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Study on Spatial Differentiation of Housing Rental Prices

–- A Case Study of Wuhan City

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Abstract

This paper employs data on housing rentals and their amenities in Wuhan City, utilizing methods such as spatial autocorrelation analysis and spatial clustering to reveal the following characteristics of rental prices: 1) High spatial autocorrelation; 2) Rental prices exhibit a circular distribution in space, with areas having higher per-unit-area costs mainly concentrated in Jiang'an, Wuchang, and Hongshan districts. Based on these findings, recommendations are made for the healthy development of Wuhan's housing rental market.

Keywords

Housing Rental; Rental Price; Spatial Differentiation; Spatial Structure; Wuhan.

1. Introduction

1.1. Significance

Housing rental refers to the act where the original homeowner provides their property to a tenant under a contract, with the tenant gaining possession and use of the property in exchange for regular rental payments. As of 2020, China's permanent urban population urbanization rate was 63.89%, with a household registration urbanization rate of 45.4%. In Wuhan, there were 9.1619 million residents under household registration, with a net population increase of 6,964 and a net migration of 100,487. With the continuous influx of mid-to-low-income migrants into urban areas, demand for housing rentals has surged. However, Wuhan's rental market still faces many issues such as insufficient rental housing supply, low rental ratios, numerous pain points in renting (low proportion of commercial properties for rent, poor rental experiences), and inadequate protection of tenants' rights (information asymmetry, rental monopolies, and a lack of specific laws to protect tenants). Therefore, this paper aims to analyze housing rental prices from a spatial distribution perspective to support scientific management of the market and promote its healthy and orderly development.

This paper employs web scraping techniques through Lianjia.com to collect housing data in Wuhan and uses ArcGIS Pro software to create a geographic information database to calculate and analyze the spatial autocorrelation of rental prices. Through spatial clustering and heatmap analysis, conclusions on the spatial differentiation of rental prices are drawn, leading to recommendations such as strengthening urban-rural integration, accelerating the development of the housing rental market, and urging the government to enact relevant legislation.

2. Research Theory and Methods

2.1. Residential Space Differentiation

Residential space differentiation is a phenomenon observed within cities where residents with distinct characteristics tend to cluster in different spatial areas, leading to a sort of residential segregation or even isolation throughout the city. Within these relatively isolated areas,

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homogeneous groups share similar social traits, follow common customs, and uphold shared values, or maintain a consistent subculture. In contrast, substantial differences exist between these segregated areas. These disparities can be seen in the varying house and rental prices across different residential spaces. Thus, by analyzing the property attributes, pricing characteristics, and influencing factors of heterogeneous spaces, we can provide insights and recommendations for urban planning and policy adjustments.

2.2. Spatial Autocorrelation Analysis

Spatial autocorrelation refers to the correlation between a study subject and its spatial location. Spatial autocorrelation analysis considers both the location and attribute information of spatial entities, revealing the distribution patterns and interrelationships of spatial data. Spatial autocorrelation can be divided into global and local types, which describe the overall spatial distribution patterns of the study area and the spatial heterogeneity of local regions, respectively. Global spatial autocorrelation is an index that measures the overall spatial data to reflect whether the data shows clustering or dispersing trends, along with the strength and significance of these trends.

2.3. Moran's Index

As we can see on the Figure 1, Moran's Index, along with the Geary's C and Getis-Ord indices, are commonly used to measure spatial autocorrelation. This paper uses the widely applied Moran's Index. The Moran's Index, which can be viewed as the ratio of the covariance to the variance of spatial locations, serves as a spatial autocorrelation coefficient. The index ranges from -1 to 1. A value above 0 indicates positive spatial correlation, where neighboring elements show a clustering trend of "high-high or low-low" values. Conversely, a value below 0 suggests negative spatial correlation, where neighboring elements exhibit an alternating "high-low or low-high" distribution. A value near zero indicates a random spatial distribution, showing no significant correlation.

As we can see on the Figure 2, here, n is the number of elements, x and xj are the attribute values of elements i and j, respectively, the bar over x represents the mean attribute value, and wj is the spatial weight between elements i and j. The spatial autocorrelation (Moran's Index) tool in ArcGIS can be used to perform this analysis.

