Article

Heterogeneity, Differentiation Mechanisms and Social Effects of Urban Residential Space in China's Large Cities: A Case Study of Wuhan

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Abstract: Different choices of living space for urban residents are concrete reflections of a social class divide. Emerging residential space differentiation is a critical issue in Chinese cities. This paper aims to explore the current situations and mechanisms of residential spatial differentiation, and reveal its social responses in Chinese cities. Taking Wuhan, the largest city in central China, as an example, this research divides the residential space based on social resource structures. It analyzes and compares spatial differentiation and influencing factors of different residential areas and houses with different prices in Wuhan by spatial differentiation indicators and geographic detector. The results show that residential areas are divergent due to differences in urban resource spatial structure, with few and concentrated high-quality residential areas. The spatial differentiation level of different residential areas also varies, with central location, landscape, educational resources, and other dominant scarce resources being the key to residential spatial differentiation in most of China's big cities. In addition, residential spatial differentiation can lead to issues including housing wealth inequality, resource deprivation, and class identity solidification. In the end, this paper puts forward policy implications on alleviating residential spatial differentiation and optimizing allocation of residential resources.

Keywords: residential space differentiation; housing price; geographic detector; social effect; Wuhan

1. Introduction

Residential space differentiation is a classic topic in urban geography which refers to the differentiation, segregation, and even polarization of social groups and residential spaces in cities, and is specifically manifested in the tendency of groups with similar racial, economic, and cultural attributes in cities to live in communities of similar price, location, and quality [1,2]. Residential space differentiation has been extensively studied in cities of the Western world, uncovering deep-rooted problems such as spatial structure differentiation within the city, as well as social integration and limited development for residents of marginal communities caused by spatial differentiation [3,4]. China's large cities are currently in a transition period after rapid economic growth. In the previous period, these large cities accumulated resources to generate large-scale economic income, but at the same time, the distribution of wealth was different and dislocated among different social groups. Social groups and residential spaces in cities have been continuously alienated, interacted, and coupled, constructing an urban social space characterized by residential space differentiation [5,6]. In view of this, China's large cities have become a hot spot for analyzing residential space differentiation, attracting the attention of a large number of scholars.

Research on residential space differentiation began at the beginning of the 20th century. At that time, the United States was undergoing rapid industrialization, and a large number of immigrants poured into American society in search of economic opportunities and formed race-based cluster in certain communities of cities [7]. Competition for spatial

advantage among different social groups and individual differences in ability to pay produced location differences in land prices, housing values, and rents, creating divisions in social class and land use. Spatial differentiation allows for the uneven distribution of urban resources and service facilities [8]. In Western societies, groups with political power or social wealth are more likely to secure public services for their communities. Limited and high-quality resources are concentrated in white communities and more wealthy communities [9], while communities that the disadvantaged live in are not only deprived of development opportunities, but are also labeled as "territorial stigmatization" by mainstream society [3]. Social differentiation and spatial differentiation interact with each other, with social differentiation contributing to the formation of spatial differentiation in cities and spatial differentiation reinforcing social differentiation.

Since the reform and opening up of China in 1978, Chinese society has become stratified. However, under the housing allocation system, housing was allocated by workplaces, reflecting a strong egalitarianism. Social stratification was not reflected in the residential space differentiation, and the spatial differences in the value of urban housing were even "hidden" [10]. Until the housing marketization reform in 1998, the rapid economic growth of China's large cities attracted a large number of foreign populations, while the cities continued to expand outward and dig inward, greatly driving the development of the real estate market. The "rent difference/gap" between residential value and better locations has been "activated" and rapidly reflected in the price and spatial difference of commodity housing [11]. Diversified urban spaces and commodity communities oriented by housing price differences were constantly being constructed [12]. The market attribute of Chinese urban real estate was further activated and amplified, with real estate developers constructing and dividing residences by material attributes such as community levels, location characteristics, landscape, and rail transit. At the same time, diversified groups resulted from class differentiation chose different types of residences freely [13], with groups with similar economic, social, and cultural attributes tending to live in communities with similar prices, locations, and qualities, marking the beginning of residential space differentiation. Over the years, not only have residential communities become the main residential space in Chinese cities, but also, housing has become the most important asset of Chinese urban households. Housing is dividing Chinese cities into different classes. Housing has become a symbol that shapes different classes in Chinese cities, on the one hand, the material attributes of housing, such as environment and landscape, job opportunities, and educational resources, are attracting people with specific capital and demand preferences to gather; on the other hand, the price of housing serves as a threshold to "purify" the residential space, and the value of housing has exceeded the value of home ownership, playing a decisive role in class identity and inter-generational transmission [14]. Many scholars believe that many large cities in China now show significant and ever-increasing residential space differentiation, which deserve being emphasized and restrained, or else it will jeopardize the green, healthy, and sustainable development of China's urban residential space in the new era [15,16].

Research on residential spatial differentiation in China began in 1980s. Since then, there have been a lot of studies on this issue in China. Some scholars are more willing to analyze and show differences in the "social-spatial" structure of urban housing [17–19], while others focus on measuring the degree of residential space differentiation in Chinese cities, including Beijing, Guangzhou, Hangzhou, and so on [11,20]. For example, based on geographic information technology, spatial heterogeneity of different resource structures in Hangzhou was demonstrated [13]; A multi-dimensional indicator system has been used to divide residential space in the core area of Beijing and analyze differences in resource structures of different residential spaces [21]. Based on multi-group and multi-scale spatial differentiation measurement methods, the diversified, fragmented, and spliced residential space landscapes in Nanjing have been found [11]. As far as existing studies are concerned, differences in the resource structure of the residential space are less discussed as an important factor affecting the development of individuals and society. There have

been few studies on the mechanisms of residential space differentiation and the intrinsic significance of differentiation indices. Further, social problems caused by residential space differentiation, such as space and resources deprivation, fairness in living, and solidified social identity have been largely neglected.

