Social-spatial Differentiation and Residential Segregation of Hangzhou, China: Evidence from the Subdistrict-level Data

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Abstract. Social-spatial differentiation is a feature of Chinese cities and is undergoing dynamic change as part of urbanization. This paper studies the social-spatial differentiation in Hangzhou by the subdistrict-level data from the resident trip survey combined with an accurate map. After create 29 demographic, educational, occupational and housing variables for 96 subdistricts, a mixed method approach include principal components analysis (PCA), hierarchical clustering and spatial segregation analysis is used to analyze and classify the spatial segregation of diverse social groups. The study finds a complex pattern of social-spatial differentiation and residential segregation in Hangzhou, China, and then analyze both the external and internal force of Hangzhou's residential space differentiation.

Keywords: Subdistrict-level, Social Zone, Residential Differentiation, Hangzhou.

1. Introduction

Social-spatial differentiation has many dimensions but is most often related to racial and ethnic segmentation, and occasionally class or income segmentation [1][2]. Urban spatial structure has long held an interest for those who study cities, and research has been done a lot in Africa, Asia and Latin America. Nowadays Chinese housing market has attracted a substantial amount of attention, which is unsurprising given the extraordinary growth in Chinese cities and the fundamental shifts in Chinese political economy [3].

With the development of economy, cities expand exponentially through the construction and development of the surrounding area. At the meantime, families of different social classes chose their house according to their own economic strength and basic needs. Such choices directly promote the further development and reconstruction of the residential space in China's big cities, and residential segregation begins to appear. Socio-spatial segregation has long been a focus of analysis in Western cities [4]. Since 1990s, research on the social-spatial differentiation in Chinese cities start. However, previous studies ignored the importance of the spatial data properties and failed to break the limitations of the statistical analysis of social space.

This paper studies the social-spatial differentiation in Hangzhou using data at the subdistrict or jiedao level combined with an accurate map. It can overcome the spatial data deficiency in sociologically oriented studies before, and enrich the domestic study at the subdistrict scale. Moreover, the study of social-spatial differentiation is instructive to urban planning and sustainable development of a city.

2. Methodology

2.1 Data and Study Area

Hangzhou is the capital of Zhejiang Province and the center city in the southern wing of the Yangtze River Delta. Over the past two decades, Hangzhou's urban area has expanded and its population has grown significantly. Along with the rising house price, Hangzhou's residential space has also undergone tremendous changes and is worthwhile to be studied. The city areas include the main urban area (districts of Binjiang, Gongshu, Jianggan, Shangcheng, Xihu, Xiacheng, Xiaoshan and Yuhang).

This paper uses the 2015 resident trip survey results of Hangzhou traffic management department as the analysis data, which mainly includes the distribution data of family size, population ratio, occupation, income, travel time, car ownership and so on in a subdistrict.

2.2 Analysis Methods

In this case study, a mixed method approach using index- and statistical analysis-based methods is adopted for social and spatial analyses, specifically principal components analysis (PCA), hierarchical clustering and spatial segregation analyses. PCA is a well-established data exploration tool used to reduce large data sets into a more manageable and interpretable number of highly independent components. This method, together with clustering methods, has been extensively utilized for analyzing socio-spatial segregation, for example, in the case study of Shanghai [5], Guangzhou [5] and Nanjing [7]. Therefore, a hierarchical cluster approach is applied based on Ward's minimum variance method [8] to identify the socio-spatial linkages between subdistricts. The combination of these two methods enables the identification and classification of social groups.

3. Results

3.1 PCA Components

In total, 29 variables are utilized and a matrix is constructed for the 96 subdistricts. Given that a large amount of variables make any worthwhile judgment and interpretation impossible, the method of Quart Imax rotation in PCA that yields the most interpretable results was applied to the matrix.

The PCA analysis yielded 8 components after 13 iterations (Figure 1), and the results explain 78.18 percent of the total variance.