Z-value and difference significance relationship table

Abs (Z)	The value of P	Degree of difference
⩾ 2.58	⩽ 0.01	Very significant
⩾ 1.96	⩽ 0.05	Significant
< 1.96	> 0.05	Not significant

Figure 1. z-value and difference significance relationship table

Calculation formula (Moran index)

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Figure 2. calculation formula

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3. Data Acquisition and Processing

3.1. How to Acquire Information and Data

This paper gathers rental information through the "Lianjia Renting Website," which has a significant market share in Wuhan's rental market, with authoritative housing information and standardized management. With the aid of the "Bazhuayu Data Collector," the site provided access to 200,000 rental listings, including details such as rental price, price per unit area per month, apartment layout, floor level, building area, layout structure, type of construction, orientation, renovation status, structural integrity, elevator ratio, ownership of the transaction rights, as well as longitude and latitude coordinates. To enhance the validity of the research results, the paper excluded listings with abnormal coordinates outside the study area or incomplete rental information, ultimately utilizing data from 148,231 available listings.

3.2. How to Process Data to Generate Images

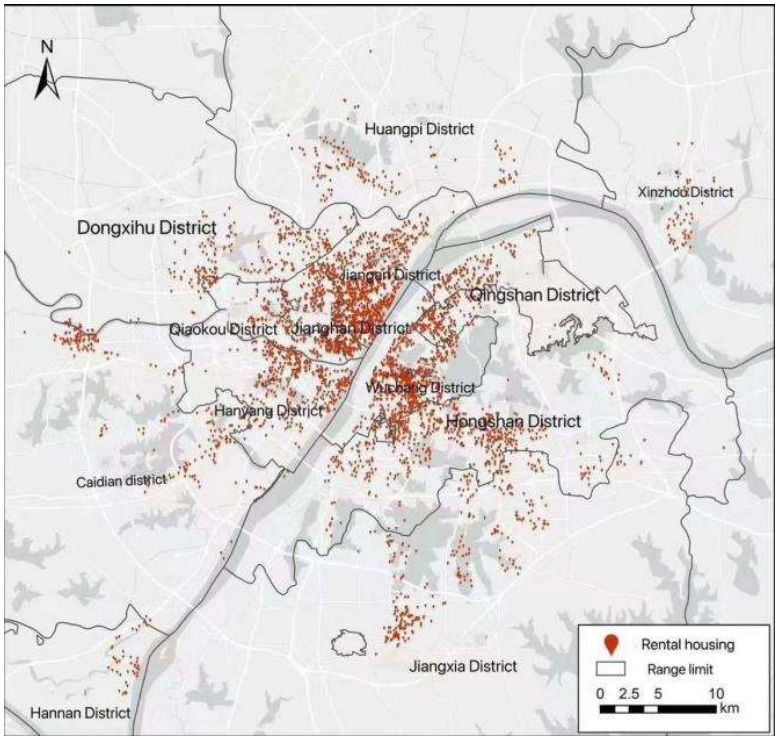

Figure 3. Housing distribution map

4. Spatial Differentiation of Housing Rental Prices

As depicted in the Figures 4, this paper conducts a spatial autocorrelation analysis of rental prices using ArcGIS Pro, yielding a Moran's I index for Wuhan's rental prices of 0.842379 and a Z-score of 354.29. The high Z-score indicates that the likelihood of such clustering occurring by chance is less than 1%, suggesting a positive spatial autocorrelation and a significant clustering pattern in Wuhan's rental prices, i.e., neighboring rents are notably similar.

We have thus confirmed a significant global spatial correlation in Wuhan's rental prices, rendering the original sample data potentially unsuitable since it comprises point data for each individual rental price. To better analyze the spatial distribution characteristics of rental prices, we opted to cluster analyze the price per unit area data of each housing unit. According to this approach, the per-unit area rental price was calculated for each data point, added to the point attribute table, and cluster analysis was performed, leading to the results illustrated in the accompanying figures.

