Economic Management Analysis and Modeling of Rural Economic Development based on Fuzzy Mathematics Theory

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Abstract: - The importance of agricultural production has gradually increased, and the requirements for agricultural economic development have become more and more refined. Agricultural economic management and rural economic development as a complex giant system, and how the two promote each other are related. Based on the theory of fuzzy mathematics, the interaction between them can be well analyzed and modeled, and the key factors can be identified. Through scientific agricultural economic management, production factors such as rural land, water resources, labor, and funds can be reasonably allocated, improving resource utilization efficiency, reducing waste, and laying a solid foundation for rural economic development. Encourage the development of modern agricultural technologies, such as smart agriculture, green agriculture, and circular agriculture, to promote the transformation of the agricultural industry structure from traditional to modern, enhance the added value of agricultural products, and strengthen market competitiveness. Establishing a sound agricultural economic management system, including market information monitoring, natural disaster warning, and response mechanisms, can help farmers respond to market fluctuations and natural risks promptly, ensuring stable agricultural production.

Key-Words: - fuzzy mathematics, rural economics, agricultural management, conversion index, management strategies, sustainable development.

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1 Introduction

Only by deeply understanding such impact and optimizing agricultural economic management, can we really effectively promote rural economic development. Agricultural economic management is essentially a social function. At the same time, it emphasizes government leadership and management, applies modern agricultural science and economic principles, and on the basis of following objective laws, organizes, leads, makes decisions, and encourages relevant groups and personnel to achieve the agricultural development goals. For rural economic development, the development guarantee provided by agricultural economic management also needs to be paid attention. This guarantee is mainly reflected in pointing out the development direction and standardizing rural economic behavior. The effect of rural economic development can be improved accordingly, [1]. Introduce advanced agricultural technologies and equipment, such as intelligent irrigation systems, drone spraying, precision agriculture technology, etc., to reduce labor costs, and improve production efficiency and crop yields. At the same time, optimize the planting structure through technological means and select high-yield and high-quality varieties that meet market demand, [2]. The low comprehensive quality of some management personnel, and the difficulty in adapting management concepts and strategies to the requirements of the development of the times.

As the premise of China's rural economy, a market economy, combined with the agricultural economic management practice carried out in various parts of China in recent years, is not difficult to find that the theoretical guidance it provides plays an important role. Through an in-depth analysis of the operating mechanism of the market economy, it is not difficult to find that the vigorous development of China's market economy is built on the solid foundation of active participation and widespread support from the broad masses of the people. This kind of enthusiasm for national participation is like an inexhaustible source of power, which not only directly promotes high-speed economic growth, but also profoundly affects the optimization of social structure and the significant improvement of public welfare. In the vast rural world, as the main force of economic development, the enthusiasm and creativity of farmers have a decisive significance in promoting the comprehensive revitalization of China's rural economy. In this context, the importance of agricultural economic management as a bridge connecting agricultural production and market demand has become increasingly prominent. It can not only become a key force in stimulating farmers' enthusiasm and guiding the optimization of agricultural resource allocation but also play an irreplaceable role in establishing the strategic positioning of rural economic development and consolidating the dominant position of rural market economy. Under effective guidance, the level and quality of rural economic development will continue to improve, and the Rural Revitalization Strategy will be better implemented, [3].

Agricultural economic management integrates the theoretical essence of multiple disciplines such as economics, management, and ecology, providing scientific theoretical guidance for rural economic development. These plans and policies are not only forward-looking and targeted but also effective in addressing various challenges and problems encountered in rural economic development, leading the rural economy towards a healthier and more sustainable direction. Agricultural economic management not only improves the quality and safety of agricultural products but also reduces environmental pollution and damage caused by agricultural production. At the same time, agricultural economic management also focuses on the improvement of farmland and the development of circular agriculture. Through scientific and reasonable rotation, intercropping, and intercropping, the circular utilization of agricultural resources and the virtuous cycle of farmland ecosystems have been achieved. This green transformation not only promotes the improvement of agricultural production level but also lays a solid foundation for the sustainable development of rural economy. In management practice, relevant personnel and departments will conduct in-depth research on the laws of agricultural economic development, analyze market dynamics and consumer demand, and based on this, formulate scientific and reasonable management plans and policy measures. Driven by agricultural economic management, the rural economy is gradually transitioning from traditional models to green ecological models. By strengthening the supervision and control of pesticide and fertilizer use, and promoting green production methods such as organic agriculture and ecological agriculture, [4].

Given this complexity, traditional precise mathematical methods are inadequate in handling information related to agricultural economic management and rural economic development, as they often struggle to capture and express vague, uncertain, or subjective factors. Fuzzy mathematics, as an emerging branch in the field of mathematics, has developed to address such fuzzy phenomena and concepts. Fuzzy mathematics, by introducing concepts such as fuzzy sets and fuzzy logic, enables mathematics to be more flexibly applied to describe and handle practical problems with fuzziness, greatly expanding the application boundaries of mathematics. Therefore, introducing fuzzy mathematics into the modeling process of agricultural economic management and rural economic development is not only an innovation and supplement to traditional management methods but also an inevitable choice to adapt to the characteristics of complex economic systems. Through fuzzy mathematics, we can more comprehensively and accurately characterize the fuzzy information in the agricultural economic system, such as the uncertainty of market demand, differences in agricultural production conditions, and lagging policy effects, thus providing strong support for formulating scientific and reasonable agricultural economic management strategies.

At present, there are many theoretical analyses of the two, but there are few empirical studies, and qualitative analysis is more than quantitative analysis. How to model and analyze agricultural economic management and rural economic development, and put forward targeted suggestions, have reference significance and reference significance for realizing the sustainable development of rural economy and theoretical breakthrough in China.

The innovation of this article lies in the first application of fuzzy mathematics theory to the analysis and modeling of rural economic development and agricultural economic management, providing a more accurate and in-depth description of the interaction between the two; Secondly, through empirical research, this article identifies the key factors that affect the mutual promotion of rural economic development and agricultural economic management, providing an important basis for formulating scientific and reasonable policies and management strategies; Finally, this article constructs a comprehensive agricultural economic management system, which not only covers market information monitoring, natural disaster warning and response mechanisms, but also emphasizes the promotion and application of modern agricultural technologies such as smart agriculture, green agriculture, and circular agriculture, providing strong support for the sustainable development of rural economy.