This paper aims to explore the current status of residential spatial differentiation in major Chinese cities, elucidating the interplay between urban resource structures and spatial differentiation, and revealing various social phenomena related to housing resource deprivation and class identity in China. In light of this, this paper delves into the study of residential space differentiation in Wuhan, a crucial city in the central region of China. The following section outlines the research design, encompassing theoretical introduction, research methodology, case study area, data sources, and analysis methods. Section three presents the results of the analysis, showcasing variations in resource structures among different residential areas within the city, compares and analyzes the degree of spatial differentiation of different residential areas and different types of housing in Wuhan. The fourth section engages in a focused discussion, summarizing the heterogeneous features within China's major cities, the mechanisms influencing residential spatial differentiation, and revealing a series of unfair phenomena triggered by such differentiation. The article concludes by summarizing the research findings and proposing policy recommendations.

2. Research Design

2.1. Theoretical Introduction and Research Ideas

Since the 1990s, scholars have increasingly applied "Neo-liberalism Theory" to comprehensively discuss the interaction between social groups, urban systems, and residential spatial differentiation. As stated by the "housing class", housing is a crucial component of social stratification [22]. Unlike those British, American, and European cities, where the middle class moved into working class communities which led to gentrification, the housing class in Chinese cities are formed by the unbalanced allocation of resources triggered by the government's spatial development, suggesting a totally different relationship of "social classes-spatial differentiation" between China and the West [23]. In the context of China's social system, China's housing class is a product of spatial economic change rather than a promoter [19]. The expansion of Chinese major cities inevitably resulted in uneven restructurings of urban space and resource allocation and manifested in unequal distributions of transportation, supporting services, landscape quality, and school district attributes in residential spaces [13]. In view of this, we can better explore the mechanisms of residential space differentiation in China's large cities from the perspective of differences in the resource structure of urban residential space.

Urban housing prices are the market expression of uneven spatial resource allocation [24] and a reliable indicator for analyzing residential spatial differentiation in China's major cities. Residents' choice of housing type and price is a choice of specific residential resources, and the spatial differentiation reflected by different resource structures and prices are not completely consistent [25,26]. There is spatial heterogeneity in urban housing prices, leading to different degrees of access to and solidification of resource services. Therefore, we hold the view that the value of spatial differentiation in different areas of the city is not static, and it is necessary to refine the residential space in the city. In order to better show the spatial differentiation within the city, we need to explore the spatial differentiation of different resource structures and different housing prices. This study combines housing resource structure and housing price to identify the characteristics of residential spatial differentiation, and analyzes the interaction between resource allocation and residential spatial differentiation, which is innovative in research ideas.

The index of dissimilarity (ID) proposed by Duncan et al. in 1955 can well describe the uniformity of isolation on the basis of the location quotient [27]. In 1988, Massy and Denton improved the isolation index to multi-dimensional analysis, namely, the five dimensions of homogeneity, contact, concentration, centrality, and clustering [28]. Reardon et al. believed that there was overlap between these five latitudes, combined the five dimensions into two,

and proposed the spatial entropy index (H) and spatial exposure index (P) [29]. Reardon et al. incorporated spatial location information into the index, so that the two indexes can describe the distribution of different groups among spatial units and the spatial degree of contact between different groups, respectively, and can be considered good indicators for measuring the differentiation of residential space [11]. Therefore, this paper takes the housing price as the classification standard, and adopts Reardon's multi-group spatial differentiation index to measure the differentiation level.

To better analyze the mechanisms of residential spatial differentiation, this paper also uses spatial autocorrelation and geographic detectors. Spatial autocorrelation can illustrate the spatial distribution characteristics of different residential types, facilitating the analysis of their differentiation [30]. The "society - space" dual attribute of residential space differentiation determines the complexity of its influencing factors, and there is a coupling relationship between different social resources [11]. The geographical detector's interaction factor influence can analyze the combined impact of two single factors, better revealing the critical influencing factors of residential spatial differentiation [31].

2.2. Research Area and Data Resources

Wuhan, the core city of the Yangtze River Economic Belt, is located in the middle and lower reaches of the Yangtze River in central China and has important strategic advantages in terms of geography and historical significance. Wuhan's urban spatial pattern and housing price are representative among China's large cities: on the one hand, Wuhan's geographic pattern of "three towns divided by two rivers" leads to a multi-core urban spatial structure, which reflects the general pattern of multi-center development in China's large cities; on the other hand, unlike Beijing, Shanghai, and Shenzhen, Wuhan has not experienced a large population influx or overflow, and the supply and demand for housing is relatively balanced, with commodity housing prices always rising steadily. Wuhan has 13 municipal districts under its jurisdiction, and this paper focuses on the downtown areas of Wuhan, namely the seven central areas of the Jiangan District, Jianghan District, Qiaokou District, Hanyang District, Wuchang District, Hongshan District, and Qingshan District (Figure 1). The main urban area of Wuhan is about 955.15 km^2, accounting for 11.15% of the administrative division of Wuhan. Compared with other districts, the main urban area is the center of real estate development with concentrated and significant residential space differentiation.
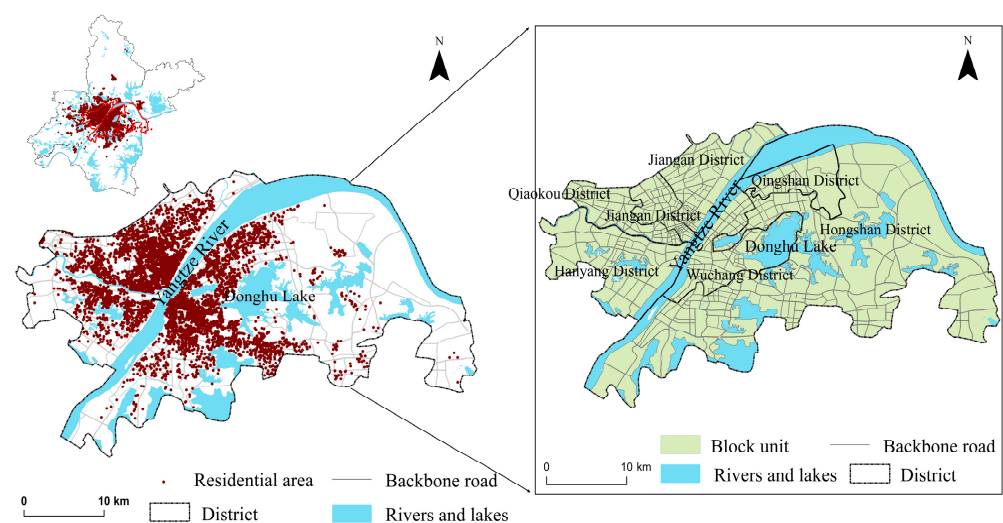

Figure 1. Research area and block units.

