

Urban contraction in Liaoning Province

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Abstract. With the development of social economy, the current changes in the flow of people in the three eastern provinces and the development of cities show the trend of GDP reduction and population loss, which can be called urban contraction. Based on the changes of the population and GDP of 30 cities in Liaoning Province, this paper discriminates the types of urban development, further classifies the shrinking cities, explores the factors that affect their shrinking degree, summarizes different urban types and puts forward corresponding improvement strategies, and finally forecasts the future development and evolution of these cities.

Keywords: Urban contraction; Grey relational analysis model; Entropy weight method; Comprehensive evaluation model of rank ratio; Grey prediction model.

1. Introduction

The concept of "urban contraction" was first put forward by foreign scholars in 1988. This definition shows that this phenomenon is the loss of urban population and even the hollowing out of local areas. There are many factors that lead to this phenomenon, such as the slow process of industrialization, the acceleration of social aging and the sudden change of political system. The research shows that the urban contraction in the three northeastern provinces is the most obvious. Liaoning province, as the traditional heavy industry base of our country, is also the first province to start industrialization and urbanization, and it is also facing the problem of urban contraction. Then, it is particularly important to explore the degree of contraction of cities in Liaoning Province, and how to explore its influencing factors, and then put forward suggestions and strategies for urban development. To revitalize the Northeast, starting from the "new", it will help the Northeast to revitalize again.

2. Establishment and solution of the model

The description of urban contraction is as follows: "A shrinking city is one with a decrease in population for three consecutive years". Therefore, according to the population of 30 cities from 2009 to 2020 in the statistical table of Liaoning urban population, it can be roughly calculated that the year of decreasing population in each city can be divided into several consecutive years and a total decrease of several years. On the basis of hypothesis one, ignoring the influence of lack of data, the city with a continuous decrease in population for three consecutive years is defined as shrinking. The Symbol description.

Table 1. Parameter settings

Symbol	Symbol description	Unit
Y	Number of registered population	ten thousand people
X_i	Economic indicators	ten thousand people
$\xi_i(k)$	Correlation coefficient	
r_i	degree of association	
W_j	Weight of each index	
RSR_i	Actual value	

The shrinking cities are further classified into mild, moderate and severe. The classification results are shown in Next Table , and the specific data are shown in Appendix:

Table 2. Shrink city classification

Type		Zone
Non-shrinking city		Shenyang Dalian Yingkou Panjin Chaoyang
Shrinking city	Mild (0-4 years)	Jinzh Tieling Huludao Wafangdian Zhuanghe Haicheng Donggang Lingyuan
	Moderate (5-8 years)	Dandong Liaoyang Gaizhou Dengta Kaiyuan Beipiao Xingcheng
	Severe (9-12 years)	Anshan Fushun Benxi Xinmin Fengcheng Linghai Beizhen Dashiqiao Diaobingshan

A city whose population loss accounts for at least 10% of the total population or whose average annual population loss rate is greater than 1% can be defined as a shrinking city ".Because the data shows the population change from 2009 to 2020, we can first calculate the annual population loss rate of each city, and then get the average annual population loss rate. See the appendix for the specific calculation results. As the population growth is positive and the population decrease is negative, the average annual population loss rate of each city is preliminarily classified as shown in Next Table.

Table 3. Shrink urban change

Zone	Shenyang	Dalian	Jinzhou	Yingkou	Liaoyang	Panjin	Chaoyang
Average annual population loss rate	1.79%	3.14%	0.18%	0.46%	1.42%	5.91%	0.27%

Zone	Anshan	Fushun	Benxi	Dandong	Fuxin	Tieling
Average annual population loss rate	-0.13%	-0.44%	-0.90%	-0.25%	-0.57%	-0.44%

Zone	Huludao	Xinmin	Wafangdian	Zhuanghe	Haicheng	Donggang
Average annual population loss rate	-0.32%	-0.62%	-0.49%	-0.37%	-0.73%	-0.37%

Zone	Fengcheng	Lingyuan	Beizhen	Gaizhou	Dashiqiao	Dengta
Average annual population loss rate	-0.71%	-1.36%	-0.67%	-0.76%	-0.59%	-1.59%

Zone	Diaobingshan	Kaiyuan	Beipiao	Lingyuan	Xingcheng
Average annual population loss rate	-0.94%	-0.65%	-0.88%	-0.28%	-0.55%

“Combined with the increase and decrease of population and urban GDP, cities can be divided into four types according to their interrelated growth: absolute growth type (both of which increase), population agglomeration type (population increase, urban GDP decrease), smart contraction type (population decrease, urban GDP increase) and absolute contraction type (both of which shrink)”, as shown in Table :

Table 4. Correlation of population to GDP

Popular GDP	Increase	Reduce
Increase	Absolute growth type	Population agglomeration type
Reduce	Smart contraction type	Absolute contraction type

