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Wenyan Liu
School of Business, Hunan University of Science and Technology, China, lwy_19971128@163.com

Zhenjin Li
Hunan University of Finance and Economics, Changsha 410205,China, zehnjinli@yeah.net

Zhi-qiang Zhou
School of Business,Hunan University of Science and Technology,Xiangtan 411201,China, zzq0007@hnust.cn

Shun Li
Xiangtan university, Xiangtan 411201,China, lishuntop2021@163.com

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Comprehensive Benefit Evaluation and Regional Difference Research of State-owned Mixed-ownership Enterprises

Wenyan Liu[1] Zhenjin Li[2] Zhiqiang Zhou[3] & Shun Li[4]
[1&3]School of Business, Hunan University of Science and Technology, Xiangtan 411201, China
[2]Hunan University of Finance and Economics, Changsha 410205, China
[4]Xiangtan University, Xiangtan 411201, China
lwy_19971128@163.com , zzq0007@hnust.cn, Zehnjinli@yeah.net, lishuntop2021@163.com

Abstract-Scientific and accurate assessment of the comprehensive benefits and regional differences of state-owned mixed-owned enterprises is an important link in promoting the steady progress of mixed-ownership reform of state-owned enterprises and achieving high-quality development of the state-owned economy. Using factor analysis method and GA-BP neural network model to evaluate the comprehensive benefits of listed state-owned mixed enterprises, the results show that, first, the main factors affecting the comprehensive benefits of state-owned mixed enterprises are profitability factor, sustainability factor and solvency factor, and the effect is as follows: profitability factor>sustainability factor>solvency factor; second, factor analysis effectively improves the evaluation performance of the GA-BP neural network model. Further analysis of regional differences, it is found that the average comprehensive benefit of regional state-owned mixed enterprises is: eastern region > central region > western region. Among them, the profitability factor and solvency factor are as follows: eastern region>central region>western region, and the size of sustainability factor is: eastern region>western region>central region. Therefore, we can start from deepening the classification reform of state-owned enterprises, increasing investment in innovation, reducing financial leverage, and improving regional linkages, so as to improve the profitability, solvency and sustainability of enterprises, narrow regional differences, and achieve coordinated development between regions.

Keywords: State-owned mixed enterprises; Factor analysis; GA-BP neural network; Regional differences

1. Introduction

General Secretary Xi Jinping clearly pointed out in the "Report of the 19th National Congress of the Communist Party of China": "Deepen the reform of state-owned enterprises, insist on developing a mixed-ownership economy, and cultivate world-class enterprises with global competitiveness". With the continuous deepening of mixed-ownership reform, since 2016, the National Development and Reform Commission and the State-owned Assets Supervision and Administration Commission have launched 4 batches of 208 mixed-ownership reform pilot enterprises. Among them, the enterprises that have

completed the main tasks of the pilot program have an average increase of more than 20% in state-owned capital equity, and their revenue is higher than the reform. The previous average growth rate was 33.9%, indicating that China's state-owned enterprise mixed ownership reform (hereinafter referred to as "state-owned enterprise mixed reform") is advancing in an orderly manner and has achieved remarkable achievements. State-owned enterprises and state-owned mixed enterprises are the backbone and lifeblood of the national economy, and the improvement of their comprehensive benefits is of great significance to the smooth operation of the entire national economy and the realization of common prosperity. Therefore, scientifically and accurately assessing the comprehensive benefits of state-owned mixed-owned enterprises and identifying the key factors affecting the benefits are an important part of examining the effect of mixed-ownership reform of state-owned enterprises and providing the basis for decision-making on mixed-ownership reform of state-owned enterprises and the high-quality development of the state-owned economy, and an important theory that needs in-depth research and realistic issues.

At present, China's economic growth is of great significance to world economic development[1].However, due to the differences in natural conditions, development history, human geography and national regional economic development strategies among different regions in China, regional imbalance in China's economic development has become a prominent problem. In particular, some scholars have found that the achievements of China's rapid economic development over the past 30 years have been unfairly distributed among different regions, which has largely resulted in regional inequality [2]. As the economic subject of regional development, the increasingly aggravated regional differences will inevitably lead to the inequality of the development status and comprehensive benefits of regional state-owned enterprises, thus leading to the obstruction of China's overall economic development. With the deepening of the mixed reform of state-owned enterprises, the participation of private enterprises and other non-public enterprises, what is the impact on the comprehensive benefits of state-owned enterprises? Will it help narrow regional development disparities? These are questions that need to be answered, but the existing literature has not dealt with this question. Therefore, to explore the comprehensive benefit of state-owned mixed companies in different regions of the differences, can not only deepen and enrich the current studies, also helps to explore the objective laws of economic development, for the government and the enterprise related department put forward the corresponding policy recommendations, so as to further deepen the state-owned enterprises to change, narrow the regional difference, improve the overall level of economic development.

In view of this, this paper constructs the comprehensive benefit evaluation index system of state-owned mixed enterprises, uses the method of combining factor analysis and GA-BP neural network model to evaluate the comprehensive benefits of state-owned mixed enterprises, and compares and analyzes the state-owned mixed enterprises in the eastern, central and western regions. The average comprehensive benefit difference of enterprises

and the average score difference of main influencing factors. Compared with the traditional parameter model method, the neural network model is more flexible and effective, and can effectively estimate various complex functions. The reason why this paper uses the GA-BP neural network model is that the BP neural network has the problem of slow convergence speed and easy to fall into local optimum. The GA-BP neural network model optimized by genetic algorithm is introduced, which has fast convergence speed and good calculation effect. Improve the prediction accuracy and network performance of the BP neural network model, and reduce the algorithm error and its fluctuation range.