2 Overview

Building a scientific and rational agricultural economic management mechanism is the key to ensuring the sustainable development of the rural economy. This mechanism should closely align with the unique situation of China's agricultural development, reflecting both the deep implementation of national agricultural support policies and the emphasis on improving the efficiency of rural resource utilization and promoting the optimal allocation of resources. At the same time, by implementing regional agricultural planning, clarifying development goals, guiding farmers and agricultural enterprises to develop in an orderly manner, and forming industrial agglomeration effects, the overall level of the rural economy can be promoted. In the field of academic research, the issue of agricultural economic management and rural economic development has always been of great concern. Many scholars at home and abroad have conducted in-depth explorations in this field from different dimensions and perspectives. Among them, the research of scholars such as [5] is particularly noteworthy. They innovatively introduced the fuzzy linear programming model into the practice of agricultural economic management and verified the effectiveness of the model in predicting the resilience of agricultural economic management through empirical analysis. This study not only enriches the theoretical system of agricultural economic management but also provides powerful tool support for decision-making in practice. [6], studied the impact of the perfection of the supply chain of fresh tomatoes in Argentina on the economic development of local communities. They found that the unfairness among farmers was related to the information distribution mode and the concentration mode. The uncertainty of the model considered the unfairness between farmers' income and gross profit rate in the actual market transactions. With the acceleration of agricultural modernization, rural economic management is also facing unprecedented challenges, especially with financial and ecological environmental risks becoming increasingly prominent. The prevention of financial risks requires the establishment of a sound rural financial system, enhancing the self-generating ability of the rural economy, and strengthening financial supervision to prevent the occurrence of systemic risks, [7]. Ecological and environmental risks require us to pay more attention to ecological balance and environmental protection while pursuing economic benefits, promoting the development of green agriculture, and achieving sustainable development of agricultural production. In order to effectively address these risks, a five-in-one risk response strategy based on the theory of political, economic, social, cultural, and ecological complex networks is particularly important. This strategy emphasizes that when formulating rural economic management policies, the interaction and influence between various factors should be fully considered to form a synergistic effect, thereby reducing the overall risk level, [8]. For example, through policy guidance, promoting the integrated development of agriculture, tourism, culture, and other industries can not only enrich the rural industrial structure but also enhance the rural economy's ability to resist risks. In addition, the rational utilization and protection of rural land resources is also an important part of rural economic management, [9]. The phenomenon of abandoned rural land and conversion of agricultural land not only affects the stability of agricultural production but also exacerbates the pressure on the ecological environment. Therefore, strengthening rural land management, promoting land system reform, and establishing a sound land transfer mechanism are of great significance for promoting agricultural economic management. At the same time, the deepening of rural legal reform also helps to better control land use changes, safeguard the legitimate rights and interests of farmers, and promote the harmony and stability of rural society, [10].

The climate environment has a great impact on agricultural production, so there is many researches on climate environment management. For example, [11] studied the relationship between agricultural production and flood control reservoirs in Slovenia. The results show that in areas suffering from floods and droughts for a long time, the absence of flood control reservoirs will reduce the crop output in rural areas by 520 hectares, and the economic loss will reach 1.7 million euros, and the impact of such loss will last for 3 to 5 years. Research has shown that expanding the area of water allocation for agricultural production can indeed bring significant production benefits to irrigation-dominated agricultural regions in the short term. Increasing irrigation water supply can ensure sufficient water supply for crops, improve yields, increase farmers' income, and stimulate agricultural economic growth. However, the long-term implementation of this strategy faces many challenges and potential risks. Expanding the allocation of water for agricultural production may exacerbate water resource competition and conflicts between regions. In arid regions, water resources are already limited, and the competition for water resources is particularly fierce among different regions and industries. When a region increases water use to expand agricultural production, it may encroach on the water share of other regions or industries, causing conflicts and tensions between regions and affecting social stability. Overexploitation of agricultural production water may also have adverse effects on the ecological environment. The ecological environment in arid areas is inherently fragile, and excessive reliance on irrigation may lead to ecological problems such as a decrease in groundwater levels, wetland drying up, and reduced river flow, which in turn can affect the balance and stability of the entire ecosystem. The deterioration of the ecological environment will in turn constrain the sustainable development of agricultural production, forming a vicious cycle, [12]. Similarly, there is a relationship between power resource management and rural economic development. As an important factor of production, it has an important impact on rural economic development, [13]. Some regions have carried out ecological certification to promote the sustainable development of the rural economy. For example, through the research on Rwandan coffee producers, [14] found that rural managers have extended the agricultural value chain through the certification of the tropical forest alliance, which uses inverse probability-weighted regression adjustment to reveal the relationship between the certification of the tropical forest alliance and economic sustainability. Similarly, the research in Canada also has similar conclusions. For example, the research of [15] found that the strengthening of environmental management by departments is conducive to the intensification and sustainability of agricultural production. When managing agricultural water resources in arid regions, it is necessary to adopt more scientific, rational, and sustainable strategies. On the one hand, it is necessary to strengthen the efficient utilization and conservation management of water resources, and reduce the water demand for agricultural production through measures such as promoting water-saving irrigation technology and optimizing planting structure; On the other hand, it is necessary to strengthen the coordination and cooperation of water resources between regions, establish reasonable water rights allocation and water resource trading mechanisms, and alleviate water resource competition and conflicts between regions. At the same time, attention should also be paid to the protection and restoration of the ecological environment, ensuring the coordinated development of agricultural production and the ecological environment, [16].

Fuzzy mathematics theory has been widely discussed in many fields since it came into being. It is of great significance and profound theoretical value to use fuzzy mathematics theory to discuss economic problems and solutions, [17], [18]. It has a set of fuzzy system theories, which reveals the essence of fuzzy phenomena and the due laws by mathematical methods. Fuzzy mathematics has made concrete breakthroughs in medicine, economic management, psychology, meteorology, environment, and biology. The research results found that an app with a quick start, fast information processing, and consideration of the psychological factors of the elderly has the most advantages, [19]. For example, [20] used fuzzy mathematics theory to test software quality management. The research results show that the software quality evaluation system based on fuzzy mathematics theory can avoid the appearance of local maxima and improve the accuracy of software quality evaluation. [21] used the fuzzy mathematics theory to select the best stock. The method based on the fuzzy mathematics theory and the random forest model can reduce the investment risk. The investment strategy under the combination of the two models has higher investment and stability. [22] studied the effects of various threats and network attacks on the optimization of network securities by using fuzzy mathematics theory. This method is more robust and robust than traditional methods. [23] constructed the credit evaluation index system for China's household agriculture and animal husbandry based on the fuzzy mathematics theory and Bayesian model and solved the actual problem of sample imbalance under different default conditions. In addition, fuzzy mathematics theory is also introduced in higher education teaching evaluation. [24] integrated fuzzy mathematics theory into machine learning. When processing complex data and distinguishing complex rules, they can effectively simulate expert knowledge and experience, and then effectively extract teaching quality factors. In the field of psychological research, fuzzy mathematical theory is widely used, such as the use of fuzzy mathematical theory to study synchronicity and non-local phenomena in clinical work, as well as consumer sensitivity and preference modeling, [25], [26].

