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The Spatial Pattern of Entertainment Service Places in Hong Kong

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Abstract: Leisure and entertainment are one of the basic functions of a city. The leisure and entertainment services of urban residents have become an important symbol of the city and the driving force of social and economic development, and the quality of leisure life has become an important indicator for urban residents to measure their living environment and happiness. In order to explore the relationship of spatial patterns of entertainment service places in Hong Kong between residents' income and regional housing prices, this project studied the layout characteristics of entertainment service places in Hong Kong using R programming and investigated its relationship with residents' income and regional housing prices in the aspects of descriptive statistics, point pattern and area pattern analysis to provide references for entertainment service places planning in the process of urban development.

Keywords: Spatial Data Analysis; R; GIS; Hong Kong; Entertainment Service Places.

1. Introduction

In modern society, with the growth of economy and production, people's living pressures are also increasing. Our social needs and desire for entertainment cannot be ignored. The consumption of cultural entertainment has become an important part of residents' lives and the spatial layout of entertainment facilities can largely reflect the living standards of residents and the level of social and economic development. Although entertainment facilities are widely distributed in urban areas, people don't know much about their specific distribution patterns. Therefore, exploring the distribution of various facilities in the city is a popular research topic among scholars. As for the spatial distribution of entertainment venues, a number of scholars have published relevant research literature. Back in 2004, Andrew Ryder[1] studied the changing nature of adult entertainment districts. He investigated the factors affecting the development of adult entertainment and analyzed the development of each city and the adult entertainment industry by reviewing the distribution of adult entertainment districts from the 19th to the 20th century. Then in 2014, Xue et al. [2]conducted a study on the spatial pattern of the cultural and entertainment industry in Xi'an. They used method of vector symbol, exploratory spatial data analysis and Kriging spatial interpolation to study the spatial pattern characteristics of the cultural and entertainment industry in Xi'an in 2011 in terms of scale grades, degree of concentration, hot zones and their spatial patterns respectively. While in 2018, Yang et al.[3] studied the spatial pattern of the entertainment industry in Xi'an. They used methods such as mean nearest neighbor analysis, kernel density estimation and standard deviation ellipse to analyze the spatial distribution characteristics and evolution patterns of cinemas in Xi'an. By 2019, Jia et al.[4] explored the spatial pattern of urban recreation in Urumqi based on POI. Based on Baidu POI data, researchers used Ripley's *K* function, nearest neighbor hierarchical clustering, and spatial autocorrelation to study the spatial layout of public leisure facilities in Urumqi, summarize the pattern characteristics of urban leisure space, and then explore the influencing factors of leisure space. And the most recent relevant study was conducted by Dan et al.[5] in 2021 on the spatial distribution and influencing factors of urban cultural and entertainment facilities in Beijing.

By reviewing relevant research, this project studied the layout characteristics of entertainment service places in Hong Kong and investigated its relationship with residents' income and regional housing prices in order to provide references for urban planning and help guide the layout adjustment and spatial optimization of cinemas and other entertainment service places in the process of urban development.

2. Study Area and Data

Table 1. Datasets and sources

Genres	Sum	Source
Income	18	Census and Statistics Department [8]
House value	18	Midland Realty [9]
Entertainment Service Places	416	Baidu Map [10]
District boundary	18	Amap [11]

***The above geographic data have been processed and unified into the WGS84 coordinate system.**

As the third-largest international financial center globally [6], there is no doubt that Hong Kong is one of the wealthiest regions in the world. However, Hong Kong only ranks 77th in the UN's "World Happiness Report 2021" [7]. This result is undoubtedly related to Hong Kong's high population density and housing prices. After a busy workday, nighttime entertainment has become the primary place for Hong Kong citizens to relax. Therefore, Hong Kong's nightlife is famous worldwide, and the entertainment is often more exciting after nightfall. The fantastic and gorgeous lighting scene, the trendy shops with endless aftertastes, and the prosperous night streets linger on are real-life aspects of Hong Kong.

In order to improve the happiness index of Hong Kong citizens, this research will study the current layout of entertainment facilities in Hong Kong and its relationship

with residents' income and regional housing prices. This study uses 18 districts in Hong Kong as research units and collects various data from official sources. The data types and sources are as in table 1.

As listed, the first one is the income median of each district collected from the Hong Kong Department of Census and Statistics. Next, is the average house price of each district, which is collected from Midland Realty. What's more, this research mainly focuses on bars, karaoke, and cinemas in Hong Kong for entertainment places; therefore, a total number of 416 entertainment places have been collected from Baidu Map. In addition, the district boundaries from AMap for zoning have also been collected.