2. Literature Review

Improving the comprehensive benefits of state-owned mixed-owned enterprises is one of the important goals of mixed-ownership reform of state-owned enterprises. For this reason, the academic community has carried out beneficial explorations on the topic of mixed-ownership reform of state-owned enterprises by taking state-owned mixed-owned enterprises as the research object. For example, Avner[3] and Kevin[4] confirmed that the mixed ownership reform of state-owned enterprises is conducive to improving the enterprise management system and maintaining the stability of the macro system. The research of Ma Ning and Ji Xinlong [5, 6] found that the mixed ownership reform of state-owned enterprises can effectively reduce the risk level of enterprises, keeping their systemic risk and financial risk at a low level. However, scholars have different conclusions on whether SOE mixed reform improves corporate performance and how it has an impact. Zhou Guanping [7] pointed out that mixed-ownership reform is conducive to improving the profitability of state-owned enterprises, and improving the profitability of state-owned enterprises by optimizing the incentive mechanism. Wu Qiusheng and Du Zhengyuan [8] proposed that mixed ownership reform of state-owned enterprises is beneficial to alleviate the high debt problem of state-owned enterprises, but the government's invisible guarantee will restrain this effect to a certain extent.Yang Xingquan and Yin Xingqiang [9] proposed that mixed ownership reform improved the cash holdings of state-owned enterprises, and further confirmed that mixed ownership reform can significantly improve corporate performance [10].However, there are also views that the relationship between mixed ownership reform and the benefits of state-owned enterprises is in an inverted "U" shape. Only in a perfect institutional environment, the effect of mixed ownership reform on performance improvement is significant, and the positive effect of foreign shareholders is significantly better. Regarding private shareholders [11], some scholars have found that pure mixed-ownership reform cannot substantially improve corporate performance [12]. It is not difficult to see that the academic community has not reached a consensus on the benefits of the mixed reform of state-owned enterprises, which needs to be further verified.

In addition, as a microscopic manifestation of state-owned mixed reform, the scientific evaluation of its comprehensive benefits is the key to promoting mixed reform of state-owned enterprises and promoting the high-quality development of the state-owned economy. Relevant literature is rare, but some scholars have evaluated the benefits of state-

owned enterprises. provide useful evidence for this article.Yu Liangchun[13], Xie Zhi[14], Huang Qunhui, Yu Jing[15], Yang Jing[16] and other scholars have evaluated the benefits of state-owned enterprises based on the perspective of corporate debt, and the results all show that state-owned enterprises have low economic benefits , the overall operating efficiency is low, the financial leverage ratio and the asset-liability ratio remain high, and further research shows that compared with other types, large state-owned enterprises, state-owned enterprises affiliated to government agencies, service-oriented state-owned enterprises, competitive state-owned enterprises and state-owned enterprises in the western region More debt and higher leverage [17].Based on the three index dimensions of profitability, development and efficiency, the research group of state-owned enterprise operating efficiency research group et al. evaluated and analyzed the operating efficiency of state-owned enterprises, and the results confirmed that the profitability of state-owned enterprises in different industries and different regions needs to be improved[18].Some scholars further incorporate profitability into the SOE benefit evaluation system while considering liabilities. For example, Wezel T and Carvalho N [19] found that nearly half of state-owned enterprises are not profitable, and the larger companies also suffer from a lack of liquidity and excessive leverage, which affects the sustainability of the debt stock. Gao Taishan [20] used factor analysis method to evaluate the economic benefits of state-owned enterprises in China from the aspects of liabilities and profits, and found that the benefits of state-owned enterprises showed a fluctuating upward trend, which is consistent with the research conclusions of Long Axe and Wang Jinchao[21], that is, that the low efficiency of state-owned enterprises is a pseudo-scientific proposition. Considering the singleness of the above financial indicators, some scholars have evaluated the benefits of state-owned enterprises from non-financial perspectives such as the overall competitiveness and decision-making power of enterprises. For example, Lin C et al. [22] conducted a comprehensive evaluation of the international competitiveness of the marine industry in China, Japan and the United States based on the constructed marine industry international competitiveness evaluation index system, and found that the overall international competitiveness of China's state-owned technology enterprises is relatively weak. Wang et al. [23] used the DEA model to evaluate the intelligent decision support system of state-owned enterprises, showing that the efficiency of state-owned enterprises is low, and gave the optimal decision-making scheme. Du Fei et al. [24] conducted subjective performance evaluation of state-owned enterprises and found that the new measurement standard would create fairness issues, prompting supervisors to consider personal preferences in the subjective performance evaluation process.

To sum up, some scholars have explored the benefits of state-owned mixed-ownership reform (state-owned mixed-owned enterprises) and its influencing factors. The comprehensive evaluation of state-owned mixed enterprises is still relatively lacking, and it is urgent to strengthen research. Existing research mainly evaluates from a financial perspective. This paper believes that it is difficult to evaluate the overall situation of enterprise development based solely on

financial indicators, and it is necessary to incorporate financial indicators and non-financial indicators into the same evaluation system. This paper refers to the existing research results and uses solvency and profitability as financial evaluation indicators. For non-financial evaluation indicators, the main consideration should be the long-term development ability that can ensure the long-term prosperity of the enterprise in the fierce market competition, and whether the enterprise can achieve long-term development is rooted in its sustainable development ability. It has an important impact on the sustainable development of the economy, society and the natural environment [25].Therefore, sustainable development capability should be regarded as an important dimension for evaluating the comprehensive benefits of state-owned mixed enterprises, and innovation is the foundation and source of sustainable development. As the backbone of the national economy, state-owned enterprises assume the main responsibility for innovation and development. The measurement of the comprehensive benefits of state-owned mixed enterprises must not only be limited to the level of financial efficiency, but should also pay attention to whether the enterprise has the ability of sustainable development, especially the ability to invest in innovation [26]. Obviously, the existing literature does not pay enough attention to it. Based on this, this paper innovatively introduces the sustainable development dimension of enterprises into the evaluation model, and evaluates the comprehensive benefits of state-owned mixed enterprises from the three dimensions of profitability, solvency and sustainability, and clarifies the impact on state-owned mixed enterprises. The key factors of comprehensive benefits provide new ideas for deepening the mixed reform of state-owned enterprises.

Due to the differences in resource endowment, infrastructure, economic foundation and policy inclination among different regions in China, the regional economic development levels shown are significantly different. As the microscopic embodiment of the regional economy, the comprehensive benefits of enterprises will inevitably be affected by the macroeconomic environment impact. Some foreign scholars have found that the regional environment will directly affect the innovation ability and innovation efficiency of enterprises and the effect will be heterogeneous due to regional economic development or institutional differences [27, 28]. Factors such as the level of development and different income levels [29] will have different impacts on the development of enterprises. Domestic scholars have pointed out that there are obvious regional differences in the growth effect of new industrialization in China's inland and coastal areas, and between the east and the west, and the polarization pattern is obvious [30]. There are also obvious problems such as low economic efficiency and excess capacity of state-owned enterprises. Regional differences, in general, the benefits of SOEs in North and Northeast China lag behind those in East and South China [31, 32].It can be seen that the regional differences in the development of China's state-owned enterprises are relatively significant, and there are few studies on regional differences in the evaluation of comprehensive benefits of state-owned enterprises. Therefore, a systematic analysis of the regional differences in the comprehensive benefits of state-owned enterprises, especially state-owned mixed

enterprises, has important theoretical and practical significance for guiding the reform of local state-owned enterprises, promoting the coordinated development of regional enterprises, and driving the high-quality development of the overall economy.

