Using BP neural network and entropy weight method to analyze computer technology applications in China's agricultural modernization

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ABSTRACT

Since the 1850s, agricultural transformation has significantly impacted society and continues to do so with the new round of agricultural revolution. Despite remarkable achievements in agricultural modernization, China also faces contradictions and challenges. The government has issued documents to support agricultural modernization and promote comprehensive agricultural system construction. This article analyzes provincial agricultural modernization level index using catastrophe progression, Entropy weight combination expectation, and BP neural network methods. It constructs a regional economic indicator system and builds a coupling model between agricultural modernization and economic growth based on coupling theory. The article visualizes agricultural modernization levels, indicating regional imbalance in China's agricultural modernization development. The eastern, southern, and coastal regions have better overall and various indicators than the western, northern, and border regions. There is a situation where provinces and cities with the same centers are decreasing towards the surrounding areas. Therefore, suggestions such as rationally allocating agricultural development resources and suitably planning agricultural input and output structure are put forward. Using coupled rationality theory to construct a coupling model between modern agriculture and the regional economy, it was found that there is imbalance in the level of agricultural modernization between regions and disharmony between agricultural modernization and the economic level within regions.

Keywords: Agricultural Modernization Level Index; Entropy Weight Method; BP Neural Network; Coupling Model

1. INTRODUCTION

1.1 Research background

Agricultural modernization applies modern technology and management to enhance production and sustainable development. This process has expanded since the 18th century, accelerated by digitalization and globalization in recent years. China, with one-fifth of the world's population, uses 9% of the world's arable land to produce a quarter of the world's food annually. While China has made notable achievements in agricultural modernization, it faces challenges like low resource utilization, inadequate technological innovation, and shrinking cultivated land per capita. However, in recent years, our government has also increased its support for agricultural modernization. In 2022, the central government issued the "14th Five-Year Plan for Promoting Agricultural and Rural Modernization", which clearly stated that by 2025, agricultural and rural modernization will have made important progress, and looking forward to 2035, agricultural and rural modernization will be basically realized [1]. It can be seen that strengthening the level and innovation of modern agricultural science and technology, building a modern rural industrial system, promoting green agricultural development, and promoting the construction of a modern agricultural management system [2] are the top priorities for current agricultural modernization.

1.2 Research purpose and significance

Agriculture constitutes the foundation and pillar of the national economy. Its contribution to national economic development manifests across four key dimensions: factors, products, markets, and foreign exchange. Scholars analyzed that from 1978 to 2012, net capital inflow from rural to urban areas totaled approximately 26.66 trillion yuan. Since the 21st century, China's agricultural product processing industry has developed rapidly. In 2016, it achieved primary business income of 20.1 trillion yuan, accounting for 19.6% of the manufacturing industry [3]. It has become an important pillar of the national economy and a key livelihood industry. Besides providing grain products and agricultural and sideline products, agriculture can also furnish raw materials for other sectoral development. Simultaneously, the continuous expansion of rural consumer and production means markets has further stimulated development of related industrial product manufacturing industries.

However, the level of China's agricultural modernization development exhibits unevenness across all aspects and large inter-regional gaps. By overall development level, the ranking is: East > Central > West, but each region has advantages and disadvantages. The east features high output and good benefits yet insufficient agricultural protection; the central region has balanced development, but the overall effect is unremarkable; the west has more mountains and hills due to geographical conditions, with major shortcomings in the agricultural industry system.

In studying agricultural modernization, it's critical to find a measure for comprehensively evaluating the level of agricultural modernization statistically and constructing a comprehensive indicator system. Accurately understanding the level of agricultural modernization in each region of our country helps each province, city, and autonomous region clarify its advantages and shortcomings and core competitiveness, constantly improving its agricultural quality and efficiency. Analyzing China's agricultural economic effects helps build a diverse, complementary, efficient, and coordinated agricultural system, significantly promoting green, balanced, high-quality development of the agricultural economy.

1.2 Main research content

This article selects various data on agricultural modernization in 2021 from the National Bureau of Statistics and other channels to construct an indicator system for regional agricultural modernization development in China. Among them, the entropy weight method is used to calculate the weight and objective expectation of the standardized data, and then the mutation series method is used to calculate the subjective expectation. The combined expectation value of the two is used to establish a BP neural network model and fit it to obtain the agricultural modernization level index of each province. , and finally performed K-MEANS clustering to quantify the agricultural modernization development level of 31 provinces and municipalities. Secondly, the agricultural modernization index system and the regional economic development index system are used to construct a coupling model of agricultural modernization and economic growth, and the level of coordinated development of modern agriculture and regional economy is analyzed through the coupling degree and coupling coordination degree models, and ways to improve the development of agricultural modernization are explored.

