize the governance level of the board of directors of the parent company, reduce operating costs, and relieve the financing pressure faced by enterprise groups in the process of innovation.

1. Introduction

At present, China has entered a new stage of economic development. Implementing the innovation-driven strategy is an inherent requirement and urgent task of economic development.

Compared with individual corporate enterprises, enterprise groups have advantages in scale and scope, and are an important carrier of China's independent innovation strategy, and shoulder an important mission in leading technological innovation. In recent years, Chinese enterprise groups have made many achievements and breakthroughs in technological innovation, but at the same time, there are also problems such as lack of positive innovation strategy, low innovation power, insufficient R&D investment, and inefficient R&D management (Li et al., 2012). In the operation and management activities of an enterprise group, the parent company (also known as the group company and the group headquarters) plays a core position, plays the role of wisdom and decision maker for the subordinate enterprises, controls the whole group (Xie, 2014). As the leader and supervisor of a group, the board of directors of the parent company not only decides the major issues of the group headquarters, but also has an important influence on the operation and management activities of the subordinate companies by participating in decision-making, investment budget, performance evaluation, personnel evaluation and coordination services (Qiao, 2012). Then, what is the relationship between the board governance of the parent company of an enterprise group and the technological innovation of the whole group? This is a question to be explored in this paper.

In recent years, domestic and foreign researches on this aspect generally start from the following three aspects: First, in terms of the impact of group governance on technological innovation, scholars generally believe that group governance has an important impact on technological innovation activities. Liu et al. (2010) studied the relationship among member units within enterprise groups from the perspective of game theory and found that the establishment of cooperative innovation organizations within enterprise groups can better integrate the advantages of various enterprises and promote the technological innovation of enterprise groups. Zhang et al. (2015) analyzed the relationship between corporate governance and technological innovation from the three aspects of shareholders, board of directors and management, and found that increasing ownership concentration, board size, proportion of independent directors and proportion of senior executives' shareholding can significantly promote enterprise R&D and innovation. Lou et al. (2019) found that appropriate concentration of equity of the parent company, improvement of independence of the board of directors and increase of management ownership can reduce the adverse impact of low efficiency of cash allocation on technological innovation. Secondly, in terms of the impact of group governance on financing constraints, most studies believe that improving the level of enterprise group governance can help ease the pressure of enterprise financing. Buchuk et al. (2014) through model analysis, believed that group operation reduced the efficiency of capital allocation and effectively alleviated the problem of insufficient R&D investment of enterprises. Belenzon and Berkovitz (2010) pointed out that the innovation degree of enterprise groups in western European developed economies was significantly higher than that of independent enterprises. Further investigation found that enterprise groups could

use internal capital market to replace external capital market to reduce financing costs and promote technological innovation. Finally, the research on the relationship between group governance, financing constraints and technological innovation has become a hot topic. By analyzing the data of Chinese industrial enterprises, found that the group could use the internal capital market to ease the financing constraints of its member enterprises, increase R&D investment and improve the technological innovation level (Huang & Chen, 2011). Cai et al. (2019) investigated the impact of enterprise groups on innovation output based on the data of Chinese listed manufacturing companies from 2003 to 2015, and pointed out that enterprise groups can alleviate the problem of "financing constraints" of innovation through internal capital market and improve innovation output.

According to the above research, the academic circle has done some research on corporate governance, financing constraints and technological innovation. However, the existing literature does not give a detailed explanation of the logical relationship among the three, and whether the impact of corporate governance level and financing constraints on technological innovation is in the same position. Therefore, this paper discusses the factors affecting the group's technological innovation from the perspective of corporate board governance and financing constraints.

Compared with the existing literature, this paper has the following obvious characteristics: First, based on the sample of Chinese A-share listed companies, empirical analysis was conducted to explore the impact of the parent company's board governance on technological innovation, which enriched the related research on board governance and technological innovation; Second, from the perspective of financing constraints, this paper tentatively studies the specific role of parent company's board governance on enterprise group innovation, which the research on the transmission mechanism of parent company's board governance on technological innovation, and provides ideas and directions for future research. Thirdly, the solution of this problem can help the enterprise group to increase the investment in research and development, and provide beneficial help for the group's scientific and technological innovation and bigger and stronger.

Based on this, this paper sorts out the existing research on the governance of parent company's board of directors, financing constraints and technological innovation, and elaborates in four parts: First, explore the interpretation path and limitations of relevant theories on the relationship among the three; secondly, it discusses how the board of directors of parent company influences technological innovation by influencing financing constraints, and on this basis, it refines the overall theoretical hypothesis; thirdly, select sample data and build empirical model; fourthly, the relationship among board governance, financing constraints and technological innovation of parent company is analyzed by empirical results. The last part is the conclusion, enlightenment and significance of this paper.

2. Theoretical Analysis and Hypothesis

2.1. The Governance Level and Technological Innovation of the Board of Directors of the Parent Company

Innovation is the soul of an enterprise's survival and development and plays an important supporting role in economic strategy. The board of directors of the parent company, as the highest authority of the enterprise group, is responsible for making major development plans and making major decisions, and plays a decisive role in the operation and management of the whole group. Wang and Chen (2018) research found that the larger the board size, the higher the proportion of independent directors, the fewer concurrent executives, and the stronger the technological innovation capability of the enterprise. Based on the existing research, this paper measures the board governance from the three indicators of board size, proportion of independent directors and the concurrent position of senior executives. The relationship between board governance and technological innovation is explored separately.