Based on this, this paper conducts a systematic study on the comprehensive benefit evaluation and regional differences of state-owned mixed enterprises. The possible theoretical contributions and practical values are as follows: First, to achieve the goal of high-quality development of the state-owned economy, the key is to accurately and scientifically evaluate the comprehensive benefits of state-owned mixed enterprises. This paper uses a combination of factor analysis and GA-BP neural network. The method of evaluating the comprehensive benefits of state-owned mixed enterprises can effectively reduce the subjectivity of evaluation and improve the accuracy and scientificity of evaluation; second, introducing the dimension of sustainable development into the evaluation model makes the comprehensive benefit evaluation of state-owned mixed enterprises more comprehensive, accurate and scientific. At the same time, the index system screened by correlation analysis and principal component analysis is more consistent with the research in this paper; Third, comparatively analyze the regional differences in the development of state-owned mixed enterprises, analyze the reasons for the regional differences, and provide theoretical basis and practical guidance for narrowing the regional differences in the development of state-owned mixed enterprises and realizing the coordinated development between regions.

3. Model Building and Data Sources

3.1. Data Sources

3.1.1. Data acquisition and classification

The data used in this article are all from the official website of Flush Finance and Economics. Relevant data were obtained from the 2017 annual report of state-owned mixed enterprises by manual collection, and 602 samples were obtained, excluding ST, *ST samples and missing value samples, a total of 290 samples, and the remaining valid samples 312, numbered 1-312 respectively.

Refer to the regional division standards of existing literature [33], see Table 1 for details, excluding Hong Kong, Macao and Taiwan.

According to Table 1, the effective samples are divided into regions, and the number of state-owned mixed enterprises in the eastern, central and western regions is 216, 19 and 77 respectively.

3.1.2. Index system construction

Referring to the index system [34, 35] of the existing relevant research results, the preliminary framework of the index system in this paper is obtained, supplemented by Spss24.0 to carry out correlation analysis and principal component analysis on the preliminary index, excluding those with small correlation and load lower than the index variable of 0.3 is obtained, and the comprehensive benefit evaluation index system of state-owned mixed enterprises is obtained, as shown in Table 2.

Tab1. Division of Chinese Regions

Area	Province
East	Beijing, Tianjin, Shanghai, Liaoning, Jiangsu, Fujian, Shandong, Zhejiang, Guangdong, Hainan
Central	Hebei, Shanxi, Inner Mongolia, Jilin, Jiangxi, Hunan, Hubei, Henan, Heilongjiang, Anhui
West	Guangxi, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Xinjiang, Ningxia, Sichuan, Chongqing, Tibet

Tab2. The Comprehensive Benefit Evaluation Index System of State-owned Mixed Enterprises

	Indicator variable	Indicator Variable Definition
The Comprehensive Benefit Evaluation Index System of State-owned Mixed Enterprises	X_1:current ratio	Current Assets/Current Liabilities
	X_2:Assets and liabilities	Total Liabilities/Total Assets
	X_3:cash flow ratio	Annual Operating Cash Flow/Current Liabilities
	X_4:Roe	Net Profit/Average Net Assets
	X_5:dividend per share	Total cash dividends on ordinary shares/total number of ordinary shares at the end of the year
	X_6:net assets per share	Shareholders' equity at the end of the year/total number of ordinary shares at the end of the year
	X_7:Proportion of researchers	Total R&D personnel/Total number of companies
	X_8:R&D expenditure ratio	R&D expenditure/operating income

As shown in Table 2, the comprehensive benefit evaluation index system of state-owned mixed enterprises includes 8 index variables. Among them, the current ratio, asset-liability ratio and cash flow ratio all reflect the size of the company's solvency. The larger the current ratio and the cash flow ratio, the stronger the company's solvency, and vice versa, the weaker the company's solvency;The asset-liability ratio is a comprehensive indicator that reflects the solvency of an enterprise. Within a reasonable range, the higher the asset-liability ratio, the stronger the ability of the enterprise to borrow and operate, and the stronger the solvency of the enterprise, and vice versa weaker ability. The return on equity, dividend per share and net assets per share all reflect the size of the profitability of the company, profitability is weaker. The proportion of scientific research personnel and the proportion of R&D expenditures both reflect the size of the company's sustainable capacity.

In the above indicator system, due to the inconsistency of the dimensions of the original data among the indicator variables, it is impossible to directly calculate the comprehensive benefit. In order to eliminate the influence of dimension, the original data of the indicator variables are processed without dimension, and the formula is as follows:

$$x_{ij}^{'} = \frac{x_{ij} - min_j(x_{ij})}{max_j(x_{ij}) - min_j(x_{ij})} \quad (1)$$

Among them, i=1,2,...,8，j=1,2,…,312, x_{ij}represents the i index, the original value of the j sample.

3.2. Model building

This paper adopts the method of combining factor analysis and GA-BP neural network model to evaluate the comprehensive benefits of state-owned mixed enterprises. Therefore, the model construction mainly includes the construction of factor analysis model and GA-BP neural network model.

3.2.1. Factor analysis model

Factor analysis is a statistical method to extract common factors from index variables, aiming at describing the hidden variables hidden in index variables, which are more basic but cannot be measured directly.

The main principles of the factor analysis model are as follows: Firstly, the common factors in the index variables are extracted through factor analysis, and the weight of each common factor is calculated according to the proportion of the contribution rate of each common factor to the cumulative contribution rate. Then, the synthetic evaluation function is constructed by summing the product of weights and corresponding common factors. When the load of principal component matrix is difficult to explain, it is necessary to carry out orthogonal transformation of the load matrix, namely rotation, to obtain the rotated principal component matrix, which has a simpler structure and reduces the difficulty of factor interpretation. Therefore, compared with principal component analysis, factor analysis has stronger maneuverability and more obvious advantages in explaining factors. At the same time, the new principal component matrix obtained by rotation transformation endows factor interpretation with new economic connotation and has more practical significance.