1.3 Innovation points of this article

1. This article selects 31 provinces and cities to compare regional agricultural modernization levels in 2021. By reasonably constructing an indicator system, it obtains indicator data for 31 regions, making up for the analysis of provinces with missing data in previous studies. Unlike studies that focus on a specific region, this article has a broader coverage.
2. For the agricultural modernization evaluation system, this paper uses the mutation series-entropy weight combination expectation method to process the data, and uses the BP neural network model fitting index to obtain the agricultural modernization level index, which is more reasonable and scientific in data processing.
3. Most research focuses on the coordination of other industries and regional economy. This paper builds a coupling model of agricultural modernization and economic growth to analyze the connection between modern agriculture and the coordinated development level of regional economy, and simultaneously develops regional economy by strengthening the level of agricultural modernization.

2. Literature Review

2.1 Overview of Agricultural Modernization

Agricultural modernization refers to the transition from traditional to modern farming methods, aiming to increase productivity, efficiency, and sustainability. Knickel, K., Ashkenazy, A., Chebach, T., & Parrot, N. (2017) explore the relationship between agricultural modernization and sustainable agriculture, identifying contradictions and complementarities. They suggest that while modernization aims to improve productivity and sustainability, it must also address social and ecological resilience to be truly effective [3].

2.2 Application of Computer Technologies in Agriculture

The integration of computer technologies in agriculture has been pivotal for modernization. Qu, D., Wang, X., Kang, C., & Liu, Y. (2018) discuss the advancements in Information and Communication Technologies (ICT) in China, highlighting their role in enhancing agricultural and rural modernization. These technologies, including the Internet of Things (IoT) and big data, contribute significantly to the optimization of agricultural processes, increasing efficiency and sustainability [4].

2.3 Entropy Weight Method (EWM) and BP Neural Network Principles

The Entropy Weight Method (EWM) is a critical tool for evaluating the significance of various factors in complex decision-making scenarios. Zhu et al. (2020) discussed EWM's effectiveness in decision-making, highlighting its utility in weighing diverse variables based on their dispersion, a fundamental approach that benefits agricultural modernization by objectively determining indicator weights [5]. Similarly, Li et al. (2019) integrated EWM in agricultural water resources management to optimize allocation schemes, demonstrating EWM's versatility in managing scarce resources efficiently [6]. Zhu et al. (2021) also revealed EWM's peculiarities in dynamic evaluations, providing insights into its application limitations and suggesting modifications to enhance its accuracy [7]. This methodology's strength lies in its capacity to quantify the variability of information, making it invaluable for assessing agricultural modernization efforts where diverse factors influence outcomes.

The Back Propagation (BP) Neural Network, a form of artificial intelligence, has found extensive application in predicting and modeling agricultural phenomena. Its capability to learn from data and identify complex nonlinear relationships makes it ideal for forecasting crop yields, analyzing soil conditions, and optimizing agricultural inputs. Although direct references to BP Neural Networks in the context provided were not identified, their general application principles suggest their potential in enhancing decision-making in agricultural modernization by providing predictive insights and facilitating the efficient use of resources.

2.4 Foundations of Coupling Theory

Coupling Theory explores the interdependent relationships between systems, such as between agricultural modernization and regional economic development. It postulates that harmonizing these relationships can lead to sustainable and balanced growth. While specific studies directly addressing Coupling Theory in the provided references were not found, its conceptual framework underlies the efforts to align agricultural advancements with broader economic goals, ensuring that modernization efforts contribute positively to regional development. This theory underscores the necessity of integrated approaches that consider the synergies and tensions between agriculture and economic systems, aiming for a cohesive strategy that supports sustainable progress.

3. Research methods and data sources

3.1 Specific application of entropy weight method

The entropy weight method is an objective weighting method and is widely used in multi-index comprehensive evaluation problems. It determines the weight of each indicator by calculating the information entropy of each indicator to reflect the importance of each indicator in the overall evaluation.
Assume that x_{ij} is the observation data of the jth indicator of the i-th sample, and use the min-max method to standardize:
Positive indicators:

$$y_{ij}^{p} = (x - x_{min})/(x_{max} - x_{min}) \tag{1}$$

Negative indicators:

$$y_{ij}^{n} = (x_{max} - x)/(x_{max} - x_{min}) \tag{2}$$

In the formula, $y_{ij}$is the standardized value of x_{ij}
Calculate the proportion of y_{ij}:

$$f_{ij} = y_{ij}/\sum_{i=1}^{n} y_{ij} \tag{3}$$

Calculate the entropy value of the jth indicator:

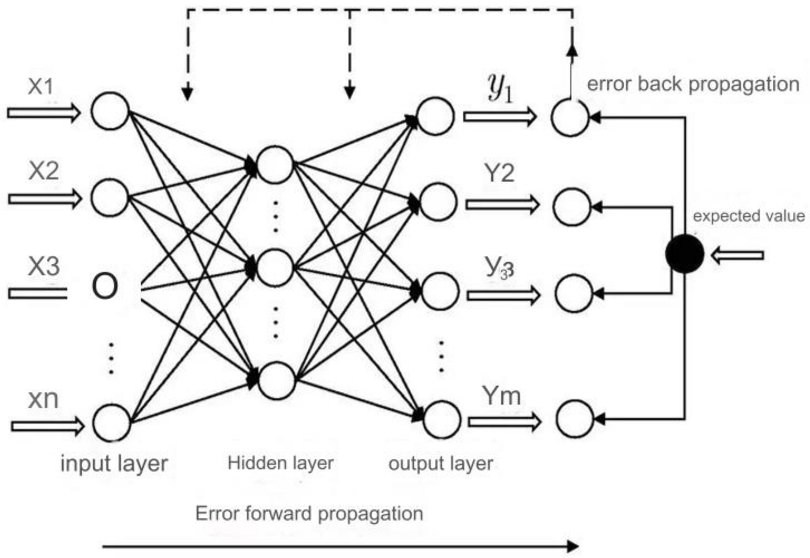
$$H_j = -k\sum_{j=1}^{n} f_{ij}\, ln(f_{ij}), \mathrm{k} = 1/ln(n) \tag{4}$$

Calculate the weight of the jth indicator:

$$w_j = (1 - H_j)/(n - \sum_{j=1}^{m} H_j) \tag{5}$$

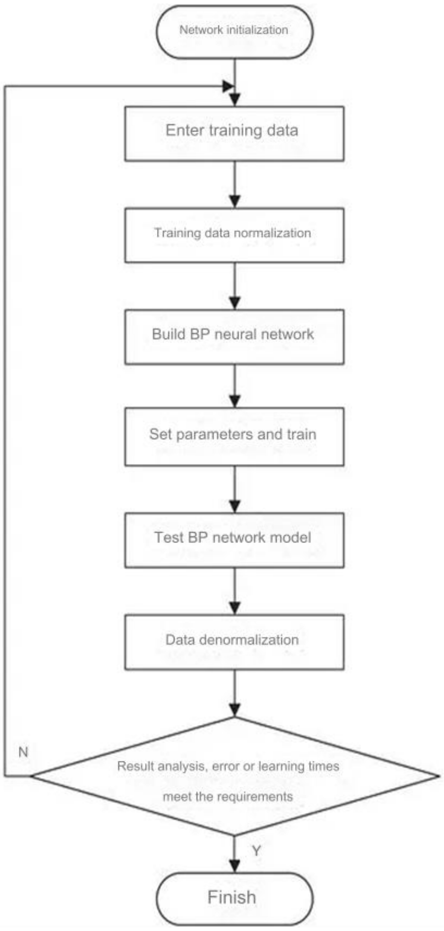
3.2 BP neural network model construction
BP neural network is a multi-layer feedforward neural network trained through the backpropagation algorithm. In this study, BP neural network was used to fit the provincial agricultural modernization level index. The structure is shown in Figure 1:

Figure 1: Neural network structure diagram



The BP neural network training diagram is shown in Figure 2:

Figure 2: BP neural network training

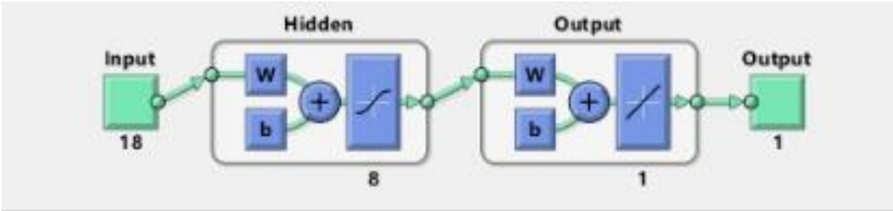


Use MATLAB to build a BP neural network structure with one layer each of input layer, hidden layer, and output layer. This article uses a total of 18 three-level indicators C1-C18 in the constructed indicator system as input layer neurons to import the model: the output layer is agriculture Modernization level combined expected value, 1 neuron in total. There are different academic methods for the number of hidden layer neurons. Based on the consistency with the content of this article, refer to the research method of Gao Daqi (1998) [8] for analysis, as shown in (6):

$$K = \sqrt{0.43ij + 0.12j^2 + 0.77j + 2.54i + 0.35} + 0.51 \quad (6)$$

Among them, i is the number of neurons in the input layer, j is the number of neurons in the output layer, in this article, i=18, j=1, and the K value calculated by the above formula is approximately equal to 8. According to this article, the topological structure of the BP neural model is shown in Figure 3:

Figure 3: Neural network topology diagram



3.3 Method of establishing coupled model

The coupled model is used to analyze the interaction between agricultural modernization and regional economic growth. The coupling degree model formula is as follows:

$$C = \sqrt{C_A \times C_E} \quad (7)$$

Among them, C is the coupling degree, C_A is the agricultural modernization level index, and C_E is the economic growth index. The closer the coupling degree value is to 1, the higher the coupling degree between agricultural modernization and economic growth, and the stronger the interaction.