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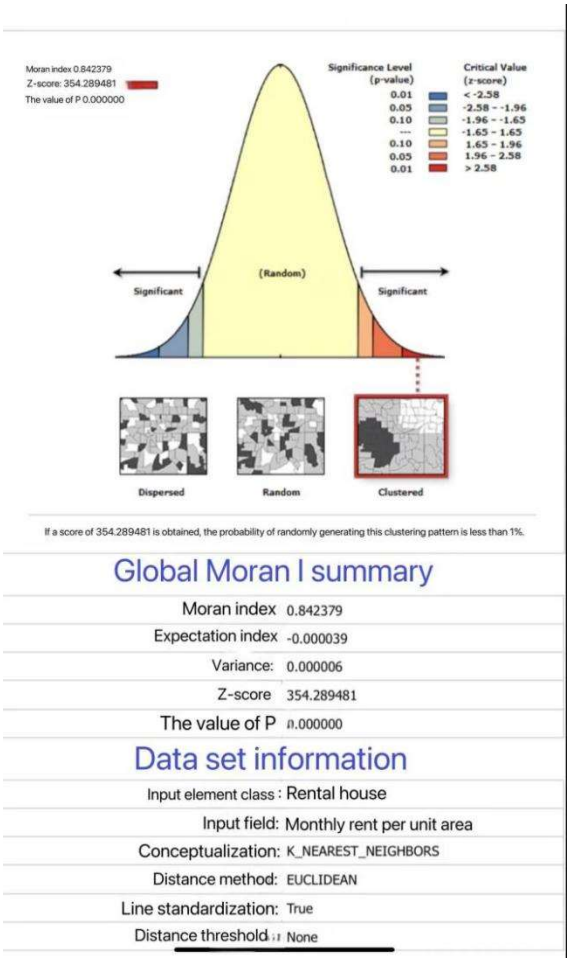

Figure 4. Spatial autocorrelation analysis results

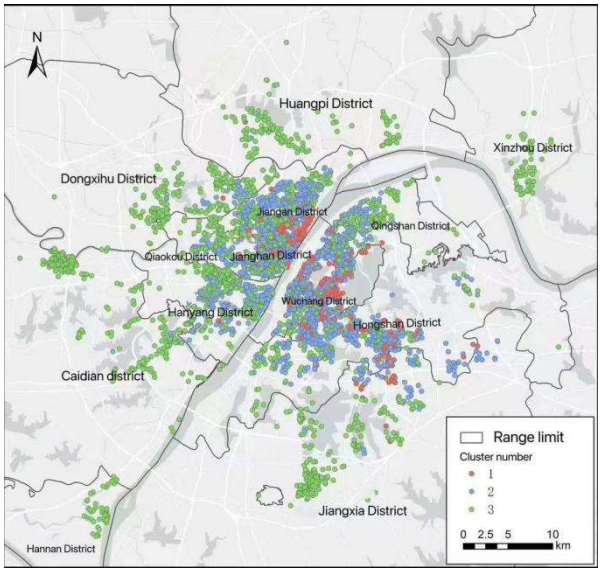

Figure 5. Result of cluster analysis of unit rent

As we can see on the Figure 5, the results identify three main categories of housing in Wuhan: the first category, scattered in red around the center and in Jiang'an, Wuchang, and Hongshan districts, features high rent per unit area; the second category, in blue, with moderate rent per unit area, covers most of Jiang'an, Jianghan, Wuchang, Hongshan, Hanyang districts; the third

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category, in the outer green areas, with low rent per unit area, spans Caidian,Huangpi, Dongxihu, Xinzhou, Jiangxia, and Hannan districts.