1) The size of the board of directors and technological innovation of the parent company

The scale of the board of directors refers to the number of directors in the board of directors. For ordinary or small and medium-sized listed companies, such companies often do not have the ability to invest in several R&D projects at the same time, and the risks of technological innovation are not too great, so the requirements for the size of the board of directors are not high. In this respect, the situation is different among the boards of the parent companies of conglomerates. Compared with individual legal entity companies, technological innovation in enterprise groups is characterized by hierarchies, networking, coordination, independence of members and complexity of relations among members (Li et al., 2012). The improvement of innovation ability in the group largely depends on the integration of innovation resources inside and outside the group, and the board of directors of parent company plays a core role in the establishment of innovation system and integration of innovation resources. With the increasing scale of the board of directors, there will be more directors with different educational and professional backgrounds. The directors can better realize resource sharing, knowledge complementation and experience transfer, which will help alleviate the problem of information asymmetry, promote the board of directors to improve the quality of decision-making and reduce the risk of technological innovation to a certain extent. Promote the implementation of enterprise R&D strategy and technological innovation activities (Liu & Jiang, 2012).

2) Proportion of independent directors and technological innovation of parent company

As for the problem of board member structure and enterprise technological innovation, the agency theory holds that under the condition of the separation of ownership and management. It is easy to cause the major shareholders and managers of enterprises to manipulate technological innovation activities for their

own interests, thus affecting the efficiency of technological innovation. The increase of independent directors can effectively avoid this problem, and there is a significant positive relationship between the proportion of independent directors and the investment in technological innovation of enterprises (Zhao & Wen, 2011). However, the resource theory emphasizes the resource dependence characteristics of independent directors, and believes that under the condition of a fixed board size, increasing the proportion of independent directors can enrich the board's knowledge system and management experience, and can improve the quality of R&D decisions made by the company's board of directors (Zhou, 2018).

3) The chairman of the parent company is also a senior executive of the subsidiary company and a technical innovator

Large enterprise group is a system integrating particularity and complexity. The parent company has different control over its subsidiaries. Although the parent company of the group can help subsidiaries reduce resource constraints and expand business activities, subsidiaries still have problems of risk aversion and lack of innovation and entrepreneurship motivation. Therefore, there is still some debate about whether the chairman of the parent company who is also a subsidiary executive can promote innovation. Chen and Zheng (2016) based on the Shanghai and Shenzhen two city data of a-share listed companies from 2012 to 2015, the longitudinal analysis found that the group parent company personnel of subsidiaries executives help group supervision which innovation process, and this kind of behavior magnifies the trust relationship between parent-subsidiary, guarantee the subsidiary of innovation (Huang et al., 2017). However, other scholars believe that large enterprise groups have a huge organizational system, diversified business scope, and there may be more members of the board of directors of the parent company. Multiple control of the decision-making behavior of the board of directors of the subsidiary is not conducive to the board of directors of the subsidiary to supervise the innovative decision-making of the managers (Zhang & Guo, 2014).

Through the above analysis, it is found that for the parent company of the group, the expansion of the size of the board of directors, the proportion of independent directors and the gradual improvement of the diversification level of directors are conducive to absorbing different opinions from all parties and reducing operational risks, which will have a significant promoting effect on technological innovation. While the chairman of the parent company is also a senior executive of the subsidiary, the direction of the impact on technological innovation is unknown, which has yet to be tested.

Based on this, hypotheses are proposed:

H1a: The larger the board of directors of the parent company is, the stronger the technological innovation capability of the enterprise group is.

H1b: The higher the proportion of independent directors in the parent company, the stronger the technological innovation capability of the enterprise group.

H1c: The influence direction of the chairman of the parent company who is also a senior executive of the subsidiary company on the technological innova-

tion of enterprise groups is unknown.

2.2. Corporate Governance and Financing Constraints of the Parent Company's Board of Directors

The level of corporate governance means the size of its business risks, and the level of governance of the board of directors of the parent company directly affects the willingness of banks and other financial institutions to lend to enterprise groups. From the perspective of financing, the expansion of the board of directors can reduce principal-agent problems and financing costs. The increase in the proportion of independent directors provides enterprises with cross-industry and cross-regional resources and meets the needs of enterprises for heterogeneous resources. The chairman of the parent company participates in the strategic decision-making of the subsidiary by concurrently serving as a senior executive of the subsidiary, which may lead to the "overhead" of the management of the subsidiary, which is not conducive to the daily operation of the enterprise (Zona et al., 2013).

1) The size of the parent company's board of directors and financing constraints

As the decision-making center of an enterprise, the size of the board of directors is related to its information processing ability and then affects the allocation of resources. Expanding the scale of the board of directors can help to avoid risks, increase the controllability of technological innovation, and have a positive impact on enterprises' technological innovation activities. In addition, the size of the board of directors is an important feature reflecting the governance ability of the board of directors. On the one hand, the expansion of the size of the board of directors is conducive to strengthening the supervision of the management, effectively solving the agency problem and alleviating financing constraints (She, 2015). On the other hand, it can provide diversified expertise for innovation decisions and provide various core R&D resources (including capital and talent). It is beneficial to realize the complementary advantages of resources within the board of directors, reduce the deviation degree of corporate cash holding and the risk of innovation investment, and improve the R&D investment ability.

