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Graduate School of Frontier Sciences

The University of Tokyo

2019

Master's Thesis

The Visualization and Analysis of Spatial Distribution of Foreign Restaurants: A Case Study of Tokyo Wards Area

Submitted July 12, 2019

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LI Changwen

Abstract

With the process of globalization, various foreign food culture could be enjoyed in Tokyo. Foreign restaurants have developed into kinds of spatial agglomeration phenomena.

This thesis explores the characteristics of spatial distribution of foreign restaurants in Tokyo wards area. Gini coefficient and Lorenz curve are used to capture the overall agglomeration degree of restaurants and Global Moran's I is used to analyze spatial autocorrelation. In particular, Kernel Density Estimation is utilized to visualize the spatial clusters of foreign restaurants. This study summarizes the distribution characteristics of Chinese, Korean, Indian, French and Italian restaurants. It compares the differences among foreign restaurants and explains the cause of formation of the spatial patterns. This study also visualizes the spatial distribution of newly opened foreign restaurants and the areas where the number of foreign restaurants has grown from 2009 to 2017. Furthermore, OLS model and GWR model are employed to examine the association between foreign restaurants and two characteristics: foreign population and land price. It is found out that the significance of foreign population and land price is different depending on the type of foreign restaurants. The results contribute to gain more accurate understanding of foreign restaurants in Tokyo wards area.

Key Words: spatial distribution; visualization; foreign restaurants

Acknowledgements

First of all, I would like to express my sincere gratitude to Professor Yukio Sadahiro, for his help during my graduate study period. His instructive and useful advice gives me great help in my thesis. I am deeply grateful for his help in the completion of this thesis.

Then, I would like to appreciate Professor Takaaki Takahashi, who provides me helpful suggestions. I would also like to thank Assistant Professor Takahiko Kusakabe to check my thesis. I also thank to all professors, teachers and laboratory members for giving me advice on laboratory seminars. I am thankful for help from Wataru Morioka.

I would like to thank the University of Tokyo and Center for Spatial Information Science for providing me the great academic environment and research data.

Finally, in particular, I would like to express my gratitude to my parents for their support. I would like to express my gratitude to all those who helped me during my graduate study period.

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1. Introduction

1.1 Background

Food is a primal necessity to human and the foundation for the development of human society. Food culture is an important part of each regional culture throughout human history. In general, different types of food could reflect their different culture background, and by studying the food culture of a region or country, we could understand the geographic characteristics, living habits, living conditions, and even cultural heritage of people in the area.

Japan's main cuisine is named washoku, which means Japanese traditional food. Due to the geographical conditions of the island country, seafood is very common in the Japanese cuisine. However, Japanese cuisine has a long history of being affected by foreign culture. During the Kamakura era, Buddhist cuisine, which is vegetarian without any meat, was brought to Japan from Chan (Zen) Buddhism. In 16th century, Portuguese-style Nanman cuisine was spread to Japan. In the early modern period, Chinese-style Shippoku restaurants appeared first in Nagasaki, and then spread to other cities, for example Edo. Since the Meiji era, influenced by western cultures, a large number of western food entered Japan, and these dishes have gradually developed into yoshoku with Japanese food characteristics. So far, the dietary life in Japan has undergone tremendous changes. Not only Japanese cuisine has become more internationally accepted, but also Japanese food culture has been influenced by the diversity of international cuisines along its history of interacting with various exotic cultures.

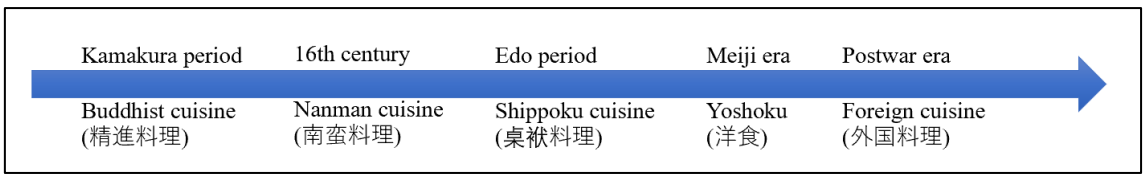

Figure 1.1 History of Acceptance of Foreign Cuisine in Japan

With the process of globalization, a large number of foreigners have come to Japan and nowadays a variety of food cultures could be enjoyed in Tokyo. For example, we could observe a rapid increase of Southeast Asian cuisine in recent years and the recent popularity of pearl milk tea (Bubble tea) among Tokyo female high school students. There are other various foreign food culture in Tokyo. Because of the immigration policy, it could be predicted that the number of foreigners living in Tokyo will continue to increase in the future. In addition, since 2020 Summer Olympics will be held in Tokyo, more foreign tourists could be expected in Japan. With a history of accepting foreign cuisines in Japan, more foreign restaurants might appear in the future. It becomes meaningful to study ethnic cuisines in Tokyo. While there is a great deal of study on the distribution of business facilities in Japan, the study of spatial distribution of foreign restaurants in Japan is relatively insufficient. This study tries to explain the spatial distribution characteristics of foreign restaurants in Tokyo and the possible causes.

1.2 Purpose

Food culture is a crucial part of human society. And in modern society, eating out is one of the significant human activities and it relates to the openings of various restaurants. As there are increasingly different foreign restaurants opened in Tokyo, it could be observed that foreign restaurants exhibit a certain agglomeration phenomenon. Such as many Chinese restaurants are located in Ikebukuro and a lot of Korean restaurants have gathered in Shin-Ōkubo. Why are these foreign restaurants gathering in these places? Is there any difference among the many kinds of foreign restaurants? Are there any factors influencing the location?

For example, ethnic neighborhoods, such as the Chinatown and Koreatown, are always known as places for ethnic restaurants as well. Thus, it might be reasonable to hypothesize that the distribution of population of certain ethnic background may have an impact on the distribution of foreign restaurants. Compared with Asian cuisine, French cuisine is usually considered as haute cuisine, and thus French restaurants could be easily found in the business

districts such as Ginza and Roppongi. It is supposed that the cost of running a restaurant might have different impacts on diverse kinds of foreign restaurants.

In order to understand the different distribution phenomenon among these various foreign restaurants in Tokyo, to clarify how they have changed in recent years, and to find out the factors that affect the spatial distribution of foreign restaurants, this research was designed to achieve the following objectives. First, the study aims to verify whether such areas as Ikebukuro and Shin-Ōkubo have gathered quite a few foreign restaurants as people perceived. Through the visualization of spatial distribution, the most concentrated areas could be found, and the characteristics and regularity of spatial distribution of foreign restaurants in Tokyo could understand more intuitively. The research discusses the differences of spatial distribution of kinds of foreign restaurants which would help us catch on the location preferences of foreign restaurants. Secondly, analysis of spatial distribution evolution is conducted to reveal the opening and increase phenomenon of foreign restaurants in recent years. Based on the results of maps, the study explores the reasons for the formation of agglomeration phenomenon. Finally, the regressions are conducted to analyze the correlation between the influencing factors and foreign restaurants.

This study analyzed the spatial distribution of restaurants through nationality classification. It visualized the spatial distribution of foreign restaurants in Tokyo wards area. The overall characteristics of spatial distribution of foreign restaurants at the macro level are summarized, which could help gain a basic understanding of location preference of foreign restaurants. With the progress of globalization, the spatial location research related to foreign culture will become one of the important trends of future human geography, and this research is conducted to contribute to the further extension of geography research content.

2. Literature Review

Research on food and restaurants has related research in many fields, such as economics, geography, anthropology, sociology, history, environmental hygiene, and nutrition. This research studies the spatial distribution of restaurants from a geographical perspective.

2.1 Foreign Literature Review

Foreign scholars have a long history of geospatial research and many research theories have been formed. In the early 1930s, the German geographer Walter Christaller first explored the use of settlements as a research core. He proposed market coverage and network structure analysis in the orderly arrangement of an urban hierarchy. This theory was named as "Central Place Theory". In 1931, Riley proposed the law of retail gravitation and created a retail gravity model, which regards the "human" factor as one of the important indicators of social market appeal. According to the theory of "differential rent", Gettis (1961) deeply analyzed the distribution pattern of commercial space in the city, and found out that the commercial marketing amount has a significant positive correlation with the price of the land, and then the different types of commercial willingness or affordable land price is the core influencing factor of its location. In 1963, Huff believed that if there were multiple business district aggregation in the same place, the sizes of the cluster district and the distance of residents from the business district would be an important consideration for residents to choose which business district to go. This research method is called the "Huff's Model." Letail (1992) identified the site-location and market area factors that contribute to sub shop restaurant sales. He found out traffic counts, site access and visibility and market area income are associated with high sales, while the ratio of population per competing restaurants is negatively associated with sales. In 2000, David J. Egan and Kevin Nield considered hotel distribution without the perspective of design but from the perspective of socioeconomics. They applied the principles of classical economics and the Alonso model to analyze the spatial distribution of hotels in London. Star-rated hotels are mostly located in the city of London, and low-star hotels or non-star hotels tend to distribute in the outer ring of the city or city edge due to

economic costs. Sharkey et al. (2009) explored the correlation between neighborhood needs and two criteria of food environment access. They found out neighborhood needs are positively associated with distance to the nearest food stores or fast food restaurants and number of food stores and fast food restaurants. Shwu-Jing Jeng (2010) analyzed the evolution of foreign restaurants from 1940 to 2005 in a town in Kentucky and conducted research in combination with the expansion of foreign groups and cities. The correlation between the number of restaurants and population was understood that with the increase in the number of foreigners such as Hispanics, the number of corresponding foreign restaurants also increase. Girish Prayag et al. (2012) evaluated and visualized the location of Hamilton's restaurant during the 12-year period (1996-2008) by using GIS technology and the central place theory, spatial interaction theory, and the principle of minimum differentiation. Two urban clusters were found in the result, one in the area with a shorter walking distance from the CBD and the other in the north of the city.

In summary, foreign scholars' research on urban functional space relies more on the mainstream urban functional space layout theory at that time, and covers a wide range of topics, including transportation costs, agglomeration levels, land prices, transportation, agglomeration effects, and distribution trends.

2.2 Japanese Literature Review

In Japan, there are numerous geography studies on living space, and many studies focus on Japanese local social issues. Atsuyuki Okabe and Yukio Sadahiro (1994) proposed and compared three models to examine the relationship between discretely distribution and continuously distribution. The proposed measures were used to verify the relationship between the population distribution and retail stores distribution in a suburb of Osaka in Japan. Tsutomu Suzuki and Masanori Oshirousing (2012) used kernel density estimation to visualize the density of urban facilities and explored the correlation between the density of urban facilities and age structure by multiple regression analysis. The result shows the

change of urban facilities could be explained by the population density. Nobuyuki Ohigashi (2014) used GIS to clarify the elderly ratio in old Saeki-ward and eastern Hatsukaichi-city and evaluate the near distance of facilities. It turned out that the area where the elderly ratio was decreasing had high service levels and there is a close relation between the elder population and facilities. Sekiguchi Tatsuya (2015) analyzed the commercial agglomeration and expansion of various small-scale shops in several regions of Japan and captured the changes in the composition of business types in these regions. Using the size and distribution of shop, and population distribution, the logical model was used to predict the possibility of closure of stores. And a model for evaluating the business environment is proposed in the end. Ushigaki Yuya, Kidani Ryutaro and Naito Akira (2016) collected the data of shops, such as Maid cafés and restaurants, through fieldwork in Akihabara district. Based on the analysis of characteristics and change of commercial accumulation of Akihabara from 2006 to 2013, it was found out that Akihabara district has become a homogenized commercial space gradually because of closures of small shops and opening of chain stores. Rikako Kondo and Yasuo Ohe (2017) used a rank logit model to explore the factors attracting visitors to restaurants in Tokyo Skytree area. It found out that the quality of provided food was most essential and the distance from Skytree was important for attracting foreign tourists. Tomoha Ishiwata et al. (2018) identified the geographical characteristics of restaurants in accumulation and eating experience from the perspective of traffic. The accumulation feature of various restaurants along the Yamanote Line was understood, and the business district classification of the station was carried out based on the type of cuisines. Yukio Sadahiro (2019) proposed a model to analyze the appearance and disappearance of points in ratio to indicate the intensity of spatial and temporal patterns. And the model was used to analyze shops and restaurants in Shibuya, Tokyo. The results support the technical feasibility of the method and reveal the phenomenon of openings and closures happened in temporal and spatial distribution.

It could be found out that research on spatial information is not only about methodological innovation, but also various studies of sociological attributes with Japanese characteristics,

including the spatial distribution of facilities related to population issues such as the aging problem. In addition, there are many studies on the spatial agglomeration of retail and restaurants in Japan. There is still no study on the classification of restaurants from the perspective of foreign cuisine and the differences of their distribution.

3. Methodology

3.1 Study Area

Tokyo, officially called as Tokyo Metropolitan (Tōkyō-to), was originally named Edo. It became a major city in Japan from the Tokugawa Shogunate and renamed Tokyo after the Meiji Restoration. Tokyo is now Japan's political, economic, and cultural center. Tokyo now includes 23 special wards, Tama area (26 municipalities, 3 towns and 1 village) and Tokyo islands (2 towns and 7 villages). Tokyo is not only the largest city in Japan, but also one of the largest cities in the world.

More and more foreigners have come to Japan, and one fifth of them lived in Tokyo in 2017. And Tokyo's business activities are extremely diverse, and many well-known international stores could also be seen here. Therefore, Tokyo could be considered as the most representative city in Japan, with a diverse and internationalized culture. Furthermore, the food culture phenomenon in Tokyo also reflects changes in Japanese preferences and popular culture. For example, in recent years, pearl milk tea is popular among young people in recent years and more and more milk tea shops are opened in Tokyo.

The largest population of Tokyo and the places with most concentration of restaurants in Tokyo are not Tama area, but 23 special wards. The “Tokyo” in the spoken language often refers to the 23 wards, not the entire Tokyo metropolitan area. However, this study has collected data for the entire Tokyo metropolitan area. In view of the fact that most restaurants and foreign populations are concentrated in the 23 wards, it is decided to regard the Tokyo wards area as the main research area to study the spatial distribution characteristics of foreign restaurants.