3. Methodology

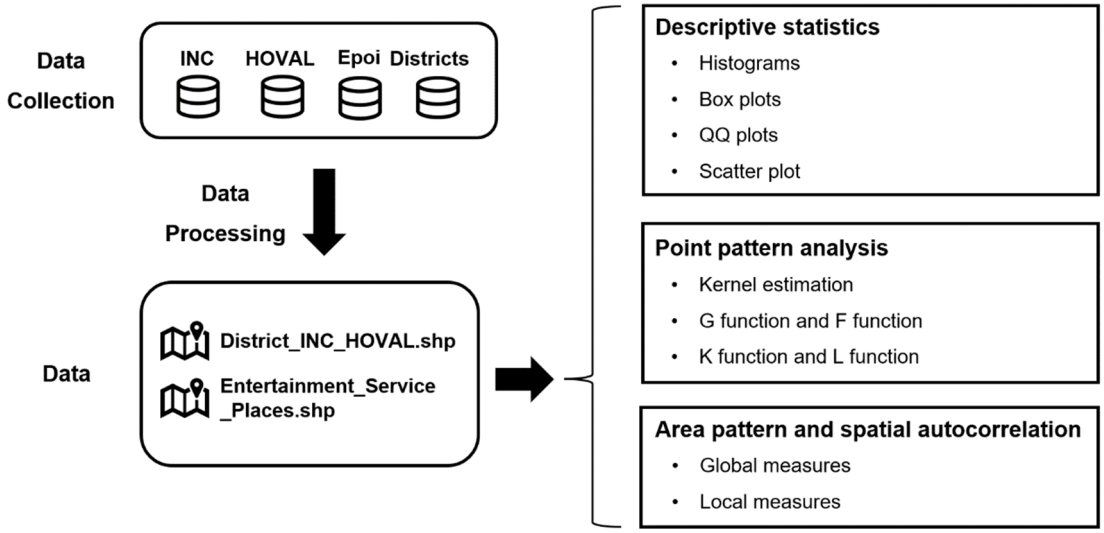


Figure 1. Project framework

The framework of this project is shown in Figure 1. As the first step, data collection is the most basic and important work to do. The data of district boundary, residents' income, house value and entertainment POIs of each district were first collected from official websites and then they were integrated and converted to the *shp* format that can be recognized by R. As the section of data shows, the data collected above were integrate into two datasets. The *District_INC_HOVAL.shp* is a polygon dataset of 18 districts in Hong Kong with the attributes of income and house value. The *Entertainment_ Service_Places.shp* is a point dataset recording the coordinates of each entertainment place. With the data of Entertainment POIs, house value and income, the analysis started with conducting three aspects of experiments. The first one is descriptive statistics – in this part, the data was represented by histograms, box plots and Q-Q plots respectively. The second analysis is Point pattern analysis – the point pattern of entertainment POIs was analyzed by kernel estimation, G,F,K and L function. Area pattern and spatial autocorrelation was conducted lastly. After the attribute of number of entertainment POIs was added to each district, the area patterns the districts were studied. At the end of this part, spatial autocorrelation was also used to investigate the residuals of entertainment POIs between house value and income these two variates; therefore, their relationship was concluded. The three experiments will be introduced in detailed in the following sections.

3.1. Descriptive Statistics

After completing the data collection of Hong Kong's income, house value, and entertainment POIs mentioned above, they were sorted out according to 17 districts. The first step is the analysis of descriptive statistics.

The term "descriptive statistics" refers to the process of describing data through the use of tabulation and classification, graphs, and computational summary data. The purpose of descriptive statistical analysis is to generate a statistical description of the relevant data for all variables in the survey population, which includes frequency analysis, central tendency analysis, dispersion analysis, distribution analysis, and some basic statistical graphics. Descriptive statistics can be easily performed using the R language. The main functions used here are as follows:

- *summary():* Get summary statistics.
- *str():* Display the data structure and content of the object, you can view the properties of each variable in the data frame.
- *attributes():* Extract various attributes of an object.
- *describe():* Number of variables and observations, number of missing and unique values, five largest and five smallest values.
- *hist() :* Draw the histogram of the data.
- *boxplot():* Draw the box plot of the data.
- *qqnorm() & qqline() :* Draw the quantile-quantile plot of the data.
- *plot():* Generate the scatter plot matrix comparing multiple data.

3.2. Spatial Point Pattern Analysis

Spatial point pattern mainly has three characteristics: regular, clustered, or random. And" Spatial point pattern analysis "mainly measures the distribution characteristics of points in space. Generally, measures include density-based point pattern measures and distance-based point pattern measures. In this report, the measures used are Kernel Estimation in density- based point pattern measures and G Function, F function, K function and L function in distance-based point pattern measures. The main functions involved in R Programming Language are as follows:

- *st_read():* Read the shp file.
- *st_transform():* Converts the coordinate system of the read shp file to the required coordinate system. In this

report, the original coordinate system needs to be converted to the projected coordinate system.

- *class():* Read the data type of the shp file.
- *as.ppp():* Type conversion of data to sf.
- *density.ppp():* Get Kernel estimates.
- *Gest():* Get G estimates.
- *Fest():* Get K estimates.
- *Kest():* Get K function and L function.

3.3. Area Patterns and Spatial Autocorrelation

3.3.1. Adjacency Matrix

For area analysis, Adjacency Matrix representing the adjacency relationship between areas. The adjacency matrix of areas must be symmetric. And in our group, we use the Hong Kong zoning map as base map to analysis the adjacency connection of them. The main R language functions used in this part are:

- *HK_nb=poly2nb(HKData,queen=ture)*
- *plot(HKData,border="grey60")*
- *plot(HK_nb,cords,pch=19,cex=0.6,addt=TRUE)*

3.3.2. k-Nearest Neighbors

The number of recreational facilities in each district of Hong Kong is the main research data of our project. Using this data, our project analyzes the k-nearest neighbors of each district of Hong Kong. In this part we set two different k values (k=1 and k=2) to analyze the k-nearest neighbors. The main R language functions used in this part are:

- *nbk1=knn2nb(knearneigh(cords,k=1),row.name=IDS)*
- *nbk2=knn2nb(knearneigh(cords,k=2),row.name=IDS)*

3.3.3. Map Classification by Value

Before the spatial autocorrelation analysis, our project needs make a map to show the distribution of entertainment POIs in Hong Kong. According to the characters of the entertainment POI data, we divided it into 20 intervals according to the size of the value. The main R language functions used in this part are:

- *HK.W = nb2listw(hk_nb, style="W")*
- *themeMaps3(HKData, Epoi, n, lgdloc)*

3.3.4. Moran's I

In this part, we used the global Moran's I to analyze the spatial autocorrelation of the entertainment POI data. A permutation test (Monte-Carlo simulation) was also used with Moran's I to analyze the entertainment POI data. Then we drew a scatter diagram of entertainment POI data. The main R language function used in this part are:

- *moran.plot(Epoi, HK.W, pch=19)*
- *moran.test(Epoi, HK.W,zero.policy=T)*
- *mI_perm999 = moran.mc(Epoi, HK.W, 999)*

3.3.5. Local Indicators of Spatial Association (LISA)

Local indicators of spatial association (LISA) are statistics used to identify local clusters in the spatial arrangement of lattice data. The statistic is calculated for each areal unit in the data. We used LISA method to plot a LISA Cluster Map to analyze the area pattern of the entertainment POI data. The main R language functions used in this part are:

- *mI_local = localmoran(Epoi, HK.W)*
- *quadrant[cCrime >0 & C_mI>0] = 1 # high-high cluster*
- *quadrant[cCrime <0 & C_mI>0] = 2 # low-low cluster*
- *quadrant[cCrime >0 & C_mI<0] = 3 # high-low cluster*
- *quadrant[cCrime <0 & C_mI<0] = 4 # low-high cluster*
- *quadrant[mI_local[,5]>signif] = 0 # non-significant Moran's in the category '0'*
- *clr.c = cols.c[quadrant+1]*

3.3.6. Regression Model's Residuals

In this part we use the OLS model to create a residuals map of the entertainment POI data. And the regression of Hong Kong entertainment POI with housing value and household income is used for qqplot and Moran's I analysis. The main R language function used in this part are:

- *HK.lm=lm(POI ~ INC + HOVAL, data=HKData)*
- *ols.resd=resid(HK.lm) # get residuals*
- *ols.res=(ols.resd-min(ols.resd))/diff(range(ols.resd)) #normalized the*
- *residuals to 0-1 to better show the difference among area units*
- *plot(HKData$HOVAL,ols.resd,ylab="Residuals",xlab="HOVAL")*
  ls",xlab="INC")
- *qqnorm(ols.resd, ylab="Residuals")*
- *qqline(ols.resd)*
  moran.plot(ols.resd, HK.W,pch=19)
- *lm.morantest(HK.lm,HK.W)*
- *ols.mI_perm999 = moran.mc(ols.resd, HK.W, 999)*

4. Results

In this section, the results of each step of experiments will be given and analyzed in detailed.

4.1. Descriptive Statistics Analysis

4.1.1. Hong Kong Average Income Statistics

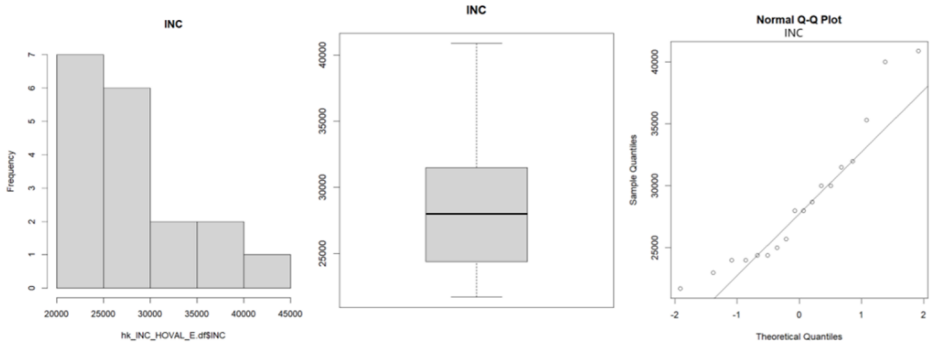


Figure 2. Histograms, Boxplot, Q-Q plot of income data in Hong Kong

The per capita monthly income of each district in Hong Kong is divided according to the level of 5000HKD. From the income histogram, it can be seen that the monthly per capita income of each district in Hong Kong is generally between

20,000 and 45,000 HKD, with the largest number of people below 30,000 and the least number of people with income above 40,000. Even, the number of people in the lowest income group (20000-25000HKD/mouth) can be said to be more than 7 times that of the highest income group (40000-45000HKD/mouth). The entire histogram shows an obvious right skewness. It can be seen that the per capita income of Hong Kong conforms to the law of head and tail distribution.

It can be seen from the box plot that the upper and lower edges of average monthly income of each district in Hong Kong are around 40,000 and 20,000 respectively. The upper quartile is around 32,000, while the lower quartile is around 24,000. The median is about 28,000, and there are no significant outliers in the income data.

From the Q-Q plot of income, it can be seen that the data can present an upward Q-Q line with an angle close to 45°. Most of the scattered points are near this Q-Q line, but there are actually A few scatters jump out of line.

4.1.2. Hong Kong Average House Value Statistics

The average house price in each district of Hong Kong is divided according to the 2000HKD/sq. From the histogram of house value, we can see that the average house price in various districts in Hong Kong is between 10,000-22,000 HKD/sq. There was also a small peak in housing prices between 20,000 and 22,000. It is speculated that the existence of ultra-highly priced real estate has pushed up the average housing price in the region. From the whole histogram, we can see that the average house prices in various districts in Hong Kong show a clear normal distribution law.

