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THE INFLUENCE OF THE NETWORK POSITION OF THE BOARD OF DIRECTORS ON THE INSUFFICIENT INVESTMENT OF ENTERPRISES

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ABSTRACT

As one of the core contents of modern enterprise financial management, investment activity plays an important role in economic growth and scientific and technological progress, and is also an important research object in the field of accounting research. In practice, investment often faces the problem of non-efficiency investment. Non-efficiency investment is mainly realized as insufficient investment in China. In recent years, academic circles have begun to use the emerging social network theory to analyze the lack of investment, and found that the social network relationship behind the board has had a major impact on the lack of investment in enterprises. Social network theory believes that social capital is a resource embedded in the social network relationship. Individual behavior is embedded in the social network and will be affected by non-economic factors from the network. The position of the individual in the network determines the individual's ability to get resources. Studies have shown that the phenomenon of chain director between boards of directors of listed companies is very common. Based on this, this paper studies the impact of the board of directors formed by chain directors on the lack of investment in enterprises from the perspective of social networks.

This paper takes the 2015-2017 Shanghai and Shenzhen A-share main board listed companies as a sample to explore the impact of the board's network location on under-investment. The improved Richardson model was used to measure the lack of investment, and the differences in the influence of the network position of the board of directors on the under-investment of enterprises under different ownership forms were further explored. This paper selects the network center degree and structural hole limit index of the board of directors to measure the network characteristics of the board of directors, and builds a multivariate regression model by using social network theory and structural hole theory as the theoretical basis. Through descriptive statistics, correlation analysis, and regression analysis, it is found that: (1) The higher the centrality of the board's network location, the more beneficial it is to alleviate the lack of

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investment; the closer the board structure hole is to the center, the lower the degree of under-investment; (2) Compared with state-owned enterprises, the network position of private listed companies' board of directors has a better governance effect on under-investment.

Keywords: network location, under-investment, board governance, board network, structural hole location

1. INTRODUCTION

Investment activities are a very important part of the company's financial management process. Efficient investment can help enterprises control risks, obtain income, and achieve corporate financial goals. However, in practice, due to agency problems, information asymmetry, financing constraints, etc., corporate managers often have non-efficiency investments in the process of investment activities, and non-efficiency investment problems are common in Chinese enterprises. In recent years, the number of directors in listed companies has increased, and the network size of the board of directors has become larger and larger. However, academic circles rarely pay attention to the impact of the board network on investment efficiency. The articles on the relationship between the network position of the board of directors and the non-efficiency investment relationship are still relatively less. In addition, at present, the research on non-efficiency investment in China's academic circles mainly focuses on the research of excessive investment, and to some extent ignores the problem of insufficient investment. However, the research results of Yao Hui and Gao Xian show that the proportion of under-investment in non-efficiency investment of listed companies in China is even greater. With the introduction of new regulations on capital management in 2018, China's financial market began to strengthen supervision, further standardize the funding pool, reduce liquidity risk, and reduce excessive dependence on indirect financing, which has a certain impact on the cash flow of corporate investment activities. The relative tightening of liquidity has made the problem of insufficient investment in enterprises more and more serious.

As the executive body of the highest authority shareholder meeting of the enterprise, the board of directors is responsible for the decision-making and management of the business activities of the enterprise. It is also the medium and bridge for information communication between the internal and external enterprises, and plays an important role in helping enterprises make decisions and obtain resources. However, traditional research on the board of directors mostly focuses on the personal characteristics of the board members' age, tenure, and academic background. They only see individuals, do not see each other's connections, and rarely consider the influence of different inter-departmental relationships on corporate behavior (Knoke , 1990). With the rise of social network theory, the board of directors formed by listed companies due to the concurrent

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appointment of directors has gradually entered the public's research horizon. According to social network theory, the network of the board of directors refers to a social structure composed of directors as nodes. Each node in this relationship will be affected by other individuals and external factors in the network. Social networks are already an important source of information and social capital for companies in modern society. For example, Meng Yan and Zhou Hang (2018) studied the relationship between network location, governance environment and earnings quality; Yan Xu (2018) studied the relationship between chain shareholders, corporate networks and corporate mergers; Zuo Xiaoyu and Sun Qian (2018) explored the relationship between director network, company centrality and investment efficiency.

State-owned listed companies and private listed companies have different considerations in the investment decision-making process. Private enterprises often only need to consider the project's net present value and corporate capital flow, while state-owned companies usually need to consider some market factors and social responsibility factors. For example: balance regional development, promote the development of landing areas, solve employment, support new industries, and so on. Moreover, the major shareholders of the board of state-owned enterprises are highly concentrated in the country and are not the same as private enterprises. So is there a difference in the impact of the network position of corporate boards of different ownerships on underinvestment? This article will combine the empirical data of China's A-share main board listed companies in 2015-2017 to empirically explore the above issues.

2. LITERATURE REVIEW

2.1 Causes of underinvestment

The research conclusions of domestic and foreign scholars on the causes of insufficient investment are mainly concentrated in the following aspects.

2.1.1 Agent problem

Wu Yingjun (2016) through empirical research on listed family enterprises in China, found that the existence of agency problems makes company executives tend to make non-efficiency investment behaviors. Such problems are particularly special in listed family enterprises. The ubiquity of the problem makes management have a private interest tendency that is different from the value of the company, investing in projects that damage the wealth of shareholders but bring benefits to them; Aggarwalr and Samwick (2006) put forward the manager's private cost theory in the article, pointing out that when a company invests in a new project or upgrades an existing project, it often brings more work to the manager, and the manager must spend more time and energy to deal with capital investment projects, so when the private cost of the

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investment project is high, management may give up investment projects that can bring the net present value to the company for its own interests.

2.1.2 Information asymmetry

Takashi Shibata and Michi Nishihara (2011) found that corporate investment decisions are later in information asymmetry than in full information. In order to minimize the distortion of information asymmetry on corporate investment behavior, business managers need to do more work to reduce possible underinvestment. Xiao Wei, Ren Chunyan (2014) found that information asymmetry can aggravate the underinvestment in private enterprises. Holding cash flow will also have a wide impact on corporate investment efficiency. Establishing an efficient and transparent communication mechanism can alleviate The adverse effects of information asymmetry.

2.1.3 Institutional constraints

Ding Yan and Wang Xiaolan (2016) found that among local state-owned enterprises, under-invested enterprises accounted for 53% of all non-efficient investment enterprises. In terms of the term structure of debt, whether it is high government intervention or low level of government intervention, short-term debt can effectively manage the underinvestment of local state-owned listed companies. Some scholars have found that countries with imperfect investor protection systems have greater incentives for companies to invest in non-efficiency (Rui Albuquerue, 2008). Chi Guohua and Wang Wei (2017) studied the impact of disclosure of internal control defects on underinvestment from the perspective of information disclosure. With the disclosure of internal control defects, the level of underinvestment will also increase, the more serious the internal control defect information, the higher the level of insufficiency of investment, and the disclosure system has a regulatory effect on insufficient investment.

