# Research on the Spatial Distribution Change of Chongqing Housing Price

Jinhong Xu and Jisi Su(✉)

School of Smart City, Chongqing Jiaotong University, Chongqing 400074, China
710214138@qq.com

**Abstract.** In this paper, taking the main urban area of Chongqing as the research area, the average nearest neighbor analysis, the global Moran's I index, the LISA clustering map, and other analysis tools are used to explore the spatial distribution model and change the law of housing prices. At the same time, the ordinary Kriging analysis method is used to verify the spatial characteristics of housing prices. Finally, the spatial distribution changes and reasons of housing prices are deeply analyzed. The results show that: ① There is no obvious change in the spatial correlation of housing prices in the main urban area of Chongqing, which are positive spatial correlation. Jiangbeizui is still the housing price center in the main urban area of Chongqing. But the number of price sub-centers is increasing, and there is collaborative development among groups; ② Location, educational conditions, commerce, and other factors are important factors that affect the spatial distribution of housing prices.

**Keywords:** Housing price · Nearest neighbor index · Kriging · Chongqing

## 1 Introduction

With people's higher requirements for supporting facilities in residential quarters, the spatial heterogeneity of housing prices is enhanced. Analyzing the spatial change of urban housing prices is beneficial to the reasonable control of housing prices by relevant departments. At present, Hedonic Price Model, trend-surface analysis (TSA), and Kriging method are mainly used to analyze the spatial variation of housing prices. The characteristic model is the global parameter estimation of the common least square method. The trend surface analysis method is to use the least square method to fit a binary nonlinear function. And the Kriging interpolation method is to make the unbiased optimal estimation of the regionalized variables in a limited area [1]. Brad R.Mumphreys, Pace, and others used the price characteristic model to analyze the spatial distribution changes and laws of housing prices in the United States [2, 3]. Xia, Chen, Gao, and others all use the ordinary Kriging interpolation method, taking housing prices in Nanjing, Fuzhou, and Beijing as research samples, drawing Kriging interpolation diagrams of these three cities, and analyzing the development trend of the cities [4–6]. However, when researchers analyze the spatial characteristics of house price data, the methods adopted are relatively simple. They often only study the spatial distribution characteristics and causes of the


R. Lotfi et al. (Eds.): UPRE 2023, AEBMR 253, pp. 27–35, 2023.
https://doi.org/10.2991/978-94-6463-218-7_5

average transaction house price in a certain month or a certain year. And researchers lack research fields that have been developing in the "multi-center" structure and have been developing in the "multi-center" structure. Chongqing is a typical mountainous city in China. The geographical condition of "one island, two rivers, three valleys, and four veins" makes the development mode of the main urban area of Chongqing naturally choose "multi-center, group type".Therefore, this paper selects the historical transaction house price data of Chongqing in 2017 and 2020 as the research data to explore the distribution and change of housing prices in multi-center cities.

## 2 Method

### 2.1 Nearest Neighbor Index

The average nearest neighbor spatial analysis method reflects the spatial distribution pattern of housing price elements by calculating the nearest neighbor index. The formula expression of the nearest neighbor index is shown in formula (1).

$$K = \frac{\sum_{i=1}^{n} d_i/n}{0.5 \Big/ \sqrt{n/A}} \tag{1}$$

where: K is the nearest neighbor index; $d_i$ is the distance between element $i$ and its nearest neighbor; n is the total number of elements; A is the area of the smallest circumscribed rectangle of all features. When the value of K is less than 1, it reflects that the elements tend to be spatially clustered; When the value of K is greater than 1, it reflects that the elements tend to be spatially distributed.

### 2.2 Global Moran's I

Global spatial autocorrelation is used to describe the spatial correlation of the attribute values of house prices in the whole study area. See formula (2) for the calculation formula of Global Moran's I index.

$$I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} \left(x_i - \overline{X}\right)}{S_0 \sum_{i=1}^{n} (x_i - \overline{x})^2} \tag{2}$$

where: n is the total number of elements; $S_0$ is the set of all spatial weights; $w_{i,j}$ is the spatial weight between elements i and j; $x_i$ is house price; $\overline{X}$ is the average value of the corresponding attribute values. If I $<$ 0, the house price is distributed discretely in the study area; If I $=$ 1, the house price is randomly distributed in the study area; If I $>$ 0, the house prices are clustered in the study area.

