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Abstract: Exploring the governance modes of private listed enterprises, this paper divides private listed enterprises into categories of small, medium and large. The governance modes of private listed enterprises can be divided into 9 categories according to two different management intensities of equity capital governance and manpower capital governance. The 9 categories of governance modes of private listed enterprises are identified by using the BP neural network mode. This paper analyses the evolution of private listed companies' governance modes at different scales and analyses various governance modes. Therefore, small, medium and large private listed companies choose the "strong equity and weak manpower", "moderate equity and moderate manpower" and "weak equity and moderate manpower" governance modes, respectively. This paper comparatively analyses the governance efficiency of governance modes at different scales. The results show that "moderate equity and moderate manpower" is the most effective management mode for all three scales.

Key words：Growth period；Private listed enterprises；BP neural network；Governance model recognition

1. Introduction

General Secretary Xi Jinping stated that "private economy is an indispensable force to promote China's development" at a "private enterprises forum" held on the first of November 2018, which demonstrates the importance of private economy to China's economic development. The development of the private economy is closely related to the governance mode of private enterprises, and private listed companies, as the best among private

enterprises, play a leading and exemplary role. Strengthening the research on the governance mode of private listed companies is of great significance for promoting the high-quality development of the private economy and is undoubtedly a popular topic at present. In small private listed companies, the actual controller (or family) maintains a strong desire for control. Ownership and control rights are relatively concentrated in entrepreneurs or families, dominated by the equity capital governance mode. For the development and growth of enterprises, equity diversification and management professionalization become inevitable, and the governance mode of private listed companies gradually changes from a governance mode dominated by equity capital to a collaborative governance mode of human capital and equity capital.

At present, research results on private enterprise governance are abundant and are mainly concentrated on three levels. In terms of governance mechanisms, Jensen and Ruback (1983) proposed that the shareholding ratio of the chairman of the board of supervisors in private enterprises has a negative promoting effect on corporate governance efficiency[1]. According to Claessens and Yurtoglu (2012), the establishment of an effective corporate governance mechanism by private listed companies can better cope with the changing requirements of the institutional environment and economic environment in enterprise development[2]. Wu Lidong et al. (2016) proposed that the improvement of corporate governance mechanisms plays a key role in the transition of private enterprises from family governance to professional operation[3]. In terms of governance structure, Nohria and Ghoshal (1994) proposed that adjustment of the board of directors and related governance structure is conducive to supervision and incentive of management[4]. Jiang et al. (2010) proposed that excessive concentration of governance structure leads to higher agency costs[5]. Bacon (1973) stated that when the size of the board of directors is too large, it is likely to lead to disagreement, thus leading to failure of governance[6]. Jensen (1993) also believed that a board size that is too large easily leads to governance failure[7]. In terms of governance mode, Zhou Xiuyun and Feng Junwen (2003) stated that China's private listed companies have formed unique governance modes during the period of development, including the family-oriented governance mode and social legal person-oriented governance mode[8]. Huang Sujian et al. (2008) proposed that the governance arrangement of private enterprises follows the path evolution of "entrepreneur enterprises-family enterprises-family-like enterprises-professional managers' enterprises"[9]. Xiao Chengmin (2012) proposed that the choice of the best governance structure of private enterprises is determined by the institutional environment[10]. He Jun (2008) stated that public policy of private enterprise governance cannot directly interfere with the choice of private enterprise governance mode, and more consideration should be given to influencing entrepreneurs' governance choice from the perspective of improving the external environment[11]. Zhang Min and Zhang Yili (2014) proposed that perfect contractual

governance can reduce the cost of maintaining interpersonal relationships in a study of private enterprises in Wenzhou Province[12]. Chen Weizheng et al. (2008) stated that the governance mode of private enterprises has the dominant tendency of equity capital governance[13]. Chen Xin and Shen Leping (2009) proposed that most private enterprises in China have a family style [14]. Tian Yinhua et al. (2012) stated that 75% of private enterprises in China have family organization or family management[15]. Therefore, a large number of scholars have explored family business governance. For example, Gomez-Mejia et al. (2001) stated that weak relational contract governance is conducive to improving enterprise performance and avoiding business risks[16]. Baker et al. (2002) proposed that an unclear definition of agents' work resulted in the existence of relational contracts[17]. Chen Jianlin (2009) proposed that the governance mode of family enterprises should be selected according to the actual situation: family governance, professional governance, eclectic governance and colonial governance[18]. Zhou Zhiqiang et al. (2013) concluded that strong explicit contract governance and strong implicit contract governance are the most effective governance modes for Chinese family enterprises[19]. Liu Lin and Deng Jianming (2014) showed that with the development of family businesses, the mode of "strong contract-strong relationship governance" should be chosen[20].

In summary, scholars have conducted fruitful research on private enterprises' governance modes, laying a good foundation for this paper, but there are still some deficiencies. First, the evolution path of the governance mode of private enterprises has been studied, but which governance mode is the most effective is seldom noted. Second, human capital governance is not combined well with equity capital governance. The participation of human capital in governance is inevitable. It is difficult to analyse private enterprise governance practices effectively only from the perspective of equity capital to investigate corporate governance issues. Third, linear modes are usually used to conduct empirical research on private enterprise governance modes, which fails to reflect the nonlinear relationship in private enterprise governance and fails to accurately explain its efficiency. In view of this, this paper divides the governance modes of private listed companies into 9 categories from the two dimensions of equity capital and human capital governance according to their different strengths. In addition, the BP neural network mode is used for nonlinear empirical testing. The research conclusions are more reliable and can provide a reliable basis for the selection of governance modes of private listed companies.