Scholars from all over the world have used various methods, which has provided a lot of reference for this paper, but the above literature rarely introduce fuzzy mathematical theory into the modeling and analysis of agricultural economic management and rural economic development, [27]. The evaluation thinking process of the fuzzy mathematics evaluation method is more in line with the characteristics of human judgment and closer to the actual situation, [28]. Therefore, this paper introduces fuzzy mathematics theory into agricultural economic management and rural economic development, broadens the research ideas, and aims at the deviation of results caused by unclear definitions of concepts, goals, and methods in agricultural management and rural economic development. The use of fuzzy mathematics theory can effectively solve this problem and provide a reference for related research, [29].

3 Materials and Methods

3.1 Principles of Fuzzy Mathematical Theory

Fuzzy mathematics theory has significant advantages in dealing with problems with fuzziness, uncertainty, and complexity. In agricultural economic management and rural economic development evaluation, many indicators (such as agricultural product quality, ecological balance impact, etc.) are often difficult to describe in precise mathematical language and present a vague state. Therefore, introducing fuzzy mathematics theory and utilizing tools such as fuzzy sets, fuzzy relationships, and fuzzy operations can more scientifically and reasonably handle these fuzzy data, improving the accuracy and reliability of evaluation. This study aims to apply fuzzy mathematics theory to the evaluation of agricultural economic management and rural economic development. By constructing a fuzzy comprehensive evaluation model, a comprehensive evaluation of agricultural production management, rural economic development, and other aspects can be achieved. The development of fuzzy decision models is a multi-step process aimed at addressing decision-making problems with uncertainty and fuzziness. Firstly, it is necessary to clearly define the decision-making problem that needs to be solved, including the background, objectives, and constraints of the decision. Based on the characteristics of the decision-making problem, select relevant evaluation indicators or factors that can reflect the key aspects of the problem. Collect and evaluate data related to indicators from reliable sources to ensure the accuracy and completeness of the data. Clean and organize the collected data, eliminate outliers or missing values, and may require data conversion or standardization. Define a fuzzy set for each evaluation indicator, which determines the fuzzy member functions of input and output variables, such as the "near", "medium", and "far" distances, as well as the "left turn", "straight", and "right turn" of turning actions. Choose appropriate fuzzy membership functions to describe the fuzziness of each evaluation indicator, common membership functions include triangles, trapezoids, Gaussian functions, etc. According to the fuzzy evaluation matrix, determine the fuzzy positive ideal value of each evaluation indicator, which is the set composed of the maximum values of the fuzzy indicators in all evaluation indicators. Similarly, determine the fuzzy negative ideal value of each evaluation indicator, which is the set composed of the minimum values of fuzzy indicator values among all evaluation indicators. The development of fuzzy decision models is an iterative process that may require multiple adjustments and optimizations to achieve satisfactory results. Meanwhile, the accuracy and reliability of the model depend on multiple factors, including data accuracy, selection of evaluation indicators, and determination of fuzzy membership functions.

The weight set refers to the relative importance of each evaluation indicator (or index) in the evaluation process. Due to the varying degrees of impact of different evaluation indicators on the evaluation object, it is necessary to determine the weights of each indicator reasonably based on the actual situation. The determination of weights can be done using various methods, such as expert scoring method, analytic hierarchy process, etc. Through scientific weight allocation, the objectivity and impartiality of evaluation results can be ensured. The index set indicates which aspects of the evaluation object are evaluated and described, and is characterized by a set of several factors and secondary factors. The comment set is actually a division of the change interval of the thing being evaluated. The weight set is the influence of the indicator set, and the appropriateness of the weight selection is directly related to the success or failure of the model.

$$D=\begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & & \vdots \\ X_{m1} & \cdots & X_{mn} \end{bmatrix}=\begin{bmatrix} \frac{X_1}{X_1} & \cdots & \frac{X_1}{X_n} \\ \vdots & & \vdots \\ \frac{X_m}{X_1} & \cdots & \frac{X_m}{X_n} \end{bmatrix} \quad (1)$$

According to the hierarchical structure model, the elements of each layer are based on the adjacent elements of the previous layer, and the judgment matrix D is constructed according to the above comparison scale.

$$M_i = \prod_{j=1}^{n} W_{ij} \quad (2)$$

Multiply the elements of the judgment matrix D by rows to obtain the product M_i of the elements of each row.

$$\bar{W}_i = \sqrt[n]{M_i} \quad (3)$$

Calculate the nth root of M_i.

$$W_i = \bar{W}_i / \sum_{j=1}^{n} \bar{W}_j \quad (4)$$

Normalize the $\bar{W}$ vector:

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(DW)_i}{nW_i} \quad (5)$$

Calculate the maximum eigenvalue of the judgment matrix, i=1,2,..., n.

$$C_R = C_I / R_I \quad (6)$$

$$C_I = (\lambda_{\max} - n)/(n-1) \quad (7)$$

The judgment matrix is established by the analyst based on personal knowledge and experience, and there are inevitably errors. For quantitative indicators, the membership function method is usually used to determine their membership degree. This method first requires the construction of a target eigenvalue matrix, which consists of m quantitative indicator values for n schemes (or objects). Subsequently, based on the relationship between the actual value of each indicator and the preset threshold or standard, the membership degree of each indicator value for different evaluation levels is calculated through corresponding membership functions (such as linear functions, nonlinear functions, piecewise functions, etc.). The selection and design of membership functions should be based on actual situations and evaluation needs to ensure the accuracy and rationality of the evaluation.

$$Y = \begin{bmatrix} y_{11} & \cdots & y_{1n} \\ \vdots & & \vdots \\ y_{m1} & \cdots & y_{mn} \end{bmatrix} \quad (8)$$

Quantitative indicators can be divided into two categories: profitability indicators and consumption indicators. For the profitability index, the bigger the index, the better; For consumption indicators, the smaller the indicator, the better. The target relative membership matrix is obtained by normalizing it:

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} = (r_{ij}) \quad (9)$$

Assume the target factor set of the system to be compared in importance, and conduct the qualitative arrangement of binary comparison on the importance of the factors in the target factor set X, thereby obtaining the binary comparison matrix:

$$E = \begin{bmatrix} e_{11} & \cdots & e_{1n} \\ \vdots & & \\ e_{m1} & \cdots & e_{mn} \end{bmatrix} \quad (10)$$

From the evaluation matrix R and factor weight W, the comprehensive evaluation of scheme set a can be obtained as:

$$B = WR(W_1, W_2, W_3, \cdots, W_m) \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} = (b_1, b_2, b_3, \cdots, b_n) \quad (11)$$

3.2 Data Source and Processing

In the process of selecting indicators, targeted expert consultation was conducted simultaneously, and opinions and suggestions were sought from authoritative experts in the field in the form of seminars, telephone consultations, and questionnaires.