### 2.3 Kriging

The kriging interpolation method can estimate the attribute values of unknown points in the same range according to the attribute values of known points. In this paper, the ordinary Kriging interpolation method is selected to analyze the house price, and its principle is shown in formula (3).

$$\widehat{Z}(y_0) = \sum_{i=1}^{N} \lambda_i Z(y_i) \tag{3}$$

where: Z(yi) is the observed value of the ith position of the house price; $\lambda_i$ is the unknown weight of the observed value of the ith position of the house price; $y_i$ is the predicted position; $\widehat{Z}(y_0)$ is the estimated house price of the predicted location; N represents the total number of observations.

## 3 Research Area and Data

### 3.1 Overview of the Research Area

The main urban area of Chongqing is a typical mountainous city in China. In recent years, with the development of Chongqing's economy, housing prices in the main urban areas have soared, and the spatial distribution of housing prices has changed greatly. Therefore, this study chooses nine districts of Chongqing as the research area.

### 3.2 Research Data

In this paper, the historical transaction prices in 2017 and 2020 in Chongqing's main urban area obtained from the second-hand platform of Lianjia.com are selected as the research data to study the spatial distribution of housing prices in Chongqing's main urban area from 2017 to 2020. Among the housing transaction data samples, there were 3,157 samples in 2017, with 879 communities. The experiment adopted a stratified sampling method, and sample data was randomly selected from each community by SPSS. There were 879 experimental sample points of housing transaction data in 2017. Similarly, there are 5,313 samples and 1,856 communities in 2020. 1,856 experimental sample points were obtained by stratified random sampling. The distribution of sample points in 2017 and 2020 required for the experiment is shown in Fig. 1. Below, and Table 1 shows some sample data used in the experiment.

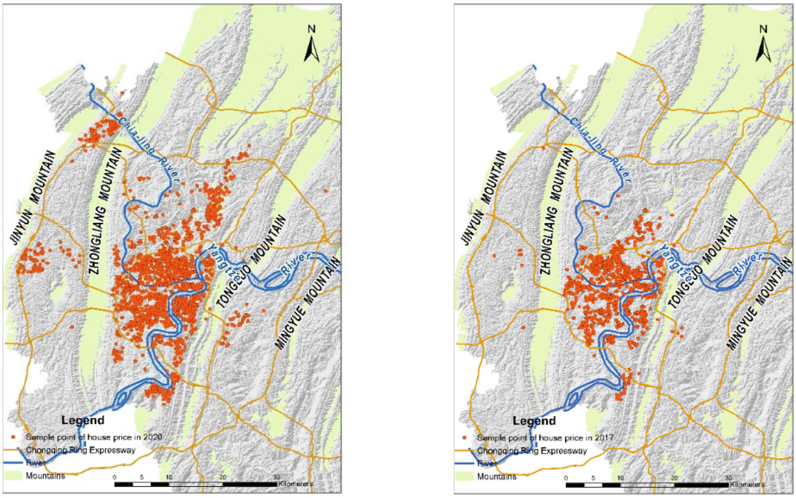
## 4 Research Results

### 4.1 Average Nearest Neighbor Analysis

The results of the average nearest-neighbor analysis are shown in Table 2. The sample in 2017 and the nearest neighbor ratio in 2020 are both less than 1, indicating that the real estate price elements in the main urban area of Chongqing are spatial agglomeration; In addition, the Z score of the samples was significantly lower than the Z score (−2.58) at 1% significance level, and all P values were 0. Therefore, it shows that the real estate prices in Chongqing's main urban areas show an obvious spatial agglomeration phenomenon.

**Table 1.** Part of the sample data

| Seq | Years | Community Name | House price | X | Y |
|---|---|---|---|---|---|
| 1 | 2017 | Kaiwen Sunshine | 12711.86441 | 106.5261464 | 29.56332583 |
| 2 | 2017 | Northern scenery | 10132.50195 | 106.5057487 | 29.5618594 |
| 3 | 2017 | Area A of Zhujiang Sun City | 14551.17491 | 106.5598877 | 29.57504968 |
| 4 | 2020 | Hengda Yulong Tianfeng | 16163.95978 | 106.5367414 | 29.56993313 |
| 5 | 2020 | Jinxiu Beibin | 11176.47059 | 106.525159 | 29.55981036 |
| 6 | 2020 | Guoxing Beianjiangshan | 16142.05004 | 106.5091538 | 29.56128077 |




a.Price sample point distribution in 2017 b. Price sample point distribution in 2020