3.4 Establishment of data sources and indicator system

This study mainly conducts data surveys from 31 provinces, municipalities and autonomous regions across the country, combined with the strategic development requirements of the Central Committee's No. 1 Document in 2022, and based on the research of scholars such as Xin Ling and Jiang Heping [9], selected various projects in 2021 Statistical data is used as basic data, and the data sources are the "China Statistical Yearbook", "China Water Resources Bulletin", "China Rural Statistical Yearbook", "China Science and Technology Statistical Yearbook" and the annual indicators of each province from the National Bureau of Statistics. By drawing on the research of a large number of scholars [10][11] and referring to the availability of data, the following index system was established (Table 1):

Table 1: Agricultural modernization indicator system table

First level indicator	Secondary indicators	Level three indicators	Indicator explanation	Indicator properties
X1 production indicators	A1 agricultural input level	C1 diesel input intensity	Agricultural diesel usage /total crop sown area	forward
		C2 agricultural film usage intensity	Agricultural plastic film usage /total crop sown area	forward
		C3 actual water consumption per mu of irrigated farmland	Amount of water supplied to the field/irrigated area	Negative
	A2 agricultural output level	C4 grain output per unit area	Grain production /grain sown area	forward
		C5 vegetable output per unit area	Vegetable production /vegetable sowing area	forward
		C6 agricultural labor productivity	Added value of primary industry /number of employees in primary industry	forward
	A3 agricultural science and technology level	C7 Research and Experimental Development (RD) funding intensity	Internal expenditure of RD funds/Gross regional product	forward
		C8 Number of computers used per 100 people in	Total number of rural computers * 100 / total rural population	forward

		rural areas (units)		
		Number of applications for C9 new agricultural plant variety rights in the current year	Number of applications for new agricultural plant variety rights in the year	forward
X2 life indicators	A4 level of agricultural social development	C10 rural Engel coefficient	Per capita food consumption expenditure /per capita total consumption expenditure (rural)	Negative
		C11 per capita disposable income of farmers	(total income of rural residents - household operating expenses - tax expenses - depreciation of productive fixed assets - property expenses - transfer expenses)/household population	forward
		C12 urbanization rate	Urban permanent population /total population	forward
	A5 agricultural economic management level	C13 agricultural mechanization level	Total power of agricultural machinery /total sown area of crops	forward
		C14 agricultural disaster prevention rate	1-(crop disaster area/crop sown area)	forward
		Proportion of output value of C15 agriculture, forestry, animal husbandry and fishery service industry (%)	agriculture, forestry, animal husbandry and fishery majors and auxiliary activities /total output value of agriculture, forestry, animal husbandry and fishery	forward
X3 ecological indicators	A6 agricultural sustainable development level	C16 pesticide application intensity	Pesticide application amount /total crop sown area	Negative
		C17 fertilizer application intensity	Agricultural fertilizer consumption /total sown area of crops	Negative
		C18 forest coverage	Forest area/total land area	forward

4. Analysis of agricultural modernization based on entropy weight method and BP neural network

4.1 Construction of agricultural modernization indicator system

4.1.1 Expected value of regional agricultural modernization level

This paper combines the entropy weight method and the mutation series method to calculate the expected value of regional agricultural modernization level, combines subjectivity and objectivity to calculate a more reasonable and credible expected value, and uses BP neural network to fit it to obtain the agricultural modernization level index, achieving a comprehensive Study and get more scientific results.
There are three common types of mutation systems: cusp mutation system, swallowtail mutation system and butterfly mutation system.
The normalization formula of the cusp mutation system is:

$$Y_a = a^{\frac{1}{2}}, Y_b = b^{\frac{1}{3}} \quad \textbf{(8)}$$

The normalization formula of the swallowtail mutation system is:

$$Y_a = a^{\frac{1}{2}}, Y_b = b^{\frac{1}{3}}, Y_c = c^{\frac{1}{4}} \quad \textbf{(9)}$$

The normalization formula of the butterfly mutation system is:

$$Y_a = a^{\frac{1}{2}}, Y_b = b^{\frac{1}{3}}, Y_c = c^{\frac{1}{4}}, Y_d = d^{\frac{1}{5}} \quad \textbf{(10)}$$

The combined expectation formula is:

$$W_j = \alpha W_j^s + (1-\alpha) W_j^o \quad \textbf{(11)}$$

Among them, W_j is the combined expected value, W_j^s is the subjective expected value, which is calculated by using the catastrophic series method and the weight of each indicator as the importance, W_j^o is the objective expected value, which is

calculated by the inner product of each indicator and the weight, and α is the subjective Preference coefficient, $1-\alpha$ is the objective preference coefficient.
Use the method of minimum sum of squares of deviations:

$$\text{minz} = \sum_{j=1}^{m}[(W_j - W_j^s)^2 + (W_j - W_j^o)^2] \quad \textbf{(12)}$$

Derivating the equation calculates the minimum point as α=0.5.
This article uses PyCharm programming to calculate the objective weight results of the three-level indicator entropy values, as shown in Table 2:

Table 2: Objective weight table of three-level indicators

Index	weight	index	weight
C1 diesel input intensity	0.1192	C10 rural Engel coefficient	0.0256
C2 agricultural film usage intensity	0.1010	C11 per capita disposable income of farmers	0.0633
C3 actual water consumption per mu of irrigated farmland	0.0237	C12 urbanization rate	0.0208
C4 grain output per unit area	0.0325	C13 agricultural mechanization level	0.1005
C5 vegetable output per unit area	0.0671	C14 agricultural disaster prevention rate	0.0223
C6 agricultural labor productivity	0.0532	Proportion of output value of C15 agriculture, forestry, animal husbandry and fishery service industry (%)	0.0542
C7 Research and Experimental Development (RD) funding intensity	0.0609	C16 pesticide application intensity	0.0210
C8 Number of computers used per 100 people (units)	0.0704	C17 fertilizer application intensity	0.0326
Number of applications for C9 new agricultural plant variety rights in the current year	0.0750	C18 forest coverage	0.0567

The subjective expectation value is calculated through the mutation series method. The objective weight of the indicator obtained by the entropy weight method is used to calculate the expectation of the standardized three-level indicator data to obtain the objective expectation value. The calculation is performed by the combined expectation formula 10. The results are shown in Table 3:

Table 3 Expected value of agricultural modernization level

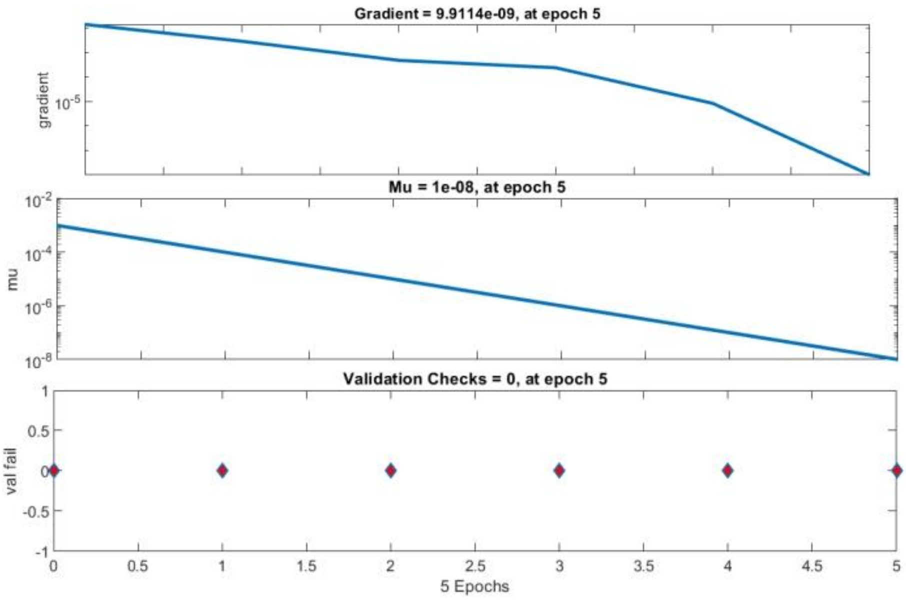
province	subjective value	objective value	combined value	province	subjective value	objective value	combined value
Beijing	0.9675	0.6023	0.7849	hubei	0.9533	0.3446	0.6490
Tianjin	0.9528	0.3832	0.6680	Hunan	0.9535	0.3450	0.6475
Hebei	0.9601	0.4397	0.6999	Guangdong	0.9500	0.2575	0.5987
Shanxi	0.9304	0.2476	0.5890	Guangxi	0.9399	0.3472	0.6211
Inner Mongolia	0.9398	0.2919	0.6159	Hainan	0.8950	0.2537	0.5972
Liaoning	0.9590	0.4008	0.6799	Chongqing	0.9408	0.2709	0.6080
Jilin	0.9493	0.3043	0.6268	Sichuan	0.9451	0.2268	0.5794
Heilongjiang	0.9520	0.3611	0.6566	Guizhou	0.9320	0.2366	0.5857
Shanghai	0.9549	0.4615	0.7082	Yunnan	0.9348	0.2883	0.5975
Jiangsu	0.9572	0.4100	0.6836	Tibet	0.9067	0.3009	0.6235
Zhejiang	0.9692	0.5693	0.7692	Shaanxi	0.9461	0.2946	0.6132
Anhui	0.9513	0.3294	0.6403	Gansu	0.9317	0.2398	0.5814
Fujian	0.9423	0.4075	0.6749	Qinghai	0.9230	0.2619	0.5997
Jiangxi	0.9438	0.2758	0.6098	Ningxia	0.9374	0.3207	0.6254
Shandong	0.9620	0.4757	0.7188	Xinjiang	0.9301	0.3446	0.6490
Henan	0.9458	0.3551	0.6505				

4.2 Function and model training results

This article chooses the L-M algorithm based on a medium-sized neural network and has a fast convergence speed. In terms of transfer function, the Tanh transfer function is selected for the input layer → hidden layer and hidden layer → output layer.