The data used in this research mainly include geographical base map data, personal point of interest (POI) data and residential housing price data in Wuhan. The data used is described in Table 1, and the spatial distribution of the required data is shown in Figure 1.

Table 1. Description of the data used.

Data Name	Data Contents	Data Sources	Time to Obtain Data
Geographical base map data	The administrative division, the water system, green space and the road network	The Resource and Environment Science and Data Center of the Chinese Academy of Sciences (https://www.resdc.cn/); The Open Street Map (https://www.openstreetmap.org/)	May 2022
Personal point of interest (POI) data	Geographical coordinates of public service facilities such as shopping malls, subways, bus stations, urban landscapes, leisure facilities, etc	The open platform of Amap (https://lbs.amap.com/)	May 2022
Residential housing price data	Information of 5574 residential districts, including name, sales price and geographical coordinates	The website of Anjuke (https://wuhan.anjuke.com/)	May 2022

2.3. Units and Scale

Neighborhoods are proven to be a suitable scale for measuring residential spatial differentiation [11,32]. Compared to administrative divisions like streets, blocks divided by roads are more suitable in size, with more consistent internal resources and services. Further, blocks are more realistic and detailed as compared to grids. Recognizing the advantage of neighborhood scale and considering the dialogue with existing research, this paper also uses blocks as units for residential space division. In this research, a block is taken as a unit to divide the residential space. Referring to the block division method proposed by Han et al. [33,34], the research takes into account the actual situation of Wuhan as the "City of Hundred Lakes", and uses the administrative division, road network, and water system to divide the block units. In QGIS, remote sensing images are combined to pre-process the acquired road network data, establish a buffer zone to form a road space layer, and use the administrative districts map of the research area to erase road and water system to obtain 447 block units (Figure 1).

2.4. Housing Type Division

This paper uses the natural breakpoint method to divide residential subdivisions into five types: high housing price, medium high housing price, medium low housing price, and low housing price.

2.5. Research Methods

2.5.1. *K-Means* Residential Space Classification Based on Indicator System

This research takes the residential space as the entry point, constructs the residential space indicator system and divides the residential space in the main urban area of Wuhan with the *K-means* method. The differences in the surrounding environment, supporting resources, and neighborhood effects of the residential community are the reflections of the residential space differentiation and, in turn, play a role in the residential space differentiation. This research constructs a residential space indicator system containing nine indicators of the center, transportation, landscape, employment, commerce, medical care, leisure, housing price, and educational resources from four levels of location characteristics, supporting services, economic attributes, and school districts [11,35] (Table 2). After calculating and counting the values of corresponding indicators of each block unit, *K-means* clustering method is used to divide the residential space in the research area.

Table 2. Indicators of residential space attributes.

Attributes	Variables	Variable Description	References
Location characteristics	Central area	The shortest distance between the block center and the urban center and the secondary commercial center	[36]
	Traffic	Number of bus and metro stations within the block	[24]
	Landscape	Sum of the shortest path between the block center and two large landscapes	[37]
	Employment	Number of government offices, public institutions and commercial buildings within the block	[24]
Supporting services	Commercial facilities	Number of large supermarkets, shopping malls and starred hotels within the block	[11]
	Medical facilities	Number of general hospitals and third-class hospitals within the block	[37]
	Leisure facilities	Number of parks, squares, attractions and sports and cultural venues within the block	[24]
Economic attribute	Housing price	Average housing price in the block	[21]
School district	Educational resources	Number of reputable primary and secondary schools in the block	[11]

Note: Wuhan's commercial center is Jianghan Road, and the secondary commercial centers are Wangjiawan, Zhongjiacun, Optics Valley business area, Jiedaokou, Zhongnan Road, Chuhehanjie, Wangjiadun, Wushang Plaza business area, and Hanzheng Street. Wuhan's large landscapes include the Yangtze River, East Lake, Yellow Crane Tower, Tangxun Lake, Han River, South Lake, and Moshui Lake. Key primary and secondary schools are provincial and municipal model schools publicized by the Wuhan Municipal Education Bureau.

2.5.2. Residential Space Differentiation Index

The spatial information entropy (*H*) refers to the evenness of the distribution of groups in space, and the larger its value is, the more uneven it is. The normalized exposure (*P*) shows how easy or difficult it is for a certain group to contact the members of other groups in the environment, and the larger its value is, the more difficult it is. This research uses the proportion of the number of different categories of residential communities to calculate the spatial information entropy (*H*) and normalized exposure (*P*), whose formulae are [38]:

$$H = \sum_{j=1}^{J} \left[\frac{t_j (E - E_j)}{ET} \right] \tag{1}$$

$$E = \sum_{m=1}^{M} \pi_m ln \left(\frac{1}{\pi_m} \right) \tag{2}$$

$$P = \frac{1}{T} \sum_{m=1}^{M} \sum_{j=1}^{J} t_j \left(\pi_{jm} - \pi_m \right)^2 \tag{3}$$

In the formulae: *E* indicates the *Theil* information entropy; *j* indicates different block units; *m* indicates the different types of housing; *T* indicates the total number of housing within the research area; *t* indicates the total number of housing in a certain block unit; π indicates the proportion of a certain housing type; t_j indicates the total number of housing in the block unit *j*; π_m indicates the proportion of the housing type *m*; π_{jm} indicates the proportion of the housing type *j* in the block unit *m*.

2.5.3. Spatial Autocorrelation

Spatial autocorrelation refers to the potential interdependence between observation data at different spatial locations in a certain area, including global spatial autocorrelation

and local spatial autocorrelation [30]. In this research, it is used to show the clustering spatial distribution characteristics of different types of residential communities.

$$I = \frac{n\Sigma_{i=1}^{n}\Sigma_{j=1}^{n}w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\Sigma_{i=1}^{n}\Sigma_{j=1}^{n}w_{ij}\Sigma_{i=1}^{n}(x_i - \overline{x})^2} \tag{4}$$

$$I_i = \frac{n(x_i - \overline{x})\Sigma_{j}^{n}W_{ij}(x_i - \overline{x})}{\Sigma_i(x_i - \overline{x})^2} \tag{5}$$

In the formulae: n indicates the total number of research units, x_i and x_j indicates the housing types of research units i and j, respectively, and w_{ij} indicates the spatial weight matrix. The critical matrix based on Euclidean distance is chosen in this paper.

