# Comprehensive Classification of Urban Agglomeration Types in China

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**Abstract.** Urban agglomeration is not only an important carrier of China's new urbanization strategy, but also a new regional unit for the country to participate in global competition and international division of labor. At present, China's regional spatial governance model is undergoing a major change, from the original administrative division management to the type of regional spatial governance. Based on the important extension characteristics of urban agglomerations, this paper classifies 23 urban agglomerations in China with the idea of comprehensive classification, and obtains the index system and clustering results of type classification, which provides scientific basis for the planning guidance of spatial pattern optimization and classification management of urban agglomerations in China. Referring to the scale and degree of agglomeration of mature urban agglomerations in the world, based on the four characteristics of urban agglomerations, the index system is constructed. Fuzzy C-means clustering (FCM) method is used to quantitatively classify Chinese urban agglomerations into five types.

## 1 Introduction

Under the background of economic globalization, urban agglomerations have become the most dynamic and potential growth point in a country's economic development, and a new regional unit for the country to participate in global competition and international division of labor. Many scholars use a combination of qualitative and quantitative methods or GIS spatial analysis techniques to define the spatial extent of urban agglomerations. However, in general, domestic and foreign scholars still focus on the classification of urban agglomerations in the qualitative division stage. A few quantitative studies are mainly based on a single feature dimension, and there are few studies on comprehensive quantitative division from multiple dimensions. Based on this, this paper starts from the divisional management of China's regional space governance mode from the divisional management of administrative districts to the need of space management according to type zones. Based on the main extension features of urban agglomerations, comprehensive classification ideas are used to integrate 23 urban agglomerations in China. The study of type division provides a scientific basis for the implementation of spatial pattern optimization and classification management planning for local urban agglomerations in China.

## 2 Research method

Fuzzy clustering algorithm is a flexible clustering method based on fuzzy partitioning. At present, there are many research methods in urban agglomerations. Fuzzy c-means clustering (FCM) algorithm performs well in urban type research. Therefore,It can be used as the main research method.

In the FCM algorithm, for the given data set, $X = \{x_1, x_2, \ldots, x_n\}$, $x_j \in R^S$, That is, each sample in the data set is an s-dimensional vector, Divided into $c(2 \le c \le n)$ classes, The vector set of each cluster center is set to $V = \{v_1, v_2, \ldots, v_c\}$, The membership of each data sample $x_j$ belonging to i-th category cluster center is $u_{ij} \in [0,1]$, and $\sum_{i=1}^{c} u_{ij} = 1, j = 1, 2, \ldots, n$.

The objective function of the FCM algorithm is shown in equation (1)

$$J(U,V) = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^m d_{ij}^2 \qquad (1)$$

Where d is the Euclidean distance between the sample $x_j$ and the cluster center $v_i$, Formula is $d = \left\| x_j - v_i \right\|$; $m$ is a fuzzy weighting coefficient

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indicating the degree of blurring of the classification matrix $U$. The calculation formulas of the membership degree $u_{ij}$ and the cluster center $v_i$ are as shown in equations (2) and (3):

$$u_{ij} = \frac{1}{\sum_{y=1}^{c} (d_{ij}/d_{yj})^{\frac{2}{m-1}}} \quad (2)$$

$$v_i = \frac{\sum_{j=1}^{n} u_{ij}^m x_j}{\sum_{j=1}^{n} u_{ij}^m} \quad (3)$$

The clustering effectiveness of **FCM** clustering algorithm needs to be tested to judge the rationality of the result [6], and its formula is shown in formula (4):

$$P(U,c) = \frac{\min_{j=1}^{c}(\sum_{i=1}^{n} u_{ij})}{\max_{j=1}^{c}(\sum_{i=1}^{n} u_{ij})} [\sum_{j=1}^{c}(\frac{\sum_{i=1}^{n} u_{ij}^2}{c\sum_{i=1}^{n} u_{ij}}) + 1 - \frac{\sum_{j=1}^{c}\sum_{i=1}^{n} u_{ij}^2 \|x_i - x_j\|^2}{\sum_{i=1}^{n} \|x_i - \sum_{i=1}^{n} x_i\|^2}] \quad (4)$$

Where $x_j \in R^m, i = 1,2,...,n$ is the m-dimensional sample vector, $v_i \in R^m, i = 1,2,...,c$ is the cluster center, and $U = \{u_{ij}\}$ is the membership matrix.