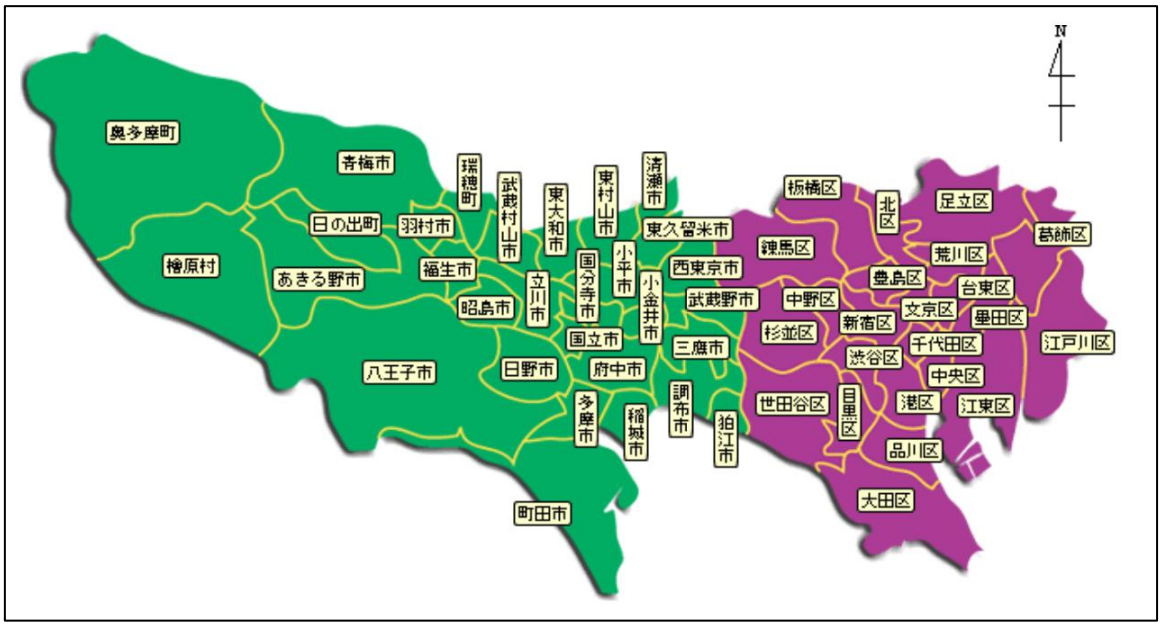

Figure 3.1 Tōkyō-to Kushichōson Map (2018)

Source: Official website of Tokyo metropolitan government

*This map doesn't include Tokyo islands.

3.2 Data

The restaurants data are the POI (Point of Interest) data collected from Telepoint Pack which provided by Center for Spatial Information Science at the University of Tokyo. Telepoint is telephone directories (Yellow pages) database "Teledata" with the addition of latitude and longitude values, which is independently manufactured by Daikei Data Processing Co., Ltd. Hence, the restaurants data are corresponding to the geographical location information on the map. These Yellow pages data from Telepoint Pack DB February 2010 to Telepoint Pack DB February 2019 were used to collect nine-year restaurants data from 2009 to 2017. All restaurants data are extracted from Telepoint, and foreign restaurants data are divided into 5 countries and others. Based on the attribute code of Telepoint, there are Chinese restaurants, Korean restaurants, Indian restaurants, French restaurants, Italian restaurants and others, which including the number of top five foreign restaurants. Because most chain restaurants locate in business districts, in order to study the characteristic of the foreign restaurants accurately and chain restaurants data are excluded to avoid the influence of chain restaurants

location. Figure 3.2 shows the POI data in Tokyo wards area map.

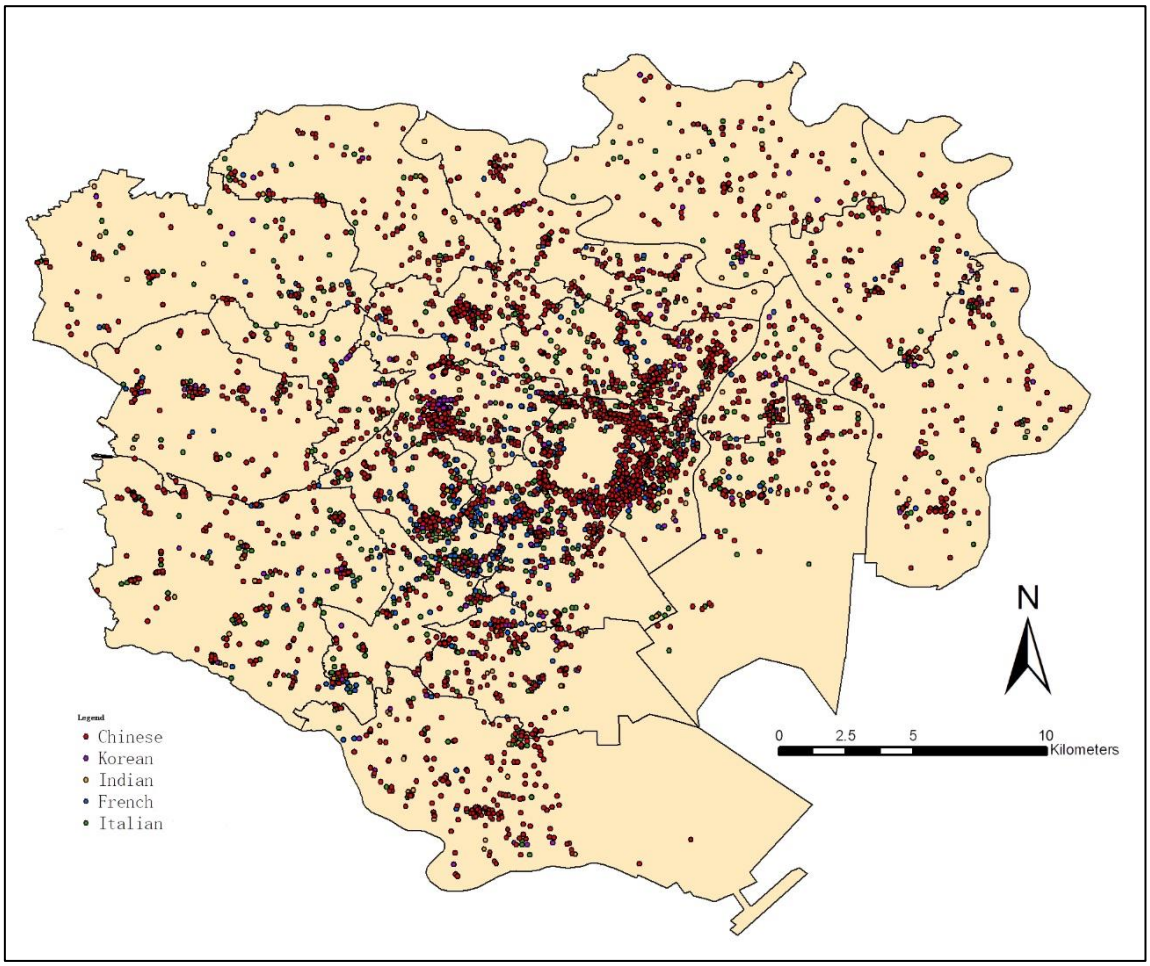

Figure 3.2 POI of Foreign Restaurants Spatial Distribution in 2017

The population data from 2009 to 2017 are downloaded from the website of Tokyo Metropolitan Government. It includes total population living in Tokyo and foreigner population of each country living in Tokyo. Foreigner population could be known in kushichōson level. Based on the consideration of many Chinese restaurants opened by Taiwanese and Korean restaurants operated by North Koreans, Chinese population includes Taiwanese population and Korean population includes the North Korean population. As for Indian restaurants, considering the fact that many Nepalese are operating Indian restaurants in Tokyo, the population is calculated as the sum of the population of India and Nepal to explore the impact of the foreign population on Indian restaurants.

The prices of different kinds of restaurants are different. Chinese cuisine and Indian cuisine have become Japanese daily dishes, while French cuisine is generally considered as haute cuisine. Therefore, different kinds of foreign restaurants are likely to be located with consideration of land price. To compare the differences among foreign restaurants, the business land prices of Tokyo are collected from Tokyo Metropolitan Government Bureau of Finance.

3.3 Research Flow

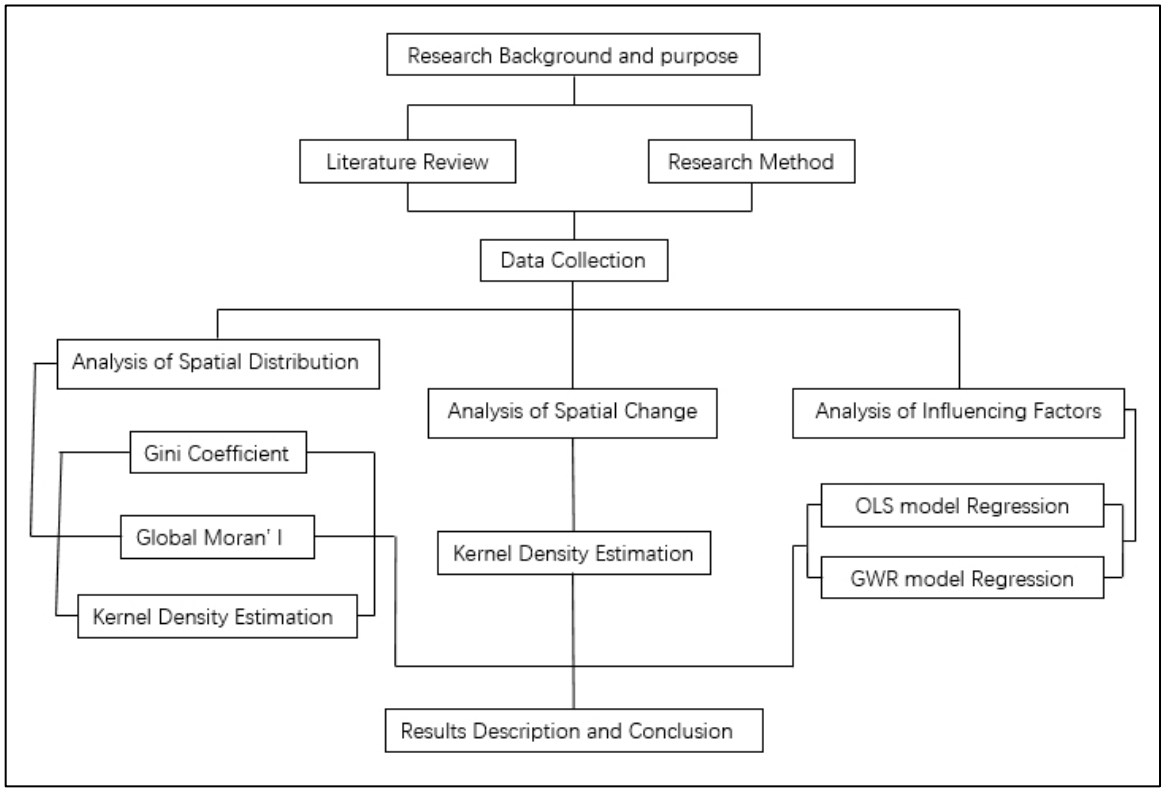

Figure 3.3 Research Flow

To find out the spatial distribution phenomenon among foreign restaurants, the research uses the Telepoint coordinate data of restaurants to map the locations in the Tokyo area. Besides of total restaurants data, foreign restaurants were classified into five kinds of foreign restaurants, including Chinese, Korean, Indian, French and Italian. The study uses the data to analyze the differences of the distribution of foreign restaurants. The numbers and ratios

of foreign restaurants in each kushichōson are counted to make the density maps which help to understand the overall situation of the spatial distribution of foreign restaurants in Tokyo. According to maps, we could find out the districts with largest number district and the highest ratio of each kind of foreign restaurants.

Gini coefficient is utilized to calculate the distribution of various foreign restaurants which could reflect the agglomeration degree. Using the numbers of foreign restaurants in this research to replace the income index could make the Gini coefficient become a measure of the degree of restaurants spatial agglomeration. In the Lorenz curve, it calculated the cumulative frequency of foreign restaurants.

To analyze the spatial auto correlated phenomenon of restaurants, the research utilizes Global Moran's I to compare the differences among various foreign restaurants. Spatial autocorrelation refers to the potential interdependence of observational data between variables in the same distribution. The spatial phenomenon could be explained by the "first law of geography" that "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970, p.236). Global Moran's I could evaluate the pattern of spatial distribution whether expressed as clustered, dispersed, or random.

Kernel Density Estimation can visualize the spatial distribution of POI data. The visualization of density could help us understand the phenomena of spatial distribution more accurately and intuitively. Kernel Density Estimation is used in the analysis of spatial distribution of foreign restaurants of 2017 in this study.

In order to explain the evolution trend of foreign restaurants in recent years, appearance data of foreign restaurants from 2009 to 2017 are extracted. These POI data are used to create the maps of spatial distribution of newly opened foreign restaurants by Kernel Density Estimation. It also helps create maps of number change of foreign restaurants by overlaying the maps of appearance and disappearance data. Through the results, we could find out the

evolutionary trend of foreign restaurants.

Then, to identify the factors that influence the distribution of foreign restaurants and analyze their correlation, multiple linear regression analysis is conducted over five kinds of foreign restaurants. For example, the ratio of Chinese restaurants is used as a dependent variable, the ratio of Chinese population and the ratio of land price are used as independent variables, and the OLS model and GWR model are utilized to explore the impact of Chinese population and land price on Chinese restaurants. In addition, the same regression analysis is conducted on Korean, Indian, French and Italian restaurants. The differences of analysis results among these foreign restaurants could be summarized to reflect the characteristics of location preference of each kind of foreign restaurant.

4. Analysis of Foreign Restaurants Spatial Distribution

4.1 Overall of Foreign Restaurants

To capture the overall of foreign restaurants, the number and the ratio of foreign restaurants are showed in Table 4.1. Comparing the results of Tōkyō-to and 23 wards, the ratio of foreign restaurants in 23 wards is bigger than Tōkyō-to although the difference is very small. It implied that most foreign restaurants opened in 23 wards. Furthermore, it could be observed that Chinese restaurants have a largest number among all the foreign restaurants, which have 2897 restaurants and occupy 5.92% of all restaurants of Tokyo wards area. The second is Italian restaurants with a number of 1535, accounting for 3.13%. The number of Korean, Indian and French restaurants have a small number of 409, 412 and 547 respectively. It indicates that although Korean cuisine and Indian cuisine are very popular in recent years, the numbers are still relatively small compared to other foreign restaurants.

Table 4.1 Number of Restaurants in 2017

	Tōkyō-to		**23 wards**	
	Number	**Ratio**	**Number**	**Ratio**
All restaurants	60065	100%	48973	100%
Chinese restaurants	3433	5.71%	2897	5.92%
Korean restaurants	458	0.76%	409	0.84%
Indian restaurants	498	0.83%	412	0.84%
French restaurants	607	1.01%	547	1.12%
Italian restaurants	1816	3.02%	1535	3.13%

The number of foreign restaurants in each ward is calculated and the results are displayed in the maps of 23 wards. The maps show the numbers and the ratios of foreign restaurants, which could reflect directly where the largest number and the highest ratio of foreign restaurants are located in.

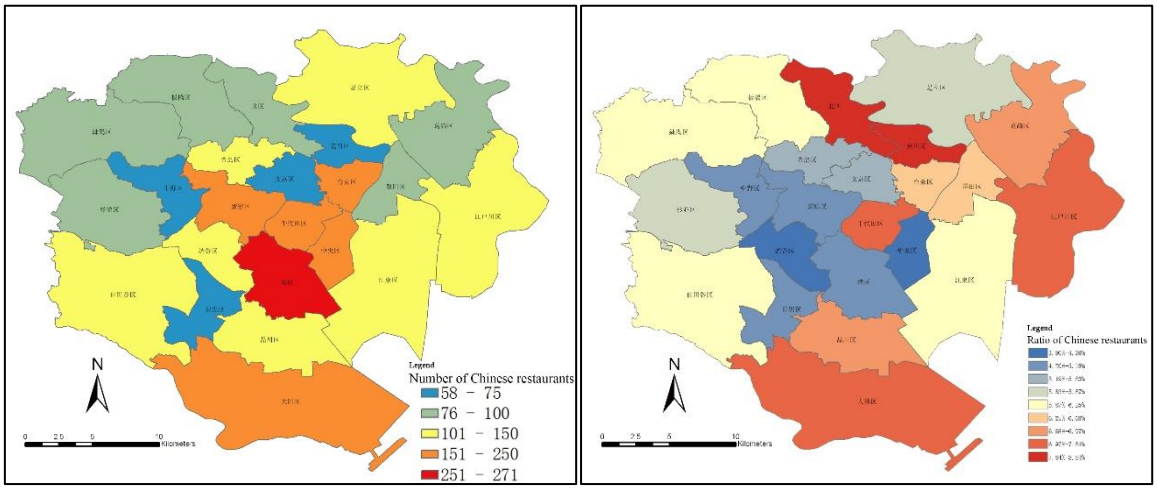

Figure 4.1 Number and Ratio of Chinese Restaurants of 23 Wards in 2017

From Figure 4.1, we could know that Minato has the largest number of Chinese restaurants. Minato is also the place with the largest number of restaurants in Tokyo. However, the ratios of Chinese restaurants in Kita and Arakawa are higher than Minato.