2) The proportion of independent directors and financing constraints of the parent company

From the perspective of social network, independent directors have a richer external relationship network than internal directors, which can help enterprises to obtain information to a large extent, enhance their ability to cope with external uncertainties, and improve their long-term development ability (Lu & Dang, 2014). Moreover, in technological innovation decision-making, independent directors have independence and balance, which can provide professional consultation for investment and avoid capital waste. For example, independent directors from investment banks, commercial banks and insurance companies can use various social capital in the financial sector to provide financial services for

enterprises, which is conducive to improving the utilization efficiency of R&D funds (Liu & Zhang, 2010). In addition, by introducing independent directors closely connected with the external environment, enterprises can create and maintain a good relationship between stakeholders, reduce transaction costs and improve the efficiency of resource allocation.

3) The chairman of the parent company concurrently serves as a subsidiary executive and financing constraints

Enterprise group set up perfect internal capital markets, group parent company as a subsidiary of the holding shareholders, can with the direct control of the board of directors of the subsidiary company, subsidiary company management to indirect control, the rational allocation of internal resources, constraints, a subsidiary of self-interest behavior, its slow excessive investment behavior, reduce the cost of financial contracts and external financing costs, Alleviating the problem of financing constraints of enterprises (Demer et al., 2012). On the other hand, due to the self-interest motive of part-time executives and the possibility of excessive intervention in subsidiaries, part-time executives may also aggravate the shortage of funds in subsidiaries. For the sake of their own career development, part-time executives tend to avoid all kinds of potential risks and excessively intervene in the operation of subsidiaries. Through to the group's major shareholders to send group for executives of listed companies executives case study found that due to the big shareholder control and ownership separation, big shareholders emptied the motives of listed companies will greatly improve, executives. Who are more likely as a main way to encourage empty large shareholders of listed companies, hinder the normal flow of funds, curbing innovation activities of listed companies (Yan et al., 2019).

To sum up, for the parent company of the group, the expansion of the size of the board of directors, the proportion of independent directors and the gradual improvement of the level of diversification of directors are conducive to the absorption of capital and the reduction of financing risks. However, the chairman of the parent company is also a senior executive of the subsidiary, which has an unknown influence on financing constraints and has yet to be tested.

Based on this, hypotheses are proposed:

H2a: The larger the size of the parent company's board of directors, the less pressure of financing constraints.

H2b: The higher the proportion of independent directors in the parent company, the lower the pressure of financing constraint.

H2c: The influence direction of the chairman of the parent company holding the position of a senior executive of a subsidiary company on financing constraints is unknown.

2.3. The Governance Level of the Parent Company's Board of Directors, Financing Constraints and Technological Innovation

Through the above research and analysis, it is found that there is a close rela-

tionship between the governance level of the board of directors of the parent company, financing constraints and technological innovation. The governance level of the board of directors of the parent company not only affects the financing constraints, but also acts on technological innovation together, showing a significant correlation with technological innovation. This paper argues that it is precisely because the governance level of the board of directors of the parent company has different impact on technological innovation, which leads to different R&D investment and ultimately forms differentiated innovation levels.

1) Board size, financing constraints and technological innovation of parent company

According to the resource theory, a small board of directors cannot provide comprehensive decision-making consultation from multiple perspectives, and it is difficult to help the company obtain necessary resources. A large-scale board of directors can not only gather directors with professional knowledge in different fields, but also be effective in performing functions such as board supervision. Moreover, the board of directors with a wide range of skills, knowledge, experience and educational background can help enterprises to obtain the necessary resources for production and operation, and the cash holding level of enterprises tends to be reasonable. Gao and Fang (2014) from the board of directors of actual operation Angle study found that with the expansion of the board of directors, independent directors will increase, which can effectively restrain enterprise agency cost, ease the pressure of financing constraints, and the board of directors of capital (human capital, social capital) is a kind of important resources, Financing constraints can be alleviated to reduce insufficient resource accumulation caused by fierce competition and ensure R&D investment.

2) Proportion of independent directors, financing constraints and technological innovation of parent company

R&D investment is the key factor of enterprise technological innovation. To satisfy the continuous technological innovation investment, sufficient internal and external capital support is indispensable. However, the cost of external financing is often high and there are many obstacles to external financing. So we have to rely on a sound corporate governance structure to ease the financing pressure of enterprises. The independent director system helps to improve the corporate governance structure, improve the company's operating performance and revenue, and alleviate the problem of insufficient funds. In addition, enterprises with a high proportion of independent directors have more social relations resources and more diversified financing channels when investing in R&D and innovation (Qu et al., 2014). In addition, increasing the proportion of independent directors to reduce external financing costs and thus increase the intensity of R&D investment has become an important way to solve financing problems (Li & Yang, 2020).

3) The chairman of the parent company concurrently serves as a subsidiary executive, financing constraints and technological innovation

The special background of the rise of enterprise group system in China leads to the establishment of most parent companies later than the listed companies. The purpose is to create closer connections among member enterprises through the holding of senior executives, expand the channels for enterprises to obtain specific production information and resource supply of other enterprises, and thus influence enterprise innovation (Gu & Zhai, 2012). Taking a-share group listed companies and their subsidiaries from 2005 to 2016 as samples, Hu et al. (2020) studied the influence of holding concurrent positions of senior executives of parent and subsidiary companies within listed companies on enterprise R&D innovation. The research finds that there are also costs for the group. For example, part-time executives will excessively favor part-time subsidiaries and allocate more resources to part-time subsidiaries, which damages the interests of the parent company and non-part-time subsidiaries and negatively affects the overall innovation level of the group.