2.2 Board network location and under-investment

Wang Ying and Cao Tingqiu (2018) believe that relying on the information advantages and resource advantages of the board of directors network, it can promote the expansion of enterprise investment scale to a certain extent, and alleviate the problem of insufficient investment of enterprises to a certain extent. This mitigation comes from two sources: resource effects and information effects. The resource effect is mainly reflected in the centrality index characteristics of the board of directors network. The higher the network centrality, the more resources the enterprise has. The information effect is mainly reflected in the structural hole position of the board network. The more structural holes that the enterprise node has in the board network, the more scarce information the enterprise can obtain.

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Sha Haowei and Zeng Yong (2016) used social network analysis methods to study the relationship between network location and enterprise inefficient investment. They found that the efficiency of corporate investment is positively related to the centrality of the network. The superior position of the company's network can not only effectively curb excessive investment, but also effectively alleviate the lack of investment. At the same time, this effect is influenced by the life cycle of the company and the nature of the equity. Chen Yunsen (2015) studied the role of "structural hole" in social networks from the perspective of financial management, and proposed that the rich location of structural holes can improve the investment efficiency and operational capability of enterprises.

3. THEORETICAL ANALYSIS AND RESEARCH HYPOTHESIS

3.1 Relevant theoretical basis

3.1.1 Resource Dependence Theory

Resource dependence theory believes that the board of directors is an important way for companies to obtain scarce resources inside and outside. The company prefers to recruit directors with diverse social relationships, and through these directors, build a broad network of boards to better informalize with other company executives. Communicate and get important non-redundant information from other companies. The network of directors can bring more high-value information and scarce resources such as management concepts and market channels to enterprises, thus improving the efficiency of investment and operation of the company. Especially for companies that lack resources, they are more dependent on establishing board network relationships to master key resources.

3.1.2 principal-agent theory

The principal-agent theory is the classic theory summed up by the book "Modern Company and Private Property" published by scholar Burley and Means in 1932. The theory proposes that when the trend of "specialization" occurs in the daily operation and management of enterprises, due to the comparative advantage, there may be a relationship between the agent acting on behalf of the principal. After the separation of ownership and management rights, due to the different interests between professional managers and owners, agents will seek to maximize their own interests and ignore the interests of the principals. In some cases, professional managers may abandon projects that maximize the client's wealth for their own pay and leisure. If the company lacks a corresponding internal control mechanism, it is easy to cause a decline in investment efficiency and insufficient investment.

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3.1.3 Structural Hole Theory

Structural hole theory was proposed by the American network analysis school representative Burt (1992) based on the research of Coleman et al. Structural hole theory holds that the entire social network behaves in two forms. One is the state in which all network nodes are fully connected, in which there is direct contact between any two network nodes. This form often exists only in small, relatively closed groups. The other is a form in which network nodes are not fully connected. Nodes in the network may have direct or indirect connections. There may also be no connection, in this network, the phenomenon of relationship breaks between different nodes. Seen from the network, it seems that there are caves in the network, the so-called "structural holes." A non-redundant association between two nodes in a network is a structural hole.

As shown in FIG. 3.1, nodes A, B, C, D, and I form one sub-network 1, and nodes E, F, G, H, and I form another sub-network 2. In subnetwork 1, B, C, and D are not directly related to each other, and only indirectly through node A. A is the position of the structural hole, which can be used as the key to connect B, C, D and I, E companies, and take advantage of this structure. Node I is the "bridge" point of the two subnets, which will capture the richest information and resources across the network.

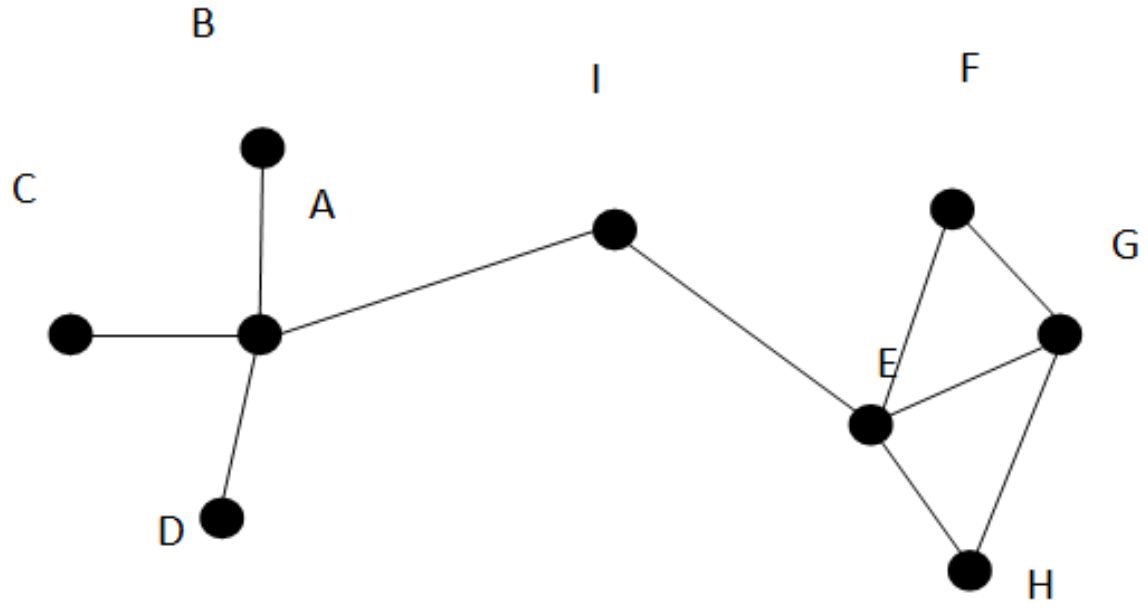

Figure 3.1: Example of a structural hole

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3.2 Proposal for research hypothesis

3.2.1 Board network location and investment

With the further transformation and upgrading of the national economy, the competition among enterprises has entered a period of more intense network competition. China is a typical human relationship society. The social relationship network plays an irreplaceable role in many aspects such as capital and information. The network of directors formed by the chain directors of listed companies has become the most important social relationship among enterprises.

Figure 3.2 is the statistical chart of the board of directors of the A-share main board listed companies in Shanghai and Shenzhen Stock Exchanges from 2015 to 2017. It can be seen that in recent years, the number of directors of listed companies in China has become more and more. Whether it is the overall number of concurrent or the number of concurrent members in the Shanghai and Shenzhen A-share main boards, the overall trend shows a rapid growth trend. The network of directors is increasingly becoming a factor that cannot be ignored. At the same time, we can see that the current directors of listed companies are still concurrently employed in non-listed companies. The three-year average A-share main board listed company's concurrent number only accounts for 7.87% of the total concurrent number. On the one hand, this phenomenon is due to the fact that directors in many group companies will also serve as senior executive positions of non-listed companies within the Group to drive the development of the whole group; On the other hand, China has not paid special attention to the directors of different listed companies at the theoretical and practical levels, the resource effects and information effects of the board network have not been fully utilized.