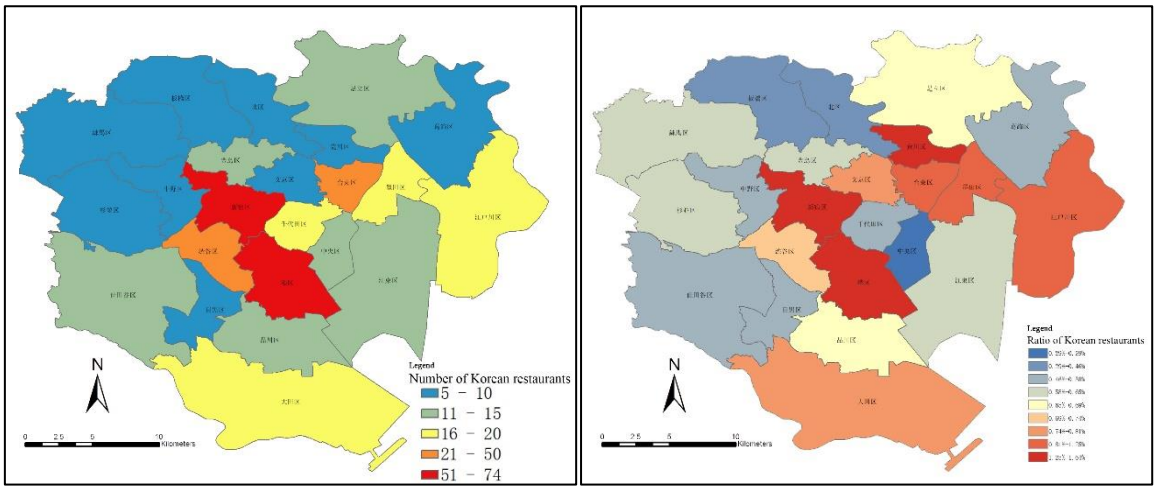

Figure 4.2 Number and Ratio of Korean Restaurants of 23 Wards in 2017

As for Korean restaurants, Shinjuku and Minato have the majority of Korean restaurants. The ratios in Shinjuku and Minato are high as well. It could be observed that the ratio of Korean restaurants in Arakawa is also high.

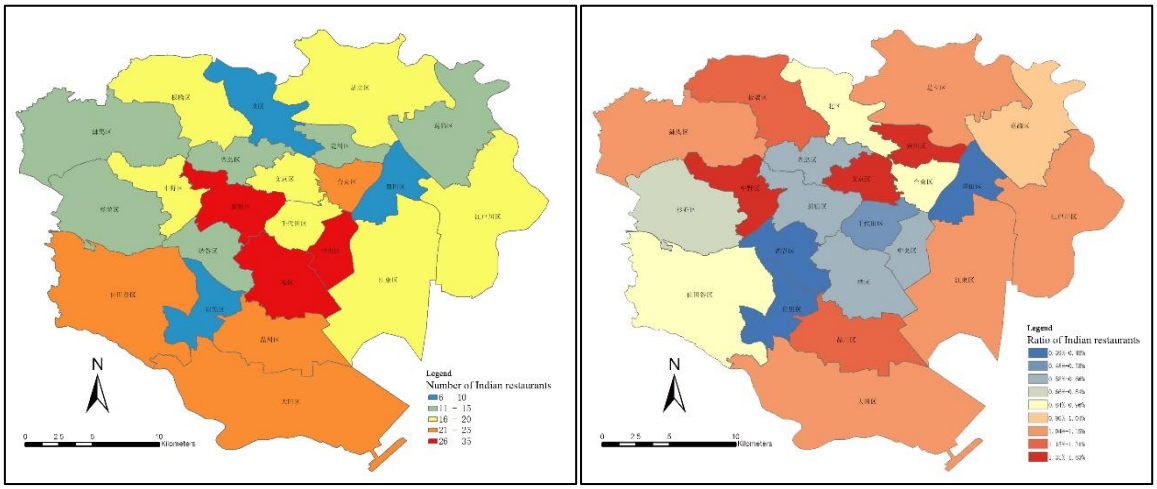

Figure 4.3 Number and Ratio of Indian Restaurants of 23 Wards in 2017

According to Figure 4.3, Shinjuku, Minato and Chūō areas have a great number of Indian restaurants. These places are all business districts. On the contrary, Nakano, Bunkyo and Arakawa show the highest ratios of Indian restaurants.

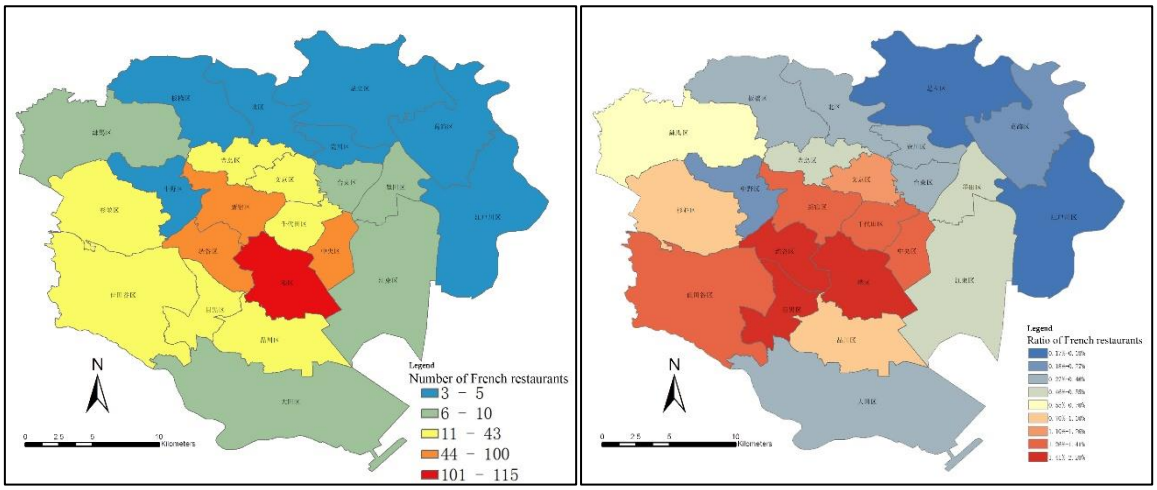

Figure 4.4 Number and Ratio of French Restaurants of 23 Wards in 2017

In Figure 4.4, Minato is displayed as the place has most French restaurants and the ratio here is also high. Besides, the ratios of French restaurants in Shibuya and Meguro are high as well.

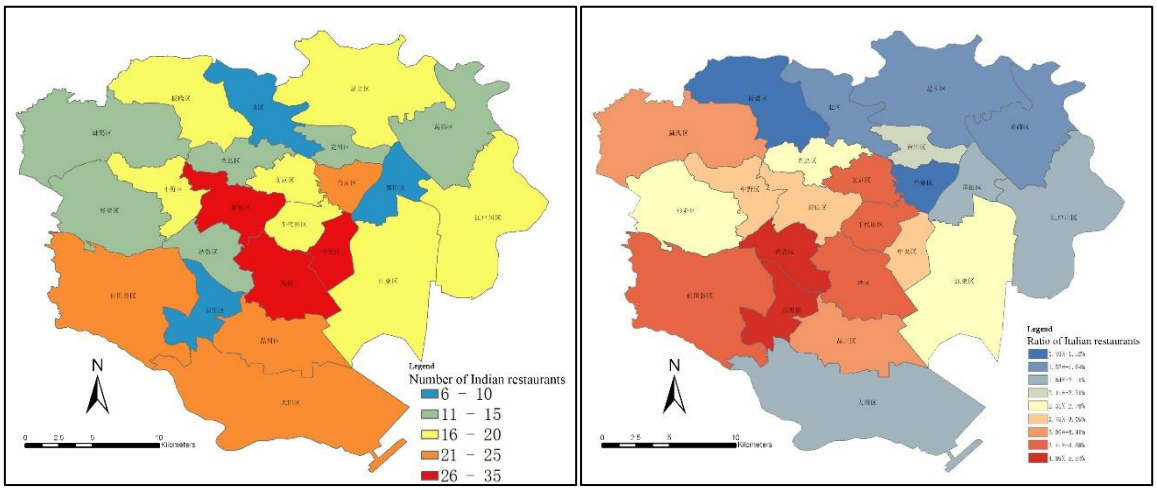

Figure 4.5 Number and Ratio of Italian Restaurants of 23 Wards in 2017

As for the result of Italian restaurants, Minato has the highest number of Italian restaurants. The ratios of Italian restaurants showed in Figure 4.5 are highest in Shibuya and Meguro.

From the results shown above, Minato has the most restaurants so there are a lot of foreign restaurants located here. Chinese restaurants and Indian restaurants demonstrate the great differences between the number and ratio. Although a great number of their restaurants opened in business districts, the high ratio comes out in other wards which are not well-known as commercial areas. The number and ratio of Korean restaurants show consistency, all in Shinjuku and Minato. The results of French and Italian restaurants have some similarities. It could be ascribed that French cuisine and Italian cuisine are both belong to western cuisine.

4.2 Gini Coefficient and Lorenz Curve

In this subsection, Gini coefficient is utilized to calculate the distribution of various foreign restaurants which could reflect the characteristic of the degree of agglomeration to find out the different distribution phenomena among foreign restaurants. In the field of economics, the Gini coefficient is used to measure the statistical dispersion to represent the income or wealth distribution of a nation's residents and is the most commonly used measurement of inequality. The cumulative percentage of the population is used as the horizontal axis, while

the cumulative percentage of income is used as the vertical axis. The curve reflects the income distribution gap of the residents is drawn, which is the Lorenz curve.

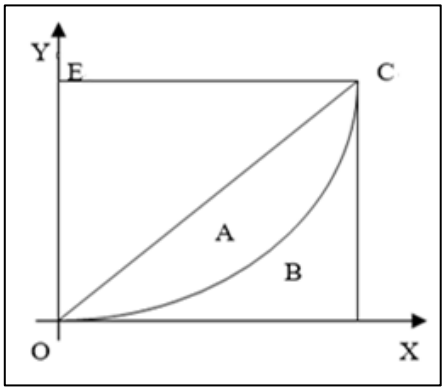

Figure 4.6 Lorenz Curve

In Figure 4.6, the Gini coefficient is defined as:

$$\mathrm{G} = \frac{S_A}{S_A + S_B}$$

When A is 0, the Gini coefficient is 0, indicating that income distribution is absolutely equal; when B is 0, the Gini coefficient is 1, indicating that income distribution is absolutely unequal. When the Gini coefficient is between 0 and 1: the larger the coefficient is, the more uneven distribution is; and the smaller the coefficient is, the more even distribution is.

The idea of calculation used in this study is similar to the method of calculating the integral calculus by geometric definition. Find n points on the X-axis and divide the area under the Lorenz curve into n parts. Each part is utilized to calculate the area by the method of direct generation. Then adding the total area to get the area of B. The more points, the more accurate the result is. When the points reach infinity, it becomes the exact calculation.

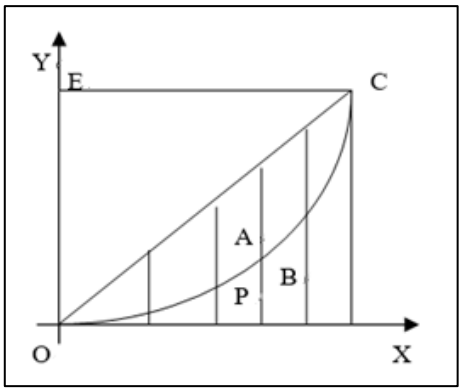

Figure 4.7 Calculation Principle of Lorenz Curve

It assumes that the group is divided into n groups, and the Y of each group is Y_i, then the area of each part P is:

$$S_P = \frac{1}{2n}\frac{\sum_{i-1} Y_i + \sum_i Y_i}{\sum_n Y_i}$$

By adding up all parts we could get the formula:

$$\mathrm{G} = \frac{S_A}{S_A+S_B} = \frac{S_A+S_B-S_B}{S_A+S_B} = 1 - \frac{S_B}{0.5} = 1 - 2\sum_1^n \frac{1}{2n}\frac{\sum_{i-1} Y_i+\sum_i Y_i}{\sum_n Y_i} = 1 - \frac{1}{n}\sum_1^n \frac{\sum_{i-1} Y_i+\sum_i Y_i}{\sum_n Y_i}$$

Using the numbers of restaurants in this study, to replace the income index could make the Gini coefficient become a measure of the degree of restaurants spatial agglomeration. In the Lorenz curve, the cumulative frequency of 23 wards is the horizontal axis and the cumulative frequency of restaurants is the vertical axis. The study counts the number of all restaurants, Chinese restaurants, Korean restaurants, Indian restaurants, French restaurants, and Italian restaurants. It calculates the cumulative frequency of each kind of restaurant. The results of each Lorenz curve are drawn as Figure 4.8.