This article further solicited the opinions and suggestions of experts through telephone consultation and questionnaire survey and optimized and improved the indicator system. For quantifiable indicators such as per capita net income, proportion of secondary and tertiary industries, labor productivity, etc., we mainly rely on statistical data released by official institutions such as the National Bureau of Statistics and local statistical bureaus. These data have authority and credibility, and can accurately reflect the actual situation of agricultural economic management and rural economic development. We conducted on-site research on indicators that are difficult to obtain directly through official statistical data, such as the number of technology promotion institutions, the proportion of scientific researchers, and the number of training institutions. By visiting relevant institutions and enterprises, we collected first-hand data to ensure the authenticity and accuracy of the data.

After collecting the raw data, we conducted data cleaning to remove duplicates, missing data, and outliers, ensuring the integrity and consistency of the data. Due to the different dimensions and ranges of values of different indicators, we standardized the data by converting the values of each indicator to dimensionless values for subsequent analysis and comparison. After completing data cleaning and standardization, we integrated the data of each indicator to form a complete database, providing a foundation for subsequent analysis and modeling. In this paper, the demand side kinetic energy, the supply side kinetic energy, and the conversion kinetic energy are regarded as a composite system of agricultural economic management and rural economic development kinetic energy conversion (Table 1, Appendix), which is recorded as Y. Y1, Y2, and Y3 are regarded as demand side, supply side, and conversion kinetic energy. The indicators of each system sub-dimension are set as level 2 indicators and level 3 indicators respectively, with a total of 14 level 4 indicators. The four-level indicators are all positive indicators, that is, the better the agricultural economic management, the more obvious the promotion effect on the rural economic development, and the conversion kinetic energy coefficient is positively correlated with the two.

4 Results and Analysis

4.1 Agricultural Economic Management Index

In agricultural economic management, many factors are difficult to describe with precise numerical values, such as soil fertility, crop growth status, market demand, etc. Fuzzy sets can be used to represent these fuzzy concepts, describing the degree to which elements belong to a certain set through membership functions. For example, a fuzzy set can be constructed to represent the levels of soil fertility and membership functions can be used to describe the transitions and overlaps between different levels of soil fertility. Fuzzy logic is a reasoning method that deals with ambiguity and uncertainty. In agricultural economic management, fuzzy logic can be used to construct an inference system that infers the most suitable agricultural economic management strategy based on input information such as weather, soil conditions, market demand, etc. For example, a fuzzy reasoning system can be designed to recommend the best irrigation strategy based on the current weather conditions and crop growth stage. From the perspective of the agricultural economic management index (Figure 1, Appendix), in 2020, the top three provinces with the highest scores were Chongqing, Inner Mongolia, and Shaanxi, and the lowest three provinces were Jiangxi, Guizhou, and Henan. The agricultural economic management index is closely related to the rural market development demand space, market potential, and rural economic vitality. Among them, Chongqing and Shaanxi are major agricultural provinces, and Inner Mongolia is also known as the upper reaches of the Yangtze River. The historical basis, geographical conditions and resource advantages of agricultural development are constantly glowing with new vitality. However, the lower three provinces, especially Guizhou, are greatly restricted in agricultural development due to natural reasons such as terrain. In addition, the agricultural development of Jiangxi and Henan is mainly based on the grain industry. The development of the agricultural industry in these areas is seriously affected by national policies. Although they have a large amount of arable land, their agricultural development is also greatly restricted. As a famous granary of the country, their agriculture is restricted to grain production areas. A single agricultural production system makes it difficult to promote the development of the rural economy. At the same time, the industrial development in these areas is relatively backward.

4.2 Rural Economic Development Index

According to the rural Development Index (Figure 2, Appendix), in 2020, the top three provinces with the highest scores were Jilin, Guangxi, and Guangdong, and the lowest three provinces were Xinjiang, Hebei, and Fujian. The rural economic development index is related to the per capita net income, the number of technology promotion institutions, and the level of comprehensive mechanization, which reflects the functional and organizational changes in productivity. Among them, in recent years, Jilin has vigorously implemented the action plan for high-quality rural development and promoted the construction of main functional areas at different levels. High and new technologies have been widely applied in the construction of characteristic agricultural economies. The comprehensive agricultural productivity has been significantly improved, and the supply-side kinetic energy has been orderly improved. The use of agricultural land in Guangdong and Guangxi is changing to intensive commercialization, and the combination of agricultural industrialization continues to inject vitality into the new driving force of the rural economy. However, the agricultural production conditions in Xinjiang, Hebei, and Fujian need to be improved, the rural scientific and technological personnel are relatively scarce, and the number of migrant workers is large. There is still a certain gap between talent, technology, and management knowledge and the national average level.

4.3 Agricultural Economic Management and Calculation of Rural Economic Comprehensive Index

The comprehensive index (Figure 3, Appendix) has increased from 0.409 in 2010 to 0.605 in 2020 and has leaped from the development stage to the acceleration stage. From the perspective of secondary indicators, the demand side kinetic energy increased most significantly, followed by the supply side kinetic energy. This shows that the changes in the transformation of agricultural economic management and rural economic development kinetic energy are mainly reflected in the demand side kinetic energy. In order to accelerate the transformation of new and old kinetic energy in the future, we must increase the cultivation of new talents, help the formation of side supply-side kinetic energy with talents, constantly improve the dual financial structure of urban and rural areas, enhance the level of financial service equalization, and expand the radiation capacity of rural finance. It is worth noting that the transformation of kinetic energy is fluctuating and declining, and its contribution to rural economic development is negative. The agricultural modernization index decreased from 0.214 in 2010 to 0.198 in 2020, and the transformation and upgrading index decreased from 0.372 in 2010 to 0.347 in 2020. First, the national average level of agricultural modernization has not reached the level of basically realizing agricultural modernization, especially the per capita net income and labor productivity need to be improved. Second, in the process of transforming the driving force of agricultural economic management and rural economic development, there are still some obstacles in ideological understanding, institutional mechanisms, laws regulations, and policies. The ecological sensitivity and comprehensive mechanization level are under great pressure, resulting in the application level and utilization efficiency of agricultural mechanization at a low level, which is incompatible with the transformation of the driving force. Therefore, the current important task is to make up for the shortcomings in the kinetic energy of structural transformation and enhance the driving force of industrial and product structure change and upgrading.