Based on the above research, it is assumed that H1a, H1b, H1c and H1a, H2a, H2b, the improvement of the governance level of the parent company's board of directors can effectively alleviate financing constraints, and the reduction of financing constraints risk is also conducive to the improvement of the group's technological innovation. Based on the above analysis, hypotheses are proposed in this study:

H3a: The board of directors of the parent company alleviates financing constraints and promotes technological innovation of the enterprise group by expanding its scale.

H3b: The parent company reduces the risk of financing constraint by increasing the proportion of independent directors and promotes the technological innovation of enterprise groups.

H3c: The chairman of the parent company who is also a senior executive of the subsidiary company may inhibit the technological innovation of enterprise groups by acting on financing constraints.

The data on the size of the parent company's board of directors, the proportion of independent directors of the parent company, the chairman of the parent company concurrently serving as a subsidiary executive, financing constraints and technological innovation of the enterprise group were collected, and the panel fixed effect analysis method was used. First, verify hypothesis 1: empirically analyze the influence of the size of the parent company's board of directors, the proportion of independent directors of the parent company, and the chairman of the parent company concurrently as a subsidiary executive on the technological innovation of enterprise groups. Second, test hypothesis 2: test the relationship between the size of the board of directors of the parent company, the proportion of independent directors of the parent company, the chairman of the parent company concurrently serving as a subsidiary executive and financing constraints. Finally, verify hypothesis 3: bring the data of the parent company's board of directors, the proportion of independent directors of the parent company, the chairman of the parent company as a subsidiary executive, financing

constraints and technological innovation of the enterprise group into the model, confirming that financing constraints are in the size of the parent company's board of directors. The proportion of independent directors of the parent company, the chairman of the parent company concurrently serving as a subsidiary executive and the role played by the technological innovation of the enterprise group.

3. Sample Selection, Variable Definition and Descriptive Statistics

3.1. Sample Selection

The initial sample of cost papers is constructed based on the data of all listed companies on the A-share main boards of Shanghai and Shenzhen stock Exchanges from 2015 to 2019. In order to avoid the adverse impact of abnormal data and enhance the comparability between samples, this paper screened the initial samples as follows: 1) due to the particularity of financial companies in terms of financial statements and capital structure, listed companies in the financial industry were excluded; 2) Excluding companies listed for less than five years; 3) Remove ST and PT company samples; 4) Some company samples with missing and distorted data were removed. 5) As the research object of this paper is a parent-subsidiary group company, the traceability method is adopted by referring to Cai et al. (2019) to eliminate the samples of non-group listed companies within the scope of merger and determine the parent company of the group. The main data comes from Wind database and CSMAR database, and is obtained after manual sorting and proofreading with annual reports issued by listed companies. In order to avoid the influence of extreme values, the bilateral extreme values of all continuous variables were tail-tailed according to 1% and 99% quantile respectively, and the data of 1094 enterprises and 5470 observed values were finally obtained.

3.2. Definition of Variables

As can be seen from Table 1, the variables in this paper are set as two categories: master variables and time variables, in which the master variables are divided into Innovation indicators, Explanatory variables, Intermediary variables, and the time variables are Control variables.

3.2.1. Master Variable

1) **Innovation indicators.** The degree of technological innovation of enterprises can be expressed as the number of patents applied and the increase of revenue brought by updating technology. However, because of the contingency, unpredictability and uncontrollability of technological innovation, the input of innovation resources may not be proportional to the output. Therefore, based on the comprehensive consideration of Ma et al. (2014), the research and sales ratio of an enterprise, that is, the ratio of R&D investment to operating revenue (RDSpend), is selected to measure the technological innovation of an enterprise.

Table 1. Master variable and time variable.

Types of variables	Variable name	Variable symbol	Variable definition
Master variable	Research and development strength	RDSpend	Research input/operating receipt
	Research input	R&D	Research input/total asset
	Board size of parent company	Size	Number of board members of parent company
	Proportion of independent directors on the board of the parent company	Indep	Number of independent directors of the parent company/total numbers of directors of the parent company
	The chairman of the parent company is also a subsidiary executive	Common	Dummy variable, if there is a concurrent phenomenon, it is marked as 1, otherwise 0
	Financing restriction	SA	Calculate the SA exponent
	Corporate liquidity ratio	Liquidity	Current assets/current liabilities
Time variable	scale	Asset	Ln(total asset)
	Return on total assets	Roa	Retained profits/total asset
	Enterprise growth capacity	Growth	Year-on-year growth rate of operating revenue
	Corporate leverage ratio	Lev	Total asset at end/gross liability
	Enterprise age	Age	Business life

2) Explanatory variables. The number of directors is used to measure the size of the board of directors, and the proportion of independent directors of the parent company is calculated by dividing the number of independent directors by the total number of directors. For senior executives, this paper defines them as all directors except independent directors disclosed in the annual report, including the chairman of the board, general manager, deputy general manager, director and chief financial officer of listed companies (Chen et al., 2006). The adjunct variable of the executive is a dummy variable. If the adjunct variable exists, it is 1; otherwise, it is 0.

