

Research Article

Optimization of Regional Economic Industrial Structure Based on Edge Computing and Fuzzy K-Means Clustering

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This paper proposes a fuzzy K -means clustering-based optimization method for regional economic industrial structure. This paper discusses the multisubject of regional industrial planning, as well as its position and function in planning, based on research into regional industrial planning system design. This paper proposes a regional industrial planning model based on regional economic differences after summarizing the general methods of regional industrial planning and the disadvantages of traditional regional industrial planning. This paper uses edge computing technology to conduct a category analysis of various industrial cities and develops three models to study the evolution law of industrial structure: alternative evolution model, unbalanced evolution model, and diffusion evolution model. The optimization model of industrial structure is established by analyzing and sorting the various influencing factors of the evolution of urban industrial structure. This paper conducts a simulation experiment to verify the content arrangement of regional industrial planning and the design theory of regional industrial structure optimization system. The findings of this study have theoretical and practical implications for the study of regional industrial structure. For the optimization of regional industrial structure, it has a certain reference value.

1. Introduction

Since the beginning of the new century, all countries and regions are adjusting their economic structure, and the economies of all countries in the world are showing the trend of integration. Economic exchanges and cooperation between different regions are becoming more and more frequent, and various resources are flowing and configured on a global scale [1]. From the perspective of economic development mode, the root of increasingly serious resource and environmental problems lies in the traditional linear economic mode characterized by “two highs and one low” of high exploitation, low utilization, and high emission since the start of industrialization [2, 3]. With the increasing trend of global economic integration, the development competition among countries in the world is becoming increasingly fierce. A major strategic task and theme for realizing coordinated regional development and building a harmonious society in China in the new period is how to avoid

resource-based regions' dependence on resources and promote resource-based regions' sustainable development through the adjustment of industrial structure in the process of continuous economic system improvement. It is strategically and practically significant [4]. In the actual formulation and implementation of regional industrial planning, there are some issues such as blindness, randomness, and poor operability [5]. Because of these flaws, regional industrial planning's guiding role in regional industrial development has been severely harmed, and its pertinence and effectiveness have been greatly reduced. The reason for this is that China is lagging behind in the development of regional industrial planning theory due to a lack of theoretical support from systematic science [6]. As a result, studying the related theories and methods of regional industrial structure optimization based on regional economy is a challenging, urgent, and strategic proposition.

At present, China's economy is developing at a high speed, the scale of the national economy is constantly

expanding, the economic structure is gradually developing from agriculture to industry, and the scale of the tertiary industry is constantly expanding, and the people's living standards are significantly improved [7]. At the same time, significant changes have taken place in the regional economic structure, and regional economic differences have become a prominent feature of China's regional economic development and an unavoidable problem [8]. The estimation of regional industrial structure optimization is a hot and key issue in economic statistical analysis, with very important theoretical reference significance for macroeconomic research. The rational estimation of regional industrial structure optimization is inextricably linked to economic structure transformation, environmental improvement, and industrial structure coordination [9]. Market failure is inextricably linked to the emergence of regional industrial structure convergence, local protection and interregional market segmentation, and urban-rural segmentation under dual economic structure against the backdrop of widening regional economic differences. For a long time, the definition and calculation of the index of regional industrial structure optimization have been somewhat perplexing, owing to a misunderstanding of its meaning, which must be clarified before it can be reasonably estimated [10]. A series of institutional arrangements put forward by government departments to meet the needs of regional industrial development, that is, regional industrial planning, is an important means to correct market failure and give full play to the government's regulatory function and also an important guarantee for the healthy, stable, and sustainable development of China's regional economy [11]. In this paper, an optimization method of regional economic industrial structure based on fuzzy K-means clustering is proposed.