4.4 Evaluation of Conversion Index in Different Provinces

From the perspective of the conversion index (Figure 4, Appendix), from 2010 to 2020, 31 provinces have passed the initial stage of conversion between agricultural economic management and rural economic development. By 2020, there were 20 provinces in the development stage, including Tibet, Zhejiang, Hebei, Guangxi, Yunnan, Henan, Chongqing, Hunan, Guizhou, Sichuan, Anhui, Gansu, Hainan, Fujian, Guangdong, Jiangxi, Shanghai, Shandong, Jiangsu and Hubei; There are 14 provinces in the acceleration stage, namely, Inner Mongolia, Heilongjiang, Ningxia, Jilin, Xinjiang, Tianjin, Beijing, Shanxi, Qinghai, Liaoning and Shaanxi. In addition, the conversion index of agricultural economic management and rural economic development kinetic energy in different provinces of China does not have the characteristics of ups and downs but shows a gradual and sustainable and steady upward trend. Most of the top provinces in 2010-2015 are still in the forefront in 2015-2020. It can be seen from Figure 5 (Appendix) that the conversion index of 31 provinces and cities is quite different, and the difference between the maximum value and the minimum value is 14.98. From the perspective of interannual change, Guangxi Province has the largest change range from 2010 to 2020, with a change value of 0.21. Shaanxi Province has the smallest change range, with a change value of 0.0048. The main reason is that Guangxi Province has made great progress in agricultural economic management and rural economic development through vigorously developing agricultural technology promotion in recent years, while Shaanxi Province has less investment in all aspects, which makes its rural economic development slow.

4.5 Differences between the EAST, the Middle, and the West

The accumulation of education, technology, and talent in the eastern region has also injected a strong impetus into agricultural economic management and rural economic development. High-level educational resources have cultivated a large number of agricultural technology and management talents, providing intellectual support for agricultural technology innovation and the reform of management models. At the same time, the eastern region has also attracted a large amount of social capital and foreign investment, providing solid financial support for agricultural infrastructure construction and rural environmental improvement. The success of agricultural economic management in the eastern region still relies on its strong policy support and government guidance. The government has effectively integrated various resource elements and promoted the coordinated development of agriculture and rural economy by formulating scientific and reasonable agricultural development plans and policy measures. At the same time, the government also focuses on strengthening the protection and governance of the agricultural ecological environment, achieving a win-win situation between the agricultural economy and the ecological environment. The eastern region has a flat terrain, many rivers and lakes, abundant water, light, and heat, and the agricultural production conditions are optimal. The central and western regions have regional differences. For example, the Sichuan Basin and Guanzhong Plain have a rich history of agricultural development and a vast economic hinterland. Therefore, agricultural economic management is quite superior to rural economic development, and the difference with the eastern region is small. However, on the whole, the economic foundation and agricultural management level in the central and western regions are inferior to those in the East. The key to reducing regional differences lies in developing regional characteristic agriculture according to local conditions. For example, Xinjiang uses irrigation water to develop economic crops such as grapes and Hami melon, which improves farmers' income, promotes the development of rural areas, and even develops a large number of agricultural production professional cooperatives. Figure 6 (Appendix) is the marginal box diagram of the structural transformation index in the east, central, and western regions.

4.6 Countermeasures and Suggestions

In the current environment of new rural construction, China attaches great importance to agriculture and has invested more energy and time in developing the agricultural economy. Agricultural economic management is of great significance to the organization and development of new rural construction. However, there are some problems in agricultural economic management that need to be paid attention to and solved by relevant departments.

Firstly, strengthening infrastructure construction and increasing capital and technology investment are the core paths to enhance the comprehensive agricultural production capacity. With the rapid advancement of technology, the modernization process of agriculture is accelerating. The application of advanced technology has significantly improved agricultural production efficiency, enhanced the ability to resist natural disasters, stabilized agricultural product yield and quality, and provided strong support for increasing farmers' income. To this end, we should continue to increase financial support, guide social capital to tilt towards the agricultural sector, focus on the research and application of key agricultural technologies, especially the popularization of cutting-edge technologies such as intelligent agriculture and precision agriculture, and empower agricultural transformation and upgrading with technology. At the same time, we will strengthen the construction of infrastructure such as agricultural water conservancy, rural roads, and cold chain logistics, build a sound rural public service system, and lay a solid foundation for rural economic development.

Secondly, continuously optimizing the rural industrial structure and promoting the supply-side structural reform of agriculture are important tasks for agricultural economic management. Faced with changes in market demand and constraints of resource environment, it is necessary to continuously adjust and optimize the agricultural industry structure, and achieve optimal allocation and efficient utilization of agricultural resources. This includes promoting the diversification of crop planting structures, developing characteristic agriculture, green agriculture, and ecological agriculture. Promote the integrated development of agriculture with the secondary and tertiary industries, extend the industrial chain, enhance the value chain, and increase the added value of agriculture. Therefore, in the period of new rural construction, we should first focus on discussing some negative situations in the agricultural industrial structure, consider specific development phenomena, and create rational, scientific, and highly practical solutions to make the industrial structure more planned. It brings important reference for the efficient development of agricultural economic management so that farmers can have enough food and clothing.

The government should develop a policy framework to support sustainable agricultural practices, including providing financial subsidies, tax incentives, and technical support. At the same time, establish a cross-departmental collaboration mechanism to ensure the synergy of agriculture, environment, technology, and other departments in promoting sustainable agriculture. Encourage farmers and agricultural enterprises to adopt sustainable agricultural technologies and management methods, such as organic farming, water-saving irrigation, circular agriculture, etc. By providing training, demonstration projects, and technical consulting services, we help them overcome obstacles in the transformation process. Support research institutions to develop and innovate sustainable agricultural technologies, strengthen cooperation with universities, and cultivate more talents with knowledge of sustainable agriculture.

5 Conclusion

In the management of agricultural production, the information contained in many data presents ambiguity, such as the quality of agricultural products and the degree of influence on the ecological balance. When analyzing and evaluating this kind of data, since there is no absolutely clear boundary for each index level or grade of the evaluated item, a fuzzy matrix can be used to describe the relationship between them. According to the effect of each index on the whole, the corresponding weight coefficient is determined, and a relatively clear normalized conclusion is drawn through the compound operation of the weight coefficient and the fuzzy evaluation matrix. Therefore, the scientific and rational application of fuzzy mathematical theory to the modeling work of agricultural economic management and rural economic development has scientifically verified the science and operability of the fuzzy comprehensive evaluation method in agricultural production management and provided new ideas and methods for agricultural production management.