The possible research contributions of this paper are as follows: First, from the perspective of the combination of human capital and equity capital, the governance mode of private enterprises is distinguished, and this distinction of the governance mode of private enterprises is more scientific. Second, using the BP neural network to identify the governance mode of private enterprises can effectively reflect nonlinear relationships, the identification

effect is better, and the conclusions are more accurate. Third, the key purpose of this article is to provide a theoretical basis for private enterprises to choose the optimal governance mode. Therefore, based on the effective identification of governance modes, the evolution of governance modes of private enterprises in different scales are analysed, and the analyses of their management efficiency are classified to provide a basis for the selection of the optimal governance modes of private enterprises.

2. Research Design

2.1. Research methods

In this paper, a BP neural network mode is built based on the multi-layer forward feedback algorithm of error backpropagation that is used to identify the governance pattern of private listed companies. Evolution analysis is carried out on the private listed company governance mode. Private listed companies can be divided into categories of small, medium and large. This paper classifies and analyses various governance modes of small, medium and large private listed companies and determines the selection trend of governance modes of private listed companies. Additionally, the governance efficiency of private listed companies' governance modes are compared and analysed at different scales, and the most effective governance mode of private listed companies is determined.

2.2. Research tools

This paper uses the BP neural network mode to explore the governance mode of private listed companies. A BP neural network can effectively simulate the mode of thinking of the human brain and has autonomous learning characteristics.

A BP neural network consists of an input layer, hidden layer and output layer (as shown in figure 1). In figure 1, x_1, x_2, …, x_n represent the initial input values of each neuron node. If the weight between neuron nodes in each layer is R_{ij}, the neuron threshold for i is a_i.

According to the formula $S_i = \sum_{j=1}^{n} R_{ij} * x_j + a_i$, the net input value of the i neuron node can be obtained. If the number of input layer nodes of the BP neural network mode is n, the number of hidden layer nodes is m, the node number of the output layer is t, the weight of the input layer and hidden layer is Q_{kj}, the weight of the hidden layer and output layer is P_{ik}, the transfer function of the hidden layer is $f_1(\cdot)$, the transfer function of output layer is $f_2(\cdot)$, the

output value of the hidden layer node $z_k = f_1\left(\sum_{j=0}^{n} Q_{kj} * x_j\right)$, and the output value of the

output layer node $y_i = f_2\left(\sum_{k=0}^{m} P_{ik} * z_k\right)$ can be obtained.
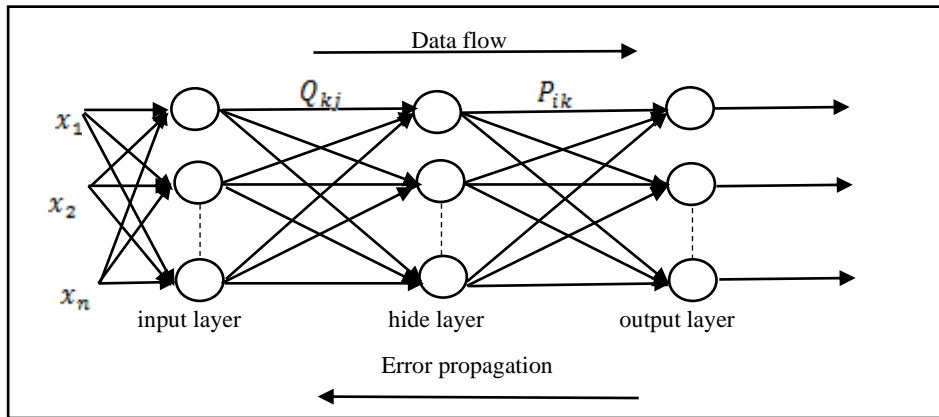

Fig 1. BP neural network topology

The BP neural network can adjust the weights between each layer through the reverse propagation error to achieve the optimal effect of the global error. This process includes the forward flow of data and reverse propagation of error, which are generated by the finite iterations of dynamic superposition of the two. The positive flow path of the data is input layer→hidden layer →output layer, and the neurons in each layer only affect the state of neurons in the next adjacent layer.

If expected results cannot be obtained from the forward flow of data, the weight of each layer is adjusted by backward propagation error. For example, the expected output of sample *t* is h_i^t, while the actual output of sample *t* is y_i^t. According to the sum of squares error

function, we can determine a single sample error $E_i = \frac{1}{2}\sum_{t=1}^{m}(\mathrm{h}_i^t - y_i^t)^2$ and then the global

error $\mathrm{E} = \sum_{i=1}^{n} E_i$.

In the comparison of the global error with the critical value of error, if the global error is larger than the critical value of error, the weight is adjusted in reverse. The weight change of the input layer and hidden layer is $\Delta Q_{kj} = E'\eta f_2'(S_i)P_{ik}f_1'(S_k)x_j$. The weight change of the

hidden layer and output layer is $\Delta P_{ik} = E'\eta f_2'(S_i)z_k$. η is the learning rate. To obtain the

optimum global error, the finite weight should be adjusted. When the optimal global error is smaller than the critical value of error, the BP neural network mode is established.