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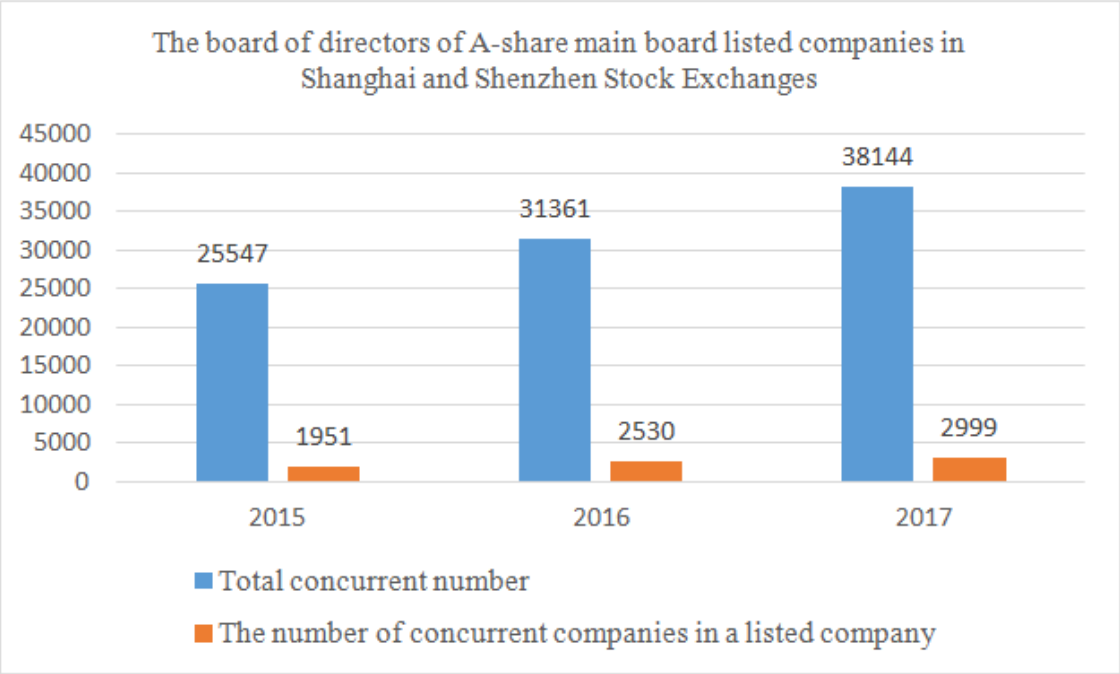

Figure 3.2: Board of Directors of A-share Main Board of Shanghai and Shenzhen Stock Exchanges

At the same time, further analysis of the position of directors and non-directors in the concurrently-owned A-share main board listed companies, as shown in Figure 3.3. It can be found that taking up directorships accounts for the vast majority of cases. It shows that the social relationship network formed by part-time companies in China is mainly represented by the network of boards formed by different board members. The study of the board of directors is of great significance.

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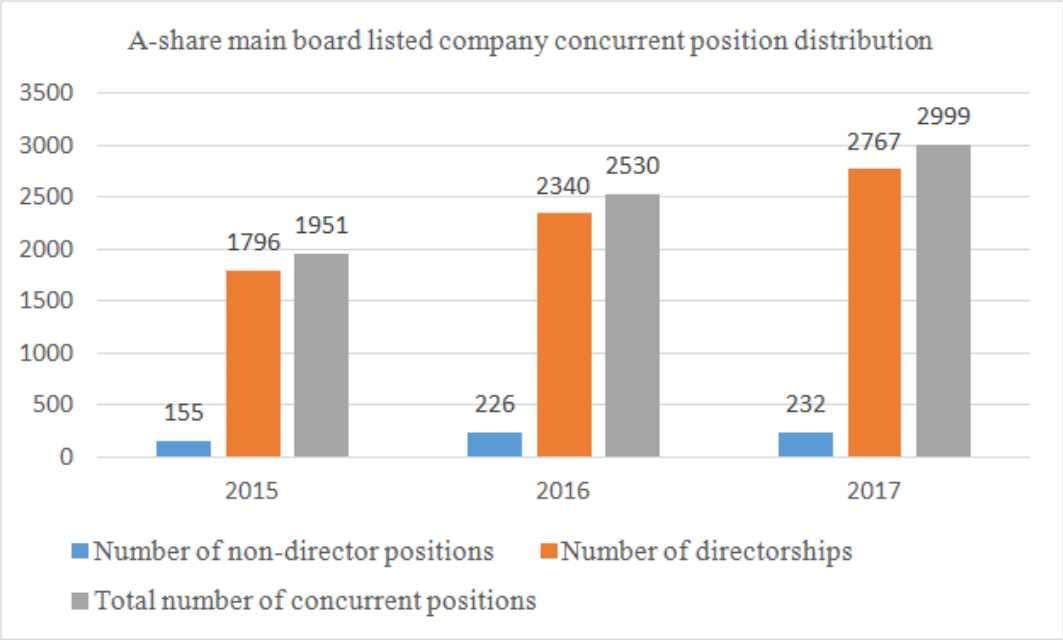

Figure 3.3: Distribution of concurrent positions in 3 A-share main board listed companies

There are a number of studies around the impact of board network locations on corporate decision-making and management. For example: director network characteristics and corporate equity acquisition behavior (Wan Liangyong, Hu Wei, 2014), director network and earnings quality (Meng Yan, Zhou Hang, 2018), director network and enterprise innovation investment (Wang Ying, Zhang Guangli, 2018), director network and corporate M&A (Liang Wen, Liu Shulian, 2018), Although the research perspective of multiple director networks has been involved, there are relatively few relevant thoughts on the impact of the directors' network on under-investment.

The efficiency of investment activities affects the success or failure of the company's operations. Efficient investment activities can maximize the use of production resources and expand reproduction. Chinese enterprises have a certain degree of under-investment and over-investment in their investment, especially the lack of investment. Qiao Jing, Hu Bing (2014) analyzed the foreign investment angle of enterprises, and found that the average degree of investment in foreign direct investment of listed companies in China in recent years was 26.59%, far exceeding the excessive investment.

The existence of financing constraints and agency problems is the most important reason for enterprises to have insufficient investment. The board of directors network can play a certain role in these two aspects. First, establishing a network of boards can deliver information more

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frequently and efficiently between companies within the network. It is able to establish more business contacts and expand financing channels, thereby reducing the information gap inside and outside the enterprise and helping enterprises to improve their external financing capabilities. The management of the company can finance from various aspects and reduce the level of financing constraints faced by the company, which helps the company to make better decisions in investment activities. Fang et al. (2012) empirical research shows that the network position occupied by corporate executives and the ability of enterprises to obtain external information and resources are positively changing. Executives with high network centers can help companies make better decisions, and the investment efficiency of the corresponding companies is higher. Engelberg et al. (2013) pointed out that the existence of social networks helps companies improve their ability to access information and resources, and convey the true state of the enterprise, thereby reducing financing costs. Wang Ying and Cao Tingqiu (2014) pointed out that the network of directors is widespread in listed companies in China. The network centrality and the financing costs of enterprises change in the opposite direction. Enterprises in the center of the network often have more diversified financing channels. Second, because the differences in directors' network characteristics represent differences in directors' governance motivation and governance capabilities in corporate governance decisions (Xie Deren, Chen Yunsen, 2011), directors of network centers are more motivated to supervise management and major shareholders, and in governance have stronger negotiation skills in decision making. They also have a stronger ability to identify “invisible” opportunistic behaviors of management and major shareholders, thereby more effectively curbing agency problems and reducing inefficient investment behavior.