Unbalanced regional economic development is a common social and economic phenomenon. The change of spatial difference of regional economic development will have direct or indirect influence on regional economic decision-making, regional economic relations, the overall operation of national economy, and even social development [12]. It has been widely concerned by regional economic and economic geographers and has achieved numerous research results. There are many theories about regional economic and industrial structure and its optimization at home and abroad, but most of them are qualitative analysis and description from the macro aspect [13, 14]. According to the principles of scientificity and reality, comprehensiveness and systematicness, simplicity and operability, and genesis and dynamics, this paper divides the regions into three types: resource industry dependent type, resource industry combined with heavy type, and resource industry leading type through cluster analysis. This paper analyzes the rationalization of regional economic industrial structure from three aspects of market adaptability, industrial coordination, and rational utilization of production factors and puts forward the marginal evaluation method of industrial structure rationalization research. This paper proposes two main lines of regional industrial planning based on regional economic differences, namely, industrial structure optimization and coordinated development of regional industries, based on a

correlation analysis between regional economic differences and regional industrial planning, combined with the industrial dimension and spatial dimension decomposition of regional economic differences. The criteria for clustering are illustrated using the characteristics of various types of regional economic structures. The mean clustering method is chosen as the method for clustering regions, and the software is used to classify regions in order to test the clustering method's feasibility. This research identifies some feasible paths for optimizing regional industrial structure, particularly in underserved areas, while avoiding unnecessary costs and detours.

2. Related Work

The industrial structure, according to reference [15, 16], is the technical and economic connection and connection method between industries, and this interindustry connection and connection method can be examined from two angles. The first is to dynamically reveal the changing trend of interindustry technical and economic connections and connection methods from a "quality" standpoint. From the perspective of "quantity," the second is to statically study and analyze the technical and economic quantity proportional relationship of interindustry linkages and linkages within a given period. References [5, 17] summarize and analyze estimation methods for regional industrial structure optimization based on theoretical research and practical progress. It tries to clarify the estimation method that best fits the meaning of regional industrial structure optimization and then provides a reference for basic estimation methods for a variety of related studies. References [9, 18] proposed a circular economy model for improving the regional leading industry selection benchmark and used the grey fixed-weight clustering model and the comprehensive evaluation model to conduct an empirical analysis on the selection of a regional leading industry and compared the analysis results to unconsidered resources. The evaluation results of energy and environmental consumption are compared and analyzed. Reference [19] proposed a new method of regional economic spatial difference analysis based on spatial clustering and hierarchical map and class axis analysis based on the analysis of traditional regional economic difference analysis methods. References [15, 20] proposed the concept of industrial structure goodness, introduced the idea of econometrics, and highlighted the role of quantitative calculation in the evaluation of industrial structure. Reference [8] believes that the analysis mode based on expert knowledge can better utilize the regional knowledge and analysis expertise of regional economic experts. However, its analysis results are highly subjective, which is prone to bias the analysis results and lacks a repeatable quantitative analysis. Reference [4] explored the leading industry and its selection theory on the basis of the evaluation of the industrial structure. Reference [21] puts forward the principle of regional leading industry selection from the perspective of giving play to regional economic advantages, building a regional advanced industrial development pattern, and promoting the rapid and efficient growth of regional economy. It

provides the basis and support for the selection of regional leading industries.

Using dynamic decomposition technology, the internal mechanism of regional industrial structure adjustment is analyzed from the perspective of industrial dimension decomposition of regional economic differences, and a three-dimensional interactive model of regional leading industry selection of “regional correlation, industrial development foundation and industrial development potential” is constructed. The time evolution characteristics of China’s industrial structure under the new normal are studied using ordered sample clustering. The application is put to the test, and the results of the analysis show that it is in line with actual regional economic development. This method can reveal not only the macro distribution law of economic data but also the micro spatial distribution characteristics, which can aid in the analysis and explanation of economic characteristics and laws contained in a large number of spatial economic statistical data, as well as the optimization of regional economic and industrial structure.

3. Methodology

3.1. Regional Economic and Industrial Structure. Regional economy is a production complex produced by the interaction of internal factors and external conditions of economic development in a certain region. Industrial structure refers to the industrial composition, technical and economic relations between industries in a certain spatial range, and the ways and means of their functions. The most intuitive external expression is the proportional relationship between industries. Industrial structure optimization and upgrading refers to the active, active, and effective strategic behavior of local governments to optimize and upgrade the best industries according to the characteristics of industrial structure and the constraints of economic development in the process of industrialization, thus driving the development of other industries. Starting from the existing balance and coordination among the three industries and within each industry, through technological progress, industry, and product innovation, a breakthrough from quantity to quality can be formed to achieve new balance and coordination [22].