2.3. Model design

On the basis of fully understanding the basic principles of the BP neural network and combined with the actual situation of private listed companies' governance, the BP neural network mode of private listed companies' governance is constructed, as shown in figure 2. Figure 2 shows the training and learning process of the BP neural network mode of private listed companies' governance. First, we normalize the initial data and randomly assign the weights of each layer and the threshold value of each neuron node. Second, we determine the sample input vector and the expected result and calculate the simulation result of the sample. Third, according to the difference and error critical value comparison between the expected result and simulation result, the weight between each layer is adjusted in the reverse direction. Fourth, we repeat the second step until the error between the simulation and expected result is smaller than the error critical value; then, the BP neural network mode learning and training are completed, and the mode establishment is completed.
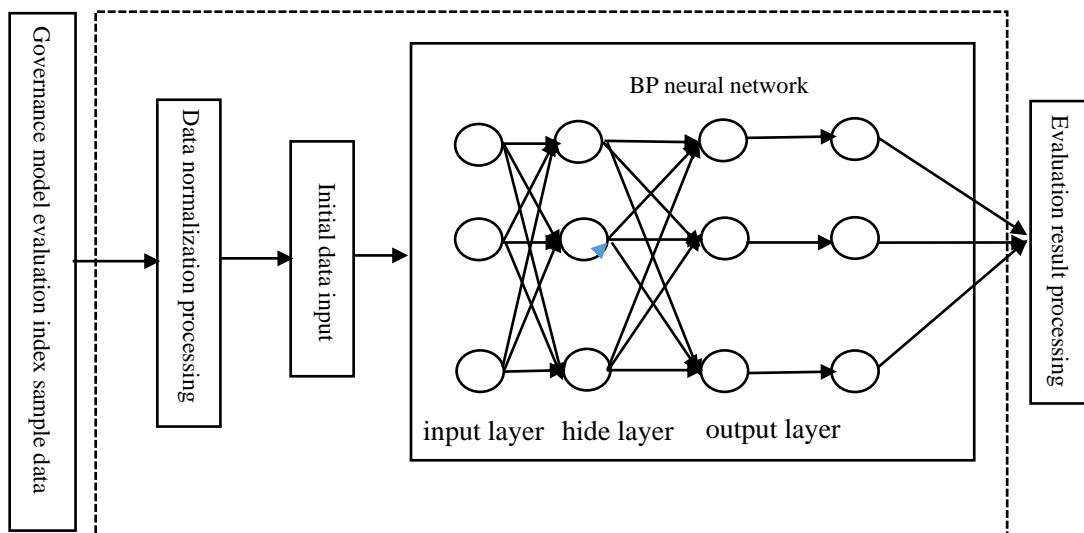

Fig 2. BP neural network model of private listed companies' governance

Weight is the key factor that affects whether the BP neural network mode can be identified accurately or not, and the determination of weight is closely related to the input vector. To determine the weight between each layer, this paper sets up a private listed company governance indicator system, as shown in table 1.

Tab 1. Index system of private listed companies' governance

Private listed corporate	Equity capital management indicators	1.The actual controller owns the ownership ratio of listed company
		2.The actual controller owns the control right ratio of listed company
		3.The actual controller holds the president position and general manager
		4.Shareholding ratio of chairman
		5.The proportion of company directors holding shares in the total number of directors (excluding independent directors)

Human capital management index	1.Shareholding ratio of senior executives
	2.The proportion of total compensation of top three executives in operating income
	3.The proportion of independent directors in the board of directors
	4.Number of board meetings
	5.The situation of non-actual controller as chairman and general manager

As shown in table 1, the governance indicators of private listed companies are divided into equity capital and human capital governance indicators. Equity capital governance mainly reflects the actual controller (or founder and family) control of enterprises. Human capital governance mainly reflects the status and role of executives, external directors and other non-actual controllers in corporate governance. Among them, equity capital management and manpower capital management include five secondary indicators. Equity capital governance indicators of the first, second and third indicators reflect equity capital management from the perspective of actual controllers. The higher the proportion of ownership and control of the company by the actual controller is, the more concentrated the equity. The actual controller holds the post of chairman of the board and general manager concurrently, which means that the more centralized the power is, the stronger the intensity of equity capital management. The fourth and fifth indicators reflect equity capital governance from the perspective of directors. The higher the shareholding ratio of chairpersons is, the lower the proportion of the total number of directors holding the company's shares on the board of directors (excluding independent directors), which indicates that the more enterprises tend to control equities and control rights, the stronger the equity capital governance. In the first and second indicators of human capital governance, the higher the proportion of senior executives' shareholding is, the higher the proportion of the total compensation of the top three executives in the operating income, which indicates that the more the attention paid to talent, the stronger the human capital governance intensity. The third indicator reflects that the higher the proportion of the number of independent directors on the board of directors is, the more enterprises attach importance to external talents and the stronger the governance intensity of human capital. The fourth indicator reflects that the more board meetings that are held, the more attention paid to the role of human capital in corporate decision-making and the stronger the governance intensity of human capital. The fifth indicator shows that when the non-actual controller holds the post of chairman or general manager or holds the posts concurrently, this indicates that the enterprise dares to use human capital and the governance intensity of human capital is stronger.