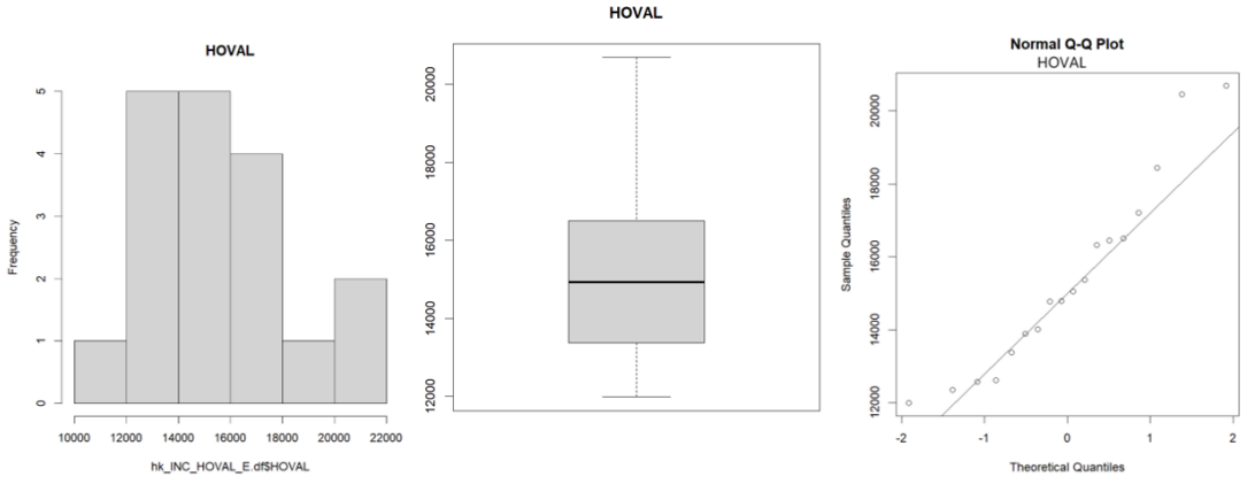


Figure 3. Histograms, Boxplot, Q-Q plot of house value data in Hong Kong

It can be inferred from the box plot of house value that the upper and lower edges of the average house price in various districts in Hong Kong are around 22,000 and 12,000 respectively. The upper quartile is around 16,500, while the lower quartile is around 13,500. The median is around 15,000, and there are no significant outliers in the house value data.

It is shown in the Q-Q plot of the house value that, the data can present a Q-Q line with a positive angle slope. Most of the scattered points are near this Q-Q line, but there are many scattered points at the low and high places. Click to jump out of line.

4.1.3. Hong Kong Entertainment POI Statistics

The number of entertainment facilities in Hong Kong is divided into 50 as levels after being classified by region. It can be seen that the area with less than 50 recreational facilities obviously accounts for the vast majority. And between 150-200 there are too high outliers.

The boxplot of entertainment POI is featured prominently, and the whole box is very 'flat'. Its upper edge is about 25 or so. The median is about 23. The entertainment POI data has three prominent outliers.

It can be obtained from the Q-Q plot of the entertainment POI that the data can present a Q-Q line with a positive angle slope but a small angle. Most of the scattered points are on this Q-Q line, but there are three particularly prominent outliers.

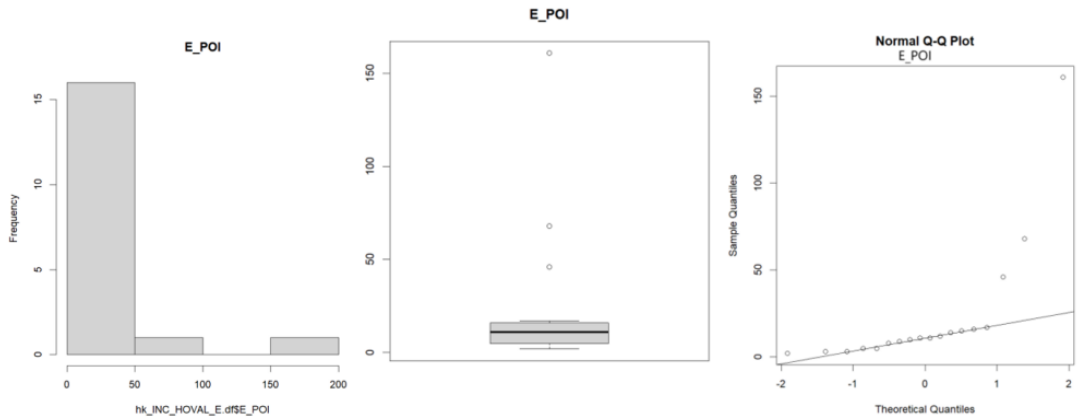


Figure 4. Histograms, Boxplot, Q-Q plot of entertainment POI data in Hong Kong

In the entertainment POI, the three prominent outliers are Yau Tsim Mong District, Wan Chai District, and Central and Western District (Figure 5). As a rule, Wan Chai and Central and Western are also the two districts with the highest income and housing prices. Although, the entertainment POI data in Yau Tsim Mong District is extremely high, even twice that of Wan Chai District.

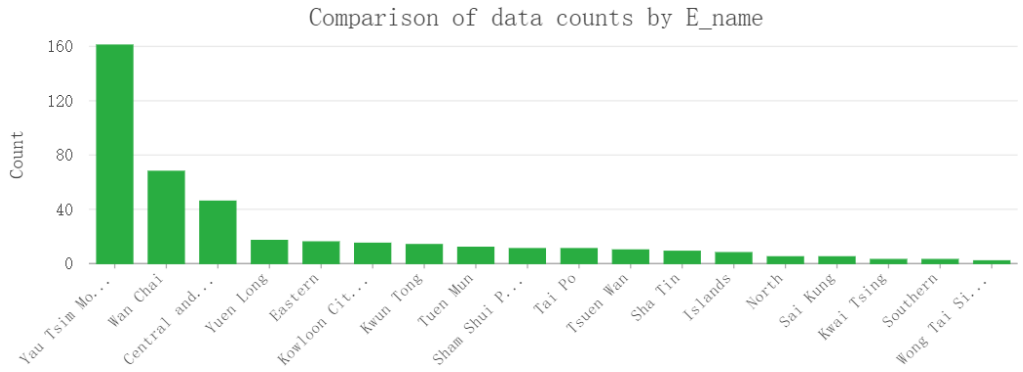


Figure 5. Entertainment POI data by region

4.1.4. Scatter Plot Matrix

In the data of various districts in Hong Kong, there is a certain positive correlation between the variable income and house value, and the degree of correlation is average, which may mean that under certain circumstances, people with higher incomes will live in higher house values; however, the relationship between entertainment POI and the other two cannot draw obvious conclusions in this scatter plot matrix, which needs to be further discovered in the following analysis.