The core and foundation of a country’s economic structure are its industry structure. It reflects the fundamental state of economic growth in a country or region, as well as the fundamental modes of economic growth. Not only is regional industrial structure the result of social production division, but it is also a result of regional division. Different natural conditions, factors, and other factors in different regions result in different regional comparative advantages, resulting in regional division of labor and resulting in different industry distributions in different regions [23]. That is, at a certain stage of economic development, adjust the related variables of the initially unsatisfactory industrial structure, straighten it out, and make resources rationally allocated and effectively utilized among industries, based on consumption demand and resource conditions. The technological differences between industries will be transformed into a

driving force for learning and further innovation during the technology transfer process. It promotes the flow of economic factors among industries and changes the demand or input relationship between industries as shown in Figure 1.

A regional industrial structure is a collection of two or more regional industrial structures that are geographically close together, economically similar, and traffic-connected. It refers to the composition, structure, and proportional relationship between departments, industries, and the planning area as a whole. The evolution and development of industrial structure are an unavoidable economic phenomenon in any country’s economic development. The theory of industrial structure evolution is constantly enriched and improved in the process of economic development [20]. There are four distinct characteristics of the regional industrial structure. (1) A country’s national economy is rarely represented in the regional industrial structure. (2) In general, there are several industrial departments in the regional industrial structure that benefit from professional labor division throughout the country. (3) Different regions have different comparative advantages, specialized departments, and industrial structures that are clearly different. (4) Industrial structures at the regional level are highly complementary and interdependent.

Reasonable industrial structure is the premise of regional economic growth, which is conducive to making full use of regional resources and improving the economic benefits of regional industries. The design of industrial structure is an important part of regional industrial planning, which mainly answers what kind of industries to develop and what proportion of industries to develop. Regional industrial structure optimization refers to the analysis of the economic development of the whole region, guided by certain values and methodology, and through a series of in-depth and meticulous qualitative and quantitative studies, the model and scheme of regional industrial structure optimization are obtained [24]. On this basis, the corresponding industrial policies should be formulated and implemented to optimize and adjust the proportional relations and related ways within and between industries in the region, so as to realize the best combination of various production factors and the best allocation of various resources and finally achieve the best economic and social benefits. The industrial structure optimization model is shown in Figure 2.

The optimization of regional industrial structure is to build a structure suitable for local development according to the optimization law and grasp the essence of industrial structure. From the perspective of total supply and total demand and mutual coordination, the industrial structure is actually a resource converter, which constantly transforms the sum of various social resources into various products and services to meet the total social demand. Therefore, the research on the optimization of regional industrial structure must be carried out by combining the comparative advantages of location resources and improving the comparative benefits of location.

The spatial layout of regional industrial productivity reflects the distribution of factors in space as well. The concentration of capital, labor, and information technology in

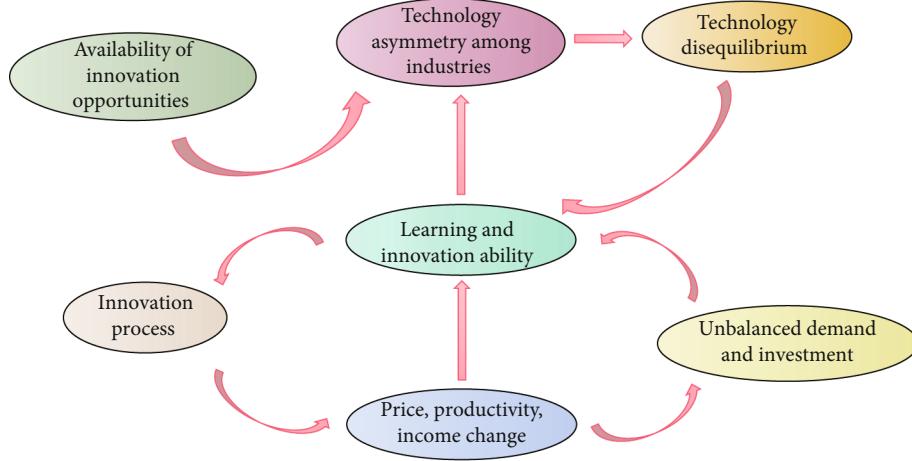


FIGURE 1: Industrial evolution model.