The BP neural network can adjust weights by reverse-propagating errors. Therefore, this paper uses the average number of indicators to assign the weight value of each layer, that is, each indicator is given the same weight.

To establish the BP neural network mode to accurately identify the governance mode of private listed companies, this paper divides the governance mode from the two dimensions of equity capital governance and human capital governance. The equity capital governance intensity is divided from low to high into weak, moderate, and strong. The manpower capital management intensity is divided from low to high into weak, moderate, and strong. The

equity capital governance intensity is taken as the horizontal coordinate and the human capital governance intensity is taken as the vertical coordinate to construct the grid mode, as shown in figure 3. Through the arrangement and combination of the governance intensity of equity capital and human capital, 9 governance modes are obtained.

Weak equity and strong manpower	Medium equity and strong manpower	Strong equity and strong manpower
Weak equity and medium manpower	Medium equity and medium manpower	Strong equity and medium manpowe
Weak equity and weak manpower	Medium equity and weak manpower	Strong equity and weak manpower

Human capital management intensity

Equity capital governance intensity

Fig 3. Governance grid model of private listed companies

3. Identification of private listed companies' governance pattern

Based on the establishment of the BP neural network mode, a BP neural network mode that can effectively identify private listed companies' governance mode is established through data acquisition and preprocessing, learning, training and testing and verification.

3.1. Data acquisition and preprocessing

There are two sources of data. The main data are obtained from private listed companies in the CSMAR database and executive shareholding ratio data of private listed companies from the RESSET database. The data from 2017 are all used to obtain 2366 samples, 409 of which are missing, and 1957 of which are valid. Based on the actual situation, according to the two dimensions of the total number of employees and assets, based on the "Statistics for the Classification of Large, Medium, Small and Micro Enterprises (2017)", private listed companies are divided into small, medium and large to ensure that the other factors remain the same and improve the accuracy of the mode simulation, and 150 small, 150 medium, and 150 large private listed companies are randomly selected from the 1957 valid samples. A total of 450 samples construct the experiment set.

The average (M) and standard deviation (s) of each indicator are calculated by MATLAB 2014a programming. The program can divide all the data into three intervals with M+s and M-s as cut-off points and assign the value located at [M+s, max] to 3. The value located at [M-s, M+s] is 2. The value located at [min, M-s] is 1. The ratio of the number of directors holding shares of the company to the total number of directors of the board of directors (excluding independent directors) is inversely assigned. For the index of concurrent posts, the value of concurrent posts is 3; otherwise, the value is 1. By adding the scores of each index, we can obtain the governance scores of equity capital and human capital, divide the governance intensity of equity capital and human capital into three categories of weak, moderate and strong, and then obtain the governance mode of 450 private listed companies.

Before using the BP neural network mode to identify the governance patterns of 450 private listed companies, the data should be normalized. To improve the learning effect and convergence speed of the mode, this paper normalizes the data to a range of 0-1 during pre-processing. The specific formula is as follows:

$$x'_{ij} = \frac{x_{ij} - min_j(x_{ij})}{max_j(x_{ij}) - min_j(x_{ij})}, \text{ where j= 1,2,3... 450, } x_{ij} \text{ is the initial value of the } i \text{ index,}$$

and x'_{ij} is the value obtained by normalization of the i index.

3.2. Determination of BP neural network structure

This paper uses a three-layer BP neural network mode with one input layer, one hidden layer and one output layer. Among them, the number of nodes in the input layer is equal to the input vector dimension, and the number of nodes in the output layer is equal to the output vector dimension. The number of secondary indicators in the private listed companies' governance indicators is 10, and the number of input layer nodes is 10. The private enterprise governance mode is divided into 9 categories. From $2^3 < 9 < 2^4$, it can be seen that the number of nodes in the output layer is 4. There is no uniform regulation of the number of nodes in the hidden layer in academic circles. According to the empirical formula, $l = \sqrt{n * m}$, where l is the number of nodes in the hidden layer, n is the number of nodes in the input layer, m is the number of nodes in the output layer, and the *Levenberg-Marquard* algorithm is combined to realize the optimal training effect. The number of nodes in the hidden layer is 7. Therefore, the topology of the BP neural network mode is established, which is 10-7-4.

3.3. Learning and training of BP neural network

In the mode, the *tan-sigmoid* function is used as the activation function of the hidden layer, and the *log-sigmoid* function is used as the activation function of the output layer. In the experiment, 145 small, 145 medium and 145 large private listed companies are selected by

stratified sampling to form the training set with a total of 435 samples. The BP neural network is trained many times with training set samples, and that with small global error is reserved for the test of remaining samples. Among them, the BP neural network mode with the number of nodes in the hidden layer of 7 is trained 24 times, and the global error is 1.50×10^{-4}, as shown in figure 4.
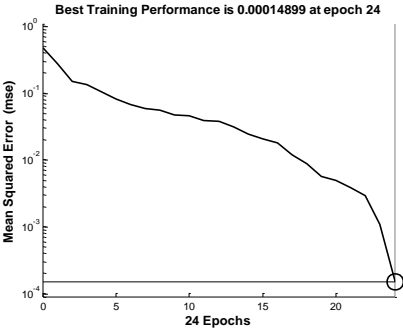

Fig 4. Training results of 7 nodes in the hidden layer

3.4. BP neural network test and verification

The purpose of establishing the BP neural network mode is to effectively identify all private listed companies' governance modes. Therefore, the mode must have a strong normalization ability. To test its normalization ability, the remaining 15 groups of data are normalized and simulated with the established BP neural network mode. The simulation results are shown in table 2. Among them, (0, 0), (1, 0) and (1, 1) represent the weak, moderate and strong governance intensities, respectively. The first two represent equity capital governance intensities, and the last two represent human capital governance intensities. Considering the existence of errors in simulation verification, this paper sets the simulation results below 0.03 as 0 and above 0.97 as 1.