**Fig. 1.** Sample point distribution of house price

**Table 2.** Average nearest neighbor analysis

| Years | sample number | Nearest Neighbor Ratio (ANN) | Z scores | P value |
|---|---|---|---|---|
| 2017 | 879 | 0.469002 | −30.117433 | 0.000000 |
| 2020 | 1856 | 0.449182 | −45.397120 | 0.000000 |

**Table 3.** Global spatial self-correlation analysis

| Years | sample number | Global Moran's I index | Z scores | P value | E(x) | Var |
|---|---|---|---|---|---|---|
| 2017 | 879 | 0.184589 | 18.862004 | 0.000000 | -0.001139 | 0.000097 |
| 2020 | 1856 | 0.314348 | 37.244388 | 0.000000 | -0.000539 | 0.000071 |

## 4.2 Spatial Correlation Analysis

**Global Moran's I Analysis**

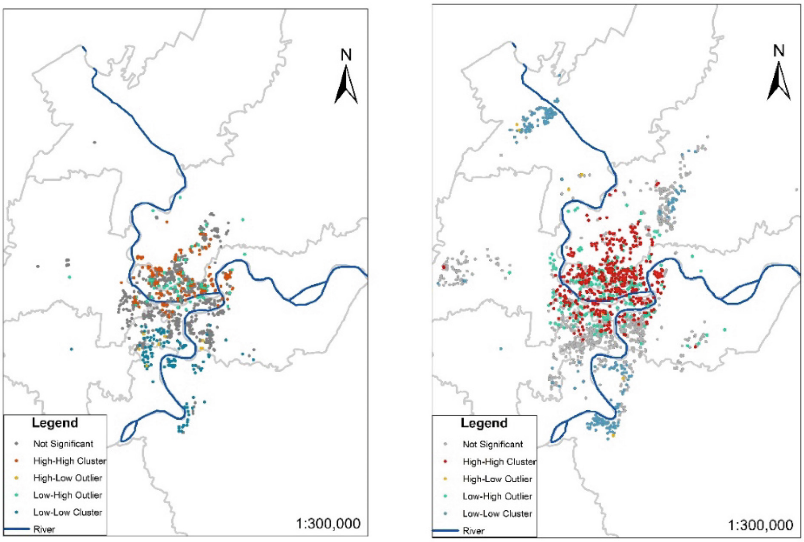
According to formula (2), two groups of samples are analyzed, and the global Moran's I index of housing transaction data in Chongqing in 2017 and 2020 is obtained. Global Moran's I index is shown in Table 3. The global Moran's I index of the two groups of data is greater than 0, and the Z scores are much larger than the two-sided test threshold of 99% confidence interval of normal distribution (2.17), with a P value of 0, which indicates that the housing prices in the main urban areas of Chongqing are generally positively correlated in space. At the same time, it can be known from the table that the global Moran's I index in 2017 is 0.184589 less than that in 2020, so the global spatial autocorrelation in 2020 is stronger.

**LISA analysis.**

Further, the local Moran index (LISA) is used to explore the spatial autocorrelation of the two samples. The resulting LISA diagram is shown in Fig. 2. It can be seen from the sample LISA diagram that the data show spatial autocorrelation, and the phenomenon of "high-high" gathering areas in the areas north of Jialing River and Yangtze River, and "low-low" gathering areas in the areas south of rivers is gradually obvious. The proportion of sample points of each spatial correlation type is shown in Table 4. According to Table 4, the proportional distribution of sample points in 2017 is roughly similar to that in 2020, and the proportion of sample points in "Low-High" distribution in 2020 has increased. This type of area is mainly concentrated in Jiulongpo District, Shapingba District, Yuzhong District, and Jiangbei District in 2020. In 2017, the sample distribution was mainly concentrated in Jiangbei District and Yuzhong District. The other spatial distribution types are basically the same, and the proportion of non-significant "Not Significant" sample points is relatively high, all exceeding 50%; The "High-High" type is mainly distributed in marble positions in Jiangbei District, Yubei District, Yuzhong District, and Nan'an District; "High-Low" type is scattered in Nan 'an District, Jiulongpo District, and Beibei District; The "Low-Low" type is mainly distributed in Banan District, Jiulongpo District, Dadukou district and the old city of Beibei. Generally speaking, from 2017 to 2020, the local spatial correlation of housing prices in the main urban areas of Chongqing is not obvious, and the overall spatial autocorrelation trend is positive.