Table 1. Rotated component matrix

	I	II	III	IV	V	VI	VII	VIII
Mean family size	.759	.244	-.162	.106	-.321	-.300	-.086	-.054
Mean car ownership	.834	.238	-.035	-.011	-.066	-.053	-.183	-.167
Percent 6-19 years old	.568	.364	-.203	.037	-.348	.322	-.148	.118
Percent 20-29 years old	.342	.021	.155	-.623	.322	-.129	-.044	-.349
Percent 30-59 years old	.853	-.084	-.088	.121	.236	.156	.039	.071
Percent 60 years old or above	-.890	-.060	.028	.254	-.229	-.120	.041	.113
Percent above college education	-.390	.417	.276	-.371	.389	.334	.183	.207
Percent permanent subdistrict residential registration	.148	-.026	-.118	.899	-.082	-.120	-.136	-.161
Percent permanent urban residential registration	.022	-.025	-.107	.936	-.054	-.109	-.062	-.094
Percent government, institution, enterprise managers	.169	.142	.197	-.026	-.065	.727	.019	.113
Percent professional and technical workers	-.065	.117	.216	-.127	.300	.663	.013	.024
Percent clerical and related workers	.050	.251	-.067	-.118	.795	.117	.038	.040
Percent frontline workers in commerce and services	.316	-.079	.152	-.373	.627	.001	.353	.315
Percent fishing, farming and construction	.175	.083	-.156	.143	-.105	-.118	-.008	.846
Percent transport and communications	.476	-.185	-.167	.107	-.453	-.181	-.153	-.480
Percent other industries	-.602	-.061	-.012	.173	-.376	-.350	-.099	.471
Percent per capita monthly income <5,000 yuan	.057	-.583	-.449	.323	.028	-.319	-.018	-.044
Percent per capita monthly income 5,000-10,000 yuan	-.407	.555	.408	-.254	.241	.324	.028	.124
Percent per capita monthly income 10,000-15,000 yuan	-.131	.302	.671	-.220	.120	.362	.251	-.060
Percent per capita monthly income >15,000 yuan	-.047	.070	.841	-.128	-.079	.225	.052	-.022
Percent monthly family income <10,000 yuan	-.154	-.905	-.271	-.029	-.119	-.066	-.026	.027
Percent monthly family income 10,000-20,000 yuan	.200	.896	-.046	.018	.112	.081	.014	-.127
Percent monthly family income 20,000-30,000 yuan	.024	.560	.668	.068	.081	.006	.116	.173
Percent monthly family income 30,000-40,000 yuan	-.148	.007	.785	-.100	.097	.093	-.116	.160
Percent monthly family income >40,000 yuan	-.007	.060	.475	-.013	-.211	-.286	-.521	.072
Mean travel time to work	-.621	.139	.132	-.195	.132	.052	.479	.301
Mean travel time to school	.002	.177	-.033	-.244	.148	-.127	.583	.023
Mean travel time for shopping	-.297	-.145	.191	.104	-.107	.078	.753	-.032
Mean travel time for entertainment	-.417	.258	-.134	-.200	.049	.076	.378	.217

The 8 components identified and shown in Table 1 can be used to delineate the socio-demographic structure of Hangzhou and form the basis of understanding its socio-spatial segregation in the city.

Component I: working parents with school-age adolescents. This component accounts for 17.54% of the variation. It contains a large proportion of school-age adolescents (0.568). In a previous study of Nanjing city, Wu et al. [7] identified a similar social group which they termed jiaoyufication ("educationisation"), by which they meant a new form of gentrifying group located around high-quality primary and secondary schools, used by families with school-age children. However, by comparison, this component in Hangzhou also contains another social group i.e. adults aged 30-59 whose proportion (0.853) is a little bit higher than in Nanjing, and adults aged over 60 whose proportion (-0.890) is a lot lower than in Nanjing. Families with young children have moved to these areas with better schools, and they are more likely to own a car (0.834). On the other hand it can explain the minimum travel time of all components, eg. Time to work (-0.621), time to school (0.002), time for shopping (-0.297) and time for entertainment (-0.417), it proves that a family with a car can travel more easily and consume less. Good quality schools in Hangzhou are mostly located in the old city around Westlake, and more of those mixed groups of residents locate in the same place.