On the basis of introducing the main principle of factor analysis model, the general operation steps of factor analysis model are further introduced as follows:

First, index variables are selected. The index variable system was determined by principal component analysis and correlation analysis combined with existing research literature. Meanwhile, the index variables were dimensionless.

Secondly, according to the determined index variable system, the representative factor variable is selected comprehensively by calculating the correlation coefficient matrix between the index variables. This article USES the KMO inspection and Bartlett spherical degree index variable calculates the correlation coefficient matrix, KMO test values for the [0, 1], the closer the value 0, said is not suitable for factor analysis, the closer the value 1, said the more suitable for factor analysis, typically, when the value is greater than 0.5, conform to the requirements of the factor analysis; Bartlett's sphericity test is based on the correlation coefficient matrix of indicator variables, and its statistics are obtained according to the determinant of the correlation coefficient matrix. When the significance probability of test statistics is less than 0.05, it indicates that the requirement of factor analysis is met.

Then, on the basis of KMO test and Bartlett's sphericity test, the factor variables are determined and the factor loading matrix is calculated. Under normal circumstances, the factor load matrix calculation method is the maximum variance orthogonal rotation method; this paper also uses this method to solve the factor load matrix.

Finally, factor variable scores are calculated. The formula is as follows:

$$F_i = \sum_{j=1}^{n} a_{ij} * x_{ij}^{'} \quad (2)$$

Where F_i represents the score of the i factor variable, a_{ij} represents the load of the j index variable in the i factor variable, $x_{ij}^{'}$represents the value of the dimensionless index variable.

Then the comprehensive score is obtained by weighted sum of factor variables. The formula is as follows:

$$\mathrm{F} = \sum_{i=1}^{m} w_i * F_i \quad (3)$$

Where, F represents the comprehensive score, and w_i represents the weight of the i factor variable.

3.2.2. Ga-bp neural network model

Ga-bp neural network model is a neural network model obtained by optimizing the weights and thresholds of BP neural network model using genetic algorithm. See Figure 1 for the operation process of GA-BP neural network model.

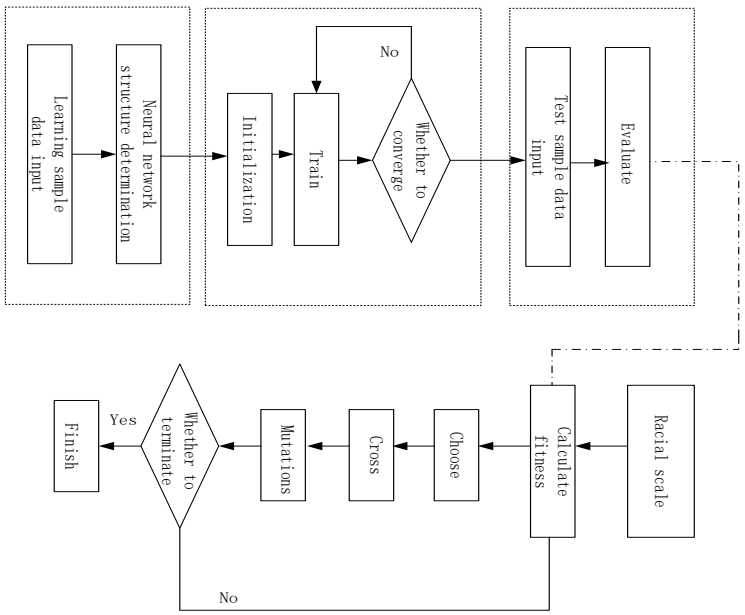

Fig 1. Operation flow of GA-BP neural network model

As can be seen from Figure 1, the operation process of GA-BP neural network model includes two parts: BP neural network model construction and genetic algorithm optimization. Therefore, the general operation steps of GA-BP neural network model are as follows:

First, the structure of BP neural network model is determined. If the input vector is: $X_k = \left(x_1^k, x_2^k, \ldots\ldots, x_n^k\right)$, the output vector is: $Y_k = \left(y_1^k, y_2^k, \ldots\ldots, y_m^k\right)$, according to the empirical formula: $l = \sqrt{n+m} + a$, where $a \in [1,10]$, the number of hidden layer nodes can be obtained, and then the topological structure of BP neural network model can be determined as $n - l - m$.

Secondly, genetic algorithm is used to optimize the weights and thresholds of BP neural network model. Firstly, the individual is coded and the sum of fitness is calculated: $F = \sum_{i=1}^{n} f\left(x_i^k\right)$, and then the relative fitness of the individual is obtained: $p_i^k = \frac{f\left(x_i^k\right)}{F}$, that is, the genetic probability. Secondly, Russian roulette is used to generate random numbers between [0,1] to determine the number of times an individual is selected. The more times an individual is selected, the greater the probability of survival. Then, the arithmetic crossover operator is used to cross combine each individual, the formula is: $c_i = c_m a + c_n(1-a)$, $c_j = c_m(1-a) + c_n a$, where c_m、c_n are a pair of individuals, and c_i、c_j are the new individuals obtained by cross combination. Finally, the weight ω_{nl} and threshold θ_i between the hidden layer and the input layer were obtained by decoding the mutant new individuals. Weight ω_{lt} and threshold μ_r between hidden layer and output layer.

Third, according to the weight ω_{nl} and threshold θ_i between the optimized hidden

layer and the input layer, the net input value of the hidden layer is obtained as follows: $s_i^k = \sum_{i=1}^{n} \omega_{nl} * x_i^k - \theta_i$, and then through the hidden layer activation function $f_1(.)$. , get the output value of the hidden layer: $z_i^k = f_1(s_i^k)$.

Fourthly, according to the weight ω_{lt} and threshold μ_r between the optimized hidden layer and the output layer, the net input value of the output layer is obtained as follows: $c_r^k = \sum_{r=1}^{m} \omega_{lt} * z_r^k - \mu_r$, and then the output layer activation function $f_2(.)$, the output value of the output layer: $h_r^k = f_2(c_r^k)$.

Fifthly, according to the output result and the expected result, the single sample error is solved: $e_r^k = y_r^k - h_r^k$, and then by the sum of squares error function, the global error is obtained: $e = \frac{1}{2}\sum_{r=1}^{n}(e_r^k)^2$.