Tab 2. Comparison between simulation results and expected results of neural network model

Serial number	Simulation results	Expected results
01	(1.0000, 0.0087, 0.9727, 0.0000)	(1, 0, 1, 0)
02	(1.0000, 1.0000, 0.0006, 0.0000)	(1, 1, 0, 0)
03	(0.9960, 0.0017, 1.0000, 0.9967)	(1, 0, 1, 1)
04	(1.0000, 0.0001, 1.0000, 0.0266)	(1, 0, 1, 0)
05	(0.1889, 0.0000, 1.0000, 0.0044)	(0, 0, 1, 0)
06	(1.0000, 0.0000, 1.0000, 0.0079)	(1, 0, 1, 0)
07	(0.9924, 0.9999, 0.0020, 0.0000)	(1, 1, 0, 0)
08	(0.9961, 0.0001, 1.0000, 0.0023)	(1, 0, 1, 0)
09	(1.0000, 0.9999, 0.0016, 0.0000)	(1, 1, 0, 0)
10	(1.0000, 1.0000, 1.0000, 0.0085)	(1, 1, 1, 0)
11	(1.0000, 0.9911, 0.0010, 0.0000)	(1, 1, 0, 0)

12	(1.0000, 0.0000, 0.9747, 0.0000)	(1, 0, 1, 0)
13	(0.9954, 0.0001, 1.0000, 0.0018)	(1, 0, 1, 0)
14	(1.0000, 0.0012, 1.0000, 0.9971)	(1, 0, 1, 1)
15	(1.0000, 0.0028, 1.0000, 0.0050)	(1, 0, 1, 0)

According to the simulation results, the simulation error is 2.55×10^{-4}, with an accuracy rate of 93.3%, indicating that the model is reasonable and the identification accuracy is high, and thus, the model can accurately identify private listed companies' governance modes.

3.5. Random test and verification of BP neural network

The recognition effect of the BP neural network mode under random conditions is further tested, and a 10-7-4 BP neural network mode is constructed. A total of 435 groups of samples are randomly selected from 450 groups for learning and training. Among them, the neural network mode with 7 nodes in the hidden layer is randomly trained 105 times with the minimum global error of 1.16×10^{-4}, as shown in figure 5.
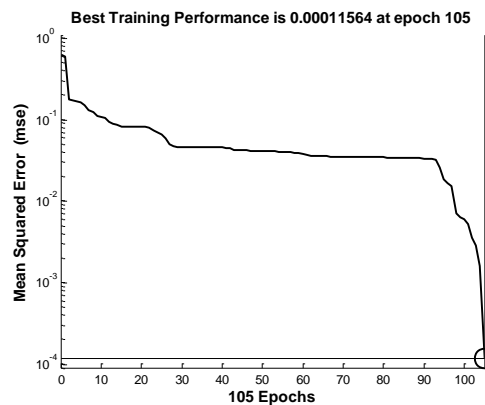

Fig 5. Random training results with hidden layer node number of 7

The remaining 15 groups of samples are used for the random simulation test of the model. The random simulation results are shown in table 3.

Tab 3. Comparison of random simulation results with expected results of neural network model

Serial number	Random simulation results	Expected results
01	(0.9786, 0.0004, 0.9795, 0.0003)	(1, 0, 1, 0)
02	(1.0000, 0.9996, 0.0005, 0.0000)	(1, 1, 0, 0)
03	(0.9999, 0.0000, 1.0000, 0.9879)	(1, 0, 1, 1)
04	(1.0000, 0.0192, 1.0000, 0.0001)	(1, 0, 1, 0)
05	(0.0342, 0.0000, 1.0000, 0.0001)	(0, 0, 1, 0)
06	(0.9861, 0.0000, 1.0000, 0.0000)	(1, 0, 1, 0)
07	(1.0000, 0.0000, 1.0000, 0.9999)	(1, 0, 1, 1)
08	(1.0000, 0.0000, 0.9999, 0.0000)	(1, 0, 1, 0)

09	(0.9816, 0.0000, 1.0000, 0.0000)	(1, 0, 1, 0)
10	(0.9924, 0.0000, 0.0259, 0.0000)	(1, 0, 0, 0)
11	(0.0000, 0.0000, 1.0000, 0.0021)	(0, 0, 1, 0)
12	(0.9995, 0.0000, 1.0000, 0.0870)	(1, 0, 1, 0)
13	(0.9982, 0.0000, 1.0000, 0.9984)	(1, 0, 1, 1)
14	(0.0063, 0.0000, 1.0000, 1.0000)	(0, 0, 1, 1)
15	(0.9461, 0.0000, 1.0000, 0.0050)	(1, 0, 1, 0)

According to the random simulation results, the random simulation error is 2.40×10^{-4}, with an accuracy rate of 80%. This shows that the model can identify the governance mode of private listed companies accurately and has high practical value under the random state.