Component II: intellectual class with middle income. This component accounts for 11.66% of the variation. It includes clerical and related workers (0.251) with high-level education (0.417), which has a negative correlation with employment in transport and communications (-0.185). Intellectual class generally have a middle income, which is highly negatively correlated with the proportion of monthly family income below 10,000 Yuan (-0.905), and highly positively correlated with those between 10,000 Yuan and 20,000 Yuan (0.896). Taking the distribution of university resources in Hangzhou into consideration, the area with high scores of this component have developed educational undertakings, numerous scientific research institutions and universities, strong cultural atmosphere and significant intellectual class proportion.

Component III: high income group. This component accounts for 11.49% of the variation. The proportions of respondents' monthly income of 10,000-15,000 Yuan (0.671) and above 15,000 Yuan (0.841), together with the proportions of monthly family income of 30,000-40,000 Yuan (0.785) and above 40,000 Yuan (0.475) are all at high level.

Component IV: local elderly population. This component accounts for 10.11% of the variation. The proportions or owning permanent urban residential registration (0.936) and subdistrict residential registration (0.899) are at high level. It includes elderly population over 60 years old (0.254), and has a significant negative correlation with population between 20-29 years old (-0.623). The high-score area includes the suburb where those elderly population may have lost the ability to work, also scattered distribution in the inner city where the old is mainly composed of local retired cadres, and the residential area corresponds to the built-up area before liberation.

Component V: commercial service personnel and clerks. This component accounts for 7.85% of the variation. The high correlation index mainly includes the proportions of clerical and related workers (0.795) and frontline workers in commerce and services (0.627).

Component VI: professionals and executives. This component accounts for 7.11% of the variation. The proportion of government, institution and enterprise managers (0.727) together with proportion of professional and technical workers (0.663) are high. In the meantime, they have a relatively high monthly income of 10,000-15,000 Yuan (0.362) or over 15,000 Yuan (0.225).

Component VII: group rely on public transportation. This component accounts for 6.56% of the variation. The proportion of car ownership (-0.183) is relatively low, and correspondingly, the travel time of all kinds of intentions are the maximum of all components, going to work (0.479), to school (0.583), for shopping (0.753) and entertainment (0.378). For one, the convenient residential location reduces the willing to purchase a car; for another, the travel time by public transportation of walking is relatively higher.

Component VIII: primary industry personnel or rural in-migrants in urban enclaves. This component accounts for 6.15% of the variation. The proportion of population engaged in primary