In practical applications, obtaining comprehensive, accurate, and reflective data on various aspects of agricultural production management is a daunting task. The lack, incompleteness, or error of data may affect the accuracy of fuzzy comprehensive evaluation. The determination of weight coefficients is a subjective and objective process that is influenced by factors such as the evaluator's experience and knowledge background. Different evaluators may derive different weight coefficients, which can affect the stability and consistency of the evaluation results. In the future, it is necessary to strengthen the research and development of data collection and processing technologies, improve the comprehensiveness, accuracy, and timeliness of data, and provide more reliable data support for fuzzy comprehensive evaluation. Explore more scientific and objective methods for determining weight coefficients, such as weight coefficient optimization algorithms based on data mining, machine learning, and other technologies, to improve the stability and consistency of evaluation results.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

The authors wrote, reviewed and edited the content as needed and they have not utilised artificial intelligence (AI) tools. The authors take full responsibility for the content of the publication.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

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Conflict of Interest

The authors have no conflicts of interest to declare.

APPENDIX

Table 1. Agricultural economic management and rural economic development transformation evaluation index

First-level indicator	Secondary indicators	Three-level indicator	Four-level indicator
The promotion index of agricultural economic management to rural economic	Demand side	Demand potential	Per capita net income Engel coefficient
		Demand vitality	The proportion of secondary and Tertiary industries Labor productivity
	Supply-side	Technical skills	Number of technology promotion agencies Proportion of scientific researchers

development		Management knowledge	Number of training institutions
			Number of management agencies
		Farming modernization	Investment efficiency
			Total funding
	Convert kinetic energy	Economic development	Soil erosion control rate
			Fertilizer use intensity
		Sustainable development	Ecological sensitivity
			Comprehensive mechanization level