All restaurants
1.2
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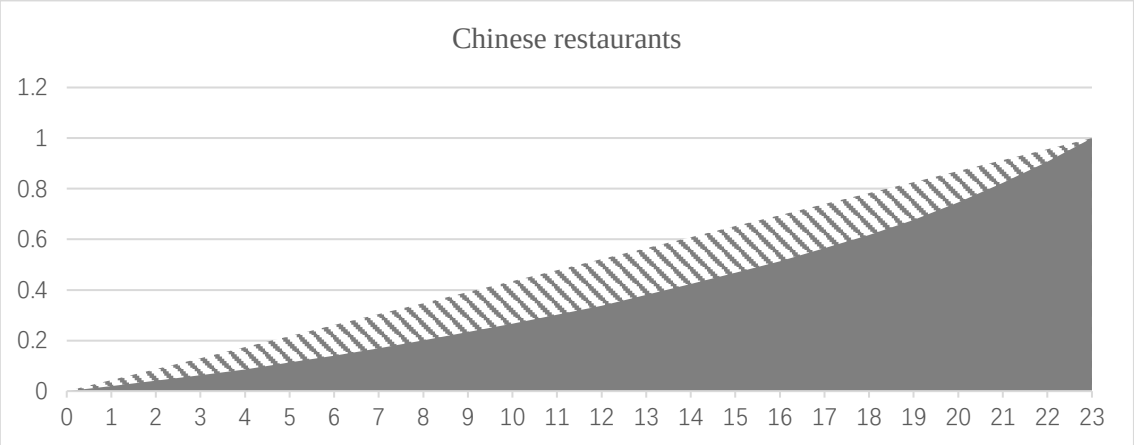
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23


Chinese restaurants
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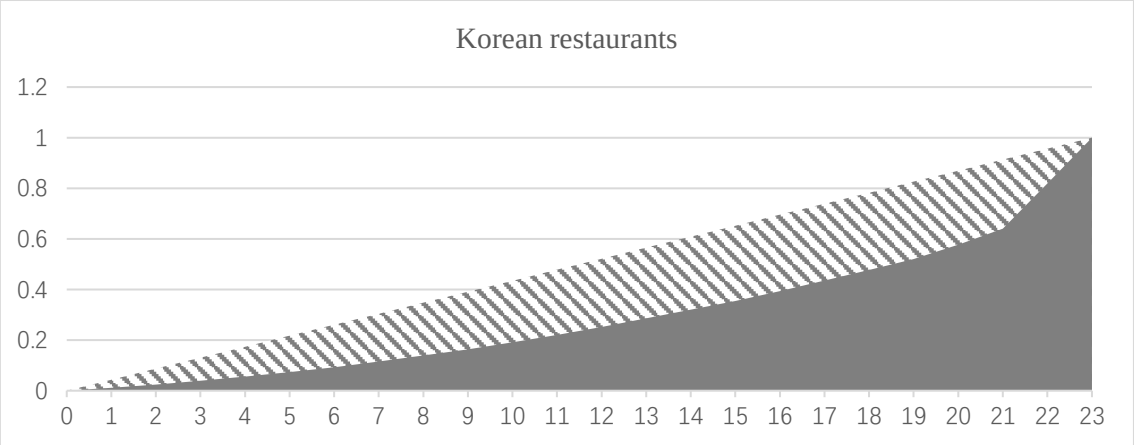
Korean restaurants
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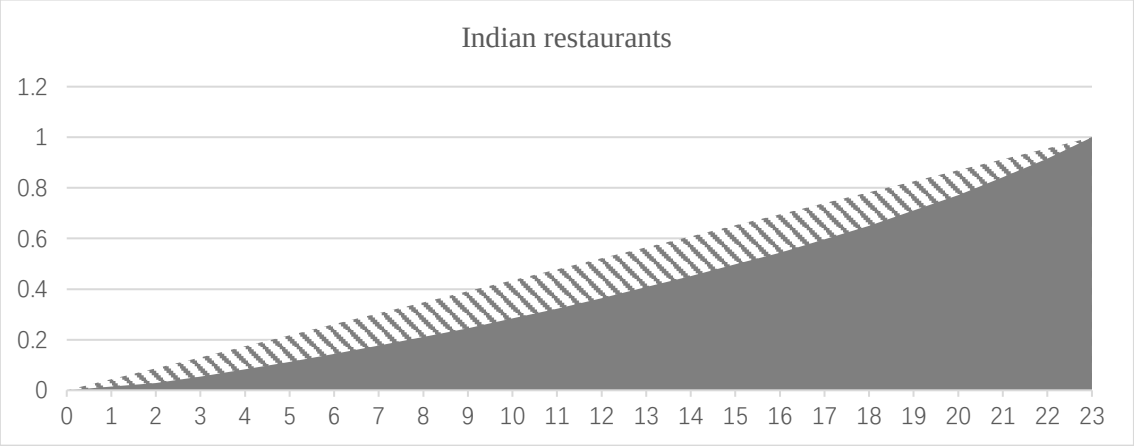
Indian restaurants
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0.8
0.6
0.4
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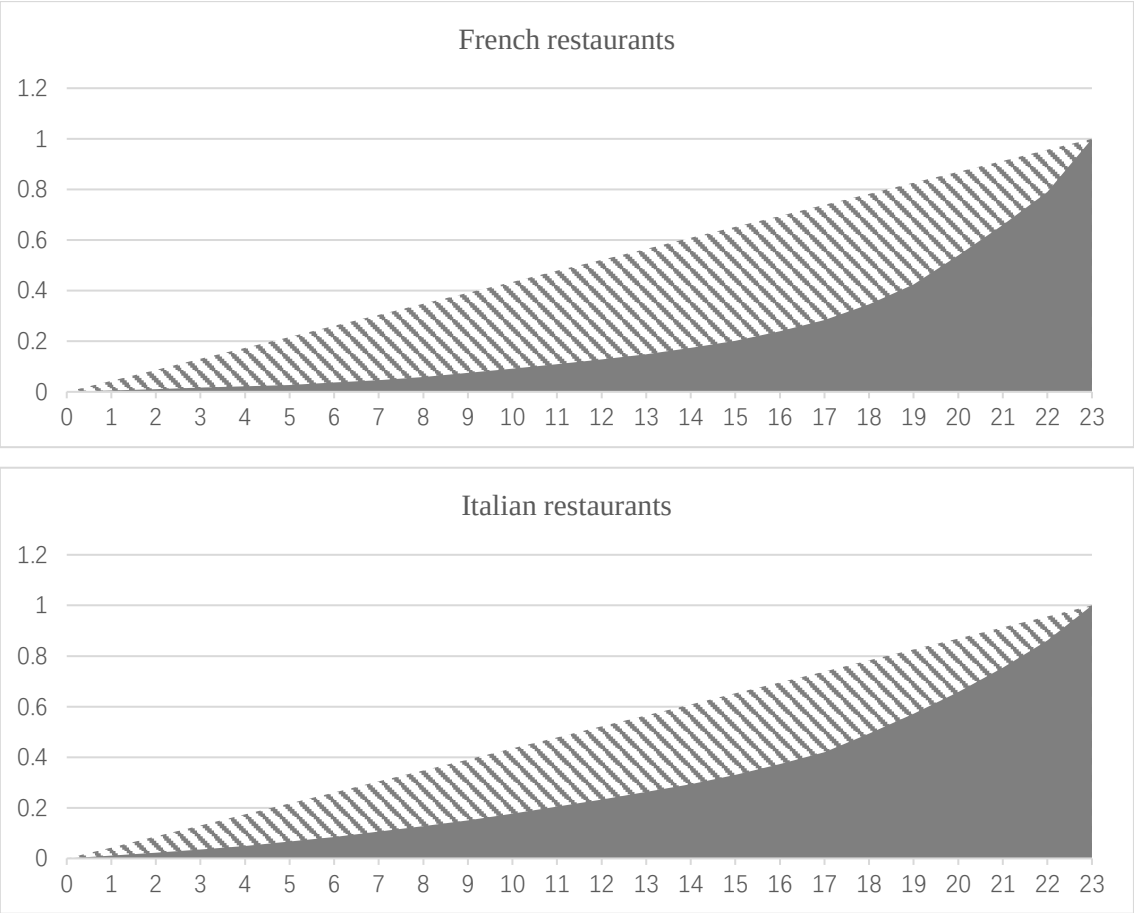

Figure 4.8 Lorenz Curve for Foreign Restaurants

The number of restaurants in the 23 wards is arranged in order from small to large, and the cumulative frequency of restaurants is calculated. The sum of the areas under the Lorentz curve is calculated and divided by 0.5. The Gini coefficient of foreign restaurants is obtained separately in Table 4.2.

Table 4.2 Gini Coefficients of Foreign Restaurants

Restaurants	All	Chinese	Korean	Indian	French	Italian
Gini coefficient	0.29	0.25	0.42	0.22	0.57	0.41

In this study, the Gini coefficient could reflect the degree of agglomeration of foreign restaurants. The bigger Gini coefficient is, the more uneven distribution is. The Gini coefficient is arranged from small to large: Indian restaurants (0.22), Chinese restaurants (0.25), Italian restaurants (0.41), Korean restaurants (0.42), and French restaurants (0.57). According to all restaurants' Gini coefficient which is 0.29, it shows that the distribution of

all restaurants in the 23 wards is relatively even.

As for the results of Chinese restaurants and Indian restaurants, the Gini coefficient is lower than Korean, French and Italian restaurants. It could be considered that Chinese cuisine and Indian cuisine are the civilian cuisine, which the business thresholds are not high, so it could present a lot in non-commercial districts. Moreover, the Gini coefficient of Korean restaurants and Italian restaurants is similar. But by comparing the Lorentz curves of the two, it could be observed that the shapes are very different. The curve of Italian restaurants is relatively smooth, while the curve of Korean restaurants is abrupt in the last part. It could be noted the fact that the number of Korean restaurants has increased sharply in the two places of Minato and Shinjuku. In particular, the Shinjuku area is the most concentrated place for Korean restaurants compared to other areas, which is consistent with the fact that a Korean town is located in Shin-Ōkubo. Finally, the Gini coefficient of French restaurants is the biggest among these foreign restaurants. Although French cuisine and Italian cuisine are both European cuisine, pasta in Italian cuisine is extremely common which could be considered as civilian cuisine. French cuisine is generally known as haute cuisine, so it is concentrated in bustling commercial areas, such as the Minato area.

4.3 Global Moran's I

The Moran's I is one of the ways of spatial cluster analysis, and divided into the Global Moran's I, proposed by Patrick Alfred Pierce Moran in 1950, and the Local Moran's I, which was proposed by Professor Luc Anselin in 1995. Global Moran's I measures spatial autocorrelation which shows a spatial correlation among one object and others surrounding it. Global Moran's I is defined as:

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

where n is the number of regions in the study area, in this case, it is number of wards in Tokyo; x_i is the number of foreign restaurants in i region; x_j is the number of foreign

restaurants in j region; $\overline{x}$ is the average number of foreign restaurants in 23 wards; w_{ij} is the spatial weight of the i region and j region, reflecting the spatial relationship of the i and j region. If the region i, j are adjacent, w_{ij} = 1, otherwise w_{ij} = 0. If there is no spatial autocorrelation, the expected value of Moran's I is $\mathrm{E(I)} = \frac{-1}{n-1}$.

Global Moran's I is utilized to measure the spatial autocorrelation of foreign restaurants in ArcGIS. The Moran's I value and both z-score and p-value are calculated to evaluate the significance of Global Moran's I. Moran's I >0 represents the spatial positive correlation. The larger the value is, the more obviously the spatial correlate. Moran's I <0 represents the spatial negative correlation. The smaller the value is, the larger the spatial disparity is. Otherwise, Moran's I = 0, the spatial distribution is random. Z-score refers to standard deviation and p-value refer to probability. Both z-scores and p-values are associated with the standard normal distribution. Therefore, it could be understood whether the distribution of various foreign restaurants expressed is clustered, dispersed, or random.

The results of Global Moran's I of foreign restaurants are shown in Table 4.3.

Table 4.3 Results of Global Moran's I for Restaurants in Tokyo Wards Area

Restaurants	Moran's I value	z-score	p-value
All restaurants	0.314478	3.087089	0.002021
Chinese	0.284232	2.765214	0.005689
Korean	0.133742	1.767173	0.077199
Indian	0.094274	1.165983	0.243621
French	0.360331	3.647836	0.000264
Italian	0.407113	3.851927	0.000117

Moran's I value of all restaurants is 0.314478 and p-value is 0.002021, which means there is a less than 1% likelihood that this clustered pattern could be the result of random chance. Moran's I value of foreign restaurants is arranged from large to small: Italian, French, Chinese, Korean and Indian restaurants. For Chinese, French, and Italian restaurants, given

the z-scores and p-values, there is a less than 1% likelihood that these clustered patterns could be the result of random chance. Based on the z-score of 1.767173 and p-value of 0.077199, there is a less than 10% likelihood that this clustered pattern of Korean restaurants could be the result of random chance. As for Indian restaurants, while the z-score is 1.165983 and p-value is 0.243621, the clustered pattern does not appear to be significantly different than random.

From the results of Global Moran's I, we could obtain the following conclusion. Distribution of restaurants in 23 wards shows a great spatial autocorrelation phenomenon. Although Chinese restaurants and Indian restaurants are both widely distributed in wards, Chinese restaurants show high spatial autocorrelation while Indian restaurants show there is no spatial autocorrelation. Chinese restaurants are numerous in Japan, and Chinese people have a culture of Chinatown, so the spatial autocorrelation is relatively high. Although there are many Indian restaurants in recent years, Indian and Nepalese do not have obvious agglomeration culture overseas at Kushichōson level, so the distribution of restaurants is not showed the spatial autocorrelation. Despite the fact that Korean, French and Italian restaurants distributed in several specific regions, the phenomenon of Korean restaurants concentrated in Shin-Ōkubo is so unique that spatial autocorrelation of Korean restaurants is weaker than that of French and Italian restaurants.

4.4 Analysis of Kernel Density Estimation

Kernel density estimation is one of the non-parametric ways to estimate the probability density function of a random variable. Since the kernel density estimation method does not make use of prior knowledge about the data distribution, it does not propose any premise assumption to the data distribution. It is a method for studying the distribution characteristics of data from the data sample itself. Therefore, kernel density estimation receives highly attention in statistical theory and application fields.

When the data of discrete points is directly represented by graphs, the spatial trend is often not obvious. Kernel density estimation can obtain the graph of the density change of the research object, and the spatial change is continuous. The density map is developed by each output cell, calculating the density of points. Conceptually, each point data is covered by a smoothly curved surface. The surface value is highest at the point location and diminishes with increasing distance from the point. The value reaches zero when distance from the point beyond the search radius. The density at each output raster cell is calculated by adding all surfaces values where they overlay the raster cell center.

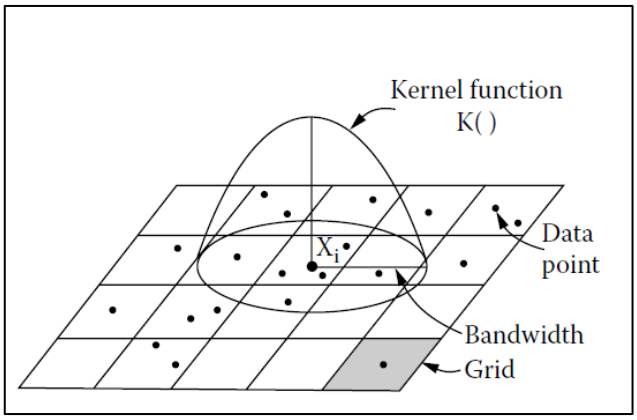

Figure 4.9 Schematic Diagram of Kernel Density Estimation

Source: Fahui Wang (2006).Quantitative Methods and Applications in GIS. pp. 37.

This research utilizes the Parzen–Rosenblatt window method to calculate the point data of restaurants, defined as follows:

$$f_n(x) = \frac{1}{nh}\sum_{i=1}^{n} K(\frac{x - x_i}{h})$$

where n is the number of points; K is the kernel function; $h > 0$ is a smoothing parameter called the bandwidth, which means maximum search radius; $x - \mathrm{x_i}$ indicates the distance from the estimated point x to the event x_i. The kernel function in ArcGIS is based on the Quartic kernel function (Silverman, 1986). Quartic kernel function:

$$K = (1 - (\frac{r}{n})^2)^2, \text{for } \frac{r}{n} < 1$$

In formula, r is a radius centered at point and h is the bandwidth. The size of the bandwidth and the kernel function are the main factors affecting Kernel density estimation.

The kernel density estimation of restaurants is calculated in ArcGIS and the maps was made to visualize the spatial distribution. Figure 4.10 shows kernel density estimation of all restaurants in 23 wards, including Japanese restaurants.