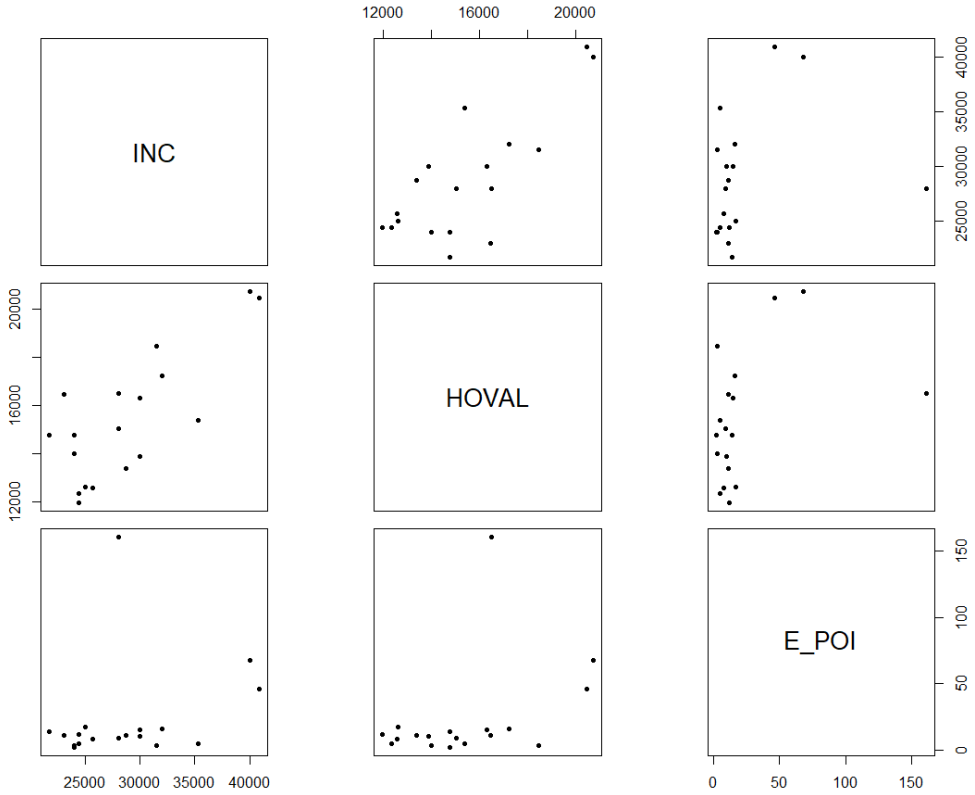


Figure 6. Scatter plot matrix of income, house value, and entertainment POI

4.2. Spatial Point Pattern Analysis

In this section, the spatial distribution patterns of entertainment POIs were analyzed.

4.2.1. Kernel Estimations of Entertainment POIs in Hong Kong

After reading the shapefile file of the entertainment service places, we first analyzed its kernel estimation. We set three different values of sigma for the analysis and the results are shown in Figure 7.

From the analysis, it is clear that the entertainment service places have the highest concentration in the Tsim Sha Tsui area. Mong Kok, Wan Chai and Central and Western districts also have a portion of entertainment service places clustered. There is also an insignificant clustering in the New Territories.

4.2.2. F Estimates and G Estimates of Entertainment POIs in Hong Kong

The results of the F Estimates and G Estimates analysis are shown in Figure 8.

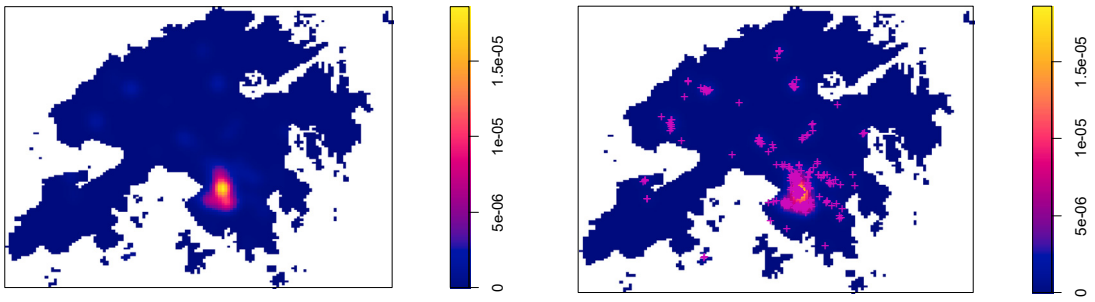


Figure 7. Kernel Estimations of Entertainment Service Places in Hong Kong (Sigma = 1000)