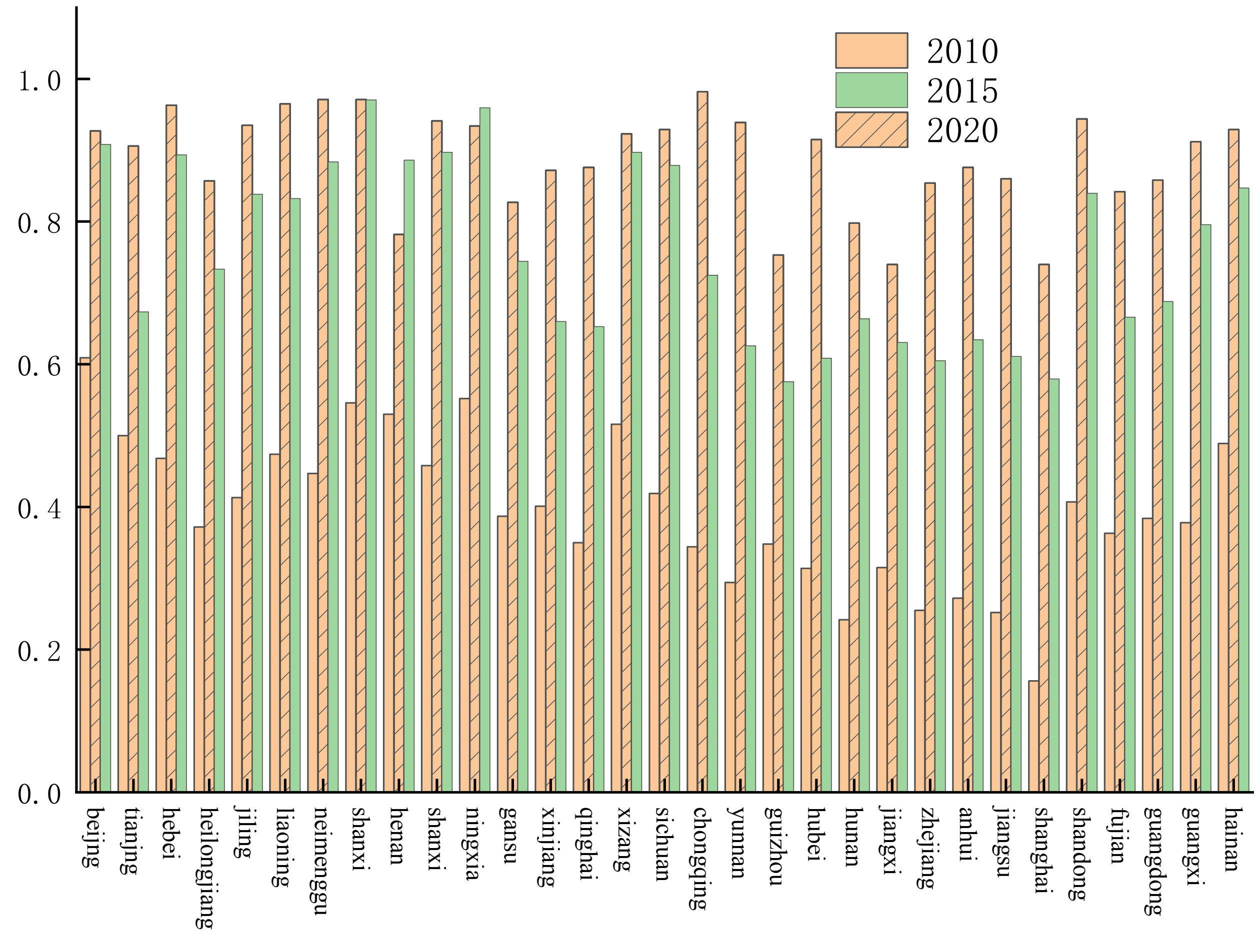

Fig. 1: Agricultural economic management index value

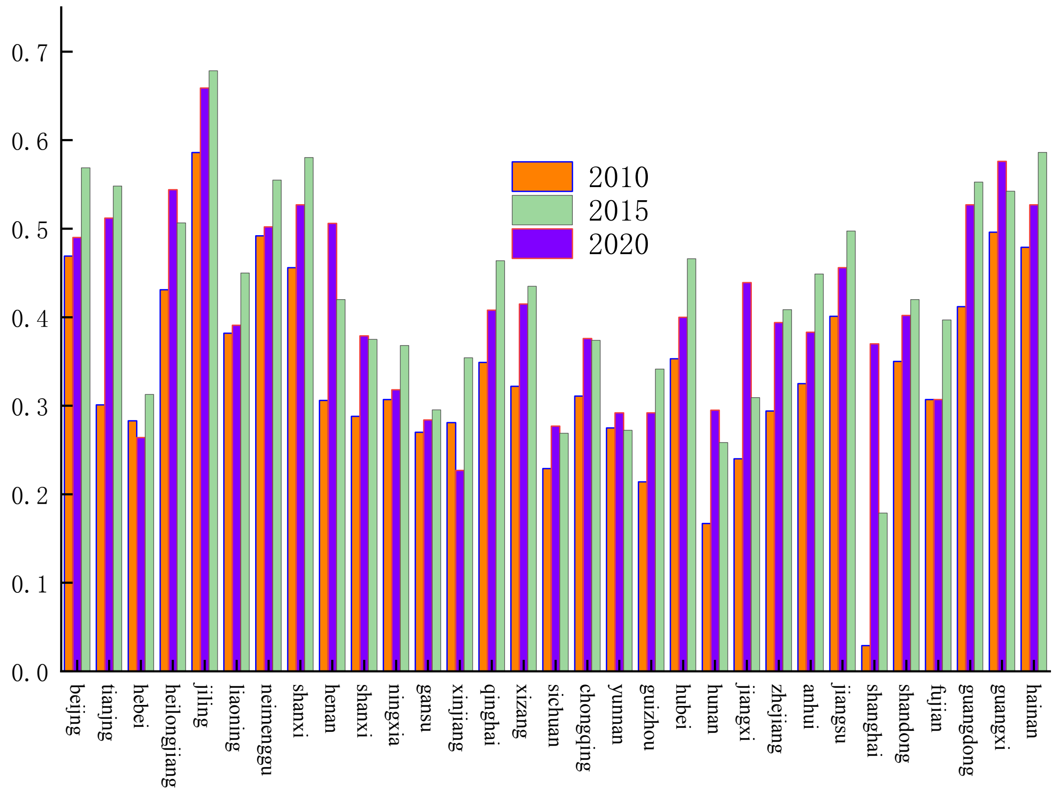

Fig. 2: Agricultural economic development index value

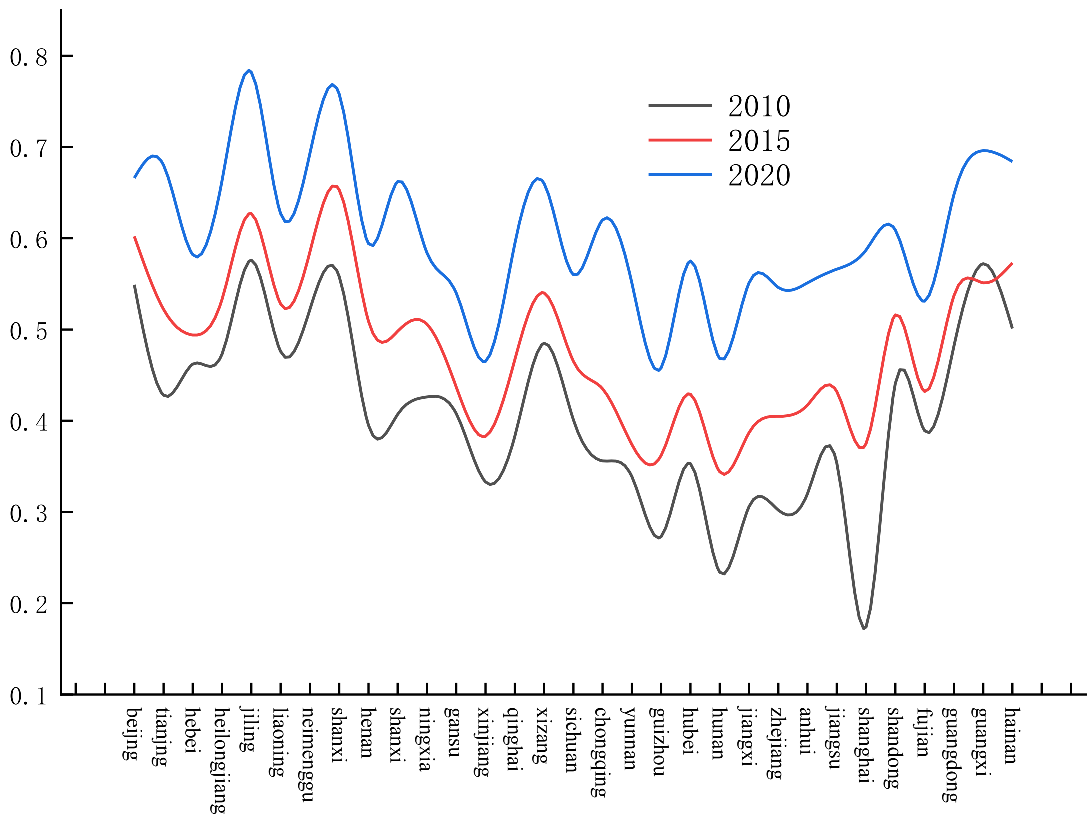

Fig. 3: Agricultural economic management and calculation of the rural economic comprehensive index