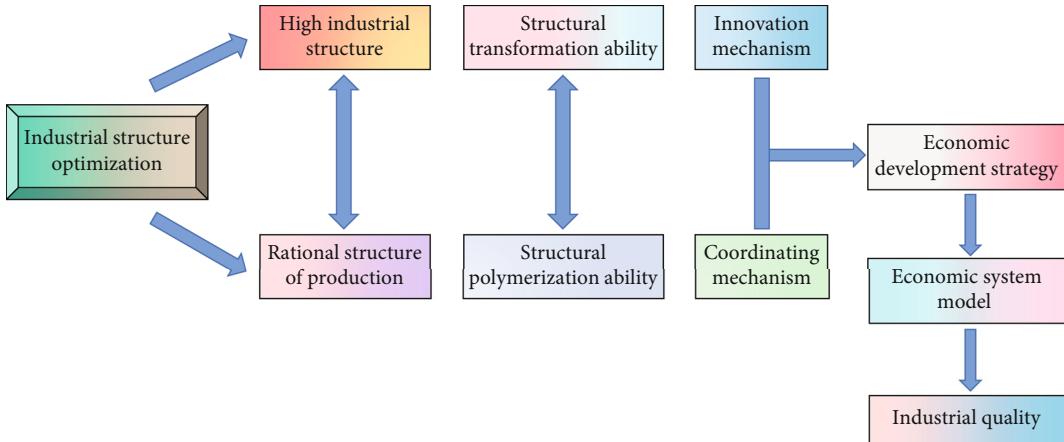


FIGURE 2: Industrial structure optimization model.

one location indicates that the industry in that region is rapidly developing, with the potential for an industrial cluster or group development pattern, in which the factors of production are allocated according to regional space. Although the specific content of optimization varies depending on the development stage and time point, it primarily consists of four aspects: (1) industrial structure rationalization, (2) there is a well-developed industrial structure, (3) industry development that is coordinated, and (4) industrial development efficiency. Realize maximum resource utilization efficiency transformation, grasp the combination of its basic principles and regional reality, break through the tedious model to the extreme, grasp the essence of theory, set the optimization direction goal, find problems, and make suggestions based on the principle of simplicity, practicability, and effectiveness.

3.2. Optimization of Regional Economic Industrial Structure Based on Fuzzy Clustering. Adopting a reasonable estimation method is extremely important for scientifically analyzing the optimization of China's regional industrial structure. When exploring the process and mechanism of regional

industrial structure optimization in China, existing estimation methods are unable to withstand the analysis. The traditional and unitary research methods of direct quantitative analysis are avoided in this paper, and methodology, which is reasonable and innovative to some extent, is neglected. The project is a critical starting point for ensuring growth and a source of regional industrial structure optimization as the primary vehicle for investment promotion. All new projects should be designed to optimize regional industrial structure, increase investment in advantageous and characteristic industries, and modern service industries, shift away from the past situation in which the secondary industry dominated, and establish a new pattern of coordinated primary, secondary, and tertiary industry development. It will be supplanted by other industries at some point in the future. The slowdown in technological progress in the leading industries is primarily to blame for the decline in their growth rates.

Because of the different dimensions and magnitude of each index, different dimensions and magnitude will produce new problems when applying principal component analysis to research. This requires standardization of data

processing. The main function of data standardization is to eliminate the dimensional relationship between variables, so as to make the data comparable. The standardized processing formula is

$$X_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j}, \quad (1)$$

where \bar{x}_j and S_j are the average and standard deviation of the data corresponding to the j index, respectively.

Consumption is the source of industrial structure change, and the influence of production and external environment is more direct. According to the general law of economics, the formation and change of personal consumption structure first depend on the per capita income level of a country. With the increase of per capita income, the personal consumption structure will change accordingly. Intermediate demand is the demand of each production department for the means of production that can transfer all its own value to the product at one time. Personal consumption, equipment investment, inventory expansion, exports, and government procurement all contribute to the total demand. Finally, the proportion of consumption and investment in demand determines the proportion between the consumption and capital data industries, limiting the development of these two industrial sectors. The change in consumption structure promotes technological progress and production change in related industries, causes the flow of financial capital, changes the external environment of industries, promotes technological progress and production efficiency improvement, and finally realizes the optimization of industrial structure. The hierarchical breakpoints based on spatial distribution are obtained by utilizing the spatial aggregation characteristics of cluster analysis data. The similarity measure used in this study is a hierarchical clustering method based on topological adjacency and attribute similarity.