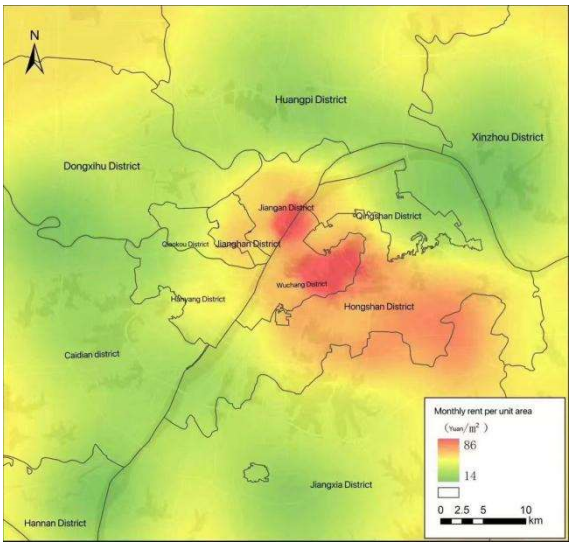

Figure 6. Rental heat map per unit area

Furthermore, as we can see on the Figure 6, the heatmap based on rent per unit area provides a more intuitive view of the analysis, correlating rent levels with color intensity, with the highest per-unit area prices predominantly concentrated in Jiang'an, Wuchang, and Hongshan districts.

5. Influencing Factors

5.1. Population Distribution (Density Maps by Region)

Table 1. the population density and average rent in each district

No.	District (County)	Population Density (people/square kilometer)	Average Rent (yuan/month/square meter)
1	Jianghan	22903.22	57.2
2	Jiang'an	12023.67	61.7
3	Qiaokou	16079.62	44.6
4	Wuchang	10140.59	52
5	Hongshan	7801.49	68.4
6	Qingshan	5749.5	31.5
7	Hanyang	7506.39	46.5

As mentioned in the introduction, in recent years, the net influx of low to middle-income populations into Wuhan has been significant. Similar to major cities like Beijing, Shanghai, and Shenzhen, Wuhan has also faced the challenge of rapid population growth during its urbanization process, which in turn has spurred a substantial demand for housing rentals. Presently, Wuhan's rental market is grappling with considerable challenges. It is well-known that there is a close relationship between population distribution and the demand for housing rentals. Taking into account the urban structure and population distribution of Wuhan, an analysis was conducted using the population densities of its various districts. As shown in the

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Table 1, there is a wide variance in population density across different districts. The majority of the population is concentrated in central service districts such as Jianghan, Jiangan, and Qiaokou; whereas remote districts like Hongshan, Qingshan, and Hanyang have a much sparser population density. This distribution correlates with the average rental prices in these districts. The figure illustrates that districts with higher population densities also command higher average rents, while those with lower densities have correspondingly lower rents.

5.2. Urban Real Estate Development (Development Status by District)

The population distribution of various districts mentioned above represents the demand side of the housing rental market, while the development of real estate in Wuhan showcases the supply side. Research indicates that significant urban residential land development in Wuhan occurred in 2017; the area increased from 161 square kilometers in 2016 to 264 square kilometers, a 63.98% rise. However, by 2018, the pace of development slowed significantly: from 264 square kilometers in 2017 to 270 square kilometers, an increase of only 2.27%. This suggests that residential land development in Wuhan is nearing saturation, particularly in the city center, leading to a shortage of housing development in the main urban areas.

5.3. Urban Employment Hubs and Functional Zoning

Wuhan is committed to creating a "one core, four sub-centers" spatial structure: the core city enhances the comprehensive competitiveness and regional collaborative development of the national central city, optimizing resource allocation and spatial efficiency; the four sub-centers, namely Optics Valley, Automobile Valley, the Airport Economic Zone, and the Yangtze River New Area, are developed according to the standards of a "large city" with populations of 100-200 thousand, integrating functions, industry, land use, and ecological quality. Furthermore, enhancing town clusters like Caidian, Zhifang, Jinkou, and Beihu, along with the construction of 44 new towns and a series of unique small towns, are also part of this plan. The main urban area and the four sub-centers are major employment centers in Wuhan, driving local rental markets with higher average rents than non-employment center areas. Additionally, comparing rental prices within employment centers reveals variations in labor cost affordability, which is reflected in the local average rents.

5.4. Transportation Conditions and Service Facility Levels

The level of service facilities related to transportation also similarly affects rental prices.