The key purpose of this article is to provide a theoretical basis for private enterprises to choose the optimal governance mode. After effectively identifying the governance mode of private listed companies, how can the best governance mode be chosen? This article further proposes the solution as follows.

Research results on private enterprises show that the level of management efficiency directly reflects the quality of the governance mode. Therefore, the optimal governance mode should be based on the management efficiency. Management efficiency is mainly reflected in the profitability, solvency and operation ability of a company. Therefore, this paper further compares the management efficiency of various governance modes in private enterprises of different scales to arrive at the optimal governance mode of private enterprises to provide a theoretical basis for the selection of the optimal governance mode of private enterprises.

4. Selection of private listed companies' governance mode

On the basis of management pattern recognition of private listed companies by using the BP neural network mode, this paper analyses the evolution of private listed companies' governance modes, classifies various governance modes at different scales, comparatively analyses the governance efficiency of various governance modes at different scales and provides the basis for private listed companies' governance mode choices.

4.1. Evolution of private listed companies' governance model

To understand the evolution trend of private listed companies' governance mode at different scales, this paper processes three groups of sample data in categories of small, medium and large. The mean score of the equity capital governance index is used to represent the equity capital governance intensity, denoted $q_1 = (q_{1,1}, q_{1,2}, \ldots\ldots, q_{1,150})$, and the mean score of the human capital governance index represents the human capital governance intensity, denoted $q_2 = (q_{2,1}, q_{2,2}, \ldots\ldots, q_{2,150})$. Additionally, the intensity of equity capital management and human capital management should be standardized, and the formula is

$q'_{i,t} = \frac{q_{i,t} - \bar{q}_i}{var(q_i)}$, where $i = 1, 2, t = 1, 2, 3 \ldots 450$, $q_{i,t}$ represents the initial value of the equity

capital governance intensity (or human capital governance intensity) of the *t* sample in group *i*, $\bar{q_i}$ represents the mean of the sample in group *i*, $var(q_i)$ represents the standard deviation of the sample in group *i*, and $q'_{i,t}$ represents the normalized value of the *t* sample in group *i*.

MATLAB 2014a programming is used to draw a scatter diagram with human capital governance intensity as the horizontal coordinate and equity capital governance intensity as the vertical coordinate, and a Gaussian kernel function is used for fitting to obtain the evolution trend of private listed companies' governance modes at different scales (figure 6). As shown in figure 6, the evolution trend of private listed companies' governance mode is roughly "L", showing the evolution law of "strong equity and weak manpower→moderate equity and moderate manpower→weak equity and moderate manpower".
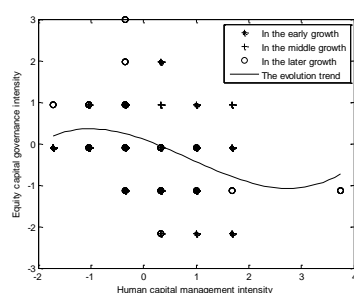

Fig 6. Evolution trend of private listed companies' governance mode in the growth period

(1) Analysis of the "strong equity and weak manpower" governance mode in small private listed companies. In small private listed companies, the actual controllers (or families) have a strong desire to control enterprises and are reluctant to transfer or dilute their ownership and control rights. In the small private listed companies, the private listed companies' structure is relatively simple, and the knowledge of by the actual controller (or family) can adapt to enterprise development, while the importance of professional entrepreneurs is not obvious. Therefore, most of the small private listed companies have strong equity capital governance. The concentration of power in the actual controller (or family) and exploration of actual controller (or family) benefit maximization are the main features of private listed companies. The actual controller (or family) has absolute authority over the decision-making of enterprises and plays a crucial role in the development of small private listed companies. The governance mode is dominated by equity capital governance, while human capital governance is relatively weak.

(2) Analysis of the "moderate equity and moderate manpower" governance mode in the medium private listed companies. The mode of equity capital leading governance is difficult to adapt to the needs of private listed companies. Additionally, with the ageing of the knowledge structure of the actual controller (or family) and the limitation of management ability, the actual controller (or family) decision-making mode with absolute authority hinders innovation and development, and professional entrepreneurs become the key factors for further development and enterprise expansion. In the medium private listed companies, private listed companies begin to attach importance to the status of professional entrepreneurs,

and professional entrepreneurs gradually become actual managers of enterprises. The importance of human capital governance becomes increasingly prominent, leading to weakening of equity capital governance intensity and improvement in human capital governance intensity. Additionally, because the human capital market in our country is not mature, the trust mechanism between the actual controller (or family) and professional entrepreneurs has not been fully established, the equity capital management intensity of medium private listed companies is decreased, while the human capital management intensity is increased. The management pattern of middle equity and middle manpower occupies the highest proportion, but compared to the equity capital management intensity, human capital management intensity is still in a vulnerable position.