Decreased GDP growth Absolute growth type population agglomeration type Reduced smart contraction type absolute contraction type Using Excel to rearrange the data, the statistical tables of GDP and population changes in Liaoning Province (30 cities) are obtained. See Appendix for details. By drawing the trend charts of population and GDP changes in 30 cities with time, the preliminary classification results are shown in Table:

Table 5. Classification of the relationship between shrinking and non-shrinking cities

Type		Zone	
Non-shrinking city	Absolute growth type	Shenyang Dalian Panjin Jinzhou Liaoyang Yingkou Chaoyang	
	Population agglomeration type	None	
Shrinking city	Smart contraction type	prefecture-level city	Fushun Benxi Dandong Fuxin Tieling Huludao
		county-level city	Xinmin Wafangdian Zhuanghe Haicheng Donggang Fengcheng Linghai Zhenggaizhou Dashiqiao Dengta Diaobingshan Beipiao Lingyuan Xingcheng
	Absolute contraction type	prefecture-level city	Anshan
		county-level city	Kaiyuan

Table Classification results according to definition 4 Type area Non-shrinking city absolute growth Shenyang Dalian Panjin Jinzhou Liaoyang Yingkou Chaoyang Population agglomeration type Urban smart contraction prefecture-level city Fushun Benxi Dandong Fuxin Tieling Huludao County Xinmin Wafangdian Zhuanghe Haicheng Donggang Fengcheng Linghai Zhengaizhou Dashiqiao Lighthouse diaobingshan city Beipiao Lingyuan Xingcheng Anshan, an absolute contraction prefecture-level city County-level Kaiyuan Among them, according to the trend of the graph line, the GDP of Dashiqiao, Fengcheng and Donggang has not increased much, but the population has decreased greatly, so the contraction degree is even more serious. The population and GDP of Tieling have not changed much in 2007 and 2020, the population has decreased slightly, and the GDP has not increased much.

2.1 Determine the analysis sequence.

The data sequence that reflects the characteristics of system behavior is called the reference sequence and the data sequence that determines the factors that affect system behavior is called the comparison sequence. We set the number of registered population in Fushun as Y , and the eight indicators of GDP, total retail sales of social consumer goods, investment in fixed assets (excluding farmers), general public budget expenditure, gross industrial output value above designated size, number of employed people in urban units of secondary and tertiary industries, water supply for domestic use and investment in real estate development are respectively set as $X_1 \sim X_8$. Let the reference sequence (also called mother sequence) be $Y = \{Y(k) | k = 1, 2, \dots, 11\}$; Comparative sequence (also called subsequence) $X_i = \{X_i(k) | k = 1, 2, \dots, 11\}, i = 1, 2, \dots, 8$

2.2 The dimensionless variables.

Because the data in each factor column in the system may be different in dimensions, it is inconvenient to compare or it is difficult to get a correct conclusion when comparing. Therefore, in the analysis of grey correlation degree, the dimensionless processing of data is generally required:

$$x_i(k) = \frac{X_i(k)}{X_i(l)}, k = 1, 2, \dots, 11; i = 1, 2, \dots, 8 \quad (1)$$

2.3 Calculate the correlation coefficient. Coefficient of correlation between $x_0(k)$ and $x_i(k)$:

$$\xi_i(k) = \frac{\min_i \min_k |y(k) - x_i(k)| + \rho \max_i \max_k |y(k) - x_i(k)|}{|y(k) - x_i(k)| + \rho \max_i \max_k |y(k) - x_i(k)|} \quad (2)$$

$$\text{Set } \Delta_i(k) = |y(k) - x_i(k)| \quad (3)$$

And

$$\xi_i(k) = \frac{\min_i \min_k |y(k) - x_i(k)| + \rho \max_i \max_k \Delta_i(k)}{\Delta_i(k) + \rho \max_i \max_k \Delta_i(k)} \quad \rho \in (0, \infty) \quad (4)$$

It is called resolution coefficient. The smaller ρ is, the greater the resolution. Generally, the value range of ρ is (0,1), and the specific value can be determined according to the situation. When $\rho \leq 0.5463$, the resolution

2.4 Sorting the correlation degree.

The correlation degree is sorted by size. If $r_1 < r_2$, the reference sequence Y is more similar to the comparison sequence x_2 . After calculating the correlation coefficient between $X_i(k)$ series and $Y(k)$ series, calculate the average value of various correlation coefficients, and the average value r_i is called the correlation degree between $Y(k)$ and $X_i(k)$. n is the best, usually $\rho = 0.5$.