In order to reduce the uncertainty of investment risks and maximize the benefits, the investing company should collect all the information and resources needed for risk decision making, including public information, confidential information, and general resources and scarce resources. Public information and universal resources are available through the market, and key resources and confidential information are information and resources that are not available from the market. If the investing company relies solely on public information and ordinary resources for investment behavior, it will be at a disadvantage and face greater risk of investment failure. At this time, the access to information resources of investment companies is particularly important. As a decision-making “head” of a company, the board of directors is often a person with more social resources in the society, which helps to obtain such scarce information and resources, thereby reducing the level of investment in enterprises.

Based on these theoretical foundations, this paper proposes hypothesis 1:

H1: The director's network location has a governance effect on insufficient investment. The

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higher the network center, the more the location structure of the company is located, and the lower the level of enterprise investment.

3.2.2 Impact of Ownership Structure on Board Network Governance

Compared with private listed companies, the board of directors has less rights in state-owned holding companies. First of all, due to the special status and historical inheritance of Chinese state-owned enterprises in the national economy, the board of state-owned enterprises is more affected by various government interventions. Moreover, in state-owned enterprises, investment decisions not only consider economic benefits, but also take into account non-shareholder wealth growth factors such as employment, local taxation, and social responsibility commitment. Therefore, the board of directors has relatively little decision-making power in corporate investment. In addition, the major shareholders of state-owned listed companies have a special status and are more capable. Large state-owned shareholders have the right to directly appoint some directors. Even if the board of directors has a high degree of network center, the motivation of directors to suppress large shareholders is not as good as that of private enterprises. Therefore, the board network has a weaker suppression effect on the second type of agency problems. Therefore, the board of directors has less inhibitory effect on underinvestment. Based on this, the following assumptions are made:

H2: Compared with private listed companies, among the state-owned listed companies, the board network has a poor effect in curbing insufficient investment.

4. RESEARCH DESIGN

4.1 Sample selection and data sources

This paper takes the listed companies in China's Shanghai and Shenzhen A-share main board market in 2015-2017 as a sample, and removed the financial insurance industry, ST class, companies listed in the same year and companies with missing data, and obtained a total of 3,503 samples. Then the Richardson model was used to estimate the level of investment, and 2,070 under-investment samples were obtained. Then, the main continuous variables were subjected to 1%-99% Winsorize tailing treatment to reduce the impact of outliers on the regression results.

For the directors' network data, this paper takes all the directors of the listed companies in the Shanghai and Shenzhen Stock Exchanges from 2015 to 2017 as a sample, and builds the “Board-Board” network matrix based on the personal data and concurrent information of the directors in the CSMAR database. For the “same name” directors who are not identifiable according to their resumes, they will be further verified by establishing a personal unique code for the directors.

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The adjacency matrix is established by using the chain directors as a bridge. Finally, UCINET software is used to calculate the network characteristics data of each enterprise board. Other financial data comes from the WIND financial database and the CSMAR database. This paper uses Eviews6.0 and SPSS for metrological analysis.

4.2 Main variable design

4.2.1. Measurement of underinvestment

The Richardson model is constructed to measure the efficiency of enterprise investment. The negative residual value of the model represents the level of under-investment. The greater the absolute value of the negative residual, the higher the level of under-investment.

$$INV_t = a_0 + a_1 Tobinq_{t-1} + a_2 Lev_{t-1} + a_3 Cash_{t-1} + a_4 Age_{t-1} + a_5 Size_{t-1} + a_6 Ret_{t-1} + a_7 INV_{t-1} + \sum Ind + \sum Year + \varepsilon \quad \text{Formula (1)}$$

In the formula (1), INV_t is the capital investment amount of the company in the t-th year, and the cash paid for the purchase and construction of fixed assets, intangible assets and other long-term assets minus the cash recovered from disposal of fixed assets, intangible assets and other long-term assets. Income from total assets at the beginning of the period; $Tobinq_{t-1}$ is the Tobin Q value of the enterprise in the previous year (enterprise value / ending assets, where the non-circulating stock market value is replaced by net assets), representing the growth opportunities of the enterprise; Lev_{t-1} is the asset-liability ratio of the enterprise at the end of year t-1; $Cash_{t-1}$ is the cash holding amount at the end of the year of t-1, measured by the proportion of monetary funds at the end of the t-1 year to the total assets; Age_{t-1} represents the listing period of the enterprise, measured by the natural logarithm of the listing period; $Size_{t-1}$ is the company size at the end of the year of the enterprise t-1, measured by the natural logarithm of the total assets of the enterprise; Ret_{t-1} represents the stock return rate of the enterprise at the end of year t-1, measured by the growth rate of the basic earnings per share of the enterprise; INV_{t-1} is the capital investment amount at the end of the year of enterprise t-1. At the same time, the model also controls annual and industry dummy variables. Use UnderINV to characterize underinvestment.

4.2.2 Measurement of network location characteristics

1. Central location metric

According to Freeman (1978), Bonacich (1972) and Chen Yunsen (2012), the indicators for measuring network characteristics are mainly degree of centrality, intermediate degree and near

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center. This paper chooses the degree of centrality as a measure of the central location.

$$Degree_i = \sum_j X_{ij} /(n-1)$$

Formula (2)

The degree of centrality can directly reflect the overall position of the network node in the network. The larger the index, the more the node is connected with other nodes, and the closer the location is to the network center, the more interactions are participated.

2. Measurement of structural hole location

The limit index is a comprehensive indicator and is also a widely used structural hole measure in the academic community (Sha Haowei 2014) (Chen Yunsen 2015). The limit index of the structural hole is as follows:

$$Constra_{ij} = P_{ij} + \sum P_{iq}\, P_{jq}$$

Formula (3)

The structural hole theory proposes that the nodes at the core of the structural hole can get more information and potential resources, so the measurement of the structural hole location is another key to the research of the board network. Before measuring specific indicators, this paper defines the direct relationship between enterprises and enterprises according to the current academic practice: the members of the board of directors of the two enterprises have a concurrent relationship with each other's board of directors. In the network of the board of directors, the two companies have direct contact.

The limit index is inversely changed from the number of structural holes owned by the enterprise. The smaller the limit index is, the more structural holes the enterprise has in the network. The closer the enterprise's network location is to the network center, the maximum value of this indicator is 1. This paper uses $Constra_{ij}$ to measure the richness of the structure of the enterprise.