2.5.4. Geographical Detector

Geographical detector is a statistical method to overcome problems such as linear hypothesis and multicollinearity and to reveal the explanatory power of its influencing factors, including four detectors: factor detection, interactive detection, risk detection and ecological detection [39]. In this research, the factor detector and interactive detector are used to explore the effect of residential space indicators on residential space differentiation.

$$q = 1 - \frac{1}{n\sigma^2}\sum_{i=1}^{L}n_i\sigma_i^2 \tag{6}$$

In the formulae: q indicates the interpretation degree of detection factors to residential spatial differentiation, and n indicates the number of research units. σ^2 indicates the total discrete variance of the study area; i indicates the number of samples in secondary regions.

3. Results and Analysis

3.1. Residential Space Division

Based the statistics of nine indicators, such as blocks, centers, transportation, landscape, employment, commerce and medical care, etc., the residential space of Wuhan main urban area is divided by *K-means* method. According to the clustering effect, when K is six, all kinds of residential spatial location and resource characteristics are more obvious. Therefore, combined with the research objectives of this paper, the value of K is determined to be six, and the residential space in the main urban area of Wuhan is divided into six categories. The residential space types **I** to **VI** are, respectively, named as: residential areas with low supporting services in the city center, residential areas with high-quality services and concentrated educational resources, residential areas with poor supporting services on the edge of urban areas, residential areas with mature supporting services in urban core, residential areas with medium supporting services in the periphery of the city, and residential areas with rich medical resources and superior location (Table 3 and Figure 2).

Table 3. The proportion of six residential spaces and the average value of each index.

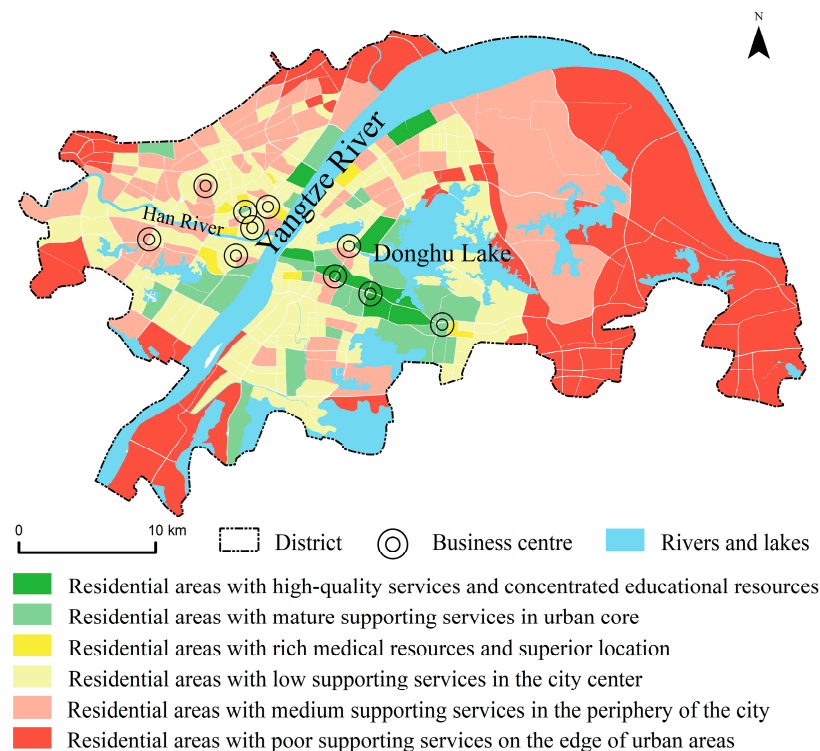| Factors	Residential Area I	Residential Area II	Residential Area III	Residential Area IV	Residential Area V	Residential Area VI
Number of residential communities	2427	579	111	718	1440	272
Proportion of communities (%)	43.75	10.44	2	12.94	25.96	4.90
Central area (km)	9.60	9.99	29.73	11.34	12.32	5.48
Traffic	3.38	12.78	2.74	5.32	12.44	6.27
Landscape (km)	5.29	3.88	12.55	4.62	6.88	3.78
Employment	4.64	39.44	1.15	8.39	13.55	9.18
Commercial facility	3.35	20	1.75	13.18	8.65	8.55
Medical facility	0.55	8.33	0.15	1.96	1.87	21.27
Leisure facility	2.62	24.44	1.19	16.61	1.87	21.27
Housing price (yuan/m^2)	18,985	22,651	17,053	19,568	16,732	18,625
Educational resource	0.16	3	0	0.46	0.47	0.45

Figure 2. Residential space zoning map in the main urban area of Wuhan.

Residential Area **I** (residential areas with low supporting services in the city center) accounts for 24.35% of the research area with the largest number of residential communities. It is widely distributed in the center of Wuhan, with obvious advantages in central area and landscape, but its traffic and employment conditions are relatively poor, and the average housing price of it is in third place among all the residential areas. Residential Area **II** (residential areas with high-quality services and concentrated educational resources) has the highest housing price per unit area (22,651 yuan/km^2), which is mainly distributed along the Donghu Lake and the Yangtze River, and has the highest-grade communities in the research area. It also gathers high-quality compulsory education resources, which can satisfy the residential needs of families of different ages. Residential Area **III** (residential areas with poor supporting services on the edge of urban areas) is the largest residential area, with the smallest number of residential communities. The main characteristic of this residential area is that it is distributed on the edge of the main urban area, and its poor location and material conditions make its house price relatively low (17,053 yuan/km^2). The number of residential communities in the Residential Area **IV** (residential areas with mature supporting services in urban core) accounts for 12.94%, which is adjacent to Residential Area **II** in spatial distribution. Its supporting services are more well-developed and mature, and its commercial facilities and leisure facilities are only second to that of Residential Area **II**, with the housing price in second place (19,568 yuan/km^2). The area and residential scale of Residential Area **V** (residential areas with medium supporting services in the periphery of the city) are both in second place, and the spatial distribution of this residential area is more extensive, adjacent to Residential Area **III** and Residential Area **I**. Its traffic and employment location are better, and the supporting services are at the medium level, but its housing price is the lowest (16,732 yuan/km^2), which is one of the low housing price areas in the city. Residential Area **VI** (residential areas with rich medical resources and superior location) is the smallest in area, but its commercial facilities and leisure facilities are second only to Residential Area **II**. The distinctive characteristic of this residential area is the rich medical resources, with its housing price in third place (18,625 yuan/km^2).