## 3 Case analysis

### 3.1. Indicator system of urban agglomeration classification

According to the statistics of the frequency of attention of urban and foreign scholars on the characteristics of urban agglomerations, it can be decomposed into seven factors and 14 quantifiable indicators, which constitute the index system of urban agglomeration type classification. The target layer and its factor quantifier are shown in Table 1.

**Table 1.** Index system for quantitative division of urban agglomeration types

| Target layer | Factor explanation | Factor level | Index level | Index code | Index Interpretation and Calculating Method |
|---|---|---|---|---|---|
| Energy Interaction Degree | An Important Factor to Measure the Source of Energy Consumption in Urban Agglomerations | Energy dependence | Energy outsourcing | L1 | Ratio of Energy Outsourcing Amount of Urban Agglomeration to Total Energy Consumption in Urban Agglomeration |
| | | | Energy outflow | L2 | The proportion of energy outward from urban agglomerations to total energy |
| Decentralization of energy consumption | Important factors reflecting the degree of decentralization of energy consumption within urban agglomerations | Equilibrium Distribution of Elements | Population multicentricity | L11 | Four City indices of population size of cities in urban agglomeration.The calculation method is based on the four cities index P1/(P2+P3+P4) |
| | | | Economic multicentricity | L12 | Four City indices of economic scale of cities in urban agglomeration.The calculation method is based on the four cities index P1/(P2+P3+P5) |
| industrial structure | Reflecting the Industrial Structure of Urban Agglomeration from the Perspective of Employed Population | industrial structure | Employment Proportion of General Processing Manufacturing Industry | L13 | Proportion of Employed Population in Machinery, Chemical Industry, Textile, Clothing, Food, Paper and Other Manufacturing Industries |
| | | | Employment Proportion of Energy Raw Materials Industry | L14 | Proportion of Employed Population in Energy Raw Materials Industries such as Mining, Electricity, Gas and Water Supply |
| | | | The proportion of employment in transportation, finance, commerce and real estate | L15 | The proportion of employed people in transportation, warehousing, finance, wholesale and retail trade, real estate and other industries |
| | | Service industry structure | Employment Proportion of Computer Research Technology | L16 | Employment proportion of information transmission, software industry, scientific research, technical services and other industries |
| | | | Employment proportion of residents in public service industry | L17 | Proportion of Employed Population in Accommodation, Catering, Leasing, Education, Culture, Entertainment and Sports |
| Resource loop effect | Environmental Effects and | Material consumption | Industrial Value Added Rate | L18 | Ratio of industrial added value above scale to gross industrial output value |

| Resource Utilization Efficiency Reflecting the Economic Development of Urban Agglomerations | level | | | above scale |
|---|---|---|---|---|
| | Environmental pollution level | Air Pollution Index | L19 | Average Concentration of PM2.5 in Urban Agglomeration |
| | | Pollution Emission Index | L20 | Ratio of Square Root of Product of Total Industrial SO2 Emission and Total Industrial Smoke Emission to GDP of Urban Agglomeration |
| | Resource utilization efficiency | Energy Consumption per Unit Output Value | L21 | Ratio of total energy consumption of urban agglomeration to GDP of Urban Agglomeration |
| | | Water consumption per unit output value | L22 | Ratio of total water consumption of urban agglomeration to GDP of Urban Agglomeration |

### 3.2. Clustering results of Urban Agglomerations

Based on the scores of the above five factors, the clustering tree was obtained by FCM method, and the urban agglomeration in China was clustered into five categories.According to the average score of each type of eigenvalue and the intra-class deviation, and combined with the expert opinions, the prominent characteristics of each type of urban agglomeration are summarized and evaluated. They are named as mature outward polykaryotic development type (abbreviated as type I), key cultivation type of dual-nucleus drive type (abbreviated as type II), environment-friendly balanced growth type (abbreviated as type III), epitaxy expansion type of mononuclear radiation type (abbreviated as type IV) and inland extensive.The loose development type (V for short) is detailed in Table 2.