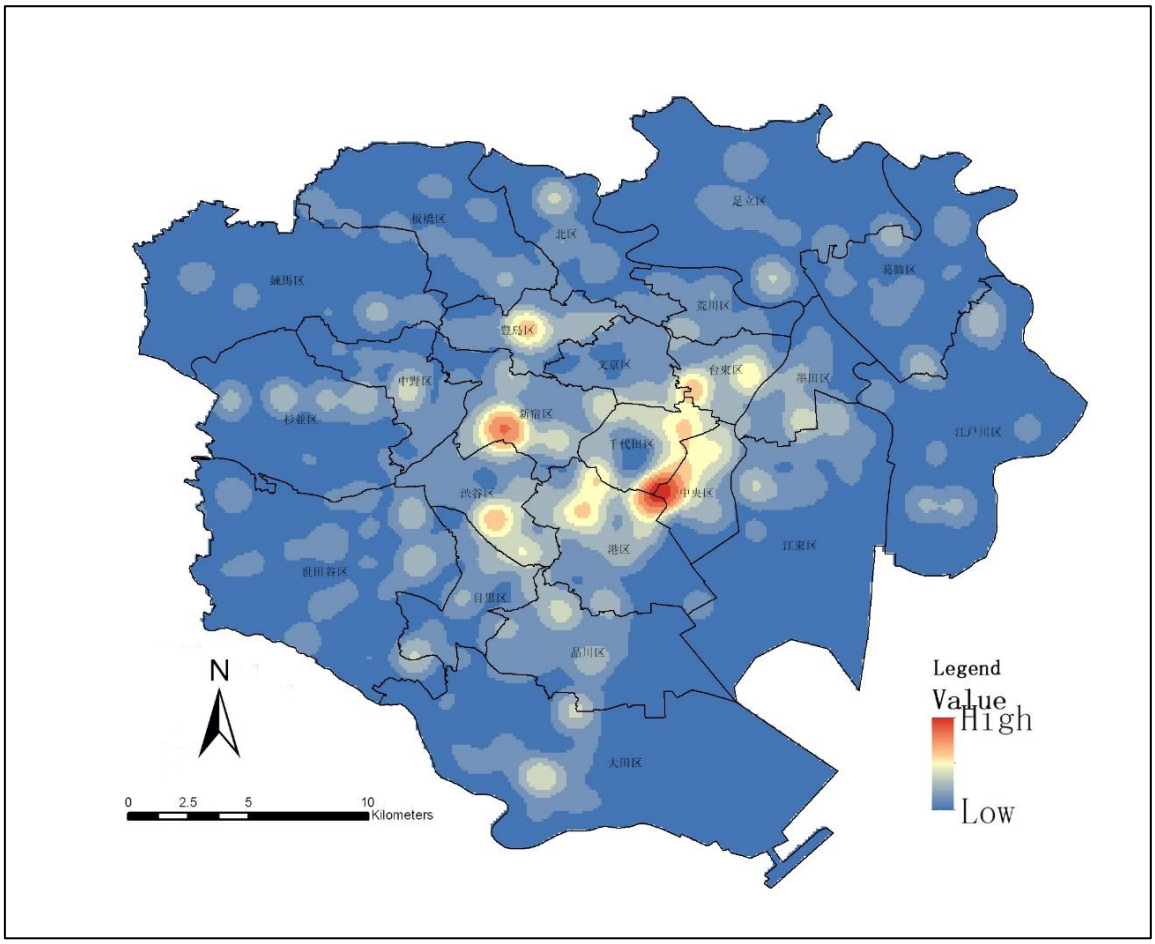

Figure 4.10 Distribution of All Restaurants in 2017

We could find out that the highest density of restaurants is in the Ginza and Yūrakuchō area, followed by Shinjuku. The restaurants in Shibuya, Ikebukuro, Ueno, Roppongi, Kanda and Akasaka are also densely distributed. Furthermore, Asakusa, which is a famous sightseeing place, congregates many restaurants as well.

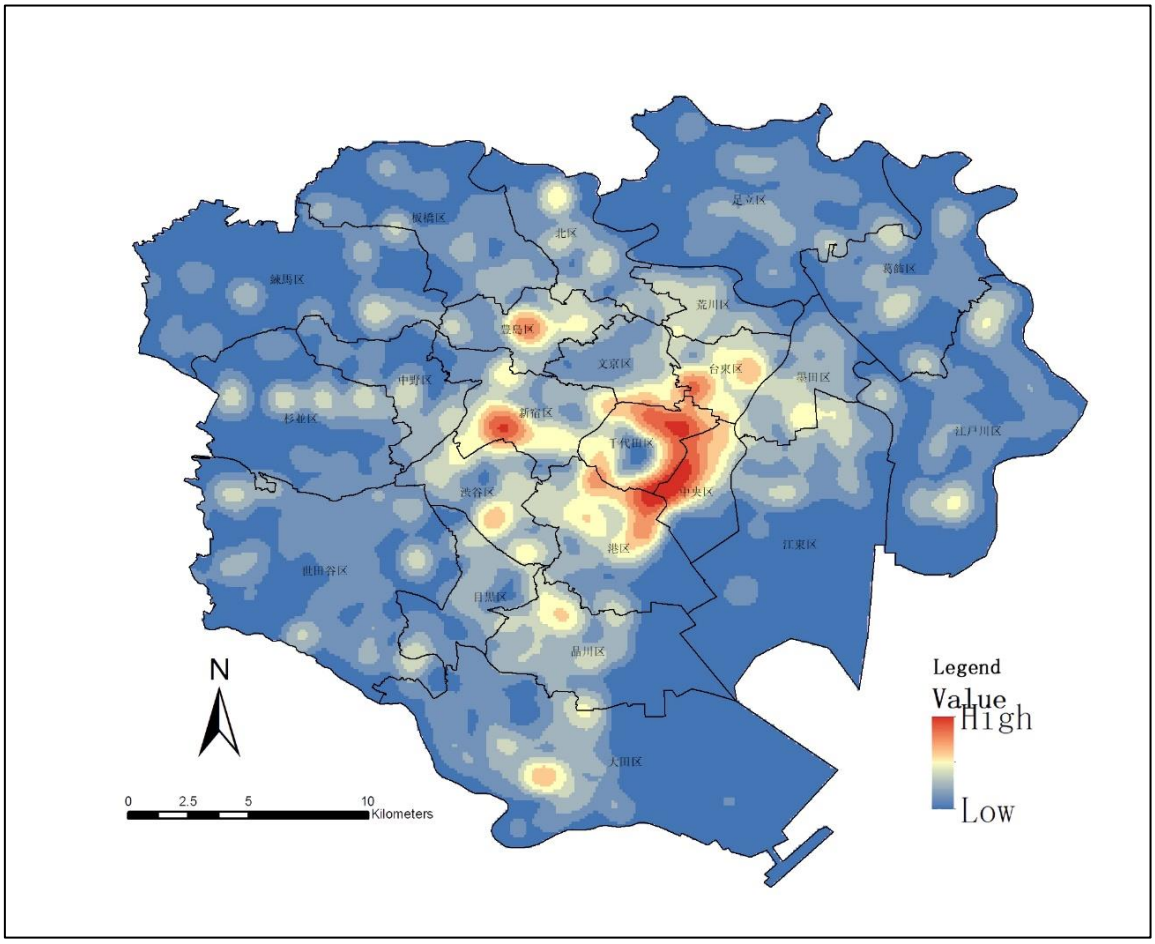

Figure 4.11 Distribution of Chinese Restaurants in 2017

From the results of Chinese restaurants distribution map, it could be noted that most Chinese restaurants are located in the Ginza and Yūrakuchō area. With the Ginza and Yūrakuchō area as a cluster center, north to Kanda, and south to Akasaka, Chinese restaurants are distributed along the Tokyo Imperial Palace. These districts are considered as business areas which have developed lots of catering industries. Shinjuku, as one of the biggest business areas, also gathers a great deal of Chinese restaurants. For the Ikebukuro, which is widely believed to have a large number of Chinese restaurants, there are indeed quite a few Chinese restaurants, but the concentration is not as good as that of Ginza or Shinjuku area. Chinese restaurants are opened in Ueno because Ueno is reckoned as sightseeing place and there are lots of catering services in Ameya-Yokochō. In addition, it could be observed that Chinese restaurants located in Asakusa, Shibuya, Kamata and Gotanda, any one of these places is a bustling commercial street.

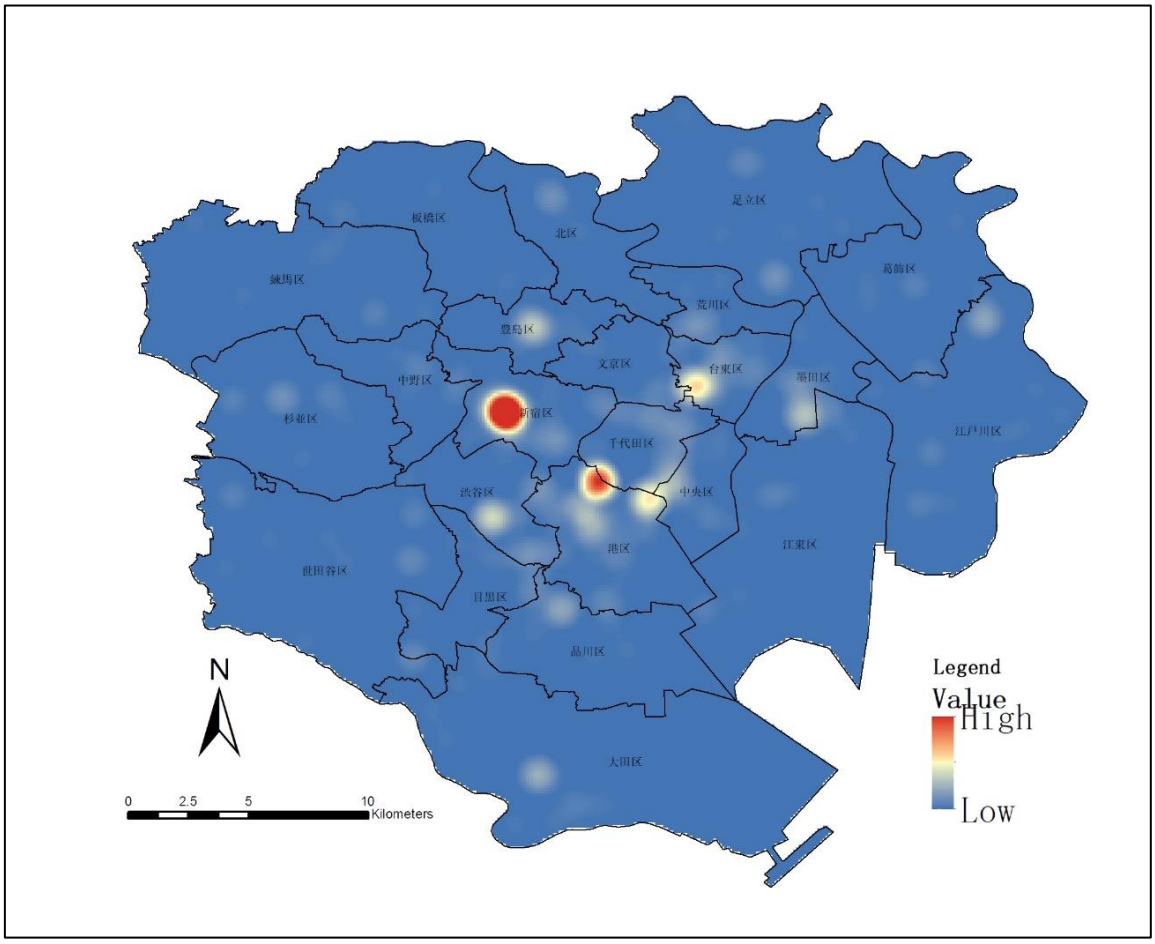

Figure 4.12 Distribution of Korean Restaurants in 2017

Korean restaurants distribution map is the most unusual one. There are two places where the density is very high. Most Korean restaurants are located in Shin-Ōkubo, where a Korean town named Shokuandori located. Lots of Korean restaurants concentrate in Akasaka area. Many Japanese corporations of Korean company are gathered here. After World War II, it was previously a place where there were only Yakuza (Japanese gangster) and Koreans. It has now evolved into a very famous Korean town in Tokyo. Ueno and Shinbashi also congregate quite a few Korean restaurants. There is another well-known Korean town in East Ueno. As for Korean restaurants gathering in Shinbashi, it is attributed to the popularity of the Korean Wave and its location near the Ginza and Yūrakuchō area. Korean cuisine is regarded as a kind of health food and is particularly popular with women. Furthermore, Shinbashi is a place for office workers to drink together after working. Hence there are increasingly Korean restaurants located in Shinbashi.

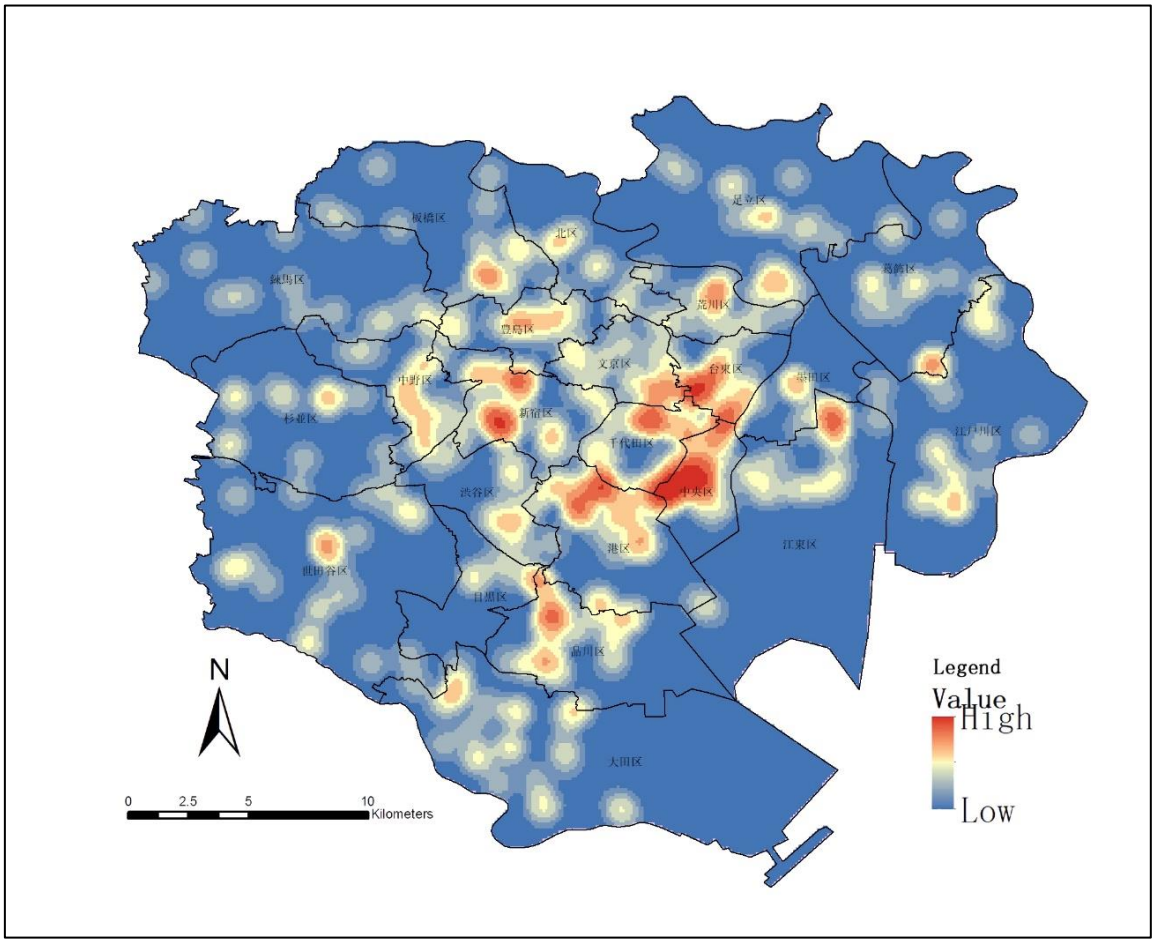

Figure 4.13 Distribution of Indian Restaurants in 2017

The overall distribution of Indian restaurants is more scattered. Similar to China, it forms a circular distribution around Tokyo Imperial Palace. The Ginza and Yūrakuchō area are the most clustered area of Indian restaurants. Various Indian restaurants also concentrate in Akasaka, Asakusabashi and Kanda-Jinbōchō. Compared with business areas such as Akasaka and Asakusabashi, Kanda-Jinbōchō is especially well-known for curry. Shinjuku and Ueno also gather a great number of Indian restaurants where various catering industries have been developed. It could be found out that there are agglomeration phenomena in Kameido, Gotanda and Takadanobaba as well. These places are business areas with large people flow. It is discovered that Indian restaurants are mainly located in Machiya, Naka-Itabashi, Shin-Koiwa, Ikebukuro, Kyōdō and Nishi-kasai, etc. It is probably a result of many Indian and Nepalese moving into these places in recent years. Machiya have lots of Southeast Asian restaurants including Indian, Vietnamese and Bangladeshi restaurants. Nishi-kasai is called “Little India” and has become a sightseeing place regarded as an Indian street. Besides,

there are a lot of Indian restaurant clusters located near stations.