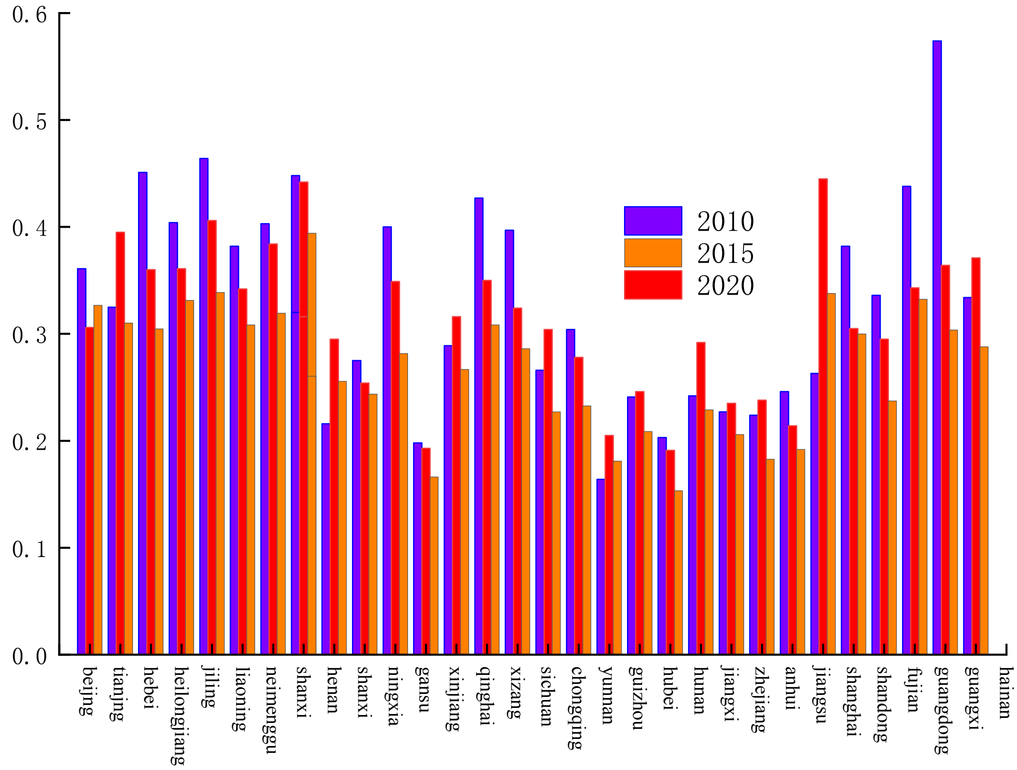

Fig. 4: Structural transformation index value

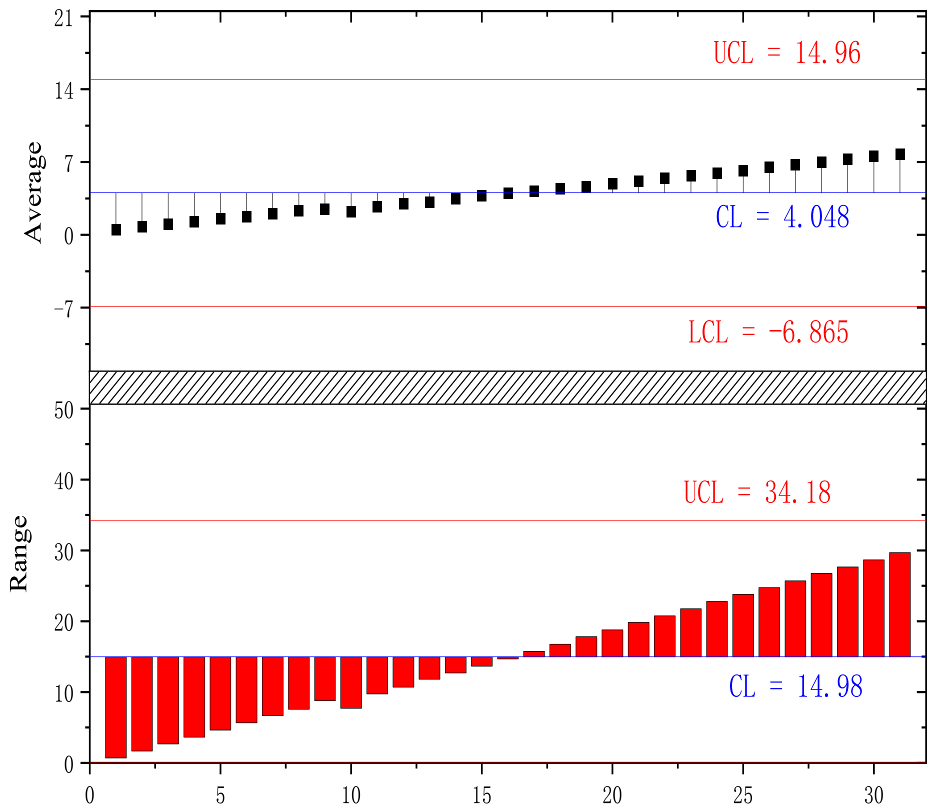

Fig. 5: Structural transformation index range diagram

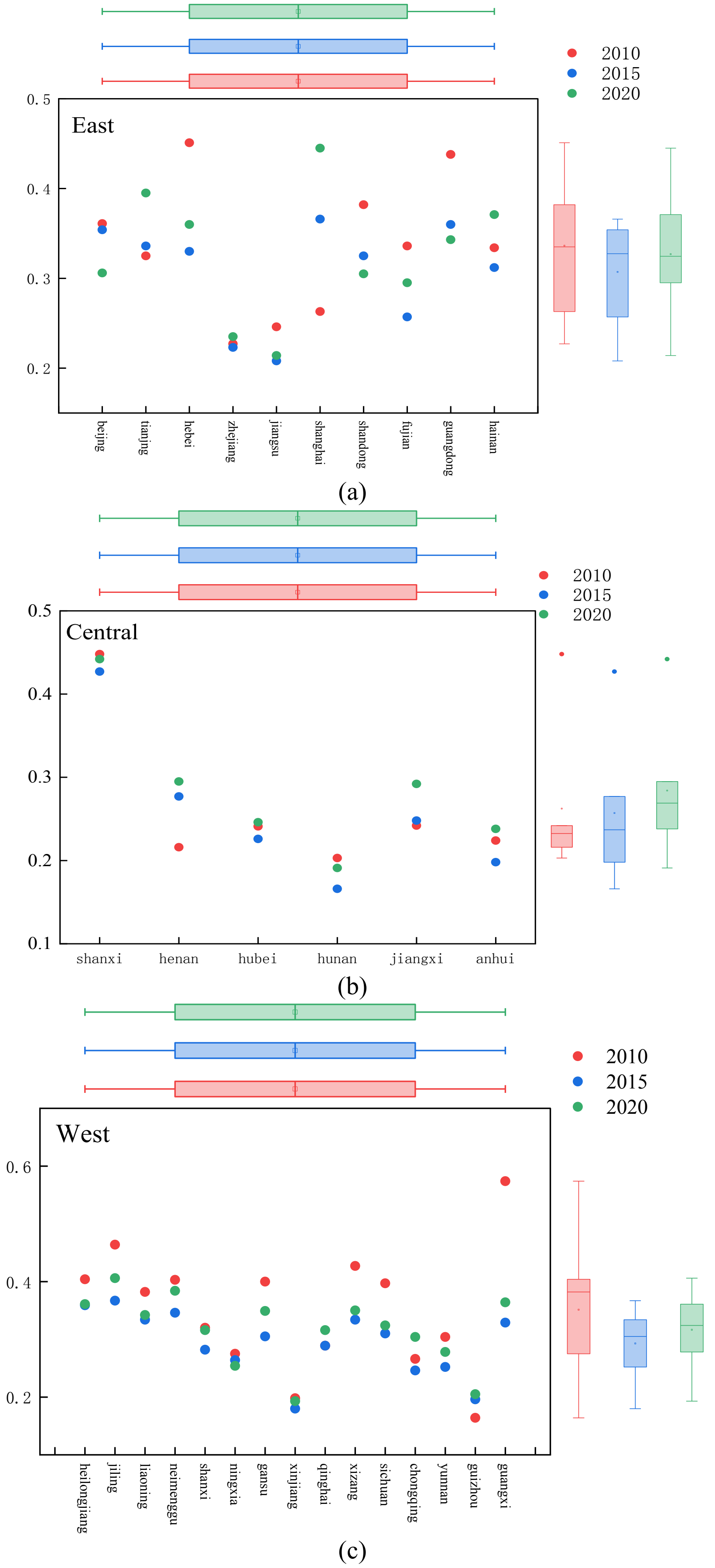

Fig. 6: Marginal box diagram of structural transformation index in East, Central, and Western Regions