Sixth, compare the global error with the error threshold. If the global error is greater than the error critical value, the weight is adjusted, wherein, the weight change of the output layer and the hidden layer is: $\Delta\omega_{lt} = e^{'}\eta f_2^{'}(c_r^k)z_i^k$; The change of the hidden layer and input layer has a weight adjustment is: $\Delta\omega_{nl} = e^{'}\eta f_1^{'}(s_i^k)\omega_{lt} f_2^{'}(c_r^k)x_i^k$.

Seventh, repeat the iteration until the global error is less than the error critical value, that is, the model convergence, then ga-BP neural network model construction is completed.

3.2.3. Training process of GA-BP neural network

The structure of GA-BP neural network is composed of one input layer, one output layer and one or more hidden layers. In this paper, the three common factors of dimensionality reduction processing are taken as the input of the model, and the comprehensive benefit of state-owned mixed enterprises is taken as the output. The input layer node is 3, the hidden layer node is 5, and the output layer node is 1. The three-layer BP neural network model is established. The training process is shown in Figure 2.

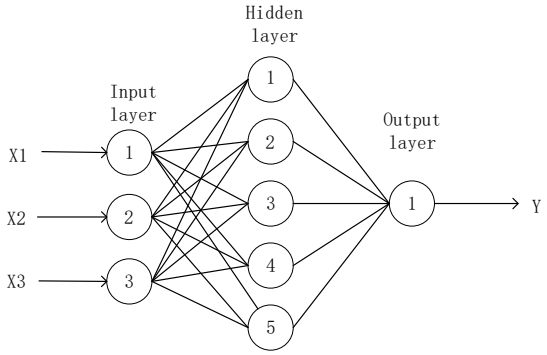

Fig 2. Training process of GA-BP neural network

In the calculation process, firstly, the three factors of profitability, sustainability and solvency are taken as the three nodes of the input layer, and each group of data enters the

hidden layer after input. Each node of the hidden layer carries out linear superposition of each entry data with weight and adds threshold, and the results obtained are taken as the input of the node of the hidden layer. Then the input of hidden layer node is substituted into the transfer function to get the output of hidden node, and then the output of all hidden layer nodes can be calculated. The output result of the output layer is calculated by the same method, namely the comprehensive benefit of the state-owned mixed enterprise in this calculation. Then the performance estimation function is used to evaluate. If the error is not within the allowable range set, the signal will be given back feedback, and the weights and thresholds of each layer of the network will be adjusted by the learning function and then the calculation will be recalculated. This is repeated until the error enters the target error range or reaches the maximum number of iterations. The comprehensive benefit evaluation model of state-owned mixed enterprises is obtained, and the existing input data is used for evaluation.

4. Comprehensive Benefit Measurement

4.1. KMO and Bartlett tests

Firstly, KMO and Bartlett tests were performed on variable indicators, and the results are shown in Table 3.

Tab3.KMO and Bartlett test results

Sample enough measurements	KMO	0.575
Bartlett's sphericity test	The approximate chi-square	522.590
	Degrees of freedom	28
	Significant	0.000

According to the results in Table 3, the KMO value is 0.575, greater than the critical value of 0.5. Meanwhile, in Bartlett's sphericity test, the approximate Chi-square is 522.590, the degree of freedom is 28, and the significance probability is 0.000, indicating that there is a strong correlation between indicator variables. In general, it meets the basic conditions of factor analysis and can carry out factor analysis.

4.2. Factor analysis

Then, the factor analysis is used to calculate the comprehensive benefits of state-owned mixed enterprises, and spSS24.0 is used for auxiliary calculation. The total variance of the interpretation is shown in Table 4.

Tab4. Total variance of interpretation

Composition	Initial eigenvalue			Extract the sum of squares of loads			Sum of squares of rotational loads		
	Total	The variance %	The cumulative %	Total	The variance %	The cumulative %	Total	The variance %	The cumulative %
1	2.137	26.710	26.710	2.137	26.710	26.710	1.911	23.889	23.889
2	1.789	22.368	49.079	1.789	22.368	49.079	1.739	21.731	45.620
3	1.284	16.055	65.134	1.284	16.055	65.134	1.561	19.514	65.134
4	0.839	10.488	75.622						
5	0.717	8.959	84.581						
6	0.578	7.219	91.799						
7	0.349	4.361	96.161						
8	0.307	3.839	100.000						

According to the results in Table 4, the eigenvalues of the first three components are all greater than 1. According to the principle that the eigenvalues are greater than 1 in factor analysis, the first three components are selected as the common factors of indicator variables. Moreover, the results also show that the cumulative percentage of the first three components after rotation is 65.134%, greater than 60%, indicating that the first three components contain most of the information of the index variables, basically meeting the requirements, and the conclusion is acceptable. Meanwhile, the component matrix after rotation of indicator variables is obtained, as shown in Table 5.

Tab5. The rotated component matrix

Indicator variables	Composition		
	1	2	3
Return on equity	0.714	0.032	0.180
Dividend per share	0.865	-0.080	0.187
Net asset per share	0.774	-0.031	-0.122
Proportion of research staff	-0.008	0.916	-0.035
R&DExpenditure ratio	-0.048	0.900	0.069
Current ratio	-0.013	0.247	0.778
Asset-liability ratio	-0.022	0.023	-0.681
Cash flow ratio	0.226	-0.145	0.636

According to the results in Table 5, the actual economic significance of the three common factors can be learned. Among them, component 1 has a high load on the three index variables of return on net assets, dividend per share and net assets per share, indicating that component 1 contains a lot of information of these three index variables. Therefore, component 1 is named as profitability factor. Component 2 has a high load on the proportion of scientific research personnel and proportion of R&D expenditure, indicating that component 2 contains a lot of information of these two index variables. Therefore, component 2 is named as the sustainability factor. Component 3 has a high load on the three index variables of cash flow ratio, liquidity ratio and asset-liability ratio, indicating that component 3 contains a lot of information of these three index variables. Therefore, component 3 is named as the solvency factor.

According to the rotated component matrix and dimensionless index variable data, the formula for calculating the standardized values of the three common factors is as follows:

$$F_1 = 0.226X_3+0.714X_4+0.865X_5+0.774X_6-0.008X_7-0.048X_8-0.013X_1-0.022X_2 \quad (4)$$

$$F_2 = -0.145X_3+0.032X_4-0.080X_5-0.031X_6+0.916X_7+0.90X_8+0.247X_1+0.023X_2 \quad (5)$$

$$F_3 = 0.636X_3+0.180X_4+0.187X_5-0.122X_6-0.035X_7+0.069X_8+0.778X_1-0.681X_2 \quad (6)$$

According to the rotated component matrix and the interpreted total variance, the relationship between the three common factors and index variables and the weight of each common factor can be obtained, as shown in Table 6.