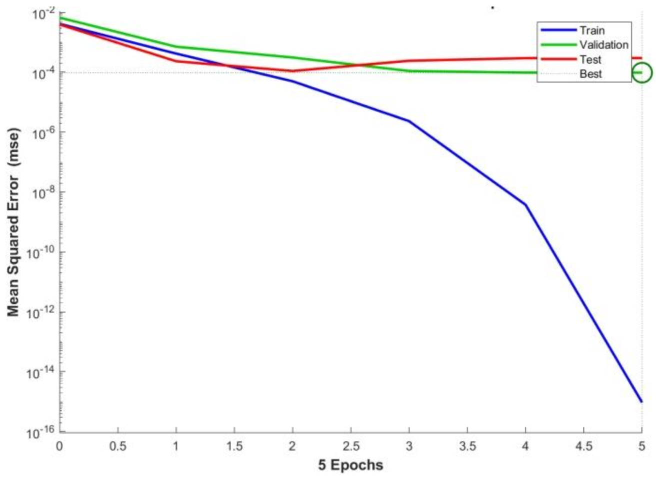
The original data of 31 provinces and cities were divided into 21 sets (Training), 5 sets (Validation), and 5 sets (Testing).
As shown in Figure 4: The decline of the gradient is accompanied by the decline of the error accuracy parameter value. After 5 consecutive trainings, the mu value reaches 1e-08. At this time, the verification set stops declining for 5 consecutive times and the training stops.

Figure 4: Training effect diagram



As shown in Figure 5, after 5 times of training, the verification set MSE reached 9.7576e-0.5, the BP neural network tended to converge, and the training was completed.

Figure 5: Dataset MSE curve



The results of the training set, validation set, and test set are organized as shown in Table 4:

Table 4: Data set training results table

DATA SET	NUMBER OF SAMPLES	MSE	R
TRAINING SET	twenty one	9.4324e-16	1.0000
VALIDATION SET	5	9.7576e-05	0.9943
TEST SET	5	2.9953e-04	0.9424

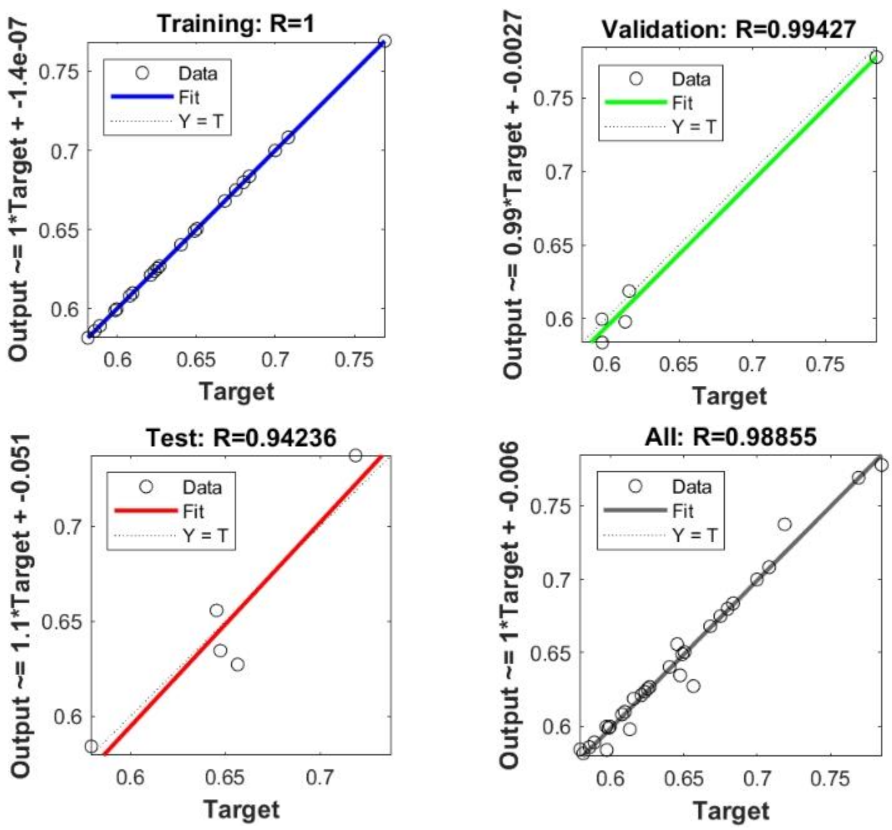
As can be seen from the above table, the MSE of the three data sets is very small, and the R value is close to 1. The BP neural network training results are good and have high credibility.
Export the error image. As shown in the figure12, it can be found that the errors of the vast majority of the 31 samples are close

to the 0 error bar. Only the sample errors in the validation set and the test set are greater than 0.01, and the model error is within the acceptable range.

Figure 6: Sample error value

Drawing the correlation analysis image of the sample data set and the original data, it can be seen from Figure 7: the correlation coefficient between the output result and the target result is as high as 0.98855. The agricultural modernization level index output by the BP neural network evaluation model is highly similar to the expected value of the agricultural modernization level combination. has practical significance.