Before spatial clustering, the adjacency matrix is generated according to the topological adjacency of regions. When judging the topological adjacency of two polygons with common edges, if $S > 0.03$ in formula (2) is satisfied, the two polygons are considered to have topological adjacency, and the corresponding row-column intersection in the adjacency matrix takes 1; otherwise, it takes 0.

$$S = \frac{L_{ab}}{L_a + L_b}, \quad (2)$$

where L_{ab} is the common side length of polygon a and polygon b . L_a is the side length of polygon a . L_b is the side length of polygon b .

The relationship between industries, that is, the industrial structure, greatly influences and restricts other aspects of national economic operation. The time evolution of industrial structure mainly includes the trend characteristics and periodic characteristics of industrial structure evolution.

Let the samples contained in a certain class A be:

$$\{a_{(i)}, a_{(i+1)}, \dots, a_{(j)}\} (j > i). \quad (3)$$

The mean vector of class A can be obtained as:

$$\bar{A}_G = \frac{1}{j-i+1} \sum_{t=1}^j a_{(t)}. \quad (4)$$

If $D(i, j)$ is used to represent the diameter of class A , the expression of $D(i, j)$ is

$$D(i, j) = \sum_{t=i}^j (a_{(t)} - \bar{A}_G)' (a_{(t)} - \bar{A}_G). \quad (5)$$

If $b(30, k)$ is used to represent a certain method of dividing 30 ordered samples into k categories, the expression of $b(30, k)$ is

$$\begin{cases} G_1 = \{i_1, i_1 + 1, L, i_2 - 1\}, \\ G_2 = \{i_2, i_2 + 1, L, i_3 - 1\}, \\ \dots \\ G_k = \{i_k, i_k + 1, L, n\}. \end{cases} \quad (6)$$

Then, the loss function of this classification is

$$L[b(30, k)] = \sum_{t=1}^k D(i_t, i_{t+1} - 1). \quad (7)$$

If k is determined, the smaller the $L[b(30, k)]$ is, the smaller the sum of squared deviations of each category is, and the classification is reasonable.

Such methods are more accurate, systematic, and comprehensive than the above analysis of the connotation of regional industrial structure optimization. The comparative advantage benchmark, which reflects the location advantage, must be considered when selecting regional leading industries. The indicator "Location Quotient" is used to represent it in this paper. The location quotient is defined as the ratio of a sector's output value to the region's total output value, as well as the proportion of a high-level sector's output value to the high-level total output value. It is expressed as follows:

$$Q = \left[\frac{d_{ij}/\sum_{i=1}^n d_{ij}}{D_i/\sum_{i=1}^n D_i} \right]. \quad (8)$$

In the formula, Q is the location quotient of the i sector in j area to the high-level area. D_{ij} is the gross output value of sector i in region j . D_i is the gross output value of the high-level i sector. n is the number of sectors in a certain industry.

When setting up the model, we cannot ignore the effect of regional income level and technological progress on the upgrading of regional industrial structure. At the same time,

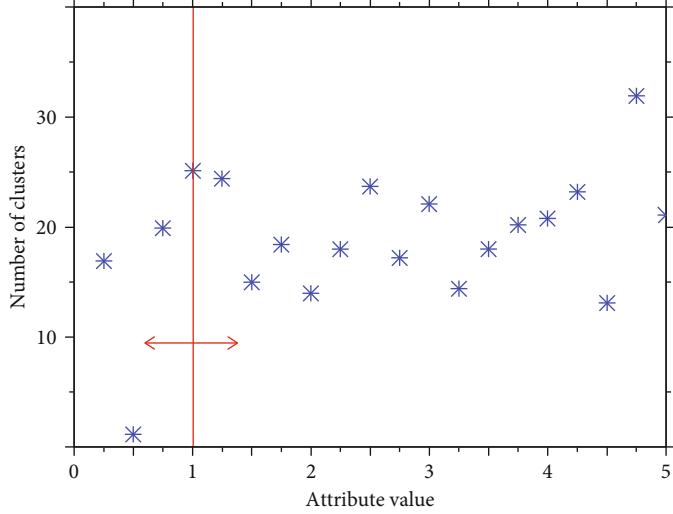


FIGURE 3: Quasi axial distribution diagram.