4.2.3 Main control variables

The company's investment decisions are influenced by the financial situation, governance behavior and its basic conditions. This paper refers to the research literature of Chen Yunsen (2015) and Chen (2011) and selects the company's financial status (cash holding ratio, current assets ratio, asset-liability ratio, the return on total assets), governance variables (management

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expense ratio, the largest shareholder shareholding ratio, management shareholding ratio) and the company's basic conditions (marketing period, asset size) variables as the main control variables to study corporate investment . The industry and the year are selected as dummy variables. The detailed definition of each variable is shown in Table 4.1:

Table 4.1: main variable definition table

name	*symbol*	*Definition*
Underinvestment	*UnderINV*	The absolute value of the residual with a regression less than 0 in formula (1)
Degree of centrality	Ndegree	As formula (2)
Limit index	Constra	As formula (3)
Return on total assets	Roa	Ratio of net profit to average total assets
Listing period	Age	the natural logarithm of the year the sample company was in minus the company's IPO year
Asset size	Size	Natural logarithm of total assets
Assets and liabilities	*Lev*	Ratio of total liabilities to total assets
The shareholding ratio of the largest shareholder	Top1	The ratio of the total number of shares held by the largest shareholder to the total share capital of the enterprise
Management expense ratio	Adm	The ratio of management expenses to the main business income of the current period
Cash holding ratio	Cash	Ratio of monetary funds to total assets
Current assets ratio	Cata	Ratio of current assets to total assets
Management shareholding ratio	Ratio	Ratio of management shareholding to total share

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		capital
Year	Year	Annual dummy variable
Industry	Ind	Industry dummy variable

4.3 Model Design

The construction of the relevant model (1) is used to examine the impact of control variables on the underinvestment of enterprises:

$$UnderINV_{i,t} = b_0 + b_1 Roa_{i,t} + b_2 Age_{i,t} + b_3 Size_{i,t} + b_4 Lev_{i,t} + b_5 Top1_{i,t} + b_6 Adm_{i,t} + b_7 Cash_{i,t} + b_8 Cata_{i,t} + b_9 Ratio_{i,t} + \sum Year + \sum Ind + \varepsilon_{i,t}$$

Model (1)

Construct the model (2) according to the research hypothesis 1 proposed in this paper:

$$UnderINV_{i,t} = b_0 + b_1 Ndegree_{i,t} + b_2 Constra_{i,t} + b_3 Roa_{i,t} + b_4 Age_{i,t} + b_5 Size_{i,t} + b_6 Lev_{i,t} + b_7 Top1_{i,t} + b_8 Adm_{i,t} + b_9 Cash_{i,t} + b_{10} Cata_{i,t} + b_{11} Ratio_{i,t} + \sum Year + \sum Ind + \varepsilon_{i,t}$$

Model (2)

Model (2) is used to examine the impact of board network centerlines and structural hole locations on underinvestment. Then use model (2) to conduct group regression analysis to explore the impact of ownership on the relationship between board network location and under-investment in companies with different ownership characteristics.

5. EMPIRICAL TEST AND ANALYSIS OF RESULTS

5.1 Richardson model descriptive statistics

According to the regression residual of the model (1) Richardson model, 2298 under-investment samples were obtained, and 1205 over-investment samples were obtained. The descriptive statistics of regression residuals are shown in Table 5.1. The proportion of regression results of underinvestment and over-investment is shown in Figure 5.1, and the under-investment sample accounts for two-thirds of the total sample of non-efficiency investments. This proves that the non-efficiency investment problem of listed companies in China is mainly due to insufficient investment. Insufficient investment is a key issue that needs to be solved urgently in the investment process of listed companies in China. At the same time, the regression residuals of

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the model generally conform to the normal distribution, and the main sample residuals are concentrated between -0.02 and 0, as shown in Figure 5.2. Compared with the existing research, the model fits well. In order to reduce the systematic deviation caused by the model, the residuals of all under-invested samples are divided into ten groups in descending order, and the group with the closest residual to zero is eliminated. There are 2,070 remaining samples, of which 693 are under-invested in 2015, 701 are under-invested in 2016, and 676 are under-invested in 2017.

Table 5.1: Richardson model regression residual descriptive statistics

Descriptive statistics	
average value	0.0000
Standard error	0.0011
median	-0.0087
Standard deviation	0.0666
variance	0.0044
Minimum value	-0.4377
Maximum	1.8049
Summation	0.0000
Number of observations	3503
Confidence (95%)	0.0022

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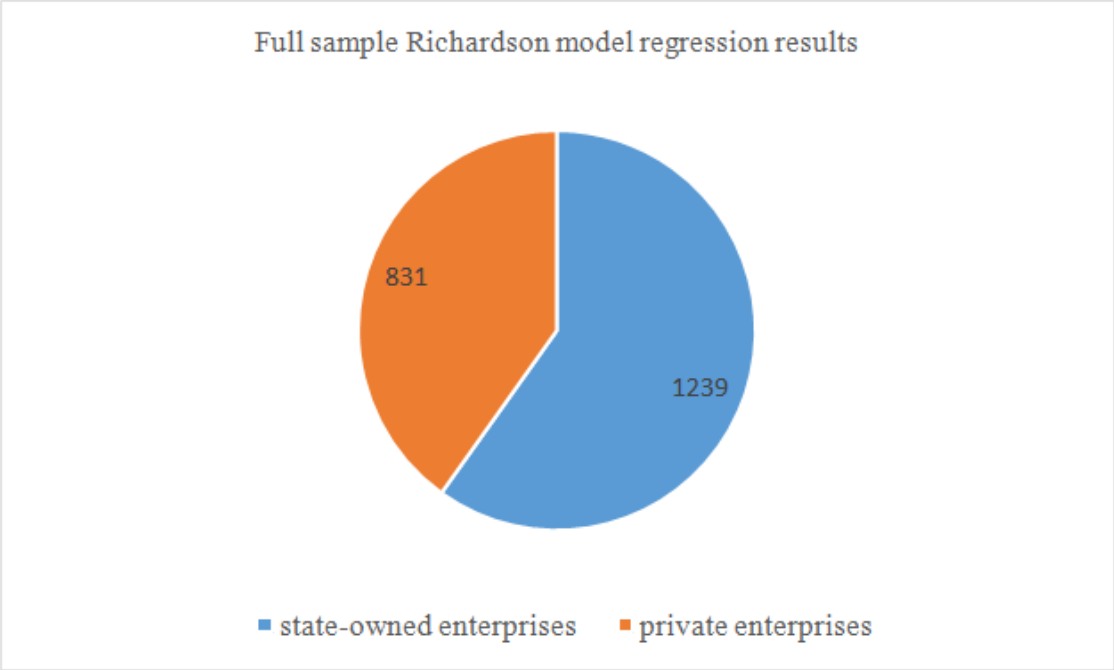