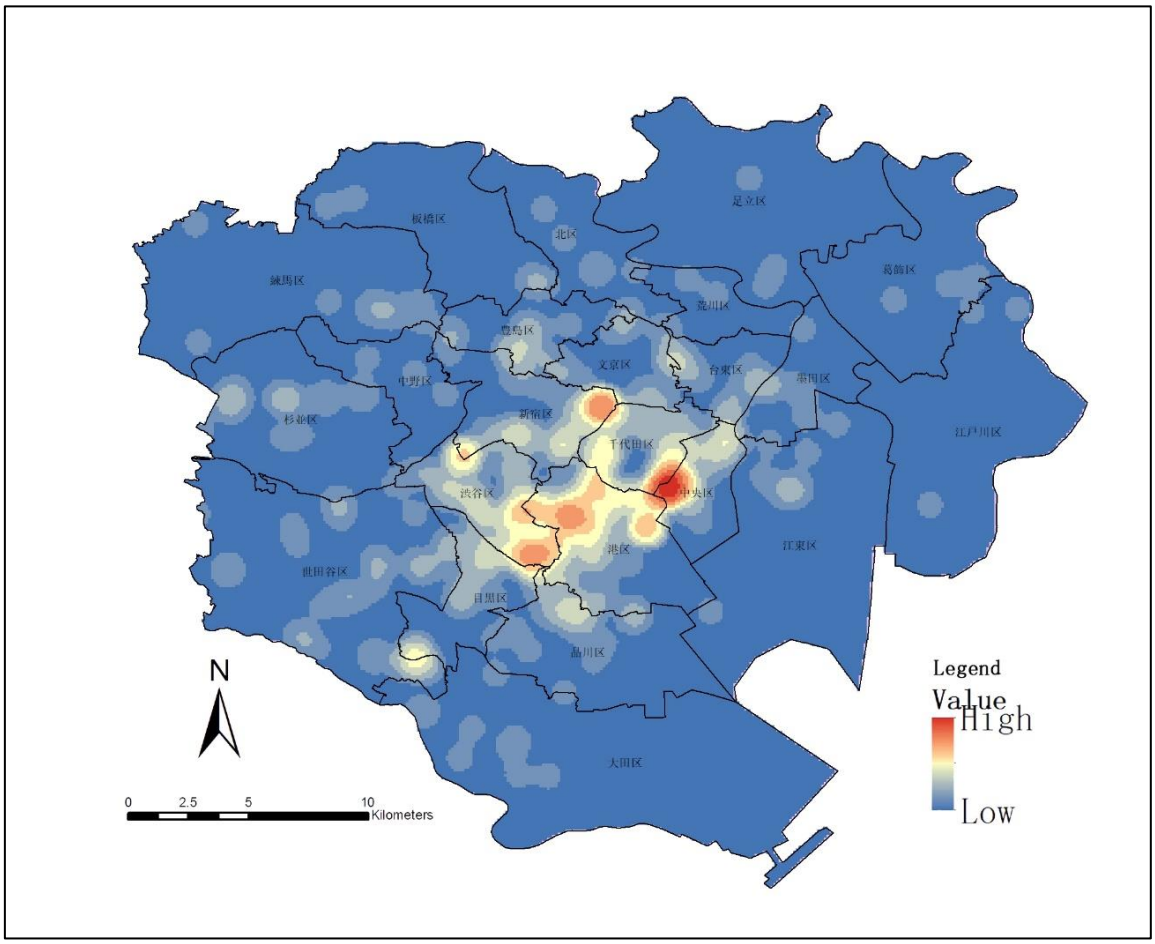

Figure 4.14 Distribution of French Restaurants in 2017

French restaurants, usually considered as restaurants of haute cuisine, mostly congregate in the Ginza and Yūrakuchō area which is the busiest commercial area in Tokyo. Besides, the concentration of French restaurants could also be found in Roppongi, Kagurazaka and Ebisu. Roppongi is famous for the affluent Roppongi Hills development area and a few foreign embassies are located close to here. During the daytime, there are many foreigners working in multinational companies here. There are also lots of night clubs where both locals and foreigners visit frequently. Consequently, Roppongi congregates various western cuisine and many French restaurants also have chosen to open here. The atmosphere of Kagurazaka where many fashionable cafes and shops are opened, shares the similar style of Paris so it also named “Small Paris”. There are not only French restaurants opened by the official organization of the French government in Kagurazaka, but also French restaurants, such as

Galette, opened by Japanese here. Around the station of Ebisu, there are a wide variety of restaurants along Komazawa-dori and Meguro River. Near Ebisu is Daikanyamachō where opens a large number of stylish stores. Therefore, there is likewise a large collection of French restaurants in Ebisu. Besides, Akasaka, Hamamatsucho and Omotesando have quite a few French restaurants gathered here as well.

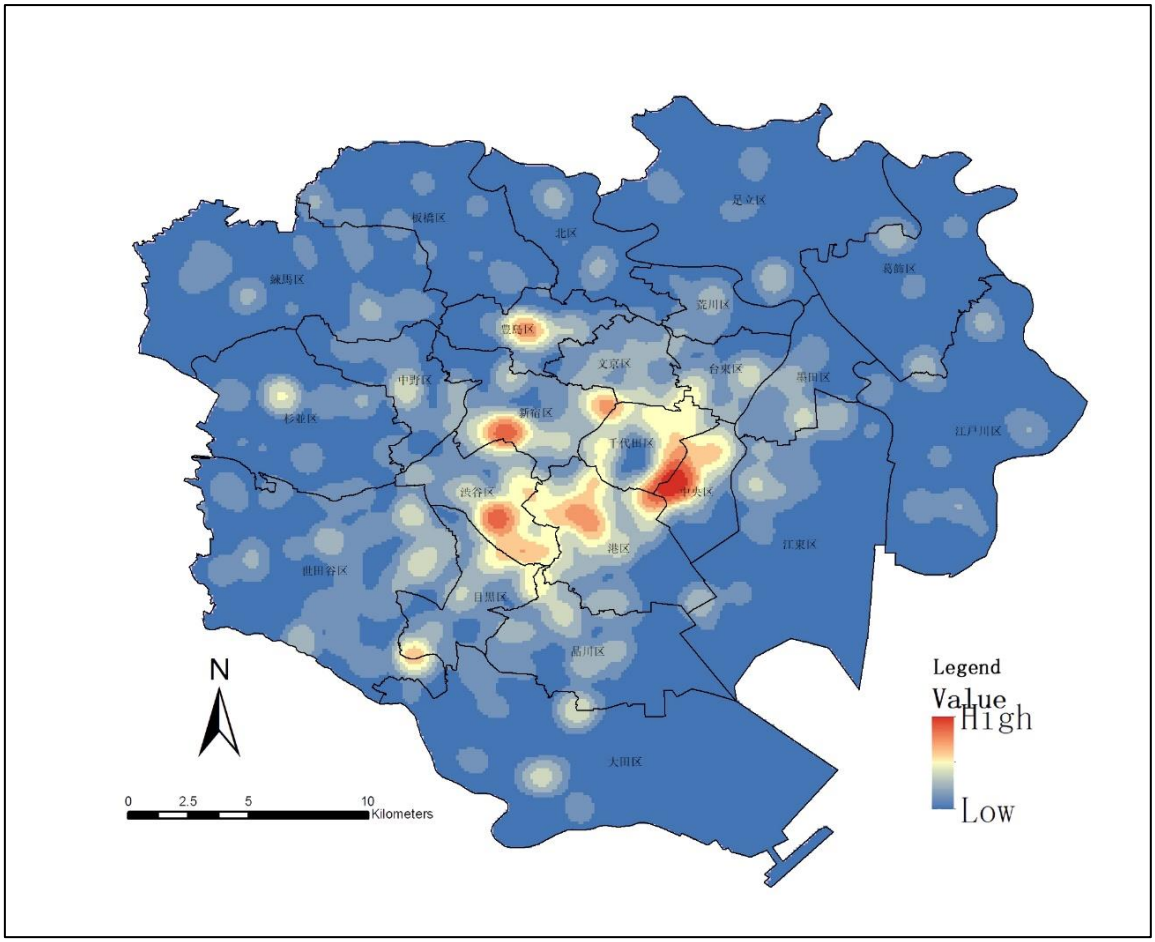

Figure 4.15 Distribution of Italian Restaurants in 2017

From distribution map of Italian restaurants, the density of Italian restaurants in the Ginza and Yūrakuchō area is the highest as other foreign restaurants. Italian restaurants are also located in typical commercial areas such as Shinjuku and Shibuya. Furthermore, Ikebukuro, Roppongi and Kagurazaka congregate a relatively large number of Italian restaurants. Quite a few Italian restaurants are located in Ningyocho and Jiyūgaoka as well. Jiyūgaoka is a business center and many visitors come here for sightseeing purpose and the street here is deemed to be European style. The cause of spatial distribution of Italian restaurants is that

not only Italian cuisine is accepted widely by Japanese, such as spaghetti, but also high-class Italian restaurants are opened in areas like Roppongi, Kagurazaka and Jiyūgaoka which are rich in western cuisine.

The study ranks foreign restaurants according to the agglomeration degree of foreign restaurants displayed on above maps. "◎" in Table 4.4 indicates the area with the highest agglomeration degree. "○" indicates the area where the agglomeration phenomenon is obvious, and "△" indicates the area where the foreign restaurants are relatively concentrated.

Table 4.4 Summary of Restaurants Location Clusters

	All restaurants	Chinese	Korean	Indian	French	Italian
Ginza and Yūrakuchō	◎	◎		◎	◎	◎
Shinjuku	◎	◎		◎		◎
Shibuya	○	△				◎
Ueno	○	○	△	◎		
Ikebukuro	○	○		△		○
Roppongi	○				○	○
Kanda	○	◎				
Akasaka		○	○	○	△	
Asakusa	△	△				
Gotanda		△		○		
Kamata		△				
Shin-Ōkubo			◎			
Shinbashi			△			
Asakusabashi				○		
Kanda-Jinbōchō				○		
Kameido				○		
Takadanobaba				○		
Machiya				△		
Naka-Itabashi				△		
Shin-Koiwa				△		
Nishi-kasai				△		
Kyōdō				△		
Kagurazaka					○	○
Ebisu					○	
Hamamatsucho					△	
Omotesando					△	
Jiyūgaoka						△
Ningyocho						△

By contrasting each kind of foreign restaurant cluster, we could summarize some distribution characteristics of these foreign restaurants. The spatial distribution pattern of Chinese restaurants is basically the same as that of common restaurants. Although Ikebukuro is thought to be the most gathered place for Chinese cuisine in Tokyo, the agglomeration of Chinese restaurants in Ikebukuro is not as dense as the public consider. The culture of Chinese cuisine has been fully integrated into the Japanese society, so it does not show the characteristics of exotic food culture by the spatial distribution. The agglomeration phenomenon of Korean restaurants shows a strong relationship between Korean town and Korean restaurants, which the places where Korean restaurants are concentrated are exactly located nearly in Korean town. Indian restaurants are scattered throughout 23 wards, forming many small clusters. Some clusters are similar to the distribution of Chinese restaurants, gathered in commercial centers. Meanwhile, some clusters have been developed to form Indian style neighborhood with regional cultural characteristics. French cuisine and Italian cuisine belong to the western cuisine. In addition to the most prosperous district, the Ginza and Yūrakuchō area, it is also concentrated in Roppongi, where has more foreigners. Besides, there are various fashionable areas and some of these places have European style streets, where French and Italian restaurants prefer to locate at. In addition, there are a large number of common foods in Italian cuisine like pasta accepted by most Japanese people. Hence, Italian restaurants, unlike French restaurants, are also concentrated in commercial areas with inexpensive price, such as Shinjuku, Shibuya and Ikebukuro.

From a regional perspective, the commercial districts of Japan are basically developed around the train stations. The catering industry is also the most concentrated near train stations. It could be observed that many foreign restaurant clusters are also located around the stations. In summary, the Ginza and Yūrakuchō area is the most bustling area where we could enjoy all kinds of foreign cuisine. Shinjuku could be regarded as the second choice for eating foreign cuisine. The areas such as Shibuya, Ueno, Ikebukuro and Akasaka are all sightseeing places or business places. There are numerous restaurants in Shibuya, but foreign restaurants are not conspicuous here. Compared to Shibuya, Ueno, Ikebukuro and Akasaka

are considered as places where we could experience more flavors of foreign cuisine. Ueno is a tourist attraction and has developed a great number of foreign restaurants at Ameya-Yokochō. Ikebukuro, on the basis of the original Chinatown, has expanded the local catering industry and gradually evolved into a place which contains all kinds of restaurants. Akasaka is an area close to foreign embassies, and the diverse neighborhoods create an exotic atmosphere which has contributed to the openings of foreign restaurants. Moreover, Roppongi and Kagurazaka are the best places to enjoy western cuisine. However, there are also many places in Tokyo where we could experience a certain kind of foreign cuisine, such as Shin-Ōkubo, where there is a concentration of Korean restaurants, and Nishi-kasai, which is named as 'Little India', as well as Kagurazaka with Paris style.