## 4.3 Kriging Interpolation Analysis

In this experiment, the ordinary Kriging interpolation method is used to select the best model: the standard average is closest to 0, the root mean square prediction error is the smallest, the average standard error is closest to the root mean square prediction error,




a. LISA map in 2017 b.LISA map in 2020

**Fig. 2.** LISA map

**Table 4.** LISA sample point proportion

| Years | sample number | High-High(%) | High-Low(%) | Low-High (%) | Low-Low(%) | Not Significant (%) |
|---|---|---|---|---|---|---|
| 2017 | 879 | 16.0 | 1.0 | 6.0 | 12.3 | 64.7 |
| 2020 | 1856 | 24.3 | 0.4 | 11.6 | 11.4 | 52.3 |

and the standard root mean square prediction error is closest to 1. The verification of the optimal model shows that the results are accurate and can be used for spatial analysis. The interpolation chart of the sample points in 2017 and the interpolation chart of the sample points in 2020 are shown in Fig. 3. And Fig. 4. Below.

According to the Kriging interpolation chart, the housing price centers in the main urban area of Chongqing in 2017 are mainly located in the Jiangbeizui of Guanyinqiao Group (Fig. 3 a), Daping of Dayangshi Group (Fig. 3 b) and Zhaomushan of Renhe Group (Fig. 3 c), among which the Jiangbeizui CBD is the price center of the main urban area of Chongqing, and Daping and Zhaomu Mountain are the sub-centers in the inner ring of the main urban area of Chongqing. In 2020, the main price center in the main urban area of Chongqing will still be the Jiangbeizui CBD (Fig. 4 a), but the price sub-centers will expand to the north and west, with the development of Central Park Price Sub-center (Fig. 4 d) and Xiyong and University Town Price Sub-centers of Xiyong Group (Fig. 4 b). The housing price of the sub-center in the Zhaomushan Park area tends to catch up with that of the Jiangbeizui. The gradient of housing prices

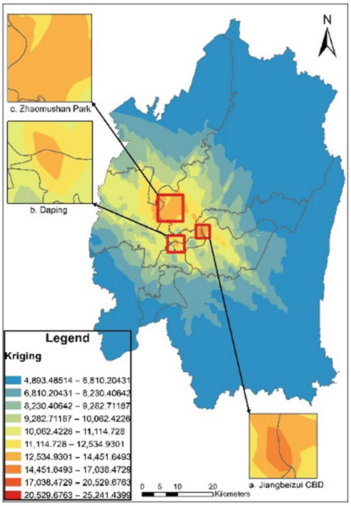



**Fig. 3.** Kriging map in 2017

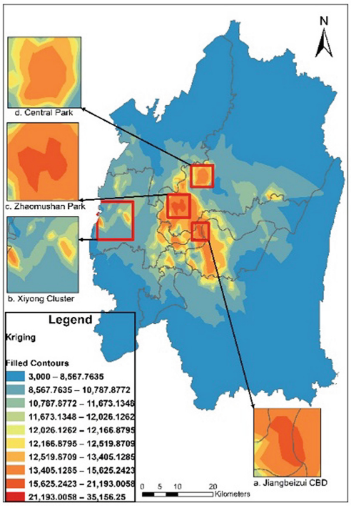



**Fig. 4.** Kriging map in 2020

around the price center and sub-center changes more closely and decreases in a circular pattern. With the increase of urban infrastructure and the establishment of "Liangjiang New Area", the urban development center has moved to the north, and the cluster of Guanyinqiao, Lijia, Renhe, Yuelai, and Konggang has developed cohesively. As a result, the northern group carries a large urban population, and the housing prices in the north continue to rise. For example, Zhaomushan Park and Central Park have become the sub-centers of new housing prices. As the image display window of Chongqing, Jiangbeizui

CBD has been the peak center of housing prices in Chongqing from 2017 to 2020. In addition, the results of sample analysis in 2020 show that there are dot-like price sub-centers in College Town and Xiyong in Xiyong Group in the west, which is due to the abundant educational resources of Shapingba District, and Chongqing Microelectronics Park, which have a large number of high-tech companies and enterprises.