(3) Analysis of the "weak equity and moderate manpower" governance mode in large private listed companies. These private listed companies gradually shift from focusing on high quantity development to high quality development; it becomes more necessary to strengthen professional management, and the important role of professional entrepreneurs becomes more prominent. In the large private listed companies, each rule and regulation within the enterprise is more complete, professional entrepreneurs' behaviour is more open and transparent, and the supervision of professional entrepreneurs' behaviour constraint mechanism and incentive mechanism is more robust. The trust mechanism between actual controllers (or family) and professional entrepreneurs has gradually been established. More authority and equity is transferred from the actual controller (or family) to the professional entrepreneur, further improving professional entrepreneurs' status and further strengthening human capital management intensity in the process, which further weakens equity capital governance intensity. However, even if human capital governance intensity is greatly improved compared with the small and medium categories, to prevent opportunistic behaviour in professional entrepreneurs due to excessive power, which damages the interests of enterprises, the actual controllers (or families) check and balance professional entrepreneurs' power. Therefore, the human capital governance intensity is still controlled within the moderate intensity in the large private listed companies.

To support the above conclusions, further classification analysis on various kinds of governance patterns of private listed firms at different scales should be conducted. According to the classification standard, 450 samples are divided into three groups according to the categories of small, medium and large private listed companies, and the proportions of all kinds of governance modes in each group is determined, as shown in table 4, table 5 and table 6.

Tab 4. Proportion of private listed companies' various governance modes in the early growth period

Governance pattern type	Proportion
Strong equity and strong manpower	4%
Strong equity and medium manpower	4%
Strong equity and weak manpower	32%
Medium equity and strong manpower	8%
Medium equity and medium manpower	20%

Governance pattern type	Proportion
Medium equity and weak manpower	16%
Weak equity and strong manpower	4%
Weak equity and medium manpower	8%
Weak equity and weak manpower	4%

Tab 5. The proportion of private enterprises' various governance modes in the middle growth period

Governance pattern type	Proportion
Strong equity and medium manpower	4%
Strong equity and weak manpower	16%
Medium equity and strong manpower	8%
Medium equity and medium manpower	44%
Medium equity and weak manpower	20%
Weak equity and medium manpower	8%

Tab 6. The proportion of private listed companies' various governance modes in the later growth period

Governance pattern type	Proportion
Strong equity and weak manpower	4%
Medium equity and strong manpower	20%
Medium equity and medium manpower	28%
Medium equity and weak manpower	4%
Weak equity and strong manpower	4%
Weak equity and medium manpower	40%

Table 4, table 5 and table 6 show that the "strong equity and weak manpower" governance mode accounts for the highest proportion of small private listed companies, the "moderate equity and moderate manpower" governance mode accounts for the highest proportion of medium private listed companies, and the "weak equity and middle manpower" governance mode accounts for the highest proportion of large private listed companies, which verifies the scientific accuracy of the above conclusions.

4.2. Comparison of private listed companies' governance efficiency

By analysing the evolution of private listed companies' governance modes at different scales and classifying various governance modes at small, medium and large scales, we obtain the evolution trend of governance modes at different scales but not the effective governance mode. To obtain the most effective governance mode, the evaluation index system of governance efficiency is further constructed, as shown in table 7.

Tab 7. Evaluation index system of private listed companies' governance efficiency

Evaluation index of private listed companies' governance efficiency	Enterprise profitability indicators	1.Operating income
		2.Rate of return on net profit
		3.Ratio of earnings per share to equity per share
		4.Net profit after deducting non-recurring gains and losses

Corporate solvency Indicators	5.Ratio of current liabilities to total assets
Enterprise operation ability index	6.Ratio of current assets to total assets

The efficiency of the private listed company governance evaluation index is divided into three first-level indicators of corporate profitability: the enterprise debt paying ability index and the enterprise capacity index. Profitability indicators reflect enterprises' profit from the perspective of revenue and profit ability size, including four secondary indexes. The higher the operating income, the rate of return on net profit, the ratio of earnings per share to net assets per share and net profit after deducting non-recurring gains and losses are, the stronger the enterprise's profit ability and the better the governance efficiency. The enterprise solvency indicators from the angle of current liabilities reflect the size of an enterprise's solvency, including a secondary index. The higher the current liability to total asset ratio and the enterprise's solvency are, the better the governance efficiency is. From the perspective of current assets, the index of the enterprise operating ability reflects the strength of the enterprise operating ability, including a secondary index. The higher the ratio of current assets to total assets is, the stronger the enterprise operation ability and the better the governance efficiency.

The same MATLAB 2014a program is used to assign values to each index of samples. The sum of each index score of the sample indicates the governance efficiency of the sample.

The samples are divided into three groups according to the small, medium and large categories. Each set of the same governance patterns is divided into a group, denoted $u_{i,t}^n$, representing the governance efficiency of the t sample of the i governance mode in the n (small, medium, large) enterprise. Then, the average governance efficiency of governance mode i in enterprise n is obtained, and the average governance efficiency is 21. The formula is as follows:

$$\bar{u}_i^n = \frac{u_{i,1} + u_{i,2} + \cdots + u_{i,n}}{i}$$

Thus, the columnar relationship diagram of governance efficiency u_i^n and governance mode type i of various private listed companies at different scales is established, as shown in table 8, table 9 and table 10.