Figure 5.1: full sample Richardson model regression results

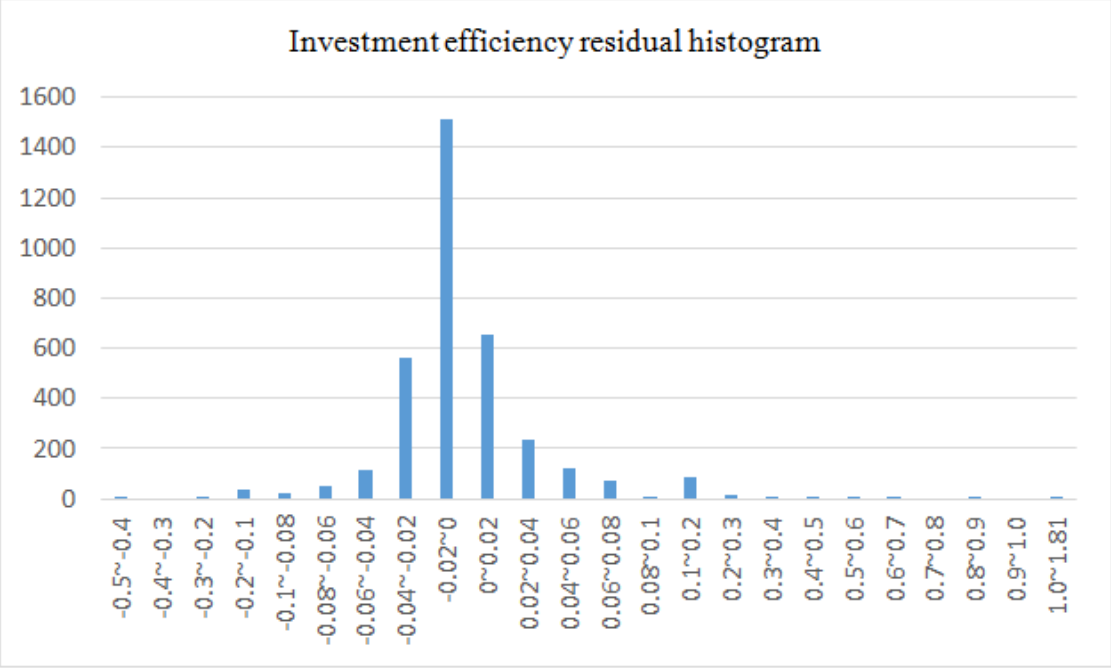

Figure 5.2: Total sample investment efficiency residual distribution

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5.2 full sample descriptive statistics

Table 5.2 lists descriptive statistics for the main variables. It can be found from Table 5.2 that the mean and median of the variables involved in model (2) are not much different. At the same time, the standard deviation of the variables is also relatively small, and there is no large anomaly, indicating that the sample data is relatively smooth. The average of all under-invested samples was 0.023, with a median of 0.017, which was basically consistent with the findings of Chen Yunsen et al. In the case of network location characteristics, the mean value of the centrality is 0.039. It shows that the degree of centrality of the sample companies with insufficient investment in China is still relatively low, and the network connection of the board of directors is less than other companies. The mean and standard deviation of the limit index of the structural hole are 0.425 and 0.460, respectively, and the maximum and minimum values are 0.989 and 0, respectively. It shows that the difference between the limit indexes of each enterprise is relatively large, and the number of structural holes in different locations in the network is very different. From the statistical results of the control variables: in the context of the introduction of new regulations on China's asset management and the de-leverage of the national economy, the average asset-liability ratio is 48.8%, which is lower than the previous year (Sha Haowei, 2016), kept in a relatively suitable range of 40%-60%, but the maximum reached 1.081, This shows that there are still some companies facing serious risk of excessive debt. The average return on total assets is 0.032, which indicates that the profitability of the under-investment sample is relatively poor, and the lack of investment affects the financial performance of the company. The maximum and minimum cash holding ratios are 0.746 and 0.004, indicating significant differences in cash holding policies between different companies.

Table 5.2: Descriptive statistical results of the main variables of the whole sample

Variable	Mean	Median	Maximum	Minimum	Standard deviation	Number of samples
UI	0.023	0.017	0.438	0.004	0.025	2070
NDEGREE	0.039	0.024	0.290	0.000	0.051	2070
CONSTRA	0.425	0.111	0.989	0.000	0.460	2070
ROA	0.032	0.028	0.361	(0.975)	0.061	2070
AGE	2.624	2.890	3.296	0.000	0.713	2070
SIZE	22.654	22.588	26.607	19.098	1.256	2070
LEV	0.488	0.491	1.081	0.028	0.202	2070
TOP1	0.354	0.333	0.891	0.050	0.150	2070
ADM	0.044	0.037	0.507	0.001	0.040	2070

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CASH	0.169	0.142	0.746	0.004	0.110	2070
CATA	0.578	0.600	0.987	0.027	0.225	2070
RATIO	0.028	0.000	0.758	0.000	0.091	2070

In addition, this paper also conducts group descriptive statistics on the main variables of the full sample of Chinese enterprises and private enterprises. The results are shown in Table 5.3.

Table 5.3: Descriptive statistical results of main variables of state-owned enterprises and private enterprises

Variable symbol	State-owned enterprise		Private Enterprise	
	Mean	Standard deviation	Mean	Standard deviation
UI	0.0221	0.0259	0.0244	0.0243
NDEGREE	0.0423	0.0527	0.0350	0.0471
CONSTRA	0.4366	0.4568	0.4087	0.4651
ROA	0.0278	0.0524	0.0372	0.0725
AGE	2.7684	0.4729	2.4076	0.9257
SIZE	22.8322	1.2365	22.3893	1.2376
LEV	0.5097	0.1961	0.4564	0.2056
TOP1	0.3790	0.1455	0.3165	0.1481
ADM	0.0430	0.0380	0.0460	0.0437
CASH	0.1670	0.1084	0.1723	0.1124
CATA	0.5604	0.2355	0.6052	0.2065
RATIO	0.0027	0.0235	0.0646	0.1327
N	1239		831	

It can be seen from the table that the average investment deficit of state-owned enterprises is 0.0221, while the average investment of private enterprises is 0.0244. Compared with state-owned enterprises, private enterprises have higher levels of underinvestment and the problem of insufficient investment is more significant. In addition, the average of the network centrality and limit index of the sample group of state-owned enterprises is higher than the average of the sample group of private enterprises. It shows that in the network of listed companies' boards of directors, the board of directors of state-owned enterprises tends to be in a more central position, but at the same time they occupy fewer structural holes. This may be due to the fact that the

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directors of state-owned enterprises are concurrently present among companies in the same system, and there is more redundant information in the network of boards. State-owned enterprises and private enterprises also differ greatly in terms of financial status, governance behavior, and their own basic conditions. The average asset-liability ratio of state-owned enterprises is 5.33% higher than that of private enterprises. At the same time, the average shareholding ratio of state-owned enterprises is 6.19% lower than that of private enterprises. The financial status and governance of state-owned enterprises are different from those of private enterprises. The structure affects the governance effect of the board network on underinvestment.

5.3 Correlation analysis

In order to test whether the model variables have autocorrelation, this paper uses Pearson correlation coefficient to analyze the correlation of the main variables. The results are shown in Table 5.4. The correlation coefficients of each variable of the model are less than 0.5, indicating that the model has no serious multicollinearity problem. The degree of degree of the board of directors (Ndegree) is negatively correlated with the under-investment (UnderINV) and is significant at a probability of 0.01; the Consta index (UnstraINV) is significantly positively correlated with the under-investment (UnderINV) at a probability of 0.05. Features do have an impact on the extent of underinvestment.