3.2. Heterogeneity Analysis of Residential Space

3.2.1. The Results of Different Residential Spaces Differentiation Indicators

The overall spatial information entropy (*H*) and normalized exposure (*P*) of the main urban area of Wuhan and the six types of residential areas are calculated based on the proportion of the number of five types of residential communities (Figure 3). The spatial information entropy (*H*) and normalized exposure (*P*) of Wuhan's main urban area are 0.2703 and 0.2219, respectively. According to the classification standard of residential space differentiation in Western academia [23], the residential space differentiation in Wuhan belongs to "low differentiation". Among the six types of residential areas, the highest and the lowest spatial differentiation values are in Residential Area **III** and Residential Area **VI,** respectively, and the spatial differentiation values of different residential areas are quite distinct. On the whole, the spatial information entropy and the normalized exposure are correlated with each other, with similar waveforms of the two differentiation curves, and the *H* and *P* values of the same residential space are close. At the same time, the residential density also has an effect on the differentiation level. Because of the large area and small total number of residences of Residential Area **III**, its residences show a pattern of cluster in small-scale and dispersion in large-scale, so it is more difficult for the residences to come into contact with each other, resulting in its relatively high differentiation level, while Residential Area **VI** is small in area and has a larger number of residences, so it is easier for residences to contact with each other, resulting in the differentiation level tending to be on a low value.
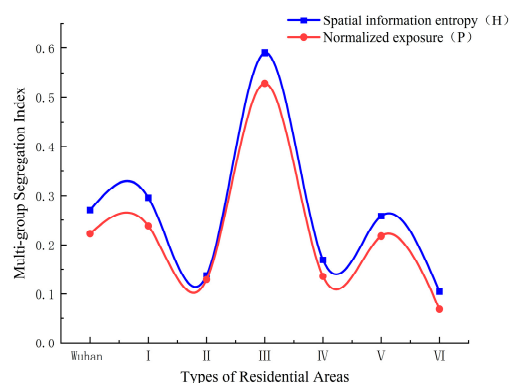

Figure 3. Information theory index and normalized exposure of different residential spaces.

3.2.2. Differentiation Characteristics of Different Housing Groups

In order to further explore the differentiation and characteristics of different housing groups, this research analyzes the cluster of each group of housing using spatial auto-correlation (Figure 4), and measures the spatial information entropy (*H*) and normalized exposure (*P*) of the five groups of residential communities in different residential spaces (Figure 5).

The spatial autocorrelation was carried out according to the proportion of the number of different groups of housings in different blocks. The global *Moran'I* of each group of housings is greater than 0, the minimum *z* value is 6.83, and the *p* value rejects the null hypothesis, indicating that the five groups of housings are clustered in spatial distribution. According to the spatial cluster characteristics of each group of housings (Figure 4), the blocks with high proportion of low-priced housings are clustered in the periphery of the main urban area in Residential Area **III** and Residential Area **V**, and the low-priced housings in the core area of the city show a low-low cluster. The blocks with a high proportion of medium- and low-priced housings are concentrated in Residential Area **I** along the north bank of the Yangtze River, and are less distributed in the vicinity of Donghu Lake. The cluster of medium-priced housings with the proportion of medium- and high-priced housings has a certain degree of similarity, that is, no significant blocks hold better proportion, high-high cluster and low-low cluster are presented in the core

area and the four corners of the main urban area, respectively, but more blocks show no significant cluster. The cluster of high-priced housings is more significant, and they are concentrated in Residential Area **II** and Residential Area **IV** along the Yangtze River and near Donghu Lake.
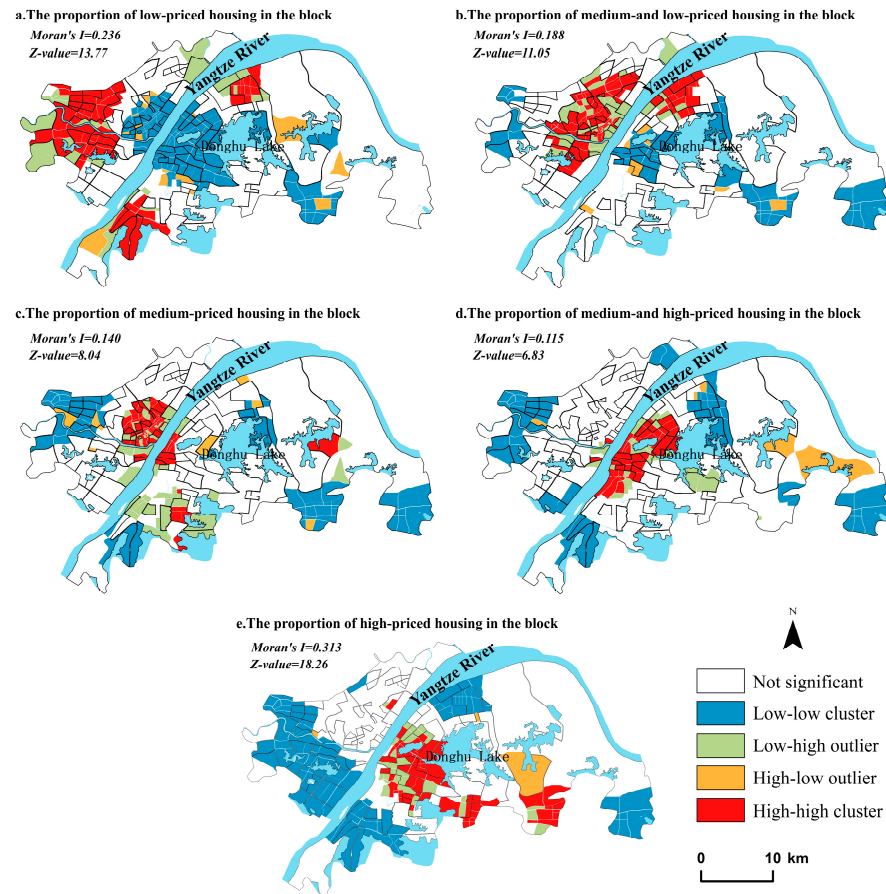