3) Intermediary variables. According to existing studies, the relatively mature methods for quantitative measurement of financing constraints mainly include KZ index, WW index and SA index. Among them, KZ index and WW index involve cash flow, capital leverage and other factors, and the interaction between these factors and financing constraints is easy to produce endogenous problems. In order to solve such problems, Hadlock and Pierce (2010) refer to KZ method and use two variables with strong externality, namely, enterprise Size and enterprise Age, to construct SA index: $-0.737 \times \text{Size} + 0.043 \times \text{size2} - 0.04 \times \text{Age}$. The empirical research results of Zhang et al. (2019) show that SA index is relatively robust and does not contain endogenous variables, which can effectively represent the degree of financing constraints faced by enterprises. Therefore, SA index is selected in this paper to represent the degree of financing constraints faced by enterprises. The calculation results of SA index are all negative, and the greater the absolute value of SA index, the more serious the degree of financing constraints faced by enterprises.

3.2.2. Time Variable

1) Control variables. Based on past studies, it can be seen that the main factors affecting the technological innovation ability of enterprises are enterprise size (Asset), net return on total assets (ROA), enterprise Growth, company leverage ratio (Lev) and company Age. Therefore, these variables are set as control variables, and enterprise size is measured by the natural logarithm of total assets. The ratio of net profit to total assets is adopted. The growth capacity of the enterprise is measured by the year-on-year growth rate of operating revenue; the leverage ratio of the company is measured by the asset-liability ratio, that is, the total assets divided by the total liabilities at the end of the period. The company's age is measured by the number of years the company has been in operation (Sun & Yin, 2020).

Table 2 is the descriptive statistics of the main variables. Among them, the minimum value of enterprise R&D investment intensity (RDSpend) is 0.69, indicating that some enterprises do not pay enough attention to technological innovation, and the maximum value is 7.82, indicating that some enterprises are keen on technological innovation, and there are obvious differences in technological innovation behavior among different enterprises. Based on the SA model, the minimum and maximum value of the financing constraint coefficient (SA) are estimated to be −2.69 and −0.66, respectively, and the standard deviation is 0.28, indicating that the financing constraints faced by Chinese enterprise groups are quite different. The minimum value and maximum value of the parent company board size variable (Size) are 5 and 15 respectively, and the standard deviation is 1.91, indicating that there are relatively large differences in the size of the board of directors of different companies. The average is 8.69, meaning that parent company boards have an average of 8.69 board members. The minimum and maximum values of the proportion of independent directors

Table 2. Descriptive statistics of variables.

Variable	Sample size	The mean	The standard deviation	The minimum value	The maximum
RDSpend	5470	5.28	1.52	0.69	7.82
R&D	5470	1.58	0.45	1.09	2.25
Size	5470	8.69	1.91	5	15
Indep	5470	0.62	0.14	0.41	0.86
Common	5470	0.85	0.35	0	1
SA	5470	−1.79	0.28	−2.69	−0.66
Liquidity	5470	0.52	0.10	3.11	1.75
Asset	5470	22.65	1.41	18.37	28.64
Roa	5470	0.15	0.32	19.14	7.45
Growth	5470	0.35	4.19	0.95	21.21
Lev	5470	10.11	60.69	0.04	22.71
Age	5470	19.92	5.36	6	53

on the board of directors of the parent company (Indep) are 0.41 and 0.86, respectively, with a standard deviation of 0.14, indicating that the proportion of independent directors on the board of directors is relatively stable, with an average of 0.62, which means that the parent company's board of directors has an average of 62% independent directors. The average value of the variable (Common) of executives concurrently is 0.85, which means that nearly 85% of the subsidiaries have concurrent executives of the parent company. Other control variables such as enterprise size (Asset) mean 22.65, return on total assets (Roa) mean 0.15, enterprise growth capability (Growth) mean 0.35, enterprise leverage ratio (Lev) mean 10.11, enterprise age (Age) mean is 19.92. It shows that in the company sample used in this article, the average value of total assets is 138.42 million yuan, the average value of net profit in total assets is 15.48%, the average year-on-year growth rate of operating income is 34.54%, the corporate leverage ratio is 1011.33%, and the company's registered age is 1011.33%. The mean is 19.92 years.

4. Empirical Results

4.1. Model Construction

In order to test the relationship between board governance, financing constraints and technological innovation, the following model is constructed with reference to Zhang et al. (2020) to test relevant assumptions.

1) Hypothesis 1 model setting:

$$RDSpend_{i,t} = \beta_0 + \beta_1 Size_{i,t} + \eta \sum Control_{i,t} + \varepsilon_{i,t} \tag{1}$$

$$RDSpend_{i,t} = \beta_2 + \beta_3 Indep_{i,t} + \eta \sum Control_{i,t} + \varepsilon_{i,t} \tag{2}$$

$$RDSpend_{i,t} = \beta_4 + \beta_5 Common_{i,t} + \eta \sum Control_{i,t} + \varepsilon_{i,t} \tag{3}$$

For the parent company's board governance and the relationship of technology innovation, this article constructs three models, $RDSpend_{i,t}$ is the Intensity of R&D investment for company i in year t, $Size_{i,t}$ is the size of the board of directors of the parent company in the t year of company i, $Indep_{i,t}$ is the proportion of independent directors on the board of directors of the parent company in the t year of company i, $Common_{i,t}$ is the situation of being the chairman of the parent company in the t year of company i and concurrently serving as a subsidiary executive $Control_{i,t}$ including virtual variables, as well as the control variables, $\varepsilon_{i,t}$ represents the random error term.