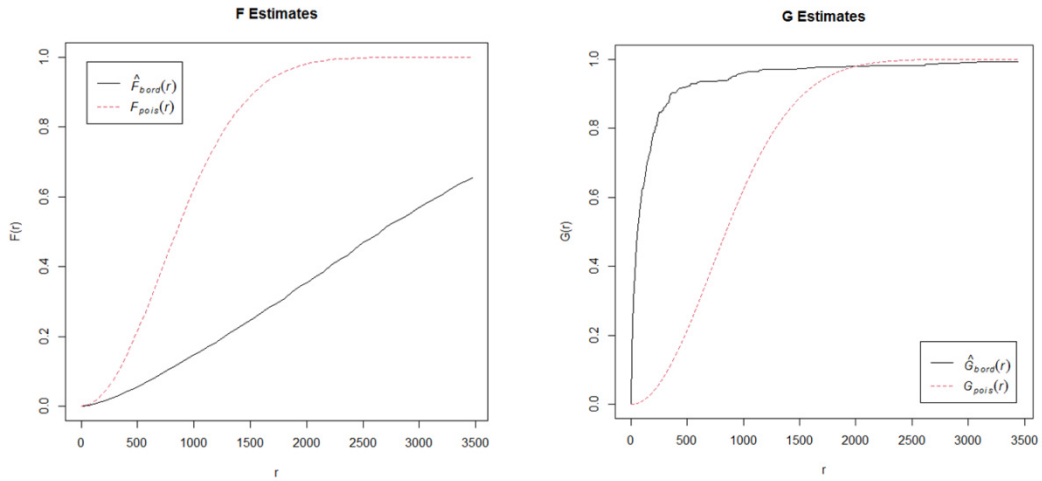


Figure 8. F Estimates and G Estimates of Entertainment Service Places in Hong Kong

The plot In F Estimates is below the CSR plot. In this case, it indicates clustering. As can be observed from G Estimates, the curve rises sharply in the early stages and then levels off, indicating clustering in the spatial distribution of entertainment venues in Hong Kong.

4.2.3. K and L Function of Entertainment POIs in Hong Kong

Figure 9 depicts the results of the F Estimates and G Estimates analyses.

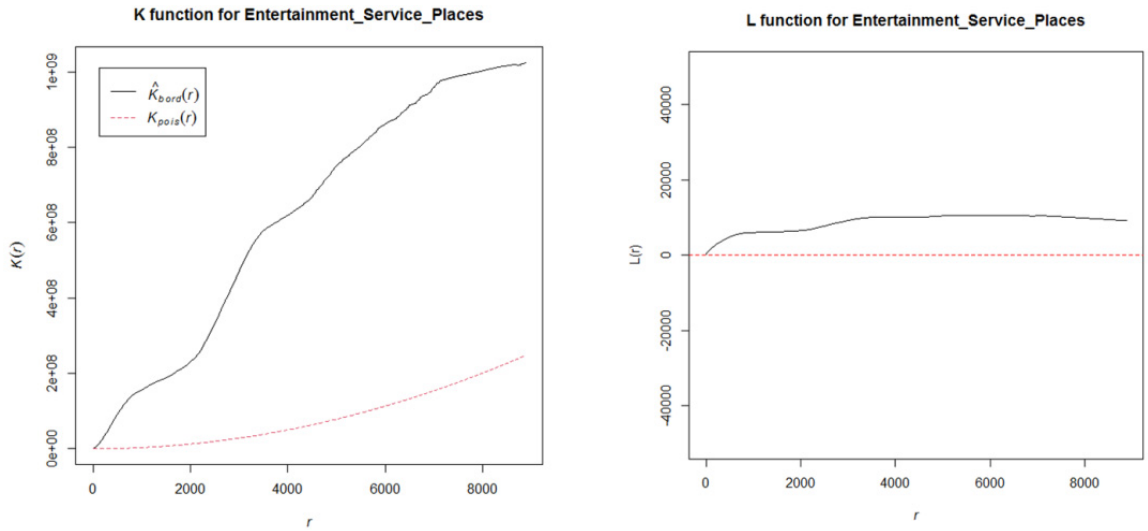


Figure 9. K Estimates and L Estimates of Entertainment Service Places in Hong Kong

In the graph of K Function, the curve is over the red line. Also, in the L Function it can be observed that L (*h*) is always greater than 0. These mean that the points are spatially clustered.

4.3. Area Patterns and Spatial Autocorrelation

4.3.1. Adjacency Connection

Adjacency Connections show whether two administrative units are sharing a common boundary. From the map we could realize that the east part of the area has a relatively stronger connection in geography while the peninsula on the west is

relatively remote from the others. K-nearest neighbors basically describe the k nearest centroids to that of the research target. From the two maps above, when considering only one nearest neighbor, there are weak connection among global range, with only some continuous links on the right-bottom side, while if two nearest neighbors considered, there are two strong unions can be seen from the left and the right.