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Table 5.4: Correlation coefficients of 4 main variables

	UnderINV	NDEGREE	CONSTRA	ROA	AGE	SIZE	LEV	TOP1	ADM	CASH	CATA	RATIO
UnderINV	1											
NDEGREE	-.058***	1										
CONSTRA	.009**	.442***	1									
ROA	.026	.031	.035	1								
AGE	-.051**	.061***	.040	-.121***	1							
SIZE	-.189***	.157***	.087***	.050**	.115***	1						
LEV	-.059***	.070***	.031	-.321***	.181***	.498***	1					
TOP1	-.009	.027	.038	.123***	-.167***	.225***	.046**	1				
ADM	.076***	-.070***	-.049**	-.099***	-.040	-.310***	-.173***	-.083***	1			
CASH	.049**	-.049**	-.012	.203***	-.032	-.106***	-.229***	.062***	.088***	1		
CATA	-.089***	.017	.012	.047**	-.047**	.047**	.185***	.055**	.001	.348***	1	
RATIO	.035	-.045**	-.002	.118***	-.424***	-.109***	-.115***	-.123***	.022	.000	.081***	1

Note: *** indicates significant (two-tailed) at the level of 0.01, ** indicates significant (two-tailed) at the level of 0.05

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5.4 Regression analysis

5.4.1 Full sample main effect test

First of all, based on the regression results of all the samples, explore the governance effect and influence direction of the network characteristics of the board of directors on insufficient investment. The regression results are shown in Table 5.5. According to the regression results of model (1), it can be seen that the asset size (Size) is significantly negatively correlated with the level of investment in the enterprise. This shows that the larger the scale of the company's assets, the more the investment is lessened, and the higher the investment efficiency, which is consistent with the empirical evidence of Sha Haowei; The company's cash holdings (Cash) and total return on assets (Roa) are significantly positively correlated with the level of underinvestment in the enterprise. It shows that the more cash held in the daily operation of the enterprise, the stronger the profit level, the more likely it is to provide opportunities for the manager's opportunistic behavior, the lower the investment efficiency of the company, which is consistent with the empirical data of Chen Yunsen and Xie Deren. The higher the asset-liability ratio (Lev), the more serious the underinvestment, which indicates that under the condition of high asset-liability ratio, external financing conditions are more demanding, and enterprises are more likely to be under-invested due to shortage of funds. The ratio of current assets (Cata) is significantly negatively correlated with the lack of investment. The greater the proportion of liquid assets, the stronger the solvency and ability to obtain external financing, the more able to raise capital, which is conducive to curbing the underinvestment of enterprises. Based on the model (1), the network location feature index is introduced: the degree of centrality and the limit index, and the model (2) is constructed. After the regression, it was found that the degree of centrality (Ndegree) in model (2) was significantly negatively correlated with the overall investment deficit at 5%, indicating that the closer the company's network of the board is to the network center, the more it can reduce its own underinvestment level. Constra and the overall investment deficit are positively correlated at 5%, indicating that the higher the limit index, the fewer structural holes the company has in the network at this time, and the higher the level of underinvestment. Accordingly, Hypothesis 1 is verified.

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Table 5.5: full sample regression results

Variable symbol	Interpreted variable: underinvestment	
	Model 1	Model 2
C	0.1299*** (10.9717)	0.1282*** （10.7841）
Ndegree		0.0031** (2.1926）
Constra		0.0031** (2.1926）
ROA	0.02710*** (2.7346)	0.0272*** （2.7423）
AGE	-0.0010 (-1.1811)	-0.0011 （-1.2137）
SIZE	-0.0049*** (-8.9299)	-0.0048*** (-8.7350)
LEV	0.0179*** (4.9367)	0.0178*** (4.9193)
TOP1	0.0056 (1.4313)	0.0053 (1.3486)
ADM	0.0161 (1.1327)	0.0162 (1.1415)
CASH	0.0199*** (3.5578)	0.0195*** (3.4771)
CATA	-0.0160*** (-5.9086)	-0.0159*** (-5.8663)
RATIO	0.0055 (0.8063)	0.0048 (0.7005)
Adj,R^2	0.0558	0.0576

Note: t value in parentheses, *p<0.10, **p<0.05, ***p<0.01 (same table below)

5.4.2 Influence of the nature of ownership on the governance of the board's network location and under-investment

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The financing environment and investment behavior of state-owned enterprises and private enterprises in China are very different. State-owned enterprises often have the support of policy banks or the dividends brought by state policies. The financing environment is relatively loose, and investment behavior is rarely plagued by insufficient funds. Insufficient investment is more affected by various reasons such as national policies, government intervention, and social influence. Private enterprises, due to their small scale, short set-up time, insufficient information disclosure and other factors, will encounter more restrictions in financing, investment behavior will be more restricted by corporate capital flow, financing constraints are the cause of investment the main reason for the shortfall. Because the nature of ownership has an impact on the lack of investment in enterprises, this paper divides the sample into two parts, state-owned enterprises and private enterprises, according to the nature of the company's ultimate controller, and studies the impact of its board network on under-investment.

The distribution of ownership of the whole sample of enterprises is shown in Figure 5.3. It can be seen that among the enterprises with insufficient investment in Shanghai and Shenzhen, there are 1,239 state-owned enterprises and 831 private enterprises, and the number of state-owned enterprises is more than that of private enterprises.

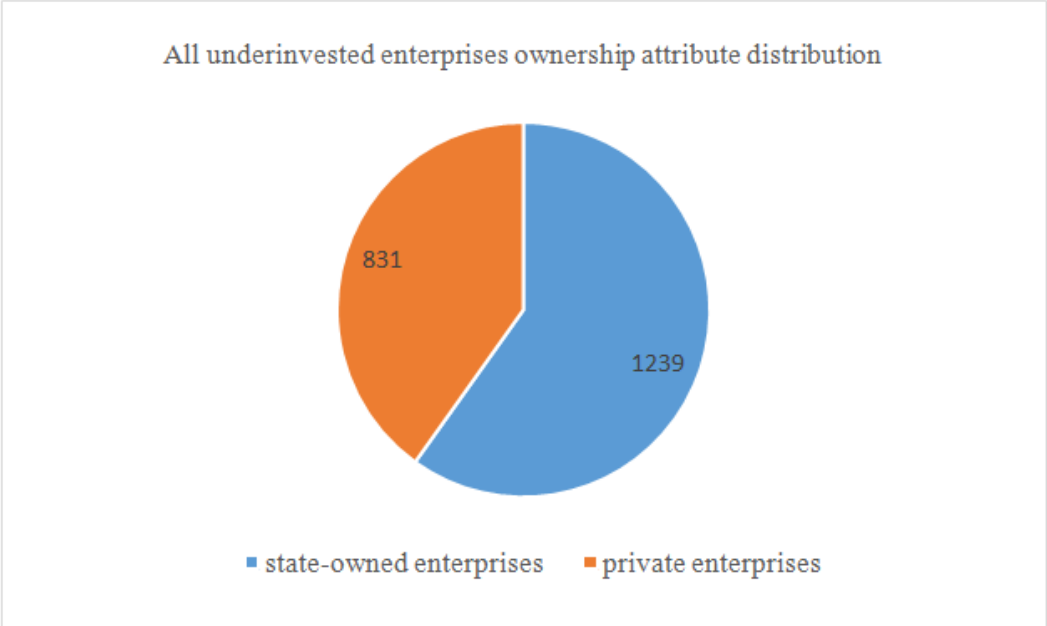

Figure 5.3: Distribution of ownership of under-investment companies

The regression results of the two groups of samples are shown in Table 5.6. In private enterprises, the degree of centrality is significantly negatively correlated with the investment

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deficit at the level of 0.05. The limit index is significantly positively correlated with underinvestment at the level of 0.1, and the network location characteristics of the board of directors have a significant impact on underinvestment. In the sample group of state-owned enterprises, although the network degree centrality and limit index of the board of directors is also negatively correlated and positively correlated with the insufficient investment of enterprises, it is not significant. The regression results show that the network location characteristics have a significant impact on the investment of private enterprises, and this effect is not significant in state-owned enterprises. Hypothesis 4 is supported by empirical results.