Figure 4. Lisa Aggregation Map of Residential Block Proportion of Different Grades.
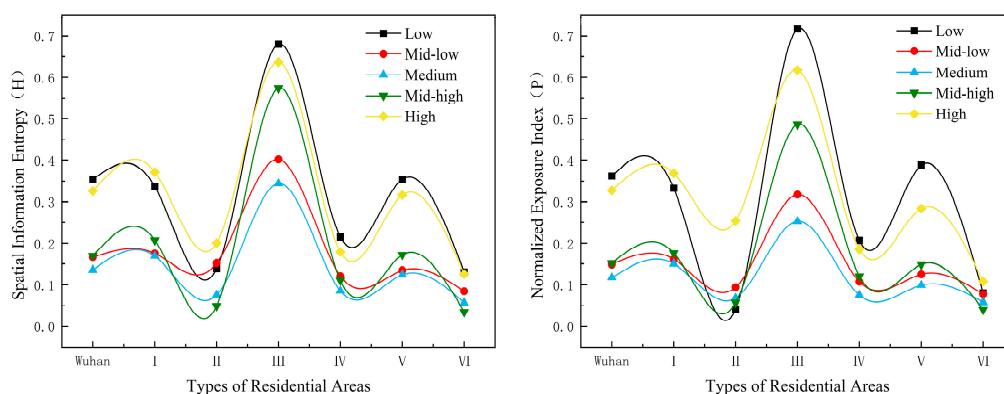

Figure 5. Segregation profiles of different housing groups in different residential areas.

Figure 5 demonstrates the spatial differentiation of the five types of residential communities, and the spatial differentiation values of each type of housing are closely related to the overall spatial differentiation values of the corresponding residential areas. The residential areas with higher differentiation levels, the five types of housing in it also have relatively higher spatial differentiation levels, and vice versa. In terms of housing types, affected by the level of spatial cluster, low-priced and high-priced housings have the highest spatial

differentiation values, that is, have the most uneven spatial distribution and are the most difficult to contact with other types of housing. In addition, the relative size of housing also affects the spatial segregation value, especially the spatial contact value. In Residential Area **II**, because the proportion of high-priced housing is large and other types of housing are relatively small, the *p* value of high-priced housing is much higher than other types of housing.

3.2.3. Influencing Factors of Residential Space Differentiation

Since the spatial information entropy (*H*) is highly correlated with the normalized exposure (*P*), this research employs geographical detectors to analyze the influence and interaction of residential space indicators on the spatial information entropy (*H*) as a means of detecting the influencing factors and the mechanisms of residential space differentiation.

As can be seen from the results (Figure 6), "employment" has the highest *q* value, followed by "commercial facilities", "medical facilities", and "leisure facilities", all of which the *q* value exceeds 0.5, and all have a strong explanatory power for the residential space differentiation indicators of the research area. The third group includes "central area", "landscape", "housing price", with *q* values ranging from 0.3 to 0.4, which have a certain explanatory power for the residential space differentiation index. The explanatory power of the factors of "traffic" and "educational resources" is relatively weak. The explanatory power of the interaction factors is significantly stronger than that of the single factors, and the influence of the interaction factor "commercial facilities ∩ landscape" is the highest, with *q* value of 0.8. The influence of the interaction factors composed of single factors with large influence such as "commercial facilities" and "medical facilities" is relatively large. At the same time, the combination of single factors with weak explanatory power such as "traffic ∩ central area" also shows strong explanatory power. It can be seen that the combination of multiple influencing factors can better show the spatial differentiation of urban residential space.
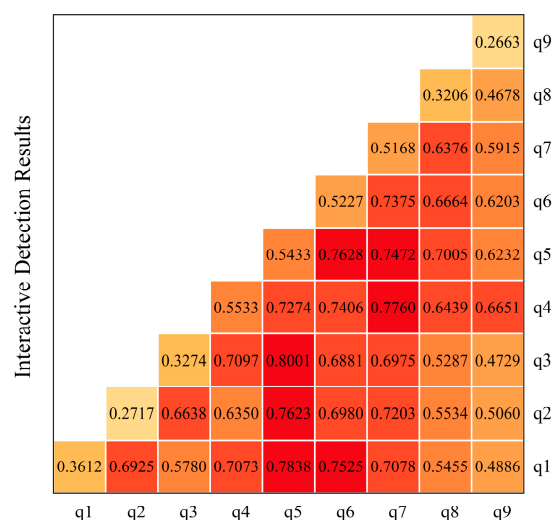

Figure 6. Results of the Geographical Detector.

4. Discussion: Heterogeneity, Differentiation Mechanisms and Social Effects of Urban Residential Space

4.1. Difference Analysis of Resource Structure of Different Residential Space in the City

This research divides the residential space by evaluating the resources allocation of blocks, it presents as the pyramid structure, with the high-quality blocks being fewer and more concentrated, and the ordinary blocks being more numerous and more dispersed. The transition from high-quality blocks to ordinary blocks is spatially presented as a ring structure from the city center to the periphery of the city, and in terms of the proportion of area. Although urban expansion in recent years has led to the rapid development of subur-

ban and new areas, there is still a big gap between their location advantages, supporting services and educational resources and the old city area, and the high-quality blocks in the city center occupy most of the city's scarce resources. In this research, Residential Area **II** and Residential Area **IV** are concentrated in Jianghan Road, Wushang Plaza, and the East Lake Scenic Area and other places in Wuhan, which have superior location characteristics, well-developed supporting services, natural landscapes, and the top compulsory educational resources. In addition to this research, research studies in Beijing [21], Nanjing [11], Guangzhou [40], and other cities also confirm the resource advantages, spatial cluster, and scarcity of urban high-grade housing. The scarcity of high-quality communities has become a common problem in the spatial structure of China's large cities, which needs to be taken seriously. It is not only because the scarcity of high-quality communities would widen the housing price gap, but more importantly, the attraction of high-quality communities to social capital groups with more funds will further promote class division and residential differentiation [15], which will become a potential social problem.