industry like fishing, farming and mining (0.846) is quite high, and the proportion of other industries is relatively high (0.471), which may include the proportion of the unemployed. The area with high scores of this component are mostly distributed in villages and towns on the urban fringe. It mainly includes the primary industry group in urban enclaves, consisting of landless farmers or rural in-migrants. The proportion of car ownership (-0.167) and permanent subdistrict residential registration ownership (-0.167) is low. The transition of the market economy promotes the construction of urbanization, which promotes the continuous expansion of urban land and rapid increase of migrant population.
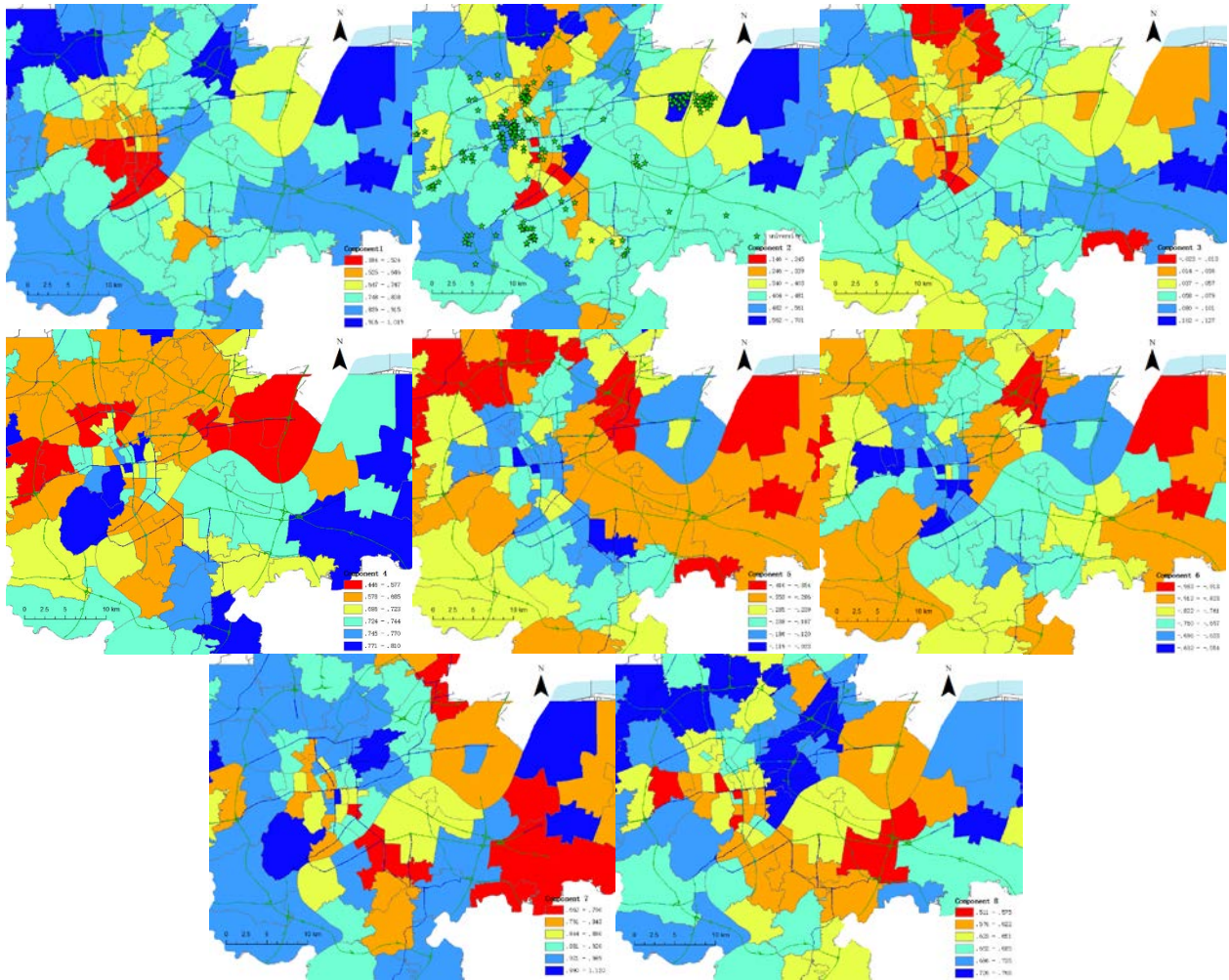

Figure 1. Spatial distribution of 8 main components
(Note: The score of each component gets higher as it varies from red to blue.)

3.2 Clusters of Social Groups

Cluster analysis enables more detailed exploration of the spatial relationships between these social structures and the identification of distinct social areas. Through a hierarchical clustering method, the 96 subdistricts were grouped into eight primary clusters (Table 2. Figure 2).

Given the significant dissimilarity in segregation between the new development areas and inner city ones, the relative index of diversity H/H_{max} is used to describe the unevenness and diversity of social groups in each social area:

Table 2. Identification of clusters

Cluster	Total	I	II	III	IV	V	VI	VII	VIII
1	12	0.237	0.056	0.031	0.130	0.221	0.129	0.122	0.084
2	7	0.064	0.128	0.067	0.159	0.131	0.072	0.148	0.167
3	9	0.362	0.243	0.165	0.118	0.344	0.246	0.369	0.322
4	18	0.144	0.045	0.096	0.032	0.111	0.141	0.087	0.124
5	7	0.131	0.141	0.137	0.135	0.078	0.218	0.090	0.125
6	14	0.110	0.078	0.129	0.123	0.059	0.108	0.104	0.143
7	22	0.060	0.050	0.121	0.142	0.015	0.031	0.080	0.112
8	7	0.218	0.254	0.129	0.144	0.130	0.240	0.106	0.235

$$H = -\sum_{i=1}^{n} p_i \ln(p_i) \tag{1}$$

Where H is the Shannon-Wiener index (1949) of each cluster, H_{max} is the maximum value among all clusters, p_i is the proportion of its social group in the social area and n is the total number of social groups.
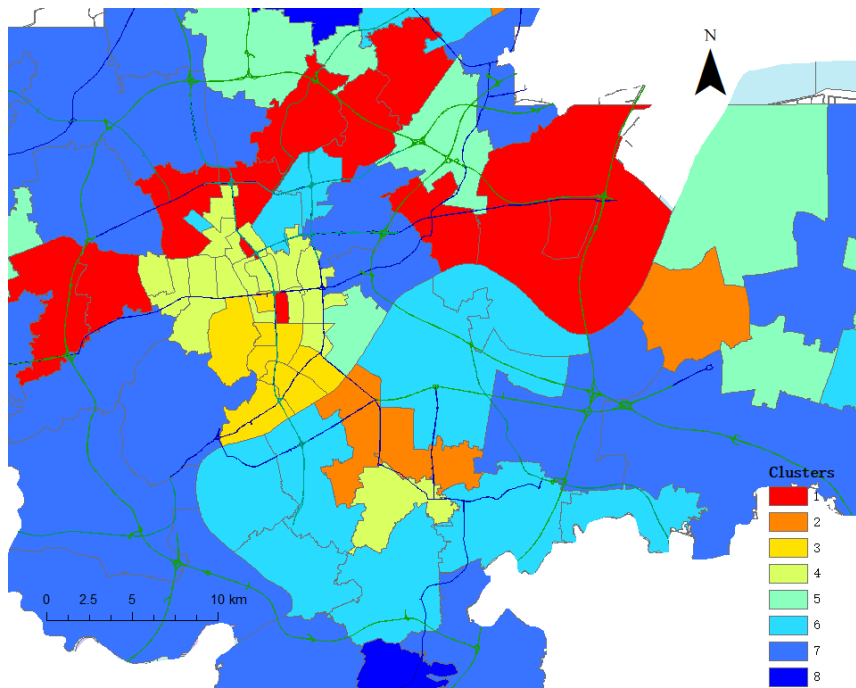

Figure 2. Clusters identified

Cluster 1, accounting for 12.5% of the total 96 subdistrict areas, is characterized by high correlations with the working parents with school-age adolescents (I) and commercial service personnel and clerks (V). The relative diversity index is 0.55, the median among all clusters.

Cluster 2, the area is substantially small and accounts for 7.29% of the total, but also has moderate correlations with several components: primary industry personnel or rural in-migrants in urban enclaves (VIII) and local elderly population (IV). The relative diversity index is 0.49.

Cluster 3, accounting for 9.38% of the total 96 subdistrict areas, comprises of group rely on public transportation (VII) and working parents with school-age adolescents (I). The area is generally located in the old city, with the highest relative diversity index of 1.0, high degree of internal mixing. It can be regarded as a special white-collar middle class formed by combining the dimensions of wealth and authority, which consists of those who rely on the accumulation of personal wealth to flow into the gathering place of the middle-class social groups and the working parents with certain financial resources and social relationship capital.

Cluster 4, accounting for 18.75% of the total and having the second largest number of subdistricts, has moderate correlations with two components: working parents with school-age adolescents (I) and commercial service personnel and clerks (V). It is the newly formed economic and political urban elite cluster, largely comprises middle-class cadres and managers, who usually live in good quality housing in gated communities around Westlake, Wulin Central Business District (CBD) or down the canal. In the urban elite cluster, the social diversity index is relatively low at 0.4, and it is highly isolated from other social groups and embedded in the middle social base.