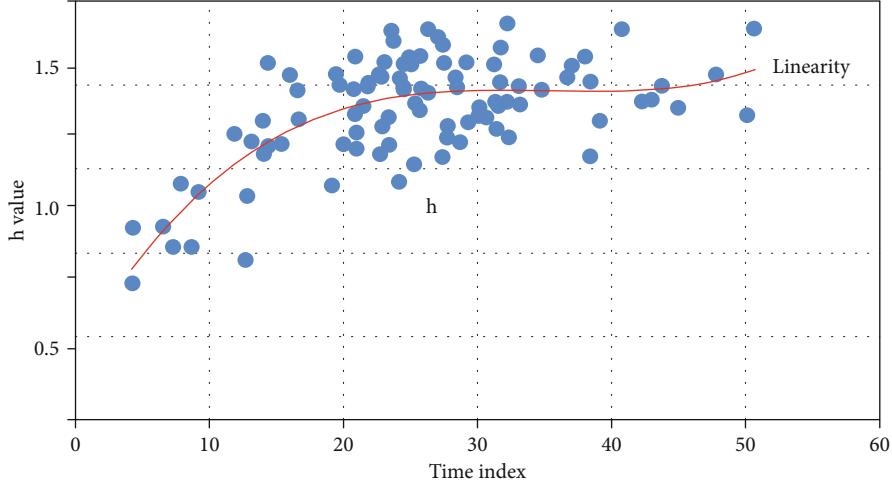


FIGURE 4: Rationalization trend of regional industrial structure.

one of the main ways for foreign capital to promote industrial structure upgrading is capital supply, and its role cannot be ignored. After the data quality evaluation, it is matched with the spatial administrative boundary data to realize the spatialization of regional economic data and establish the corresponding database system. System is also a factor to be considered. Considering the consistency and continuity of time series, according to the enlightenment of other scholars' research, it can be expressed by the combination of property right index, economic system index, and opening degree index.

Each object in N spatial entities is assigned to a class, and the similarity measure between two topologically adjacent objects is determined, for example, by calculating the absolute or relative difference of their attributes. Choose Y and create clusters of two objects that have the most in common attributes. Technological advancement is measured using an index system. This article only uses one aspect of the financial expenditure for scientific research to express inaccuracy;

it also includes many other factors such as patents and enterprise scientific research expenditure, and technological progress must go through certain procedures and accumulation, which can result in qualitative changes in regional industrial structure upgrading.

4. Result Analysis and Discussion

The distribution characteristics of attribute space are investigated using the frequency histogram and cumulative curve analysis. The frequency histogram of a data set is the most direct tool. That is, the abscissa represents the size of statistical indicators with equal spacing, while the ordinate represents the frequency of each statistical object group. Frequency histogram analysis is also a fundamental exploratory data analysis technique, with the emphasis on exploratory rather than deterministic. It is a visual data analysis method as well as an adaptive data analysis method. The comprehensive function of multiple indicators reflects a department's

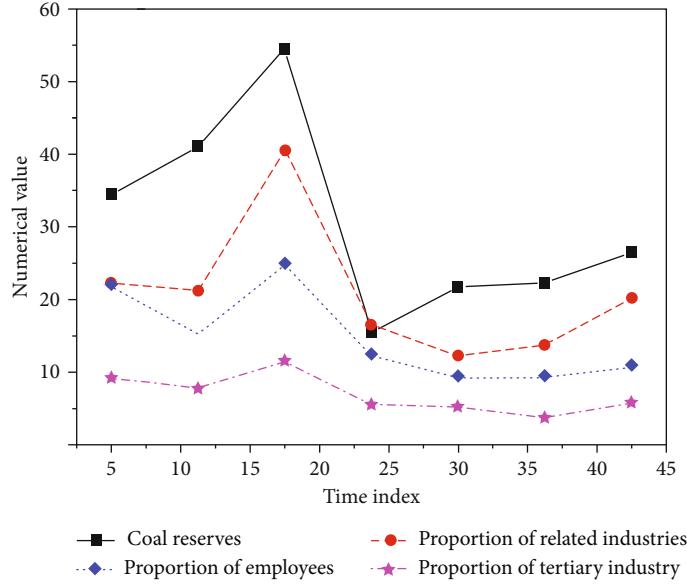


FIGURE 5: Line chart of some data in city A.

position and function in regional economic development, and the cluster model of uncertain mathematical method is used to select the regional leading industries. Regional departments are divided into three types for ease of evaluation, based on their importance in regional economic development: general industries, auxiliary industries, and leading industries. Figure 3 depicts the class axis distribution diagram. The attribute value is on the horizontal axis, the number of spatial clusters is on the vertical axis, and a horizontal line segment in the diagram represents a class of spatial clustering results. Therefore, class axis analysis is a concise visual method to transform spatial clustering results into attribute space, and spatial information can be used to correct the classification results of attribute space.