**Table 2.** Average scores and type induction of five types of urban agglomerations in China

| type | Features | Energy Interaction Degree | Decentralization of energy consumption | industrial structure | Resource loop effect | Including Urban Agglomerations |
|---|---|---|---|---|---|---|
| Type I | mean value | 90.32 | 14.77 | 90.37 | 74.56 | Yangtze River Delta and Pearl River Delta |
| | Deviation | 19.37 | 20.36 | 19.26 | 2.85 | |
| Type II | mean value | 40.59 | 14.04 | 54.87 | 53.76 | Beijing-Tianjin-Hebei, Shandong Peninsula, Liaodong Peninsula, West Bank of the Strait, Chengdu-Chongqing |
| | Deviation | 27.84 | 37.23 | 74.00 | 37.98 | |
| Type III | mean value | 15.45 | 26.41 | 38.33 | 21.61 | Chang-Zhu-Tan, Ha-Da-Chang, North-South Qin-Fang, Hu-Bao-E and Central Yunnan |
| | Deviation | 12.03 | 59.02 | 9.46 | 34.60 | |
| Type IV | mean value | 18.78 | 89.18 | 24.10 | 69.59 | North Slope of Wuhan and Tianshan Mountains |
| | Deviation | 9.11 | 21.64 | 14.89 | 10.42 | |
| Type V | mean value | 11.60 | 22.40 | 22.41 | 64.53 | Central Plains, Jianghuai, HuanPoyang, Jinzhong, Guanzhong, Yinchuan Plain, Central Guizhou and Lanbaixi |
| | Deviation | 27.97 | 24.67 | 52.04 | 52.61 | |

From the spatial distribution of urban agglomerations in China, it can be seen that the eastern coastal areas are conducive to the emergence of large-scale urban agglomerations of high-level, with a high level of integration and international competitiveness. The urban agglomerations of Qinfang and the West Coast of the Straits should give full play to their geographical advantages along the coast, strengthen opening-up and regional links, and leap over type I urban agglomerations. The urban agglomeration in the central region with flat terrain and dense population has the condition of joint development into a high-level urban agglomeration. Although the industrialization and urbanization rates in the western regions with rich energy and mineral resources and fragile ecological environment are relatively high, they are not conducive to the cultivation of urban agglomerations due to the comprehensive constraints of natural conditions and sparse land and people. The existing urban agglomerations have been developing slowly for a long time, and their extension scale and spatial agglomeration level are relatively low, so their ability to promote regional coordinated development is insufficient.

## 4 Conclusion

(1) The classification of urban agglomeration types is different from the evaluation of development degree. The latter emphasizes the description of the essence of urban agglomeration, while the former pays more attention to the measurement of the extension characteristics of urban agglomeration.Based on the statistics of the frequency of the use of the extension characteristics of urban agglomerations by scholars, this paper establishes a basic

framework for quantitatively dividing the types of urban agglomerations in multi-dimension, starting from the four characteristics of energy interaction, energy consumption dispersion, industrial structure and capital-environment effect.

(2) Based on the idea of comprehensive division, Chinese urban agglomeration urban agglomerations are divided into five types: mature export-oriented type (type I), dual-nucleus catching-up type (type II), environment-friendly type (type III), single-nucleus radiation type (type IV) and inland extensive type (type V).

(3) The eastern coastal areas are more conducive to the cultivation of urban agglomerations. The north-south Qinfang and the west coast urban agglomerations should be strengthened in their ability to open up and connect with each other. Through policy guidance, they will leapfrog to higher-level urban agglomerations. In the central region, geographical space is adjacent and there is the possibility of joint development into high-level urban agglomerations. The western region with rich mineral resources but fragile ecological environment is restricted by natural conditions, and the long-term development of urban agglomeration is not conducive to the cultivation of high-level urban agglomerations.

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