Figure 7: Sample-to-population correlation diagram



The ranking of the agricultural modernization index of each province is too precise and inconvenient to describe the agricultural modernization level of each province. This article uses SPSS to perform K-MEANS cluster analysis on the regional agricultural modernization index, and selects the clustering result with a significant number of categories of 4. . The final clustering center is shown in Table 5:

Table 5: Final clustering center

clustering	1	2	3	4
Agricultural modernization level index	0.7837	0.6489	0.7059	0.5783

5. Coupling analysis of agricultural modernization and regional economy

5.1 Construction of coupled model

When studying the coupling relationship between agricultural modernization and economic growth, the first priority is to construct its indicator system. The agricultural modernization index system has been constructed previously. According to the rese0arch of domestic and foreign scholars [12][13], we constructed per capita GDP from three aspects: regional economic development, residents' living standards and industry economic benefits. The tertiary industry accounts for the total domestic production. There are four indicators: value proportion, per capita disposable income of residents, and total import and export of goods. See Table 6 for specific indicators.

Table 6 Regional economic development indicator system

regional economic development level	**GDP per capita**	**forward**
	The proportion of tertiary industry in GDP	forward
	Per capita disposable income of residents	forward
	Total import and export of goods	forward

This study focuses on measuring the coordinated development level of modern agriculture and regional economy, draws on the concept of coupling in physics, and refers to the research of scholars to study the coupling status of modern agriculture and regional economy with a coupling model, namely:

$$C = 2[U_1U_2/(U_1+U_2)(U_2+U_1)]^{\frac{1}{2}} \quad \textbf{(13)}$$

$$U_1 = \sum_{i=1}^{m} a_i * x_i \; U_2 = \sum_{j=1}^{n} b_j * y_j \quad \textbf{(14)}$$

$$T = \alpha U_1 + \beta U_2 \quad \textbf{(15)}$$

$$D = \sqrt{C * T} \quad \textbf{(16)}$$

Among them, C is the coupling function of the two systems, T represents the comprehensive evaluation index of modern agriculture and regional economy, D represents the coupling value, U1 and U2 are the evaluation indexes of modern agriculture and regional economic development level respectively. ai, bj represent the weight of the indicator, xi, yj respectively represent the modern agricultural system indicator and regional economic system indicator after using range standardization. According to the relationship between agricultural modernization and regional economy, we formulate α=0.4 and β=0.6.

5.2 Analysis of coupling degree between regional economy and agricultural modernization

This article adopts the division model of four coordination degree types and ten coupling coordination types by He Yiqing (2016) [18]. Based on the relevant data of regional economic development in 2021, the values of C, T and D are calculated and determined based on the above table. By analyzing the system and discrimination criteria, the relationship between agricultural modernization and economic development in 31 provinces and municipalities in 2021 can be obtained. According to the relationship status table, the coupling coordination types of 31 provinces and municipalities in 2021 can be divided, as shown in Table 7 below.

Table 7 Relationship between regional agricultural modernization and economic development

area	Coupling coordination degree	Coupling coordination class
Beijing	0.815719337	B2
Tianjin	0.58225012	E2

Hebei	0.426597266	F1
Shanxi	0.340736879	G2
Inner Mongolia	0.40740644	F2
Liaoning	0.478154179	F1
Jilin	0.375840152	G1
Heilongjiang	0.362354691	G1
Shanghai	0.779373348	C3
Jiangsu	0.693347895	D2
Zhejiang	0.726080093	C2
Anhui	0.444712881	F2
Fujian	0.574261535	E2
Jiangxi	0.397841765	G2
Shandong	0.600308941	D2
Henan	0.418438947	F1
hubei	0.463777165	F2
Hunan	0.447632002	F1
Guangdong	0.709638817	C3
Guangxi	0.369348415	G2
Hainan	0.450058463	F1
Chongqing	0.459243774	F2
Sichuan	0.430570539	F2
Guizhou	0.305676168	G2
Yunnan	0.351452425	G2
Tibet	0.366314018	G1
Shaanxi	0.399993848	G2
Gansu	0.299840279	H1
Qinghai	0.323843926	G2
Ningxia	0.341949731	G2
Xinjiang	0.359070917	G1

From the four levels of coordination, Beijing, Shanghai, Zhejiang, and Guangdong are highly coordinated, and Jiangsu, Shandong, Tianjin, and Fujian are basically coordinated. On the verge of disorder include most provinces and cities across the country, including Liaoning, Hubei, Chongqing, etc. Gansu Province is the worst, suffering from disordered and declining development.

From the perspective of subclass coupling coordination types, there are seven types: B, C, D, E, F, G, and H. Among them, Beijing is the best, which is good coordination, and Gansu is the worst, which is moderate imbalance and decline.