Tab 8. Relationship chart of governance mode and governance efficiency of private listed companies at the early stage of growth

Governance mode	Governance efficiency
Strong equity and strong manpower	10
Strong equity and medium manpower	10
Strong equity and weak manpower	11.4
Medium equity and strong manpower	9
Medium equity and medium manpower	13
Medium equity and weak manpower	10.5

Weak equity and strong manpower	8
Weak equity and medium manpower	10
Weak equity and weak manpower	10

In table 8, among all kinds of private listed companies' governance modes at the small level, the governance efficiency of the "moderate equity and moderate manpower" governance mode is the highest. Therefore, it can be inferred that the "moderate equity and moderate manpower" governance mode is the most effective governance mode for small private listed companies.

Tab 9. Relationship chart of governance mode and governance efficiency of private listed companies at the middle stage of growth

Governance mode	Governance efficiency
Strong equity and medium manpower	10
Strong equity and weak manpower	9.75
Medium equity and strong manpower	10
Medium equity and medium manpower	12
Medium equity and weak manpower	9.75
Weak equity and medium manpower	10

In table 9, among all kinds of governance modes of private listed companies in the medium category, the governance efficiency of the "moderate equity and moderate manpower" governance mode is the highest. Therefore, it can be inferred that the "moderate equity and moderate manpower" governance mode is the most effective governance mode for medium private listed companies.

Tab 10. Relationship chart of governance mode and governance efficiency of private listed companies at the later stage of growth

Governance mode	Governance efficiency
Strong equity and weak manpower	11
Medium equity and strong manpower	9.8
Medium equity and medium manpower	13
Medium equity and weak manpower	9
Weak equity and strong manpower	9
Weak equity and medium manpower	10.3

In table 10, among all kinds of governance modes of private listed companies in the large category, the governance efficiency of the "moderate equity and moderate manpower" governance mode is the highest. Therefore, it can be inferred that the "moderate equity and moderate manpower" governance mode is the most effective governance mode for large

private listed companies.

In summary, the "moderate equity and moderate manpower" governance mode is the most effective governance mode for private listed companies. This indicates that to achieve optimal governance efficiency, private listed companies must implement collaborative governance of human capital and equity capital. Regardless of whether the equity capital governance intensity is too high or too low or the governance intensity of human capital is too high or too low, the optimal governance efficiency of private listed companies cannot be achieved. Excessive governance intensity of equity capital leads to "one dominant share" and "insider control". The actual controller (or family) is excessively centralized, tends to be opinionated when making business decisions and cannot brainstorm. Additionally, an excessive monopoly of the actual controller (or family) reduces the working enthusiasm of professional entrepreneurs, increases the transaction cost within the enterprise, and reduces the efficiency of enterprise governance. If the human capital governance intensity is too high, professional entrepreneurs have too much power, and opportunism easily forms. To pursue higher personal interests, professional entrepreneurs damage the interests of enterprises, leading to the decline of enterprise governance efficiency. The collaborative governance of human capital and equity capital can effectively integrate the advantages of the two and prevent the actual controller (or family) or professional entrepreneur from reducing the efficiency of corporate governance. Equity diversification and professional management make the corporate governance structure more optimized, which is conducive to improving corporate governance efficiency.

5. Conclusions and prospects

The BP neural network mode is established for China's private listed company governance pattern identification by using the multi-layer forward feedback algorithm of error back propagation. This paper analyses the evolution of the governance mode at different scales, classifies various governance modes, and compares its efficiency. The following conclusions can be obtained.

First, this paper divided the governance modes of private listed companies into 9 categories from the two dimensions of equity capital and human capital. Taking the governance index as the input vector and the governance mode as the output vector, the BP neural network mode is built to accurately identify all kinds of different scales of private listed company governance mode.

Second, through the analysis of the evolution of private listed companies' governance mode and the classification analysis of various governance modes in the small, medium and large categories, the evolution trend of private listed companies' governance mode is roughly "L". Private listed companies in the small, medium and large categories choose "strong equity and weak manpower", "moderate equity and moderate manpower" and "weak equity and moderate manpower" governance modes, respectively.

Third, this paper comparatively analyses the governance efficiency of private listed company governance modes at different scales. The results show that "moderate equity and moderate manpower" is the most effective governance mode, indicating that it is not desirable for China's private listed companies to emphasize the dominant governance of equity capital

or human capital. It is the best choice to use the cooperative governance mode of human capital and equity capital.

This paper has carried out exploratory research on private listed company governance from the aspects of human capital and equity capital synergy that enriches the existing research achievements of private listed company governance, broadens the thinking of follow-up researchers and innovatively constructs a BP neural network mode of private listed company governance (in figure 2) and the governance grid mode (in figure 3). The BP neural network mode is used to study the private listed company governance mode, which enriches the research methods. Additionally, China's private enterprise is rooted in traditional culture. Regarding the choice of governance mode, the influence of traditional Chinese Confucian culture is very high. The professional manager market is not mature at the present stage in China, the financial market order is imperfect, and the trust mechanism between entrepreneurs and professional entrepreneurs is not fully established, leading to the construction of a feasible cooperative governance mode of equity capital and human capital being hindered. I will continue to explore this concept, broaden the research objects and conduct research on small, medium and micro-sized enterprises, family enterprises, etc., in the hopes of exploring the best governance mode for all kinds of private enterprises.

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