2) Hypothesis 2 model setting:

$$SA_{i,t} = \delta_0 + \delta_1 Size_{i,t} + \lambda \sum Control_{i,t} + \varepsilon_{i,t} \tag{4}$$

$$SA_{i,t} = \delta_2 + \delta_3 Indep_{i,t} + \lambda \sum Control_{i,t} + \varepsilon_{i,t} \tag{5}$$

$$SA_{i,t} = \delta_4 + \delta_5 Common_{i,t} + \lambda \sum Control_{i,t} + \varepsilon_{i,t} \tag{6}$$

In order to study the relationship between the governance of the parent company's board of directors and financing constraints, this paper constructs three

models, namely, the degree of financing constraints faced by company i in the year t, and other variables are the same as the above. $SA_{i,t}$

3) Hypothesis 3 model setting:

$$RDSpend_{i,t} = \alpha_0 + \alpha_1 Size_{i,t} + \alpha_2 SA_{i,t} + \gamma \sum Control_{i,t} + \varepsilon_{i,t} \qquad (7)$$

$$RDSpend_{i,t} = \alpha_3 + \alpha_4 Indep_{i,t} + \alpha_5 SA_{i,t} + \gamma \sum Control_{i,t} + \varepsilon_{i,t} \qquad (8)$$

$$RDSpend_{i,t} = \alpha_6 + \alpha_7 Common_{i,t} + \alpha_8 SA_{i,t} + \gamma \sum Control_{i,t} + \varepsilon_{i,t} \qquad (9)$$

In order to study the relationship between parent company board governance, financing constraints, and technological innovation. This paper established a mediation effect test model by referring to Wen and Ye (2014). All variables are the same as those mentioned above.

To test the mediating effect model, the regression coefficient β between the board of directors of the parent company and the intensity of R&D was tested by regression of the three models in hypothesis 1. If the coefficient β_1, β_3, β_5 is significant, it means that the improvement of the governance of the board of directors of the parent company will significantly affect the technological innovation of the enterprise, then proceed to the next step; if not, the test will be stopped; Second, regression is performed on the three models in hypothesis 2 to test whether the governance level of the board of directors of the parent company and the financing constraints of the intermediary variable are significant, if the coefficient δ_1, δ_3, δ_5 is significantly negative, indicating that with the improvement of the governance level of the parent company's board of directors, the financing constraint problem can be effectively alleviated. Finally, regression is performed on the three models of hypothesis 3. If α_1, α_4 significantly positive and α_7 Significantly negative and coefficient β_1, β_3, β_5 compare with α_1, α_4, α_7 decreased. The decrease of the coefficient indicates the existence of a partial mediation effect. If the parent board governance level and R&D intensity of regression coefficient β_1, β_3, β_5 not significant, but the regression coefficient α of financing constraints α_2, α_5, α_8 significant, indicating that financing constraints play a complete intermediary role.

4.2. Preliminary Regression Results

Referring to the practice of Li et al. (2020) and tested by Hausman, this paper adopts panel fixed effect estimation method (without special explanation, this paper adopts panel fixed effect estimation method for simple regression with R&D intensity as explained variable) to conduct regression analysis on models (1)-(6). The empirical results are shown in Table 2 and Table 3.

Table 3 shows that the size of the board of directors of the parent company and the proportion of independent directors of the parent company have a positive effect on the enterprise technological innovation. The chairman of the parent company who is also a subsidiary executive has a negative effect on the enterprise group technological innovation. Scale of the board of directors of the parent company, the parent company of the independent director of executive

Table 3. Regression results of board governance level of parent company on technological innovation.

The dependent variable	RDspend (Model 1)	RDSpend (Model 2)	RDSpend (Model 3)
Size	0.585***		
	(33.36)		
Indep		1.403***	
		(33.36)	
Common			0.444***
			(3.70)
Asset	0.023***	0.023***	0.023***
	(3.95)	(3.95)	(3.93)
Roa	0.038***	0.038***	0.038***
	(6.3)	(6.3)	(6.22)
Growth	0.002	0.002	0.002
	(1.36)	(1.36)	(1.36)
Lev	0.004	0.004	0.004
	(1.12)	(1.12)	(1.13)
Age	0.036***	0.036***	0.036***
	(3.28)	(3.28)	(3.3)
_cons	12.441***	10.640***	5.460***
	(38)	(17.88)	(27.28)
N	5470	5470	5470

Note: The values in brackets are T values. ***, ** and * represent significance levels of 1%, 5% and 10% respectively.

and chairman of the board of directors of parent company, subsidiary of enterprise group under the influence of technological innovation at the 1% level significantly, the elasticity coefficient of differences, however, the board of directors of the parent company size is 0.585, the parent company of the independent director proportion is 1.403, the parent company chairman concurrently the elasticity coefficient of subsidiary company executives as a minimum. It is about −0.444, which verifies the rationality of hypothesis 1. The expansion of the size of the board of directors and the increase in the proportion of independent directors will lead to the participation of directors with different educational backgrounds and professional backgrounds, which can significantly improve the accuracy of corporate technological innovation decisions. The group parent company personnel longitudinal part-time subsidiary company executives will affect the stability of a subsidiary of innovation, not conducive to the board of directors of the subsidiary, supervise managers' innovation decision-making. From the perspective of other control variables affecting enterprise group technological innovation, enterprise size is significant at the level of 1%, indicating that large-scale enterprises are more inclined to technological innovation; The re-

gression coefficient of return on total assets is significantly positive at the level of 1%, that is, return on total assets is positively correlated with technological innovation ability. The age of an enterprise is significantly positive at the level of 1%, indicating that the earlier an enterprise is established, the more inclined it is to technological innovation. It may be because the earlier the establishment year, the richer the resources and experience the enterprise has, the stronger the technological innovation ability; the influence of enterprise growth ability and enterprise leverage ratio on technological innovation is not significant. This paper argues that the improvement of the governance level of the board of directors of parent companies can help managers increase R&D investment and implement technological innovation.