As mentioned earlier, there is a totally different relationship between Chinese and Western "social classes - spatial differentiation". China's political and economic system significantly influences urban residential space structure [41]. The positioning of urban development and planning direction largely determines China's urban spatial structure, with local governments and developers being important drivers of residential space structure. Superior location conditions within cities attract the importation of high-quality resource elements, thereby attracting socially affluent groups with high capital. This phenomenon is referred to as "slash-and-build gentrification" [42] or "new urban gentrification" [43]. Moreover, the specific social and cultural environment and diverse family life needs make China's housing stratum different from the West. This specificity is reflected in the pursuit of convenience, quality education, and scenic re-sources in housing choices. These aspects emphasize the importance of residential resource structure in residential spatial differentiation and provides policy angles for alleviating residential spatial differentiation.

4.2. The Mechanisms of Residential Space Differentiation

According to the results of spatial differentiation (Figures 3–5), it can be seen that the differentiation of different residential areas varies significantly. The closer the residential area is to the center of the city, the lower the degree of differentiation, while the closer the residential area is to the periphery of the city, the higher the degree of differentiation. The spatial cluster of residential areas of the low-priced housing and the high-priced housing is more significant, and their residential differentiation indicators are also relatively high. The more the housing price tends to be medium, the more it tends to be evenly distributed, and the lower its value of differentiation. There are scholars who have argued about the influencing factors of segregation index. *Reardon* and other scholars have proved the role of the relative size of the group on the normalized exposure, that is, the smaller the relative proportion of the group, the easier it is to have contact [11]. In the study of urban segregation in Chile, it was found that there is a strong correlation between segregation and city size, that is, the expansion of the city is conducive to the contact and integration of the residents, and the large city's racial segregation would be lower than small cities [44]. The results of the research in this paper also show that the level of the differentiation index is not solely affected by the even distribution and cluster of housing, but that the scale and density of housing also play an important role: on the one hand, the normalized exposure value of the high-priced housings in Residential Area **II** is much higher than that of other types of housing due to the disparity in the proportion of high-priced housings to other types of residences; on the other hand, the density of housing has a certain effect on the differentiation index. Under the intensive use of land in Chinese cities, there is a significant gap between the residential density of urban centers and suburbs (Figure 1). The residential density in urban centers is extremely high, even if there is cluster of different types of housing, the spatial distance between clusters is relatively small, while the residential density of suburbs is low and the spatial distance between different types of housing is

large. The gap in the residential density leads to the existence of a large difference in the degree of spatial evenness and the difficulty of contact, which is one of the reasons why the degree of differentiation in the periphery of the city is higher than that in the city center.

Regarding the influencing factors of residential space differentiation based on geographical detectors, from the perspective of a single factor, "employment", "commercial facilities", "medical facilities" and "leisure facilities" are the key factors influencing the residential space differentiation in the main urban area of Wuhan. The average values of these four indicators differ significantly among different residential areas compared with other indicators, which have strong attraction to groups with specific needs, and accordingly play an important role in the value of spatial differentiation of residential space. In terms of the interaction factors, the combination of the three factors of "central area", "landscape" and "commercial facilities" has a great influence on the residential space differentiation. These three indicators can be regarded as the representatives of the city's scarce resources, which is not only necessary for the high-quality life, but also a symbol of economic strength and social class.

In order to better reflect the characteristics of factors affecting the differentiation of residential space in different cities in China, the results of this paper are compared and analyzed with the relevant research results of Hangzhou and Nanjing [11]. It is found that the interactions of city centers, commercial facilities and high-quality landscape all play an important role in the spatial differentiation of the three cities, which indicates that urban resources reflecting the economic strength and quality of life of the living groups are the key to influencing the spatial differentiation of the residential spaces. In terms of single influencing factor of residential space differentiation, there are slight differences among the three cities, with "center advantage" and "educational facilities" having a strong influence on residential space differentiation in Nanjing and Hangzhou. Although the city's location advantage shows strong effects in all three cities, the specific aspects are different. In Wuhan, "employment" has stronger influence than the "central area", which is related to the fact that Wuhan is a multi-center city with two rivers and three towns, while Nanjing and Hangzhou are traditional single center cities. The influence of reputable primary and secondary schools on spatial differentiation of Wuhan's residential space is weaker than that of Nanjing and Hangzhou. This is because, on the one hand, Wuhan has rich high-quality educational resources which are distributed in the periphery of the city. On the other hand, Nanjing and Hangzhou have higher premium of school district housing and a more prominent "gentrification" in school districts. In all the cities of Wuhan, Nanjing, and Hangzhou, landscape resources do have a significant impact. In many Chinese cities, it has been found that the residential class shows a trend of "Green Gentrification", which is similar to some cities in the United States [45]. From the above analysis, it can be seen that the spatial structure, resources and cultural backgrounds of Chinese cities are different, and accordingly, influencing factors of residential space differentiation are not entirely consistent. However, people's pursuit of urban high-quality and scarce resources, such as the central area, better landscape, and high-quality educational resources, are the same.

4.3. Social Effects of Residential Space Differentiation

Western geographers have earlier paid attention to a series of social inequities caused by residential space differentiation in cities, such as inequitable access to public services and facilities for disadvantaged groups, and spatial segregation and limited development caused by racial differences. As a socialist country, China has always adhered to the principle of "people-oriented and sharing the fruit of development", but social classes will never be eliminated in any social form, especially in the context of upgrading and transforming China's large cities. Therefore, China's big cities are bound to have complex residential space differentiation, which inevitably brings about a series of social effects.