The level of relative cost reflects the level of resource consumption related to the production and supply capacity, which is a decisive factor affecting the change of industrial structure from the supply side. Industries with relatively low cost may have an advantage in relative national income, thus attracting resources to the sector and enabling the industrial sector to expand rapidly. Therefore, the change of relative cost will promote the change of industrial structure from the supply side, obtain the frequency of different statistical indicators and the distribution law of statistical data from the frequency histogram, and find out the characteristics of graded characteristic point value, intermittent point value, and uniform and nonuniform change of statistical indicators. Through simulation experiments, the trend characteristics of h value of regional industrial structure rationalization are shown in Figure 4.

The overall rationalization of regional industrial structure is on the rise, as shown by the linear trend in Figure 4. The overall strategy for regional industrial development is proposed, taking into account the current situation and development conditions, and includes the selection of key industries with strategic impact on regional develop-

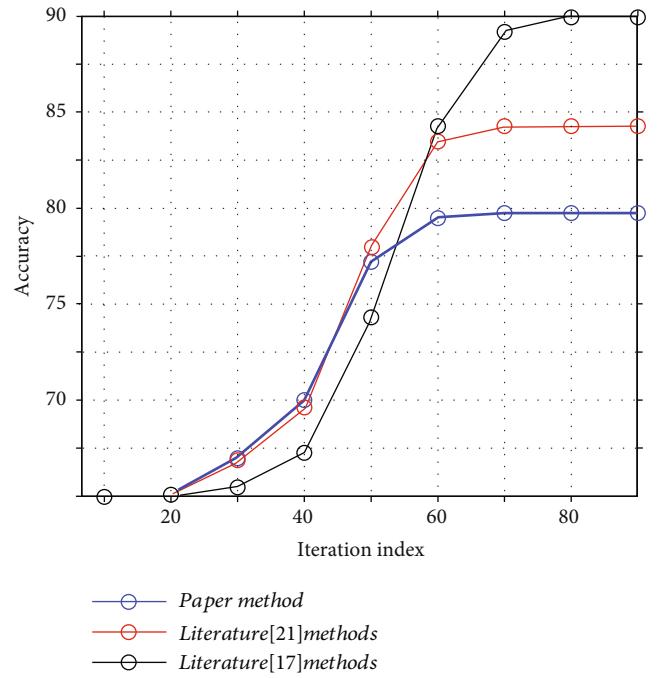


FIGURE 6: Accuracy comparison of different algorithms.

ment, the optimization of regional industrial structure and development paths, the planning and layout of key projects, and other development strategies and specific industrial policies. The core step of regional industrial planning is implementation. State variables are the model's unobservable variables. Not only can the law of the economic state in the model change with time, but it can also be proven whether the selected state truly reflects the actual situation of the observed variables by estimating the state variables of the model. To illustrate the law of the evolution of

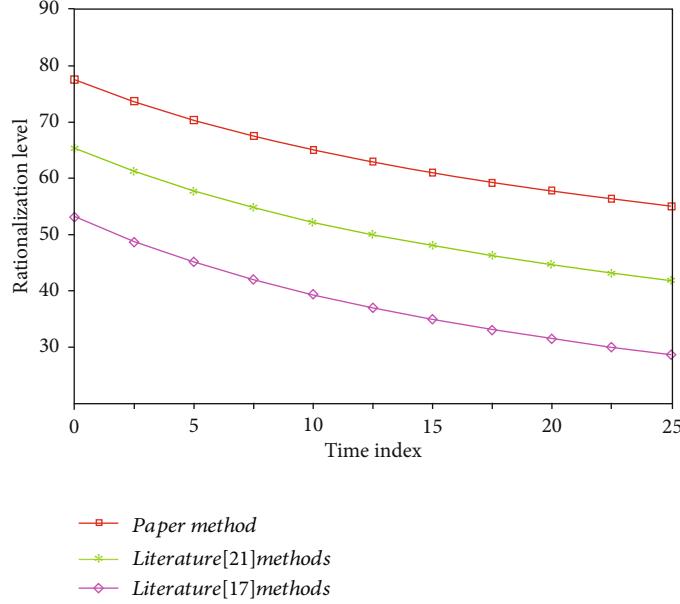


FIGURE 7: Comparison of rationalization levels of different methods.