The empirical results in Table 4 show that the size of the board of directors of the parent company and the proportion of independent directors in the board of directors of the parent company have a significantly negative impact on financing constraints at the level of 1%, while the chairman of the parent company who is also a senior executive of the subsidiary has a significantly positive impact

Table 4. Regression results of parent company board governance level on financing constraints.

The dependent variable	SA (model 4)	SA (model 5)	SA (6) model
Size	0.317***		
	(56.22)		
Indep		0.759***	
		(56.21)	
Common			0.0269***
			(5.15)
Asset	0.194***	0.194***	0.194***
	(81.18)	(81.16)	(81.18)
Roa	0.101 *	0.101 *	0.101 *
	(1.65)	(1.65)	(1.65)
Growth	0.016	0.016	0.016
	(1.32)	(1.32)	(1.32)
Lev	0.008***	0.008***	0.008***
	(19.94)	(19.94)	(20.02)
Age	0.007***	0.007***	0.007***
	(21.92)	(21.92)	(21.92)
_cons	2.7222***	2.651***	2.725***
	(325.75)	(174.53)	(27.28)
N	5470	5470	5470

Note: The values in brackets are T values. ***, ** and * represent significance levels of 1%, 5% and 10% respectively.

on financing constraints at the level of 1%, which verifies the rationality of hypothesis 2. The results show that the size of the board of directors of the parent company and the proportion of independent directors in the board of directors of the parent company restrain the financing constraint problem. However, if the chairman of the parent company concurrently serves as a senior executive of the subsidiary, there will be hollowing out, which has no obvious effect on the rational allocation of resources and the coordinated development among enterprises. From the perspective of control variables, enterprise size and leverage ratio significantly alleviate the financing constraint problem. The coefficient of firm's growth capacity is positive, but not significant, indicating that firm's growth capacity does not significantly promote financing constraints. However, the return on total assets coefficient is significantly positive at the level of 10%, and the age of enterprises is significantly positive at the level of 1%, indicating that compared with newly established enterprises, enterprises established earlier face more prominent financial problems.

3) The impact of financing constraints on the smoothing effect of board governance

Through the above empirical test, it is found that board governance does have a significant impact on technological innovation. Then, what is the internal mechanism of board governance acting on technological innovation? To reveal the relationship "black box", Using the financing constraints as the mediating variable, use the mediation effect test procedure (Huang et al., 2020), combined with hypothesis 1 and hypothesis 2. Examining the mediating role of financing constraints between board governance and technological innovation .The empirical test results (see Table 5).

Among them, the coefficient of the Size of the parent company's board of directors (Size) is significantly positive at the 1% level, and the coefficient after the addition of the intermediary variable—financing constraint (SA) is also significantly positive at the 1% level, and the coefficient increases from 0.585 to 0.729. It can be concluded that the mediating effect of financing constraint on the relationship between board size and technological innovation of parent company is very significant. At the same time, the coefficient of the ratio of independent directors on the board of the parent company (Indep) is significantly positive at the 1% level regardless of whether the mediating variable—financing constraint is added, and the coefficient increases from 1.403 to 1.749, indicating that the mediating variable financing constraint plays a significant role in the ratio of independent directors on the board of the parent company and the innovation performance of enterprise groups. In addition, after the addition of the mediating variable, the coefficient of Common between the chairman of the parent company and the executive of the subsidiary company decreases from −0.444 to −0.432, which shows that the mediating effect is part of the mediating effect, and financing constraint is only one of the transmission variables that the chairman of the parent company and the executive of the subsidiary company influence the technological innovation of the enterprise group. Prove that hypothesis 3 is reasonable.

Table 5. Regression results of board governance, financing constraints and technological innovation of parent company.

The dependent variable	RDSpend (Model 7)	RDSpend (Model 8)	RDSpend (Model 9)
Size	0.729***		
	(12.38)		
Indep		1.749***	
		(12.39)	
Common			0.432***
			(3.59)
SA	0.455***	0.455***	0.452***
	(3.24)	(3.24)	(3.25)
Asset	0.111***	0.111***	0.111***
	(3.87)	(3.87)	(3.88)
Roa	0.385***	0.385***	0.387***
	(5.99)	(5.99)	(5.93)
Growth	0.002	0.002	0.002
	(1.35)	(1.35)	(1.35)
Lev	0.001	0.001	0.001
	(0.31)	(0.31)	(0.32)
Age	0.033***	0.033***	0.033***
	(2.87)	(2.87)	(2.89)
_cons	9.770***	8.150***	6.692***
	(6.67)	(5.34)	(12.01)
N	5470	5470	5470

Note: The values in brackets are T values. ***, ** and * represent significance levels of 1%, 5% and 10% respectively.

4) Robustness test

a) Substitution variable: Refer to Xiao (2016) and replace the explained variable with "R&D expenditure/total assets". Second reference Zhou and Zhang (2017), from the perspective of endogenous financing ability indicators Liquidity ratios (average) measure of enterprise financing constraints of a company's Liquidity ratio in enterprise liquid assets in the proportion of current liabilities, said the value is, the greater the proof enterprise Liquidity conditions, the better, the smaller the financing constraints of pressure.