Tab6. The relationship between common factors and index variables

Common factor	Indicator variables	The weight
F_1	X_4:Return on equity X_5:Dividend per share X_6:Net asset per share	0.37
F_2	X_7:The proportion of scientific research personnel X_8:R&D Expenditure ratio	0.33
F_3	X_1:Current ratio X_2:Asset-liability ratio X_3:Cash flow ratio	0.30

According to the result of table 6, the profit ability factor, sustainable ability factor and solvency factor weights of 0.37, 0.33 and 0.30, respectively, showed the profit ability

factor to state-owned enterprise had the greatest influence the comprehensive benefit of scoring, followed by the sustainable ability factor, the effects of minimum solvency, suggests that the state-owned enterprise to improve the comprehensive benefit, First, it is necessary to improve the profitability of enterprises, then attach importance to the sustainable development of enterprises, and then it is necessary to strengthen the solvency of enterprises. At the same time, the calculation formula of comprehensive benefits of state-owned mixed enterprises is as follows:

$$F = 0.37F_1 + 0.33F_2 + 0.3F_3 \quad (7)$$

On the basis of factor analysis, the dimensionless index variable data are substituted into the formula for calculating the standardized value of common factor and the formula for calculating the comprehensive benefit of state-owned mixed enterprises, and the common factor score and comprehensive benefit score of 312 samples can be obtained.

5. Ga-bp Neural Network Simulation Verification

5.1. Learning and training of GA-BP neural network model

According to the common factor score and comprehensive benefit score of 312 samples obtained by factor analysis, ga-BP neural network model was further used for simulation test. The simulation test in this paper was implemented by matlab2014A programming.

Firstly, ga-BP neural network model is constructed and studied and trained. In the model, the activation function of the hidden layer is *Tan-sigmoid* function. Considering that the output values are not all within the interval [-1, 1], *purelin* function is used as the activation function of the output layer, the first 302 groups of samples are selected as learning samples, the common factor score is taken as the input variable, and the comprehensive benefit score is taken as the output variable. Under the training of *Levenberg-Marquardt* algorithm, the convergence effect is the best when the number of hidden layer nodes is 10. Therefore, the 3-10-1 GA-BP neural network model is constructed. After repeated learning and training, the one with the smallest global error was reserved for the test of the remaining 10 groups of samples. The GA-BP neural network model with 10 hidden layer nodes converges after 237 times of learning and training, and the global error is the smallest. See Figure 2 for the results. Then, test and verify. On the basis of full learning and training of ga-BP neural network model, the remaining sample data are used to test the model to verify whether the model has strong generalization ability. The test results are shown in Table 7.

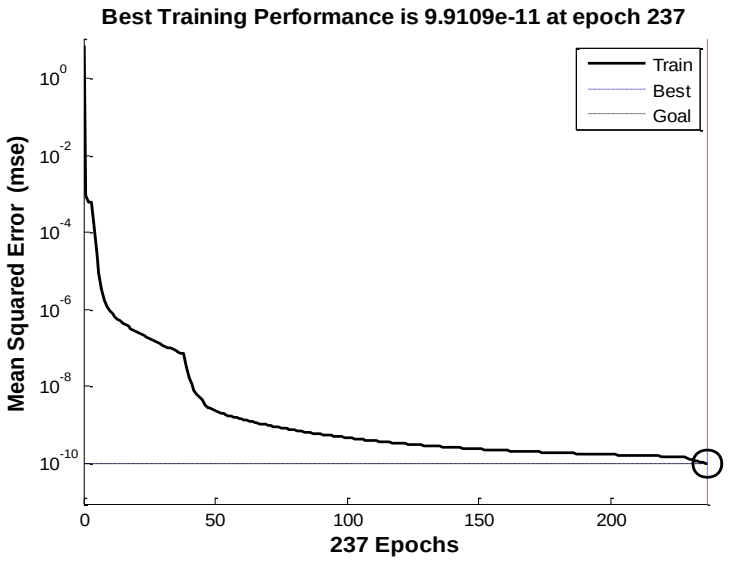

Fig 3. Training results of neural network model with hidden layer 10

Tab7. The simulation results of GA-BP neural network model are compared with the expected results

Serial number	The simulation results	Expect the result	Error	Serial number	The simulation results	Expect the result	Error
303	0.579613	0.579617	0.000004	308	0.556347	0.556344	0.000003
304	0.509307	0.509287	0.00002	309	0.602974	0.602970	0.000004
305	0.572997	0.572998	0.000001	310	0.678474	0.678475	0.000001
306	0.677281	0.677282	0.000001	311	0.614221	0.614227	0.000006
307	0.462990	0.462986	0.000004	312	0.902366	0.902361	0.000005

From the test results, it is found that the maximum error between the simulation results and the expected results is 0.00002, and the minimum error is 0.000001, both within a reasonable range and acceptable, which indicates that the model has strong generalization ability, and further indicates that the model has strong practical value.

5.2. Random learning and training of GA-BP neural network model

In order to verify the stability of ga-BP neural network model simulation results and ensures that the model has robust practical Value, the model was further tested by random simulation. Firstly, 302 samples were randomly selected from 312 sample sets, with the common factor score as the input variable

and the comprehensive benefit score as the output variable, to build the same 3-10-1 GA-BP neural network model as above, and conduct learning and training. After many times of learning and training, the one with the smallest global error is selected as the test of the remaining samples. Among them, ga-BP neural network model with hidden layer 10 converges after 219 times of learning and training, and the global error is the smallest. See Figure 3 for the results.

Then, the remaining 10 groups of samples were used to conduct random simulation tests on the model. The results are shown in Table 8.