(a)   Housing wealth inequality caused by residential space differentiation

In recent years, European scholars have discussed the impact of age and generation on housing wealth, calling today's young people in Europe "Generation Rent" because of the

inequality of inter-generational transmission of housing wealth, which has made housing unaffordable for them. The same thing is happening in China's large cities, but the situation is totally different from European countries [14]. Housing wealth can be transferred between generations. The inequality of housing wealth in Chinese cities of different administrative levels has been a major concern of scholars in the past [10]. But in fact, the residential space differentiation is also exacerbating the inequality of housing wealth in cities, which directly restricts the space appreciation of residential properties in the peripheral of the city. And, along with the further polarization of residential space differentiation, housing in cities will show greater wealth inequality and stronger inter-generational transmission, which will limit the normal mobility between classes in the long run.

(b)   Resources deprivation caused by residential space differentiation

An important manifestation of residential space differentiation is the uneven allocation of different residential resources, and the purchase of different housing will bring about different social resources. Studies by American scholars have shown that families and their offspring living in better cultural and social capital environments generally have more advantages in social competition and are more likely to obtain class identity, while groups trapped in ordinary or even poorer living environments are more likely to be restricted in their development [46,47].

Deprivation is a sociological concept that refers to the phenomenon in which the unfairness of the spatial distribution and flow of materials leads to the loss or lack of a certain resource or certain resources for the disadvantaged to satisfy the most basic needs for survival [48]. Urban residential space differentiation is manifested in the differences in the resources obtained by groups in different residential spaces. The resource environment of different residential spaces also has an impact on the differentiation of residents' habits and behaviors, which leads to the occupation of specific resources in specific residential spaces. For example, residents of the residential area with landscape resources can enjoy the landscape more conveniently, while those who are not from this community need to pay more time and higher transportation costs to access these resources; the residential area with concentrated employment resources has more jobs, residents of which have more employment resources and the right to choose, while those who lack jobs and have difficulties in upward mobility will be relatively less likely to have access to social resources and the ability to generate income; "school district housing" is a typical example of the residential space differentiation in China's large cities, in which people pay a high price to purchase school district housing in order to access high-quality educational resources, while the children of those who do not live in "school district housing" do not have access to high-quality educational resources. Geographic segregation exacerbates social segregation, leading to inequitable distribution of resources and development opportunities, which is transmitted between generations.

(c)   The class identity solidified by residential space differentiation

Housing contains more than the economic and social added value of asset appreciation, high-quality education, employment opportunities, and supporting services embedded in the property rights and spatial location of housing, but more importantly, contains the cultural value of class identity with its social status symbols and capital connotations. Urban housing bundles different economic, cultural and social capitals, and as such, housing provides access to the cultural and social resources of the community in which it is located [13,49]. It is both a marker of class status and the cultural and social capital that the middle class invests in itself and its children, facilitating the ability of future generations to inherit the identity of their class, that is, to reproduce social class. At the beginning of 2023, a video of the "Wanliu House" residential community in Beijing, a high-end residential area with an average housing price of RMB 50 million yuan, caused an uproar on social media. Once the video was released, tens of thousands of netizens referred to the person who appeared in the video as a "young master", identifying him as a member of the wealthy class through the positioning of the "Wanliu House" residential community. Housing has

gradually become an important factor in measuring social status and promoting social differentiation, while residential space differentiation further solidifies class identity [9].

5. Conclusions and Prospects

This paper explores urban residential space differentiation by taking the living environment and housing price as the entry point, and through dividing the urban residential space and exploring the differentiation levels of different residential areas. It visually shows the differences in the residential space within the city, and then analyzes the social effects brought about by these phenomena, further presenting the hierarchy and complexity of the residential space differentiation in China's large cities. The results show that:

Firstly, due to the differences in the spatial structure of urban resources, there are obvious differences between residential areas. With a small proportion of high-quality residential areas concentrated in the city center, which has a lower level of spatial differentiation, while the suburbs and new areas on the periphery of the city, which account for a large proportion of the area and have poorer allocation of resources, have a higher level of spatial differentiation. The difference in residential resource structures characterizes residential spatial differentiation and drives its formation and development.

Secondly, this paper uses geographic detectors and spatial autocorrelation to analyze the influencing factors and mechanisms of residential spatial differentiation. The spatial scale has an impact on differentiation index values, and a scientifically reasonable spatial scale can better reflect urban differentiation levels. The greater the imbalance in spatially configured city resources, the greater the impact on residential spatial differentiation. The influencing factors of residential spatial differentiation in Chinese major cities are not entirely consistent, but central location, landscape, educational resources and other dominant scarce resources are the key to the residential spatial differentiation in most of China's big cities.

Thirdly, this paper reveals the social effects caused by residential spatial differentiation in Chinese cities. Housing wealth inequality, resource deprivation, and the solidification of class identity hinder residential spatial fairness. Over time, this not only leads to "housing discrimination" but also restricts mobility between classes.

For China, the government, leveraging its institutional advantages and providing targeted guidance, can greatly alleviate residential spatial differentiation. On the one hand, the government needs to plan cities well, construct multi-center cities, promote urban renewal, and enrich and balance urban resources from both internal and external perspectives. On the other hand, advocating moderate housing mixing and social integration, enhancing the degree of residential mixing in neighborhoods of different prices, can produce positive effects and equal opportunities for public services. In the future, the government may need to pay attention to the social effects of residential space differentiation, weaken the sense of housing class identity, improve policies such as equal rights for rental and home ownership, and promote a healthy and sustainable development of China's urban residential space.

This research focuses on the classic issue of residential spatial differentiation, effectively connecting residential resource structures and housing prices. It innovatively approaches the research perspective of residential spatial differentiation, providing a comprehensive explanation of the interaction between resource structure differences and residential spatial differentiation. However, it is acknowledged that this paper has some limitations, which may offer directions for future research. Residential differentiation includes "social - spatial" dimensions. This paper focuses on exploring the determinative role of resource spatial structure differences in residential spatial differentiation, while the impact of urban social groups on residential spatial differentiation are not fully considered. In the future, social group indicators may be included in the determination of residential spatial differentiation. Another concern is that in this paper, although evaluation indicators for residential spatial differentiation are as comprehensive as possible, they may not fully and accurately depict the entire picture of resource structure in residential spaces. Additionally, while this paper reveals the deprivation effects of residential spatial differentiation

on public service resources, it does not explain the specific deprivation mechanisms and extent, which may also be discussed in future research.

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