After quantitative analysis of each influencing factor in the annex, we further select the factors that have the strongest influence on the population change in each city, that is, classify them according to the indicators with the strongest correlation, and divide the shrinking cities into the following categories, as shown in the table:

Table 6. Factors with the strongest correlation degree

Factors with the strongest correlation degree	Zone
Domestic water supply	Fushun Dandong Tieling Anshan

Number of employed persons in urban units of secondary and tertiary industries	Benxi	Fuxin	Haicheng	Fengcheng
Total retail sales of social consumer goods	Dashiqiao	Lingyuan	Xinmin	Beidian
GDP	Kaiyuan	Diabingshan	Beipiao	
Public budget expenditure	Wafangdian	Huludao		
Hospital bed	Zhuanghe	Donggang	Linghai	Dengta
	Xingcheng	Gaizhou		

We can draw the following conclusions: The factors that have great influence on the urban population in Liaoning province are the water supply for domestic use, the number of employed people in the secondary and tertiary industries, the total retail sales of social consumer goods, GDP, public budget expenditure and hospital beds. Especially, compared with other cities, hospital beds have the greatest impact on the population structure of gaizhou city. In addition, based on other factors in the annex, the impact on the population change of Liaoning Province is relatively small, the number of employed people in urban units of the secondary and tertiary industries and the total retail sales of social consumer goods have a greater impact on the urban contraction, and the number of cities affected by these two indicators is also the largest. Therefore, in the process of social development, we should constantly pay attention to the influence of the above-mentioned analysis factors, flexibly adjust the employment structure of urban units in secondary and tertiary industries, improve the social service system, living security system and medical security level, and improve the education level of relevant areas to comprehensively improve the comprehensive quality of local population and promote the harmonious and stable development of society [7].

3. The establishment of simulation model

To comprehensively evaluate all economic and social development indicators that affect the contraction, it is necessary to establish a Rank Sum Ratio Comprehensive Evaluation Model (RSR) to quantitatively compare the urban contraction degree. The indexes of prefecture-level cities and county-level cities first calculate the weight of each index by entropy weight method and make regression analysis, then get the RSR regression value to determine the contraction comprehensive index and rank the year in which they are located, and get the trend development map, which specifically includes the following steps .

3.1 ranking compilation.

Because of the different orders of magnitude among indexes, they can't be directly processed linearly, so they need to be numbered according to the values from big to small, and then transformed according to the rank to form dimensionless statistical values, which lays the foundation for the next step of weight determination.

3.2 Use entropy weighting method to determine the weight.

Standardization of data: As factors such as registered population and GDP are negative indicators relative to the degree of urban contraction, we use Formula 2 to standardize the negative indicators.

$$t_{ij} = 0.998 \frac{\max\{t_{1j}, \dots, t_{nj}\} - t_{ij}}{\max\{t_{1j}, \dots, t_{nj}\} - \min\{t_{1j}, \dots, t_{nj}\}} + 0.002 \quad (5)$$

Calculate the index variability: use Formula 3 to calculate the weight of the index value of the *i*th program under the *j*th index.

$$P_{ij} = \frac{t_{ij}}{\sum_{i=1}^n t_{ij}} (j = 1, 2, \dots, m) \quad (6)$$

Calculate the information entropy: Calculate the information entropy value of the j th index by using Formula 4.

$$E_j = -k \sum_{i=1}^n P_{ij} \ln P_{ij}, \text{ 其中 } k = \frac{1}{\ln(n)} \quad (7)$$

Calculating information entropy redundancy: Calculate the information entropy redundancy G_j of the j th index by using Formula 5.

$$G_j = 1 - E_j \quad (8)$$

Calculate the weight of the j th index in Formula 6.

$$W_j = \frac{G_j}{\sum_{j=1}^m G_j} \quad (9)$$

Calculate the linear regression equation. With $probit_i$ (the probability unit corresponding to cumulative percentage) as the independent variable and RSR as the dependent variable, the regression equation is obtained:

$$RSR_{1i} = -4.07 + 1.77 \times probit_{1i} \quad (10)$$

Finally, rank the ratings by grade. The evaluation object is obtained according to the regression equation. Rank by RSR regression value. The bigger RSR is, the stronger the contraction degree of the city is.

3.3 Analysis of experimental results

Results Taking Kaiyuan as an example, the weight of each index was calculated by entropy weight method and comprehensive model of rank sum ratio, and the following table 13 shows the weight of each index:

Table 7. Weighting of factors affecting shrinking cities

Index	Calculated weight
Number of registered population	0.179
GDP	0.249
Total retail sales of social consumer goods	0.136
Public budget expenditure	0.149
Number of employed persons in urban units of secondary and tertiary industries	0.16
Hospital bed	0.128

The final regression equation is:

$$RSR_{2i} = 0.214 + 0.07 \times probit_{2i} \quad (12)$$

We can also know by grey prediction, Get the RSR prediction values of urban evolution and development in Fushun and Kaiyuan in the next ten years, which are used to represent the degree of contraction, as shown in the figures:



Fig. 1 The RSR prediction values of urban evolution and development in Fushun

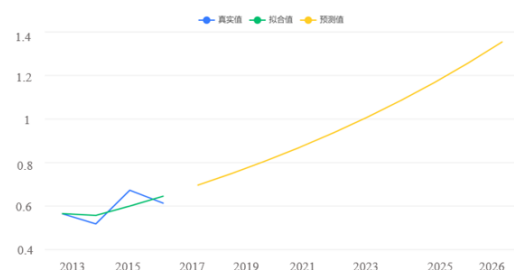


Fig. 2 The RSR prediction values of urban evolution and development in Kaiyuan

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