4.5 Analysis of Spatial Change of Restaurants

To track the evolution of foreign cuisine in Tokyo, the number of foreign restaurants is collected to reveal the change of foreign restaurants. Table 4.5 shows the data of restaurants from 2009 to 2017 in 23 wards. We could find out that the data of restaurants has decreased as a whole. However, data of Indian restaurants still increase which indicates the popularity of Indian cuisine in the last few years. Because of the reduce trend of data source which can't be used to reflect accurately with the numbers, the ratio of various foreign restaurants is calculated to reflect the more accurate situation of foreign restaurants. The trend of the change of each kind of foreign restaurant is showed in Figure 4.16.

Table 4.5 Number of Restaurants from 2009 to 2017

	2009	2010	2011	2012	2013	2014	2015	2016	2017
All	68627	58050	56492	41409	41709	52679	53199	49128	48973
Chinese	4092	3919	3815	3577	3456	3389	3179	3031	2897
Korean	587	583	588	592	580	561	482	439	409
Indian	238	307	334	341	332	341	385	393	412
French	645	637	623	603	589	596	577	568	547
Italian	1545	1576	1600	1584	1635	1633	1607	1568	1535

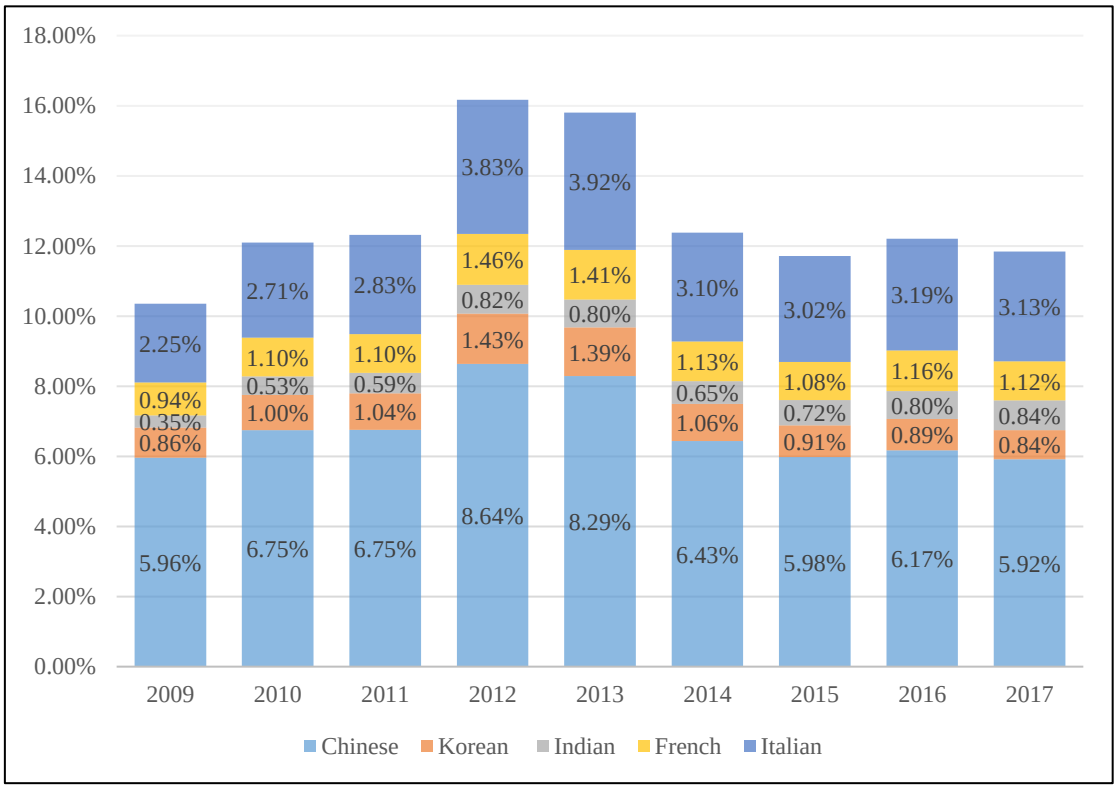

Figure 4.16 Ratio of Foreign Restaurants from 2009 to 2017

From Figure 4.16, we could find out that the ratios of foreign restaurants show a general upward trend. Compared with the decreasing number of restaurants in 2012 and 2013, the ratio of foreign restaurants in 2012 and 2013 increased instead. Consistent with the number of Indian restaurants, the ratio of Indian restaurants is further increased significantly, and the ratio in 2017 is 2.4 times that of 2009. At the same time, the ratio of French and the ratio of Italian restaurants have also increased. Compared with 2009, the ratio of French restaurants increased 1.2 times in 2017 and Italian restaurants increased 1.4 times. At the same time, the ratios of Chinese restaurants and Korean restaurants have barely changed.

In order to clarify the tendency of openings of foreign restaurants from 2009 to 2017, the study extracted the data of newly opened foreign restaurants during this period. Table 4.6 demonstrates the number of foreign restaurants in 2017, the number of newly opened restaurants during this period and the ratio of newly opened restaurants in each kind of foreign restaurant. According to the high ratio of newly opened restaurants, it implies that the catering industry is frequently updated. The ratio of Indian newly opened restaurants is the highest which consistent with the fact that Indian cuisine has prevailed in recent years.

On the contrary, the ratio of Chinese restaurants is the lowest. It is considered that Chinese cuisine has developed the longest in Japan and is accepted by the Japanese people as a daily dish. The ratios of Korean, French and Italian newly opened restaurants are all around 50%.

Table 4.6 Number of New Restaurants

	Restaurants in 2017	New restaurants	Ratio of new restaurants
Chinese	2897	1237	42.70%
Korean	409	196	47.92%
Indian	412	330	80.10%
French	547	305	55.76%
Italian	1535	862	56.16%

There are two assumptions of newly opened foreign restaurants. One assumption is that the restaurants tend to open in areas where the catering industry is developed, and the new foreign restaurants will prefer to open in the places where already gathering a multitude of foreign restaurants. The other assumption is that the newly opened restaurants have been concentrated in a particular place for some reasons in recent year. To find out the changing trend of foreign restaurants distribution, the kernel density estimation is utilized to explore the spatial distribution of the newly opened foreign restaurants.

However, some clusters of the newly opened restaurants may be just right located in the business areas where openings and closures of restaurants occur frequently. It leads to the change of number in these places seemed not obvious. In order to find out where the foreign restaurants have increased in recent years, disappearance data of foreign restaurants from 2009 to 2017, have also been extracted. We could set the same bandwidth (search radius) to make the kernel density maps for openings and closures of foreign restaurants. The value of output raster in the openings and closures maps can be calculated to create the change in the number of foreign restaurants. Consequently, the positive value of a raster cell represents the place where the number of foreign restaurants has increased, and the negative raster cell represents where the number of foreign restaurants has decreased. On the basis of the maps of the change of foreign restaurants, we could easily find out where the foreign restaurants have increased in recent years.

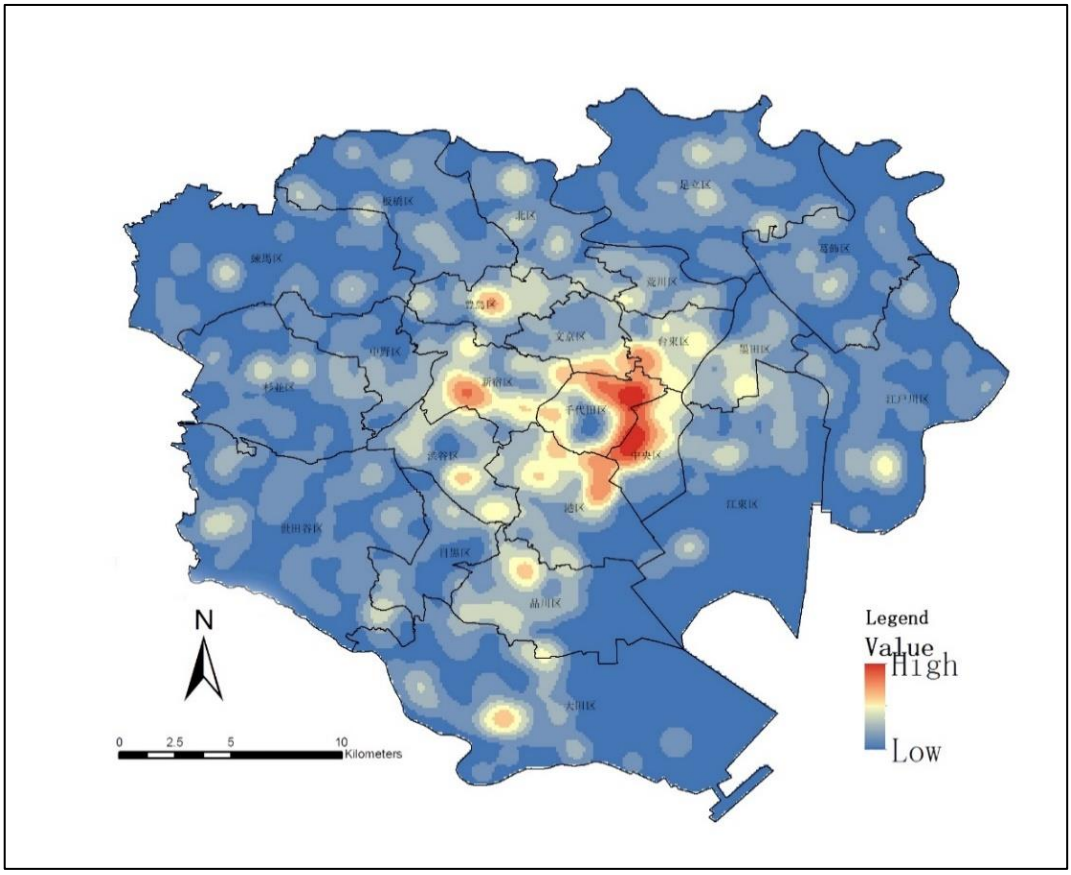

Figure 4.17 Distribution of Newly Opened Chinese Restaurants from 2009 to 2017

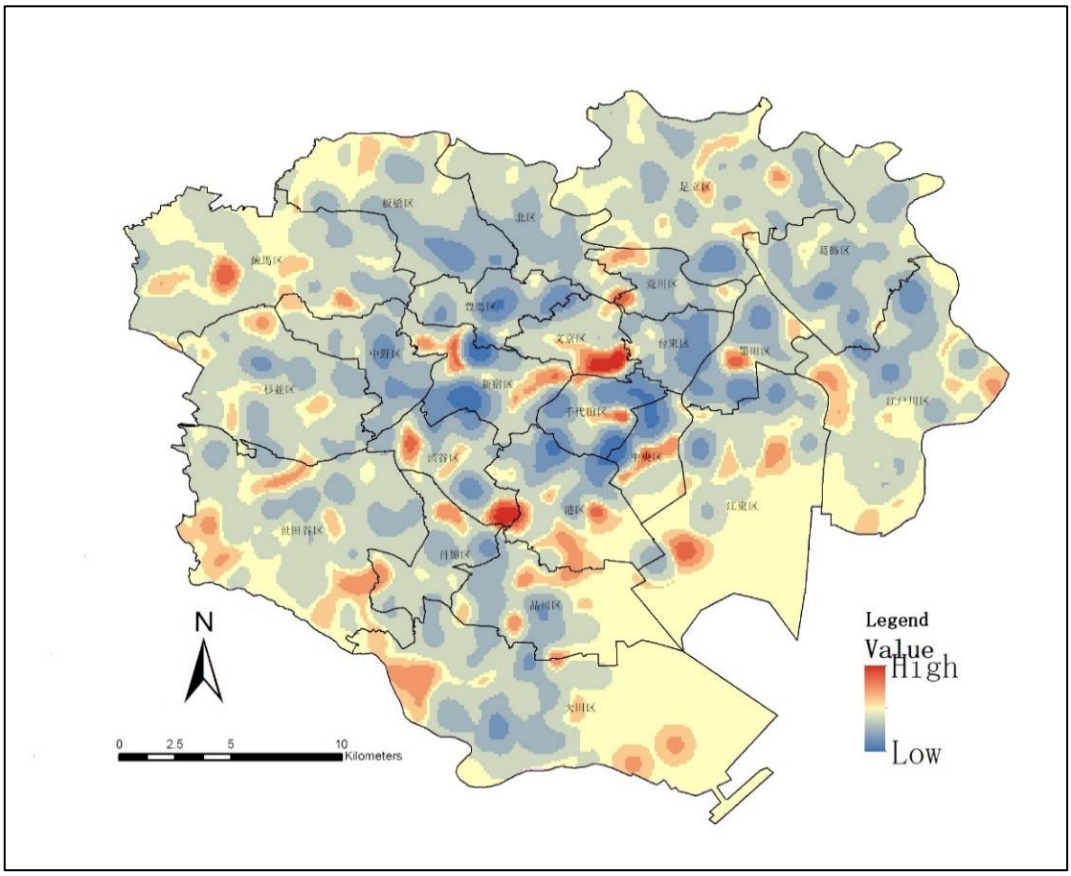

Figure 4.18 Change of Chinses Restaurants from 2009 to 2017

From Figure 4.17, we could see the newly opened Chinese restaurants congregating in Ginza and Kanda. Based on Figure 4.18, Ginza and Kanda are the places where openings and closures happened frequently for restaurants. The situation is the same in places like Shinjuku and Ikebukuro. However, from the Figure 4.18, we could find out that the number of Chinese restaurants has increased in Hongō and Ebisu. Hongō is near Ueno and several universities are located here, such as the University of Tokyo. The number of Chinese students at the University of Tokyo in 2017 is 2077, twice as many as 926 in 2009. It is inferred that the newly opened Chinese restaurants aim at the increasing Chinese students. Ebisu is near Daikanyamachō, which is famous and has been popular with Chinese visitors. Quite a few Chinese language classroom are also operated here. Furthermore, various Chinese teahouses are opened here.