Cluster 5, professionals and executives (VI) and the intellectual (II), accounting for 7.29% of the total. It reveals a powerful professional-managerial class, more closely connected to bureaucratic power and more stable in their lives. Although it is not the most elite area of the city, this cluster is populated by higher-level white-collar workers, many of whom are cadres and some are professional and technical workers. The residents of this area have a high degree of education and pay attention to the education of their children. The proportion of government and enterprise staff is large. The relative diversity index is 0.61.

Cluster 6, accounting for 14.58% of all subdistricts, is dominated by primary industry personnel or rural in-migrants in urban enclaves (VII) and high-income group (III). The relative diversity index is 0.47.

Cluster 7 has a significant proportion of local elderly population (IV) and high-income group (III). With the proportion of 22.92% of all the subdistricts, the area is the largest, and constitutes the fringe area of the city center together with Cluster 6. The outstanding feature lies in its diverse social spatial structural components, which are mixed with other types of subdistricts. The rapid expansion of urban built-up areas and the filling development of urban areas promote the phenomenon of proximity between the upper class and low-income groups.

Cluster 8, accounting for 7.29%, is inhabited by mixed residents: the intellectual (II), professionals and executives (VI) and primary industry personnel or rural in-migrants in urban enclaves (VIII). The relative diversity index is 0.27, means that though the social structure is diverse, this cluster is relatively isolated. The area is mainly at urban fringe. The large number of peasant private houses in these areas provide a cheap source of housing for the working class, who are attracted by their low cost of living.

4. Discussion

4.1 The Characteristics of Social-spatial Differentiation in the Main urban Area of Hangzhou

On the whole, the social space in the main urban area of Hangzhou presents a mosaic pattern, which indicates that the diversification trend of its social composition and structure is remarkable. The development mode of residential land in the inner city of Hangzhou has changed from sprawling to filling and renewal. The districts that had not been renewed in the past due to the demolition cost and other obstacles have become the focus of the residential space construction again under the promotion of the government's policies.

The empirical research of this paper also well proves the diversification of residential space in Hangzhou. With the implementation of trans-river development strategy, suburbanization is under rapid development, the city continues to advance eastward, and the residential space in Hangzhou continues to expand and update. Against the background of marketization, urban social spatial isolation presents various forms and variations, for instance, the phenomenon of new gentrification caused by urban renewal and gentrification or the new elite group formed by the grafting of power and wealth factors.

First of all, the urban elite and middle class gather around Wulin CBD, the traditional city center with elegant environment and convenient transportation. In addition, there are also some working parents with school-age adolescents together with commercial service personnel and clerks who live in the vicinity of the new CBD of Qianjiang. The single-center pattern of social space in Hangzhou has gradually expanded into a multi-center one.

Secondly, the subdistrict-level data analyzes the impact of education marketization on urban spatial pattern. The vicinity surrounding excellent education resources mainly compose of white-collar parents' cluster. This is the newly formed economic and political urban elite cluster, mainly composed of middle-class cadres and managers. They have complex social capital and strong economic strength. The emergence of this social division reflects a special phenomenon of social change.

Finally, the diversity and isolation of spatial distribution within the eight social clusters confirm the opposition and unity between equilibrium and diversity: the communities at the bottom and the top of the social ecological potential have a low degree of diversity and a high degree of isolation. Social areas in the middle of the social ecological potential tend to have a high degree of diversification and low degree of isolation.

4.2 Hybrid Dynamic Mechanism of urban Socio-spatial Differentiation

The dynamic mechanism of urban socio-spatial differentiation space pattern is comprehensive and hybrid. It is closed related to macro policy, urban planning, regional layout, traffic conditions and residents' individual choice.

First, national and local macro- policy factors. After the reform and opening up, China's planned economy system gradually transferred to the market economy system. Then it brought about the introduction and changes of land and housing policy, residential registration policy and other macro policies, which strongly promoted the evolution and development of urban residential space structure in Hangzhou.