Judging from the relative sizes of U1 and U2, only Beijing is in the good coordination and synchronization type, Shanghai and Guangdong are in the intermediate coordination and agricultural lagging type, Zhejiang is in the intermediate coordination and synchronization type, Jiangsu and Shandong are in the primary coordination and synchronization type, and Tianjin and Fujian are in the barely coordinated type. Coordination and synchronization type, Liaoning, Hainan, Hunan, Hebei, and Henan are on the verge of imbalance and recession, and the economy is lagging behind. Hubei, Chongqing, Anhui, Sichuan, and Inner Mongolia are on the verge of imbalance and recession, and Jilin, Tibet, Heilongjiang, and Xinjiang are on the verge of imbalance and recession. Lagging type, Shaanxi, Jiangxi, Guangxi, Yunnan, Ningxia, Shanxi, Qinghai, and Guizhou are in the mild imbalance recession synchronization type, and Gansu is the moderate imbalance recession economic lag type.

6 Conclusion

6.1 Main conclusions

① Differences in agricultural modernization development: Agricultural modernization across provinces in China shows geographical imbalance. The eastern and coastal areas are more developed, while the west is relatively backward. In particular, Xinjiang has a higher level of agricultural modernization in the western region due to its superior natural conditions. The east has obvious advantages in labor quality, capital, and technology, and the central region is in a stable development stage.

② Policy effect: The national policy in 2021 has promoted agricultural modernization, increased investment, improved the level of sustainable development, and reduced the use of pesticides and fertilizers. There are obvious differences in the level of science and technology and social development in the east and west.

③ Incoordination between agriculture and economic development: There is inter-regional and intra-regional incoordination between agricultural modernization and economic development. The coupling degree between agriculture and economic growth is high in the eastern region, while there is disharmony in the western region.

By constructing an index system and coupling model, combined with the entropy weight method and the mutation series method, the article analyzes the coordination of agricultural modernization and economic growth, uses per capita GDP to evaluate economic strength, and reveals the incompatibility between provincial agricultural modernization and regional economy.

6.2 Research limitations

This study has certain limitations in data sources and model construction. First, data collection mainly relies on publicly released statistics and literature, and there may be problems with untimely data updates and limited coverage. Secondly, although BP neural network and entropy weight method have significant advantages in handling complex problems, the accuracy of the model is affected by data quality and model parameter settings. In addition, although the coupling model can reveal the interaction between agricultural modernization and regional economy, the in-depth analysis of the coupling mechanism is not sufficient.

REFERENCES

[1] State Council: Issuing the "14th Five-Year Plan for Promoting Agricultural and Rural Modernization" - "Agricultural Machinery" - 2022-03-08

[2] Drawing a beautiful blueprint for rural revitalization - Interpretation of the important spirit of the 2021 Central Committee's No. 1 Document Haonong; - "Party Class Reference" - 2021-03-01

[3] Knickel, K., Ashkenazy, A., Chebach, T., & Parrot, N. (2017). Agricultural modernization and sustainable agriculture: contradictions and complementarities. International Journal of Agricultural Sustainability, 15, 575-592.

[4] Qu, D., Wang, X., Kang, C., & Liu, Y. (2018). Promoting agricultural and rural modernization through application of information and communication technologies in China. International Journal of Agricultural and Biological Engineering, 11(6), 1-4.

[5] Zhu, Y., Tian, D., & Yan, F. (2020). Effectiveness of Entropy Weight Method in Decision-Making. Mathematical Problems in Engineering, 2020, 1-5.

[6] Li, M., Sun, H., Singh, V., Zhou, Y., & Ma, M. (2019). Agricultural Water Resources Management Using Maximum Entropy and Entropy-Weight-Based TOPSIS Methods. Entropy, 21.

[7] Zhu, L., Xing, X., & Yan, F. (2021). The Abnormal Phenomena of Entropy Weighting Method in the Dynamic Evaluation of Agricultural Water Conservation. Mathematical Problems in Engineering.

[8] Gao Daqi. Research on the forward three-layer neural network structure of linear basic functions with teachers[J]. Computer Science Journal, 1998(01):80-86.

[9] Jiang Heping, Xin Ling. Evaluation of the development level of modern agriculture in my country [J]. Agricultural Engineering Technology (Agricultural Products Processing Industry), 2012(06):25-27.

[10] Feng Qingling, Sun Afan. Measurement and countermeasures of agricultural modernization level in Gansu Province under the rural revitalization strategy [J]. Science and Technology Work, 2022(6):149-152.

[11] Liu Yanghui, Liu Luguo. Evaluation of the comprehensive level of regional agricultural modernization in the context of rural revitalization: Empirical analysis based on provincial panel data [J]. Development Research, 2021(6):102-108.

[12] He Yiqing, Song Qiuyun, Yao Jiang. Coupling research on agricultural modernization and coordinated development of regional economy in six provinces in central China [J]. Finance and Trade Research, 2016, 27(04): 52-57. DOI: 10.19337/j.cnki.34-1093/ f.2016.04.007.

[13] Liu Xun. Research on the coupled development of agricultural modernization and regional economy in the Beijing-Tianjin-Hebei region [J]. Journal of Shandong Agricultural Engineering University, 2016, 33(09):53-57.DOI:10.15948/j.cnki.37-1500/s. 2016.09.012.