According to Table 6 and Table 7, an empirical analysis of the two test results compared with before no substantive changes, and the paper main body part are almost consistent conclusion, namely: the improvement of the board of directors of the parent company governance of enterprise group have obvious role in promoting technology innovation, and financing constraints on this relationship has played a significant part in mediating role, so that the regression results of this paper is robust and reliable.

b) Endogeneity test: there may be endogeneity problems in the empirical results. For endogeneity problems, the first order lag term (L.RdSpend) of R&D intensity and financing constraint index (L.SA) is selected as instrumental variables, and the generalized distance estimation (GMM) method is used to test the potential endogeneity problems. From Table 8 and Table 9, it can be found that the test results are basically consistent with the expected conclusions, indicating that the model parameter estimation results in this paper are robust, and the endogeneity problem is not enough to affect the conclusions of this paper.

Table 6. Robustness test regression results for expenditure/total assets.

model	(1)	(2)	(3)	(7)	(8)	(9)
The dependent variable	Size	Indep	Common	R&D	R&D	R&D
	0.242***	0.581***	0.288**	0.475***	1.141***	0.268**
	(20.27)	(20.27)	(2.41)	(10.41)	(10.41)	(2.18)
N	5470	5470	5470	5470	5470	5470

Note: The values in brackets are T values. ***, ** and * represent significance levels of 1%, 5% and 10% respectively.

Table 7. The mediating variable is the robustness test regression result of liquidity ratio.

model	(4)	(5)	(6)	(7)	(8)	(9)
The dependent variable	Size	Indep	Common	RDSpend	RDSpend	RDSpend
	0.0141***	0.0339***	0.588**	0.256***	0.256***	0.257***
	(7.28)	(7.28)	(1.76)	(5.27)	(5.27)	(5.34)
N	5470	5470	5470	5470	5470	5470

Note: The values in brackets are T values. ***, ** and * represent significance levels of 1%, 5% and 10% respectively.

Table 8. Regression results of endogeneity test for terms after the first order of R&D intensity.

model	(1)	(2)	(3)	(7)	(8)	(9)
The independent variables	Size	Indep	Common	Size	Indep	Common
L.RDSpend	3.833***	11.663***	8.423**	1.303***	11.984***	23.805**
	(3.34)	(3.61)	(0.47)	(1.31)	(3.64)	(1.88)
AR(1)	6.15	7.88	7.44	2.70	8.08	0.27
AR(2)	1.48	1.07	1.01	0.72	1.05	1.14
hansen	0.138	0.465	0.519	0.471	0.417	0.785
N	4376	4376	4376	4376	4376	4376

Table 9. Regression results of endogeneity test for terms after the first order of financing constraints.

model	(4)	(5)	(6)
The independent variables	Size	Indep	Common
L.SA	1.303***	28.543***	16.479**
	(1.31)	(4.29)	(1.81)
AR(1)	3.85	3.77	2.59
AR(2)	0.96	3.22	1.57
hansen	0.759	0.362	0.128
N	4376	4376	4376

5. Research Conclusion and Implications

5.1. Research Conclusion

This paper takes China's A-share listed companies and their parent companies from 2015 to 2019 as samples, and studies the impact of parent company board governance on enterprise R&D and innovation behavior. Furthermore, this paper constructs a mediating effect test model of "board governance—financing constraint—enterprise innovation" from the perspective of financing constraint and discusses how the parent company's board of directors influences enterprise innovation behavior. The main conclusions of this paper are as follows: Enhancing the level of board governance is helpful to enhance the level of technological innovation, the board of directors of the group parent company can promote expand the scale of the board of directors. Increasing the proportion of independent directors and reducing the chairman of the parent company concurrently serving as a subsidiary executive are three channels to improve the innovation level of the group, and part of the influence of the parent company's board of directors on enterprise innovation is achieved by easing the external financing constraints of the enterprise.

5.2. Enlightenment

Enterprise group is a kind of organization form widely adopted in the development of Chinese enterprises. At present, most of the leading enterprises in various industries are composed of enterprise groups with large enterprises as their parent companies. In order to give full play to the effectiveness of the internal arrangement of the parent company's board of directors, we should start from the following aspects to promote the group's technological innovation: First, in accordance with the requirements of the corporate governance structure, properly handle the centralization and decentralization between the parent company and its subsidiaries. Chinese enterprise groups often achieve long-term coordinated development of the group through the multiple management and control of the subsidiary by the parent company. As the main body of management and control of the entire group, the parent company has a fundamental impact on

the technological innovation of the group. The core position of the board of directors of the parent company of the group should be established, the role and function of the board of directors of the parent company of the group in scientific decision-making and internal supervision should be brought into full play, the innovation decision-making and the promotion of innovation activities of the management should be effectively carried out, the formulation and implementation of the innovation strategy of the group should be ensured. Second is to clarify the rights, obligations and responsibilities of the board of directors and its special committees, chairman of the board and directors, and establish an assessment and evaluation mechanism for the board of directors. Increase the number of board members of the parent company, expand the proportion of independent directors, establish appropriate performance appraisal standards and incentive methods for independent directors, effectively play the role of the board of directors of the parent company, and improve the technological innovation capability of the enterprise group. Third is to support the parent company of the enterprise group formulate and improve the governance system of the board of directors, and comprehensively apply formal and informal coordination mechanisms. By promoting the construction of the internal market of the group such as capital market, technology market, labor market, etc., financing constraints are lifted, knowledge spillover is realized, and technological innovation of subsidiaries and groups is promoted to promote the healthy development of enterprise groups.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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