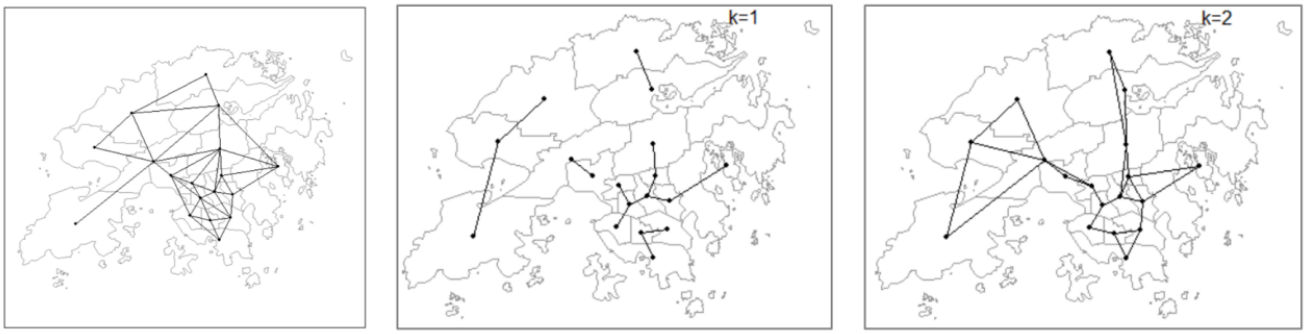


Figure 10. Plots of Adjacency connection and k-nearest neighbors

4.3.2. Theme Map of Entertainment POIs

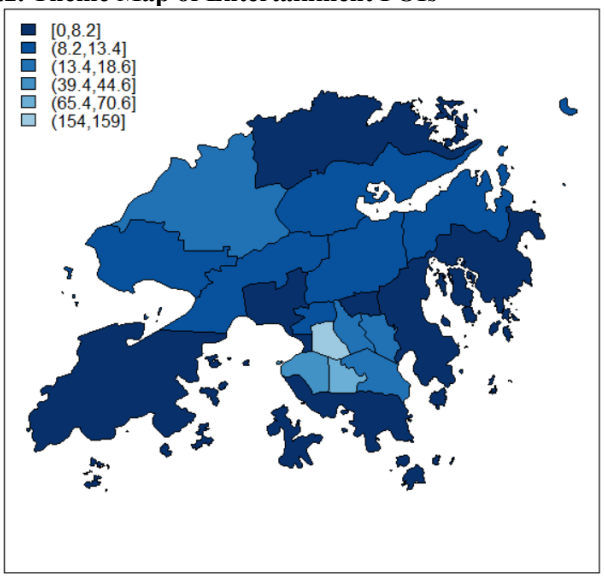


Figure 11. Theme Map

By generating the theme map of entertainment places, the area patterns can be concluded: There are few entertainment places along the outskirts of the city, and the number on east-west horizontal lines in the city is medium, while there is a large number of entertainment places in those three districts mentioned above (Figure 11).

The previous analysis basically focusses on the variable itself. In order to study the relationship between the variables, we also extracted the attributes of the 3 districts that have the largest number of entertainment places. The first one is Yau Tsim Mong district with 159 entertainment pois and its income and house value are 28 thousand and 16 thousand four hundred and ninety-six, respectively. The second and third one is Wan Chai district and Central and western district, however, with respectively 77 and 44 entertainment pois, their income and house value are much higher, which is around 40 thousand's income and around 20 thousand's housing price.

4.3.3. Moran's I

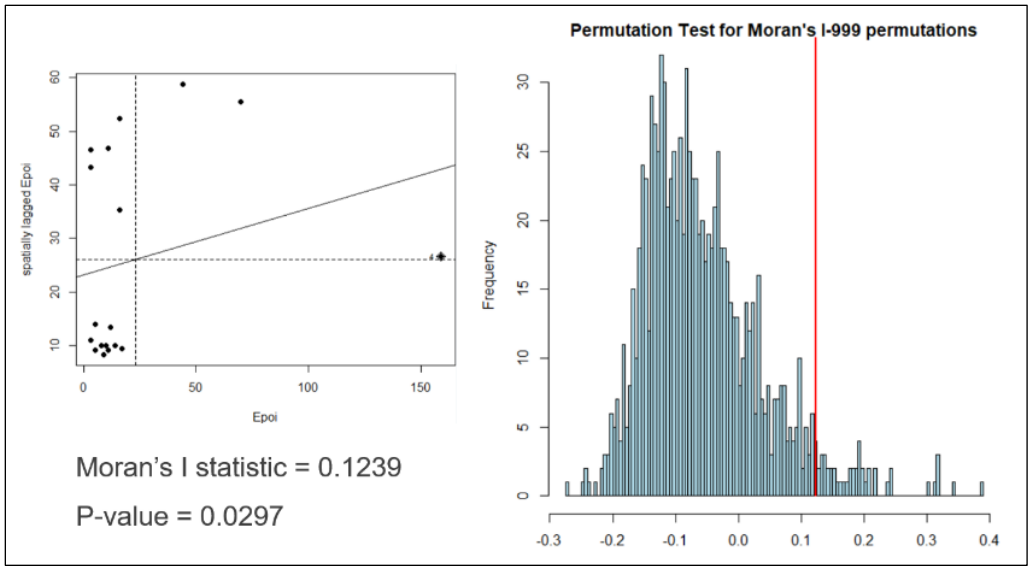


Figure 12. Moran's I scatter plot and permutation of entertainment POI

We also calculated its Moran's I for detecting autocorrelation and the value of 0.1239 with a low p-value that is smaller than 0.05 indicates that the area pattern of entertainment places is positive autocorrelation (Figure 12).

4.3.4. Local Indicators of Spatial Association (LISA)

The Moran's I index discussed just now is a global measure, here we also adopted local measure to investigate the cost and effect of each district.

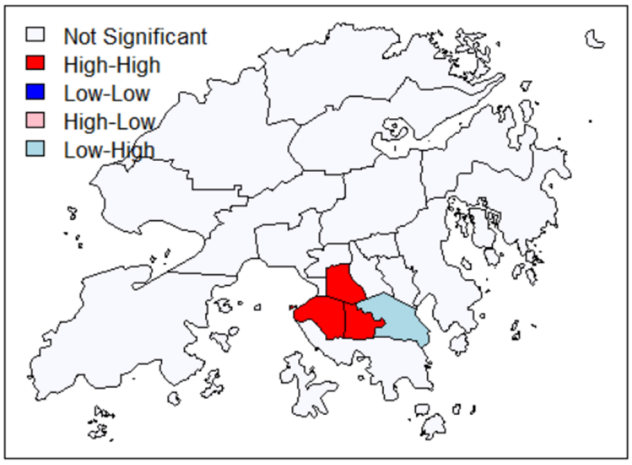


Figure 13. LISA Cluster Map

The red color ones are Yau Tsim Mong district, Wan Chai district and Central and Western districts with a High-High autocorrelation. This might result from the driving effects that if the industry is well developed in one area, then it might drive the surroundings developing as well. The light blue color one indicates that eastern district has a low-high autocorrelation. This might because the demands for entertainment places are attracted by the previous 3 districts so there is no need for constructing more entertainment places in this district.