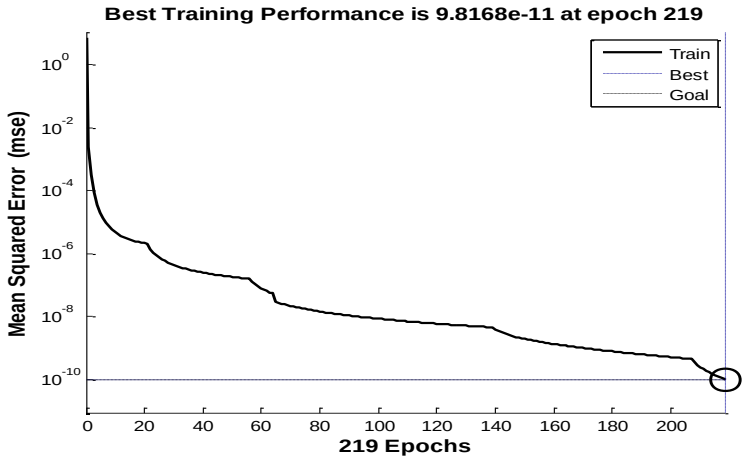

Fig 4. Random training results of neural network model with hidden layer 10

Tab8. The simulation results of GA-BP neural network model are compared with the expected results

Serial number	Random simulation results	Expect the result	Error	Serial number	Random simulation results	Expect the result	Error
001	0.477041	0.477050	0.000009	055	0.61869	0.61869	0
114	0.531703	0.531703	0	002	0.488096	0.488092	0.000004
003	0.54496	0.54495	0.00001	115	0.594781	0.594773	0.000008
116	0.565064	0.565049	0.000015	053	0.553256	0.553252	0.000004
054	0.747678	0.747687	0.000009	117	0.776341	0.776329	0.000012

According to the random test results, it can be found that the maximum error between the random simulation results and the expected results is 0.000015, and the minimum error is 0, both within a reasonable range and acceptable. It shows that the GA-

BP neural network model still has strong generalization ability under random condition, which verifies the stability of the simulation conclusion of the model and shows that the model has robust practical value. At the same time, it is shown that the interference of subjective factors to ga-BP neural network model simulation can be effectively reduced by factor analysis after data processing, so as to improve the evaluation performance of the model.

6. Regional Comparison

According to the obtained data and the regional division standard of east, West and Central China, the average comprehensive benefits of state-owned mixed enterprises in the east, central and west China are further compared and analyzed.

First, calculate the average comprehensive benefit score of different regions. Details are as follows:

If the sample set of state-owned mixed enterprises in region i isU_i, where

$U_i = (U_{i1}, U_{i2}, \dots\dots, U_{ij})$,$U_{ij}$ represents the comprehensive benefit score of the j sample in region i. By calculating the arithmetic mean value, the average comprehensive benefit score formula of each region can be obtained:

$$\overline{U_i} = \frac{\sum_{n=1}^{j} U_{ij}}{j} \quad (8)$$

Then, by substituting the comprehensive benefit score of state-owned mixed enterprises into the average comprehensive benefit score formula, the average comprehensive benefit score of each region can be obtained, as shown in Table 9.

According to the comparison of the average comprehensive efficiency scores of different regions, it can be found that the average comprehensive efficiency scores of the eastern region are much higher than that of the central region and the western region, and the average comprehensive efficiency scores of the central region are slightly higher than that of the western region. This phenomenon reflects that there are obvious regional differences in the development of state-owned mixed enterprises, which can be summarized as follows: the average development level of state-owned mixed enterprises in the eastern region > the average development level of state-owned mixed enterprises in the central region > the average development level of state-owned mixed enterprises in the western region. The possible reason is that there are significant differences in the degree of marketization development between regions. The marketization development degree in the eastern region is much higher than that in the central and western regions, and the marketization development degree in the central region is higher than that in the western region. The degree of marketization development is closely related to the improvement of total factor productivity [36], economic growth [37], technological progress [38] and many other factors. Compared with the central and western regions, eastern China has the strongest comprehensive strength with sufficient financial support, high-quality material and human resources, and strong scientific and technological foundation. Compared with the western region, the central

region has relatively full resource development and relatively complete infrastructure conditions. Therefore, the development environment of state-owned enterprises is better, leading to obvious regional differences in the development of state-owned mixed enterprises.

Further explore the differences of main influencing factors that lead to regional differences in the development of state-owned mixed enterprises, and use the same method above to obtain the average scores of profitability factor, sustainability factor and debt paying ability factor respectively. See Table 10 for the results.

Tab9. Comparison of average comprehensive benefit scores in different regions

Area	East	Central	West
Average comprehensive benefit score	0.6377	0.5937	0.5849

Tab10. Comparison of average scores of influencing factors in different regions

Area	East	Central	West
The average score of F_1	1.1348	1.1156	1.0741
The average score of F_2	0.2571	0.1888	0.2050
The average score of F_3	0.4434	0.3954	0.3390

According to the comparison of the average scores of influencing factors in different regions, it can be found that the average scores of profitability factors and debt paying ability factors are as follows: state-owned mixed enterprises in the eastern region > state-owned mixed enterprises in the central region > state-owned mixed enterprises in the western region. The reason may be that the process of market-oriented development is

consistent with the level of economic development. The difference in the process of market-oriented development in the east, central and western regions lead to the difference in the level of economic development in the east, central and western regions. The economic development level of the eastern region is significantly higher than that of the central region. The economic development level of the central region is significantly higher than that of the western region. The level of profitability and solvency of enterprises, as the micro basis of economic fluctuations [40], are consistent with the level of economic development [40]. Therefore, the average score of the profitability factor and the average score of the solvency factor reflect the law of eastern region > central region > western region.

The average score of sustainability factor is as follows: state-owned mixed enterprises in the eastern region > state-owned mixed enterprises in the western region > state-owned mixed enterprises in the central region. The reason may be that the degree of market-oriented development promotes the flow of labor [41]. The eastern region has a high degree of market-oriented development and developed economy, which not only gathers a large number of domestic talents, but also attracts a large number of foreign talents. Therefore, in terms of R&D talents, the eastern region has more advantages than the central and western regions; meanwhile, trust, as an important guarantee for the sustainable development of enterprises, is related to the degree of economic development. The more developed the economy is, the higher the degree of trust is [42], which supports the highest average score of the sustainability factor of state-owned mixed enterprises in eastern China. And appear in the western region is higher than the central region of this contrast is the cause of the phenomenon, is the national policy tilt, the western development strategy, the area along the strategy, and "the 19th report" in the country, the implementation of the strategy of rejuvenating in different extent, promote the talent to flow in the western region, to strengthen the western regions and central region for "siphon effect"., therefore, the central region, due to the effect of tilt of the national policy, the western region has more development of talent advantages, leading to the western region of state-owned mixed enterprise sustainable ability factor is higher than the average score of central state-owned mixed companies scored an average of the sustainability of factors, but also shows that under the condition of market economy system is not perfect, The government's macro policies have a more obvious effect on the improvement of enterprise sustainability.