regional industrial structure, this paper uses the resource-based city A as the research object and four indicators, including coal reserves, the proportion of employees in the extractive industry, the proportion of mining-related industries, and the proportion of the tertiary industry. The results are shown in Figure 5.

It can be seen from Figure 5 that with the exploitation of resources, the coal reserves in city A are gradually declining. Later, due to the simultaneous development of major industries, especially the rapid development of the tertiary industry, the proportion of the extractive industry continued to decline, resulting in the development of city A into a resource industry and a heavy city. According to this law, it will become a resource-industry dependent city. The smooth implementation of regional industrial planning is inseparable from a series of related policies, including industrial policy, fiscal policy, financial policy, and talent policy, mainly to provide tax incentives, financial subsidies, financing environment, institutional guarantees for division of labor and cooperation, technical exchanges, talent introduction and training, etc. In order to verify the accuracy of the algorithm in this paper, simulation experiments are carried out, and the accuracy of the method in this paper is compared with the method in the literature [17] and the method in the literature [19], and the results are shown in Figure 6.

It is clear that, over time, this algorithm has greater accuracy than the other two algorithms. As a result, this algorithm beats out the other two. One of the most common methods for creating hierarchical maps is to analyze data using a frequency histogram and then determine breakpoints. Similarly, the cumulative curve aids in understanding the overall distribution characteristics of data sets from the standpoint of cumulative distribution, and it is also one of the most widely used hierarchical map classification methods. The mixed density decomposition model algorithm can be used to solve the problem when the frequency

histogram has multiple peaks, and it is difficult to objectively select breakpoints between them using artificial methods. The attribute values of geographical entities in each category in the results are marked on the attribute coordinate axis, and the attribute range corresponding to each category in the clustering results can then be determined using the preliminary results of spatial clustering. A clear measurement mark exists for industrial structure optimization. We conduct simulation experiments and compare this method to the methods in [17, 19] in order to further confirm its effectiveness. Figure 7 depicts the outcome.

The level of regional industrial structure rationalization is higher after using this method, as can be seen. As a result, this method is better than the other two. This method's superiority is further demonstrated. The unbalanced supply and demand structure of national products cause friction and losses in the economy, which must be corrected. The evolution of regional industrial structure is influenced not only by changes in relevant national policies but also by changes in national industrial structure. The relationship between national and regional industrial structure is that the latter develops under the former's policy guidance and adjustment, while the former influences the latter's overall level and development direction.

5. Conclusions

Optimization of industrial structures is a systematic problem that encompasses all aspects of economic operation. Industrial structure is the foundation and support of economic structure, and even minor changes in industrial structure can result in significant changes in how the entire economic system operates. Following the law, combining reality, and applying the principle are the keys to optimizing regional economic and industrial structures. The central goal is to create a new regional economic and industrial structure that

functions as a resource converter that is appropriate for local conditions and current trends. The transition between old and new structures is referred to as optimization. We can grasp the inherent law of regional economic industrial structure rationalization and upgrading by formulating appropriate measures, starting with an analysis of the composition of regional economic industrial structure and its evolution history. This paper proposes the concept of regional economic and industrial structure optimization and introduces the idea of econometrics into comprehensive evaluation, based on an analysis of related factors of regional economic and industrial structure. The established related index system is analyzed using cluster analysis, and appropriate improvement suggestions are made based on the findings. Finally, this paper conducts an empirical analysis of the regional economic and industrial structure optimization evaluation model using statistical data. The empirical results show that this method can reveal the macro distribution law of economic data and tap the micro spatial distribution characteristics, which can better help to analyze and explain the economic characteristics and laws contained in a large number of spatial economic statistical data. Moreover, the evaluation system and model of regional economic and industrial structure optimization proposed in this paper have strong practical guiding significance.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors do not have any possible conflicts of interest.

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