4.3.5. Regression Model's Residuals

In order to further investigate if there is a relationship between number of entertainment places with house value and income, we did the regression and generated the residual map.

The residuals seem to be randomly distributed. Here we tested the residuals in two aspects. First is testing if the residuals are random. The Q-Q plot shows it is basically a normal distribution, but the histograms doesn't. This might because the district zoning is relatively rough since the street-level zoning could not be obtained, therefore resulting in a histogram like this.

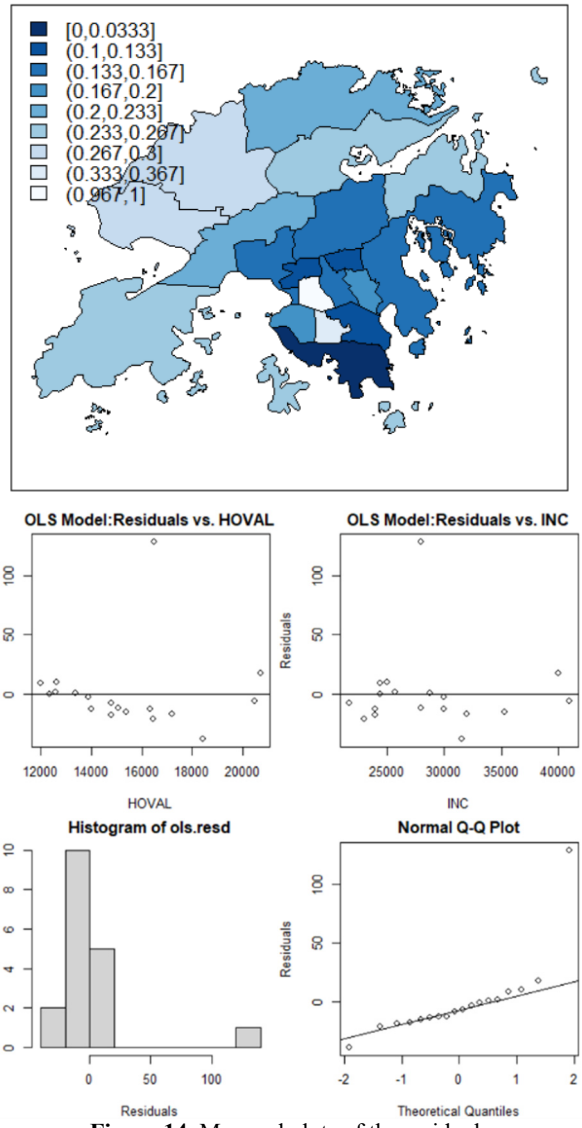


Figure 14. Map and plots of the residuals

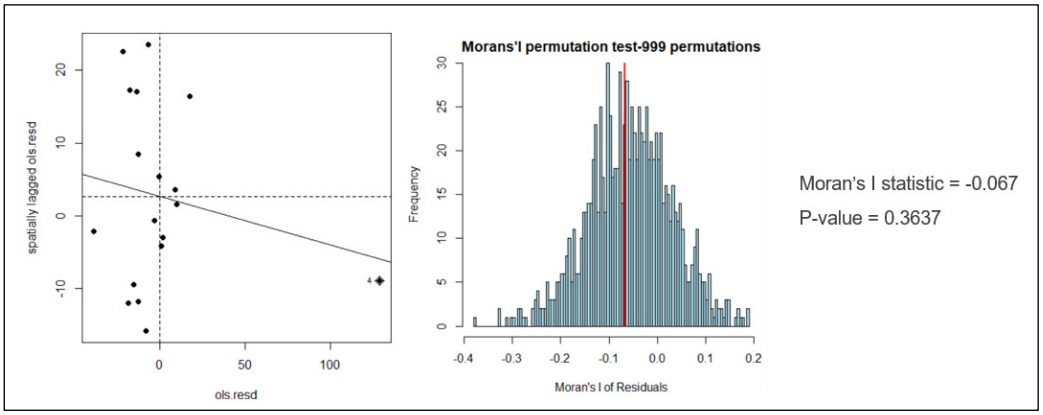


Figure 15. Moran's I of the residuals

The second way of testing residuals is to test if there is spatial autocorrelation. Here we use Moran's I for testing. The value is -0.067 which is very close to 0 and the p-value is 0.3637 which is larger than 0.05, therefore, we accepted the independence hypothesis so the residuals are random. In summary, we can conclude that there is a certain relationship between the number of entertainment places with house value and income.

5. Conclusion

According to the analysis, the entertainment services places are mainly distributed in Yau Tsim Mong district, Wan Chai district and Central and Western District. The spatial autocorrelation also reflected in these districts. For the relationship with residents' incomes and reginal house prices, the residuals of the regression analysis are randomly distributed, which means the number of entertainment places

has a certain relationship with income and house value. However, in the scatter plot matrix of the data, there is no obvious relationship. We considered the reason why this happened is, besides the income and housing prices, there are still plenty of possible factors that affect the distribution of entertainment places, which might include population density and the distribution of transportation facilities, land-use planning and so on. Therefore, in our future work, we plan to explore more factors that affect the distribution of entertainment places in order to providing more precise references for its layout planning.

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