Table 2. the number of other factors in each district

No.	District/County	Average Rent (yuan/month/square meter)	Top Primary Schools (number)	Top Secondary Schools (number)	Universities (number)	Tier-3 Hospitals (number)	Parks (number)
1	Jianghan	57.2	1	2	1	6	18
2	Jiang'an	61.7	4	4	1	13	29
3	Qiaokou	44.6	0	3	1	8	13
4	Wuchang	52	4	4	11	7	32
5	Hanyang	46.5	3	3	3	4	25

As we can see on the Table 2, firstly, rent is directly proportional to the number of business districts and hospitals. Jiang'an District and Jianghan District both have numerous hospitals and business areas, ranking first and second respectively among the five central urban districts in

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terms of rent. Malls and hospitals are centers of production that require a substantial workforce; this workforce, typically employed at these locations, tends to have both the capability and desire to rent nearby, thus driving up rental demand. Moreover, the presence of many derivative products such as subways, buses, highways, and shops around these hospitals and business districts enhances convenience and variety, which further increases the demand for rentals in these areas, culminating in higher rents.

The number of primary and secondary schools is also directly proportional to rent, but the correlation is weaker compared to hospitals and business districts. Statistical data show that the total number of schools in each district is quite similar. Jiang'an and Wuchang, along with Qiaokou and Hanyang, have a higher number of quality primary and secondary schools. By comparing Hanyang District with Jianghan District, the former, having more parks and quality schools but fewer hospitals and business areas, ranks lowest in terms of rent; the latter, with more hospitals and business areas but fewer parks and quality schools, ranks second. This is because if schools are considered production centers, the labor needs are similar across districts, not greatly affecting rent. Additionally, under Wuhan's regulations, a local hukou (household registration) and property ownership are prerequisites for admission into these top schools, and renting alone does not qualify one for admission, hence the number of top schools does not impact rents. However, the number of universities does affect rent. For instance, Wuchang, which lacks numerous hospitals and profitable business districts, has moderate rent levels, largely because almost all universities in Wuhan are concentrated in this district. University students form a consumer demographic that stimulates the emergence of many derivative products such as shops, thereby increasing labor demand and subsequently rental demand; many students also need accommodations, thus further pushing rents higher.

Regarding parks, the data does not show a direct correlation, but it is believed there might be a weak positive relationship with rents since parks often occupy large areas of land. A higher number of parks may reduce land availability, indirectly increasing the overall value of land and rent.

For subways, from a macro perspective, the central urban areas of Wuhan are uniformly covered, showing no significant disparities.

6. Conclusion and Recommendations

As previously mentioned in the introduction, Wuhan has always been a renowned transportation hub with significant population mobility. The demand in Wuhan’s rental housing market primarily comes from two groups: university and college graduates seeking employment, and migrant workers. Both are crucial to the city's construction and production, and their housing needs must be met. However, Wuhan's rental housing market faces issues such as insufficient supply and lack of regulation. In 1979, based on principles of controlling large cities, developing medium and small towns, and fostering integration, Wuhan revised its overall urban plan. This plan centered around the three towns of Wuhan, used the Yangtze River as the main axis, and the Beijing-Guangzhou railway as a secondary axis, extending towards major roads and the Han River basin, creating a multi-centered and multilevel urban cluster. However, according to the data in this paper, a multi-centered rental housing spatial pattern has not yet emerged, and high rents in central urban areas are a significant issue that cannot be ignored. These issues could significantly affect Wuhan's ability to attract talent. Based on these findings, the paper suggests the following recommendations:

First, Wuhan could continue to promote the integration of urban and rural areas by strengthening the infrastructure and public services in the suburbs, such as enhancing and improving public transportation routes, medical facilities, and retail spaces in these areas. This

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would increase the desirability and value of renting properties by improving transportation and the convenience of living, as well as the satisfaction of local residents.

Second, the government could accelerate the development of the housing rental market. It could encourage and guide the real estate industry and intermediaries to expand their rental business. For instance, encouraging real estate companies to shift from solely selling properties to a dual model of "selling and renting" would not only increase the supply of rental properties but also promote the growth of the real estate sector.

Third, the government could also introduce legislation to address unregulated practices in the rental housing market and protect the interests of both landlords and tenants. This could include setting clear operational standards and procedures for rental agencies. Such measures would increase the regulation of Wuhan's rental housing market, boost public trust in it, thereby increasing the proportion of rented properties (as more homeowners would be willing to rent out their properties) and improving the overall rental experience.

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