Table 5.6: grouping regression results of different ownership forms

Variable symbol	State-owned enterprise	Private Enterprise
C	0.1315*** （8.04）	0.1222*** （6.634）
NDEGREE	-0.0161 (-0.9984)	-0.0491** (-2.2621)
CONSTRA	0.0028 （1.5172）	0.0041* （1.8706）
ROA	0.0361** （2.34）	0.0157 （1.2206）
AGE	-0.0017 (-1.0879)	-0.0006 (-0.5967)
SIZE	-0.0050*** (-6.8817)	-0.0043*** (-5.0361)
LEV	0.0194*** （3.9176）	0.0157*** （2.921）
TOP1	0.003 （0.5668）	0.0125** （2.0354）
ADM	0.0400** （2.0085）	-0.0108 (-0.5352)
CASH	0.0186** （2.3617）	0.0194*** （2.4437）

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CATA	-0.0134*** (-3.7860)	-0.0230*** (-5.1547)
RATIO	-0.0108 (-0.3435)	0.0063 (0.8933)
N	1239	831
Adj,R^2	0.0538	0.0603

5.5 Robustness test

In order to ensure the accuracy and reliability of the above research results, the following methods were used to test the robustness.

First of all, measuring the efficiency of corporate investment is not only a method of the Richardson model, but also the Biddle (2009) model and the Chen (2010) model in the academic world. In order to test the reliability of the conclusions based on the Richardson model, the author chose Biddle's model to measure the enterprise investment efficiency again. The model uses the growth rate of operating income to measure the growth level of the company and then returns to the level of growth. The residual efficiency of the model regression is also used to measure investment efficiency.

The specific empirical model is as follows:

$$Invest_t = \gamma_1 + \gamma_2 Growth_{t-1} + \varepsilon$$

Formula (3)

In formula (3), $Invest_t$ is the capital investment of the enterprise. $Invest_t$=(Cash paid by fixed assets, intangible assets and other related assets + cash paid by equity investment and debt investment - disposal of fixed assets, intangible assets and other long-term assets) / Average total assets; $Growth_{t-1}$ is the growth rate of business revenue. The residuals and under-investment levels and distribution levels measured based on this model are basically consistent with the Richardson model.

6. RESEARCH CONCLUSIONS AND POLICY RECOMMENDATIONS

6.1 Research conclusions

Through empirical research, it is found that the greater the degree of the network of the board of directors, the more the enterprise is in the center of the network, the more it can reduce the lack

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of investment; The smaller the limit index, the more structural holes the enterprise has, and the more network nodes indirectly contact, the more effectively it can obtain network information resources and alleviate the insufficient investment of enterprises. In addition, we also take into account the impact of the nature of corporate ownership, through empirical research found that the network of the board of directors in the private enterprises better than the state-owned enterprises to reduce the level of investment in enterprises. This research conclusion can help enterprises to more effectively use the social resources of the board of directors to improve their investment behavior, improve investment efficiency, and further enrich the relevant research results on the board network and enterprise inefficient investment field.

6.2 Policy recommendations

In recent years, China is in a period of strategic opportunities for transformation and development, and economic growth has entered a “new normal”, which not only emphasizes the growth of GDP, but also requires a change in the growth pattern. The central bank will no longer provide enterprises with a loose credit policy in the form of “big flood irrigation”. This puts new demands on the enterprise market grasp, management strategy and business methods. The state put forward the strategic task of “going capacity, destocking, deleveraging, reducing costs, supplementing shortcomings”. In particular, after the introduction of the new regulations on capital management in 2018, a strong financial effect has been released. The off-balance sheet financing channel of major commercial banks has begun a new round of significant contraction, which has intensified the difficulty of refinancing enterprises. We have entered the painful period of accelerating financial deleveraging. Enterprises are facing new challenges and urgently need to improve investment efficiency and reduce waste of resources. However, in practice, due to agency problems and financing constraints, non-efficiency investment behaviors are common in Chinese enterprises, mainly due to insufficient investment. This has greatly affected the normal operation and development of Chinese enterprises. Under the complicated economic situation, it has fully mobilized various resources to enhance the competitiveness of enterprises. As the core organization and decision-making department of the management, the board of directors of the enterprise can effectively manage the problem of insufficient investment of the enterprise. Based on this, the following recommendations are made from both the government and business levels.

6.2.1 From the government level:

First, actively guide enterprises to strengthen the construction of the board of directors, and encourage competent directors to work part-time, especially in related fields with cooperation advantages, scale advantages, and information advantages; In addition to the existing director information such as gender, education, and professional experience, establish a system of

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evaluation of director relations, improve the evaluation system of directors, and give play to the effect of the network of the board on the lack of investment; At the same time, we will continue to promote the construction of the board of directors' supervision system to prevent the risk of collusion and fraud between enterprises due to the network of the board of directors.

Second, further promote the reform of state-owned enterprises, respect the laws of the market, reduce the administrative intervention in the board of directors of state-owned enterprises, give play to the basic role of the market in resource allocation, and continuously improve the investment efficiency and profitability of state-owned enterprises. Break the shackles of traditional habits and continuously promote institutional innovation in state-owned enterprises.

Third, accelerate the construction of the social credit system, remove barriers to information communication between enterprises, reduce the financing constraints faced by enterprises, and create a good financing and investment environment for enterprises. Strengthen the punishment for untrustworthy enterprises and untrustworthy personnel, and at the same time give encouragement to trustworthy enterprises and individuals.

6.2.2 From the enterprise level:

First, this paper provides direct empirical evidence of the impact of the board's network location on underinvestment, indicating that the closer the board's network location is to the center, the more structural holes an enterprise has in the network, the better it is to reduce investment deficiencies and improve investment efficiency. For the listed company in the governance of the board of directors, put forward a new perspective, When selecting a director, the company should fully consider the director's own network of directors and try to find those directors who can help the company expand resources and contacts to enter the board of directors.

Second, in private enterprises, the governance effect of the board of directors network is more obvious. Private listed companies should actively establish a network of directors across industries and sectors to share information and resources, use this channel to enrich financing sources, reduce their own financing difficulties, and find more valuable investment projects to reduce the level of under-investment.

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