7. Conclusions and Policy Recommendations

7.1. Conclusion

In this paper, factor analysis and GA-BP neural network model are used to evaluate the comprehensive benefits of state-owned mixed enterprises. On this basis, regional differences in the development of state-owned mixed enterprises are further studied and the following important conclusions are drawn:

First, through factor analysis, it is concluded that the main factors affecting the comprehensive benefits of state-owned mixed enterprises are profitability factor,

sustainability factor and debt paying ability factor. In addition, the influence of profitability factor > sustainability factor > solvency factor.

Secondly, factor analysis can effectively reduce the interference of subjective factors and improve the evaluation performance of GA-BP neural network model.

Third, there are regional differences in the development of state-owned mixed enterprises. The average development level of state-owned mixed enterprises in the eastern region > the average development level of state-owned mixed enterprises in central region > the average development level of state-owned mixed enterprises in western region.

Fourthly, among the main factors that lead to regional differences in the development of state-owned mixed enterprises, the influence of profitability factor and debt paying factor is as follows: eastern region > central region > western region; The effect of sustainability factors is as follows: eastern region > western region > central region.

7.2. Policy Suggestions

According to the above research conclusions, the following suggestions are put forward to improve the comprehensive benefits of state-owned mixed enterprises, narrow the regional differences in the development of state-owned mixed enterprises, and realize the coordinated development between regions:

First, the profitability of state-owned mixed enterprises should be improved by combining the reform of state-owned mixed enterprises with market means. First of all, we should improve the market economic system, speed up the market-oriented development process, organically combine market-oriented reform with soe reform, create a competitive market environment, and provide a favorable external environment for soe reform. To be specific, a small number of state-owned enterprises with "special nature" will be allowed to maintain their public welfare nature and continue to undertake political and social functions, such as those related to national economy and people's livelihood and public security. Other state-owned enterprises with market capacity and competitive ability will be reclassified as commercial enterprises, so that they can assume economic functions and realize the separation of government and enterprise to the greatest extent. Secondly, to improve the profitability of state-owned mixed enterprises to provide a sustainable driving force. Key to promote public welfare, the introduction of high-quality what corporation ownership, promote the business, the introduction of what private equity holdings, revitalize the mix of state-owned company internal mechanism, improve operational efficiency, achieve assets together what, a state-owned corporation, and at the same time, in what was the "new blood" to drive innovation in state-owned enterprises, realize the upgrading of the industrial chain, improve product added value, So as to effectively improve the profitability of state-owned mixed enterprises.

Second, build innovative enterprises and enhance the sustainable capacity of state-owned mixed enterprises. First of all, the state-owned mixed enterprises should give

full play to its mainstay role in state-owned economy, actively carry out scientific and technological innovation activities, strive to make breakthroughs in key and key technology of "their", concentrate human, material and financial resources to attack the key core technologies and improve their ability of independent innovation of science and technology at the same time, to break the international community to our country science and technology on and control the deadlock, Realize the closed loop within the industrial chain, so that China can always maintain the core competitive position in the global market competition. Second, talent is the primary factor in the innovation, the state-owned mixed enterprises must strengthen the good cooperation with universities, research institutes and other agencies, actively cultivate and the introduction of innovative talents of science and technology and the team, establish and improve the benign interaction between the study subjects, the system pattern of cooperative innovation, break the barrier of the enterprise innovation, focus on the strengths to create a national, provincial and municipal development platform, Actively undertake major national scientific research tasks. Enterprises should increase investment in R&D capital, including R&D material capital and R&D human capital, to form their own technological competitive advantages, and at the same time, improve talent training, incentive and evaluation system, stimulate their innovation potential. Finally, investment in environmental protection and social welfare should be increased to enhance the credibility of enterprises and enhance the sustainability of state-owned mixed enterprises in general.

Third, control financial leverage and improve the solvency of state-owned mixed enterprises. In the short term, the state-owned mixed enterprises should establish and improve the credit guarantee system, and provide credit and financial support with the credit guarantee fund to temporarily alleviate the debt crisis of state-owned enterprises. In the long run, it is necessary to strengthen supervision over debt financing of state-owned mixed enterprises, establish and improve debt supervision and risk early warning systems, and avoid improper investment and financing. At the same time, we will categorize the debts of state-owned enterprises to maximize their ability to pay debts and defuse debt risks. Firstly, according to the functional positioning of state-owned enterprises, the debts of public welfare state-owned enterprises are dealt with in the way of long-term mechanism such as national debt and PPP, the debts of commercial state-owned enterprises are dealt with in the way of marketization, and the debts of "zombie enterprises" and other inefficient state-owned enterprises are dealt with in the way of quick liquidation. Secondly, according to the business assets of state-owned enterprises, the assets with competitive advantages and development prospects of state-owned mixed enterprises are treated in the way of debt retention, and the other assets are treated in the way of debt-equity conversion. Finally, stubborn and complex debts in enterprises should be dealt with by setting up special companies and clearing them up, so as to maximize the solvency of state-owned mixed enterprises.

Fourth, we should formulate regional development strategies based on the principle

of adapting measures to local conditions; enhance inter-regional linkages and narrow regional differences. First of all, formulate investment policies in line with the actual situation of the region. By attracting investment, capital can drive the flow of technology and talents alleviate the problem of "brain drain" and "siphon effect", so as to promote the market development of the region and improve the profitability and solvency of state-owned mixed enterprises in the region. Secondly, local and trans-regional enterprises should be guided to actively participate in the construction of central Plains Economic Zone and the strategy of western development. While narrowing regional differences, inter-regional factor flow should be accelerated to improve the efficiency of resource allocation, so as to improve the comprehensive benefits of enterprises. Finally, encourage and support industries in the eastern region to transfer to the central and western regions in the form of industrial cluster transfer. Transfer industry cluster can effectively promote the eastern, central and western industrial chain combination, strengthens between eastern, central and western industrial linkage effect, promote new and high technology transfer and mobility, drive economic growth by technology innovation, and to accelerate the development process, the western region of marketization, to improve, the western region in the state-owned enterprise's profitability, sustainable ability and debt paying ability.

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