Combining the interpolation chart and LISA chart of sample points in the past two years, it can be found that the housing prices in the main urban area of Chongqing generally show the spatial characteristics of high housing prices in the north, low housing prices in the south, higher housing prices in the west than in the east, and high housing prices near the river, and this characteristic is gradually obvious. This is due to the "multi-center, group-type" development structure implemented in the main urban area of Chongqing, and the "Chengdu-Chongqing integration" policy implemented in Chengdu and Chongqing, resulting in an increase in the number of group investors in the western part of the main urban area of Chongqing; Zhaomushan Park and Central Park in the north have created a livable environment and attracted a large number of people to settle down.

## 5 Concluding

The housing price problem has always been a matter of great concern to the general public and the national government, and the trend of housing prices needs steady progress. For relevant government departments, it is very meaningful to use GIS technology to analyze the spatial distribution trend of urban housing prices. According to the spatial distribution trend of urban housing in recent years, more reasonable policies can be formulated to help cities develop rationally. In this paper, the spatial characteristics of two groups of sample data in 2017 and 2020 are obtained by the average nearest neighbor analysis, and then the global Moran's I index of housing prices is calculated to get their spatial correlation. Then LISA diagram is made for the two groups of samples to analyze the local spatial characteristics. Finally, the trend of the spatial distribution of housing price is studied by making ordinary Kriging interpolation, and the reasons are analyzed according to the natural background of Chongqing's main city and Chongqing's planning policy. Through a series of studies, it is concluded that:

(1) The overall Moran's I index increased from 2017 to 2020. It shows that the spatial positive correlation of housing prices in Chongqing's main urban areas will increase in 2020, but the overall spatial aggregation pattern has not changed significantly.
(2) The spatial distribution of housing prices in the main urban area of Chongqing shows from three centers to more centers, and there is collaborative development. Polycentric development is related to the geographical conditions of Chongqing; Urban traffic communication promotes communication and collaborative development between groups.
(3) There is no obvious change in the distribution ratio of the four spatial association types. However, the proportion of the "Low-High" distribution and "High-High" distribution in 2020 is higher than that in 2017. The concentrated areas of "High-High" are along the Yangtze River and Jialing River, while the main areas of "Low-High" are Yuzhong District and Shapingba District.

(4) The price of Zhaomu Mountain, which is organized by Renhe Group, has the fastest growth rate, with a growth multiple of more than 2.0, making it the second largest price sub-center in the Jiangbeizui of Guanyinqiao Group. And in 2020, the number of price sub-centers was increasing, including Central Park and Xiyong.
(5) Location factors, commerce, science, technology center, and education are the important factors that affect the real estate prices in the main city of Chongqing and have a very significant aggregation effect on the spatial distribution characteristics of housing prices.

## References


1. Li Junxiao, Li Chaokui, Yin Zhihui. Kriging interpolation method based on ArcGIS and its application [J]. Bulletin of Surveying and Mapping, 2013(09):87–90+97.
2. BOWEN, W.M., MIKELBANK, B.A. and PRESTEGAARD, D.M. (2001), Theoretical and Empirical Considerations Regarding Space in Hedonic Housing Price Model Applications[J]. Growth and Change, 32: 466-490.
3. FENG, X. and HUMPHREYS B.R, The impact of professional sports facilities on housing values: Evidence from census block group data[J]. City, Culture and Society, 2012. 3(3): 189–200.
4. Xia Min, Liu Jingjie. Study on the spatial distribution of commodity housing prices in Nanjing [J]. Journal of Jiangxi Agricultural University (Social Science Edition), 2013,12(03):314-318.
5. Chen Zhen, Liu Hui. Research on the spatial distribution trend and characteristics of housing prices in Fuzhou [J]. Journal of Subtropical Resources and Environment, 2015,10(04):58-62.
6. Gao Shu, Liu Jiping, Guo Wenhua, Xiao Fei, Xu Shenghua, Wang Yong. Research on spatial distribution of real estate prices in Beijing [J]. Surveying and Mapping Science, 2021,46(09):150–156.