The implementation of the housing allocation policy in the past 50 years has resulted in the characteristics of the mixed residence of different social classes based on the unit system. In 1998, the in-kind housing allocation policy was abolished and replaced by the capitalization of the housing allocation policy dominated by monetary subsidies. With the urban housing policy reform gradually been completed and the speeding up of housing commercialization and privatization, the residential space in Hangzhou presents the trend of relatively concentrated distribution, for example, the family with lower income and the migrant family gradually gathered in suburban area where the land price is relatively low. Thus they form the mixed areas of working class and the migrant population in the periphery of the city center.

Secondly, historical background and development planning of the city. Hangzhou is surrounded by mountains on three sides and by the river on one side. For a long time, the development space of the city has been confined to a narrow area, forming the layout of modern Hangzhou taking the Westlake as the center. The modern social district type of Hangzhou inherits this historical distribution feature. Currently, most of the elite and the middle class with high educational level are clustered in the city center.

With the development of Hangzhou from "Westlake era" to "Qiantang river era", it provides a broader space for the city development. The transformation of urban enclaves and the rise of urban fringe areas have resulted in the emergence of mixed areas between suburban residents and ordinary working class.

In addition, personal choice of individuals will also affect their choice of residential space.

With different economic ability, different residents tend to choose different residential space. For example, low- and middle-income residents tend to live in housing renovation areas at the edge of the inner city, while wealthy residents tend to live in independent villas. What's more, in wealthy communities, residents have higher requirements on community facilities as well as the environment, at the same time they can afford to pay a higher fee, which promotes the development and renovation of communities. In poor communities, residents' demand and consumption capacity are at a relatively low level, so social development and spatial transformation will also become sluggish.

The occupational differentiation of residents also plays a role in the social spatial differentiation. The changes of the industry development space leads to urban residential space differentiation, for instance, the replacement of land function makes the city center being occupied by business, finance

and other modern service industry, while the original industrial enterprises evacuate from the old city. Such transfer of the industry will bring about changes of the employed, resulting in the urban residential space differentiation. People of the similar occupation tend to have residential convergence. The high-grade residential area located in the adjacent areas of the CBD of the main city are mainly occupied by senior white collars workers, senior professionals, etc., who generally have the characteristic of high-income.

Different families have their own family size and life cycle. Single residents living alone, married families of two people and nuclear families with school-age children are regarded as young families. The general characteristic of Hangzhou is that the age structure of residents in the central area tends to be younger, mainly because of the high degree of commercialization in the central area, which means convenient information exchange and convenient housing leasing and transfer, and it provide more housing options for residents. Residents over 60 years old are mainly clustered in the suburbs and the edge of the central area.

People will take traffic accessibility preference into consideration when choosing the residential districts, as well as environmental preference. The accessibility of transportation is one of the significant criteria to judge whether a residential location is good or not, which directly affects the convenience of residents' commuting, outdoor activities and children's schooling. The living environment involves the shopping environment, the transportation environment and the children's school environment. The high-income group values more of the environment and can afford higher price to choose better environment which represents the quality of living than the low-income group, so the residential differentiation of different income families takes place. Transportation accessibility and residential environment constitute the external driving force for the choice of residential space, while the residential demand constitutes the internal driving force. Residents' housing needs are based on their family status, ethnic identity, cultural background and economic status, in which households with similar needs will gather at similar place.

5. Conclusion

This paper presents a unique case study of socio-spatial segregation in Hangzhou by using recent survey data at the subdistrict level. Compared with the non-spatial data of traditional sociological research, the data presented in this paper demonstrate an encouraging analytical depth. This paper identifies a new phenomenon of gentrification and emerging urban elite clusters in the field of spatial and social stratification, which is worthy of further development. And then the external and internal force of Hangzhou's residential space differentiation are distinguished both from the city level and personal level.

Residential space differentiation is the convergence phenomenon of residents with different attributes in housing choice under the filtering mechanism of housing price and the sorting mechanism of social and economic differences. On the one hand, residential differentiation is conducive to the improvement of land development benefits; On the other hand, residential differentiation and even segregation will also produce a variety of contradictions.

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