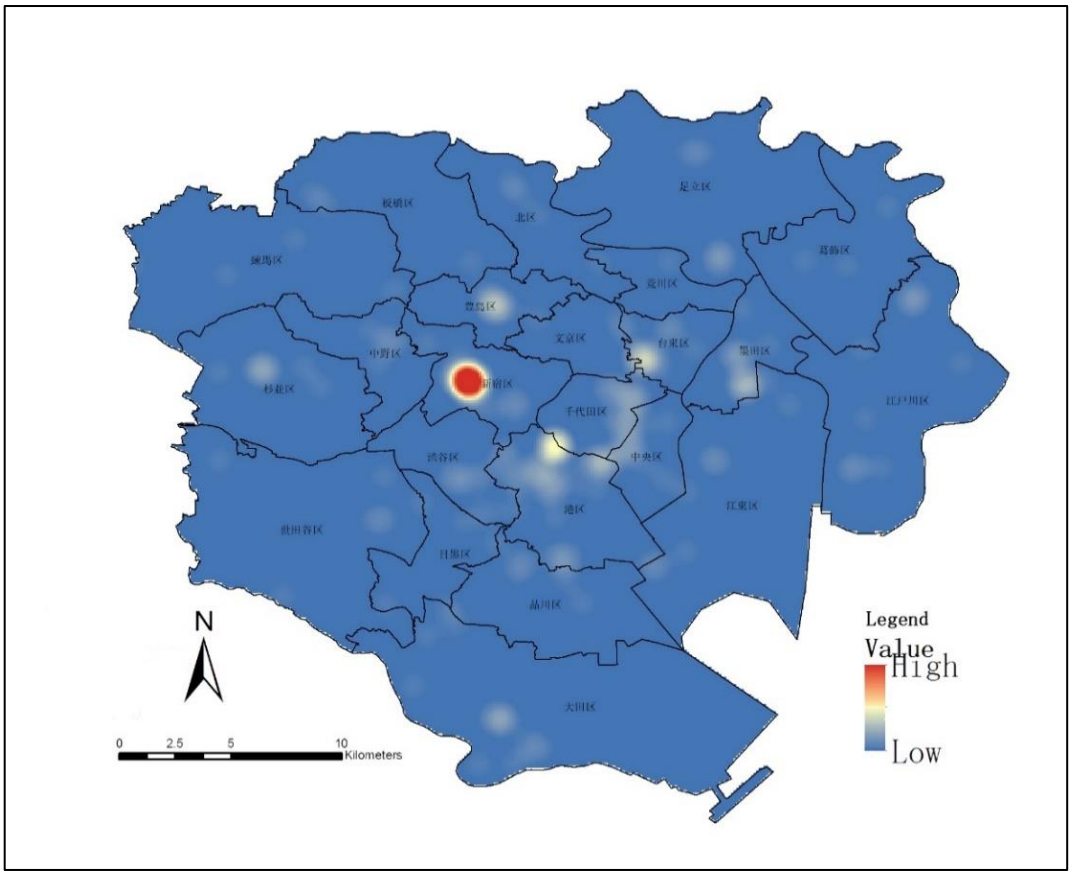

Figure 4.19 Distribution of Newly Opened Korean Restaurants from 2009 to 2017

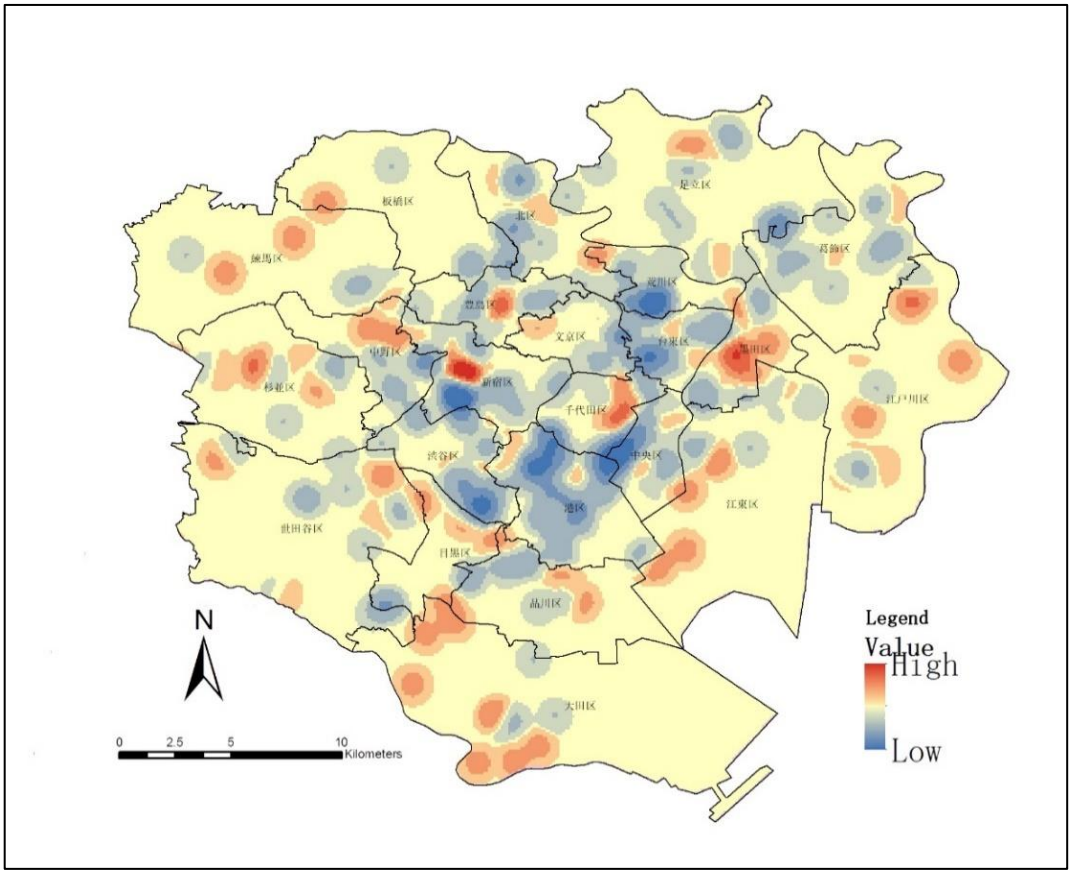

Figure 4.20 Change of Korean Restaurants from 2009 to 2017

Distribution of newly opened Korean restaurants is totally the same as the distribution of Korean restaurants in 2017. It indicates that Korean restaurants prefer to open in existing places where have already gathered Korean restaurants, such as Shin-Ōkubo and Akasaka. From the change map of Korean restaurants, we could see that the increase in the number of Korean restaurants is mainly concentrated on the north side of the Shin-Ōkubo. In addition, the number of Korean restaurants in Skytree has also increased. As a well-known sightseeing place, Skytree is also attracting foreign tourists and the restaurants there have become more diverse.

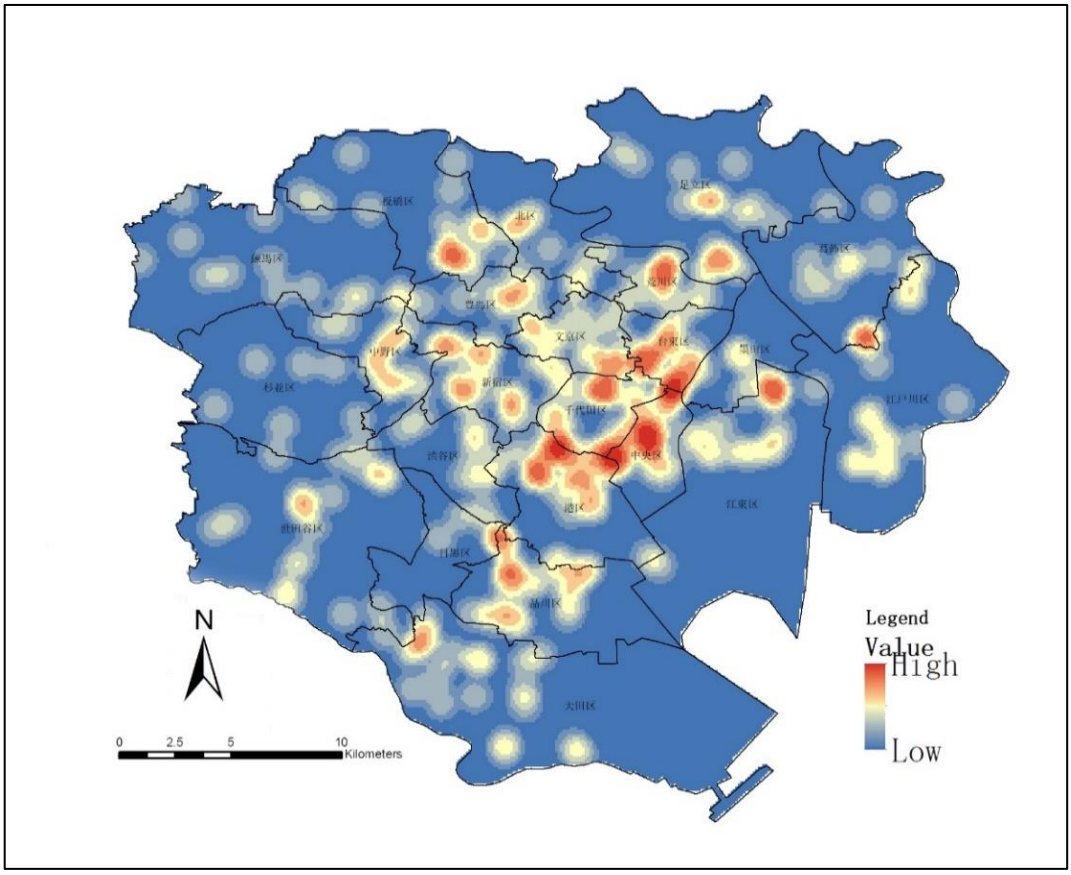

Figure 4.21 Distribution of Newly Opened Indian Restaurants from 2009 to 2017

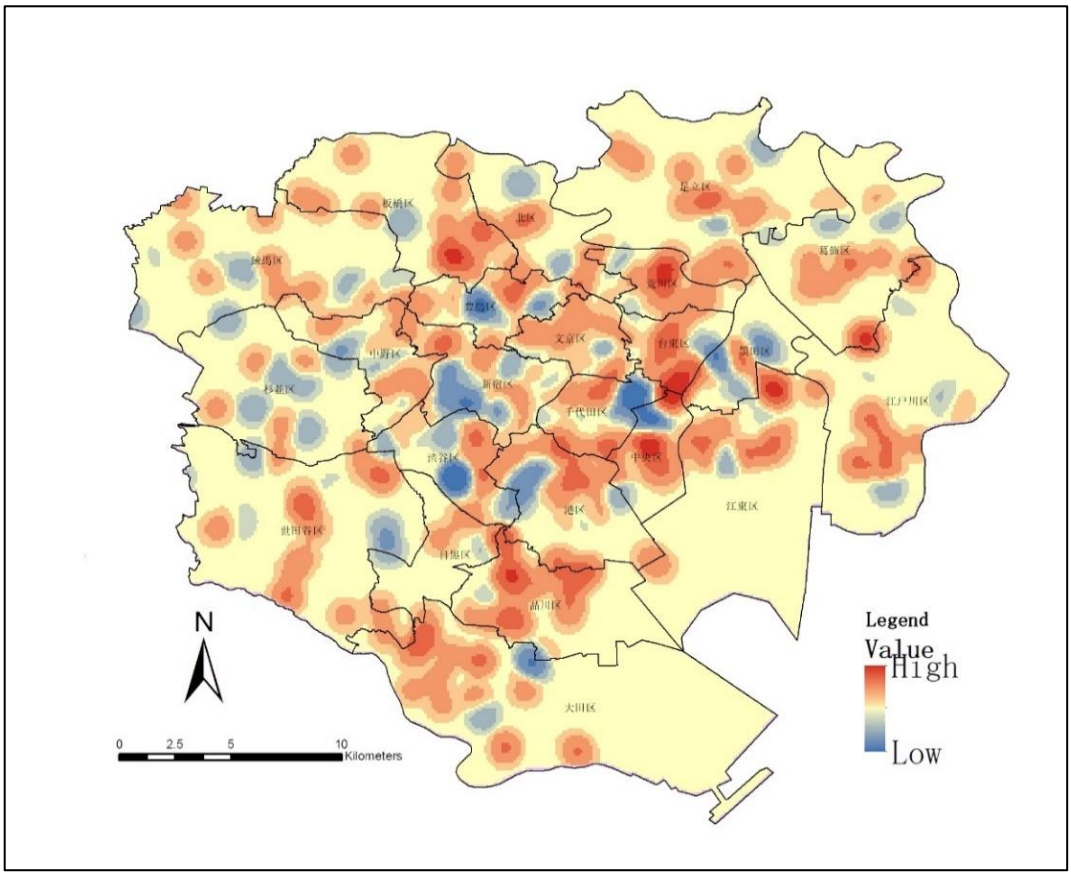

Figure 4.22 Change of Indian Restaurants from 2009 to 2017

Based on the Figure 4.21, it is found out that the newly opened Indian restaurants concentrate in Ginza, Akasaka and Asakusabashi. From the Figure 4.22, we could see the number of Indian restaurants has increased in Ginza, Asakusabashi, Machiya, Naka-Itabashi, Kameido, Shin-Koiwa and Gotanda. Combining the results of the spatial distribution of Indian restaurants in 2017, we could draw the following conclusions. Openings and closures of Indian restaurants have occurred frequently in Asakusa and the number is almost unchanged. As the most prosperous commercial district, Ginza originally had quite a few Indian restaurants, and the number is still increasing in recent years. Asakusabashi is the place where the number of Indian restaurants has increased and formed a new agglomeration cluster in recent years. Machiya, Naka-Itabashi, Kameido, Shin-Koiwa and Gotanda are also the gathering place of Indian restaurants formed in recent years.

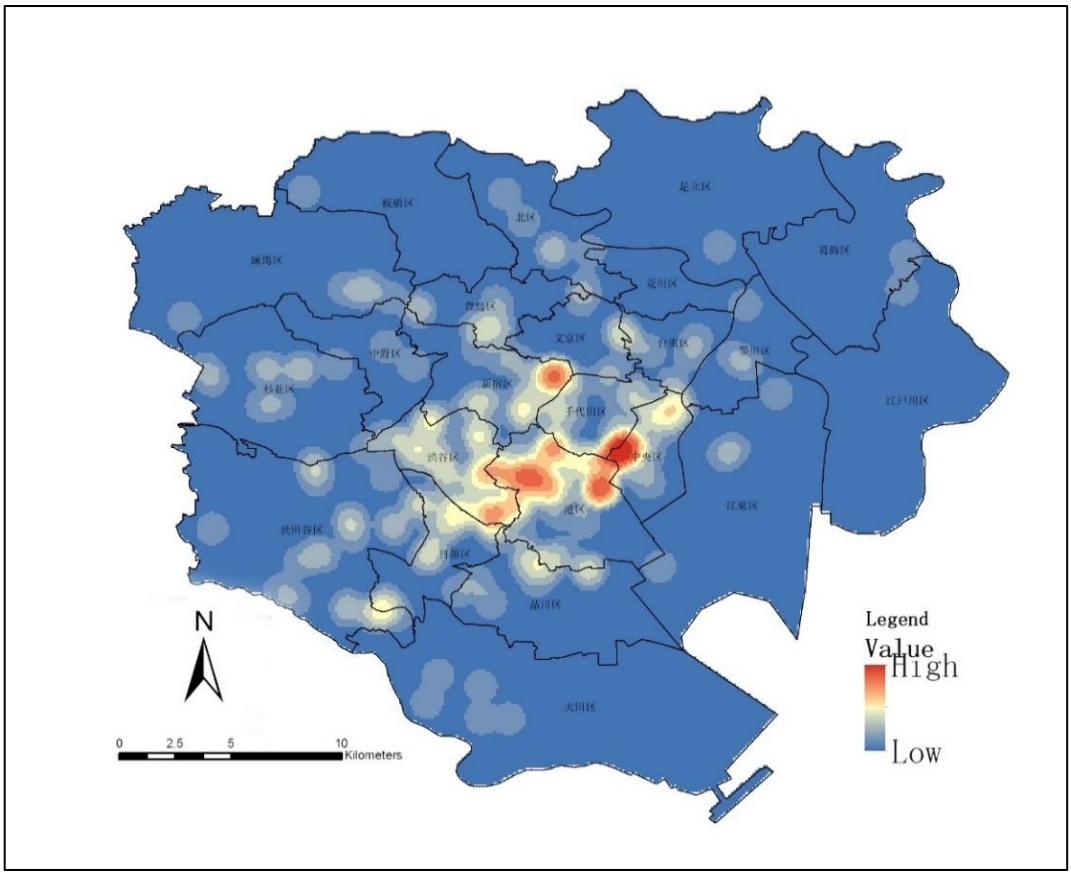

Figure 4.23 Distribution of Newly Opened French Restaurants from 2009 to 2017

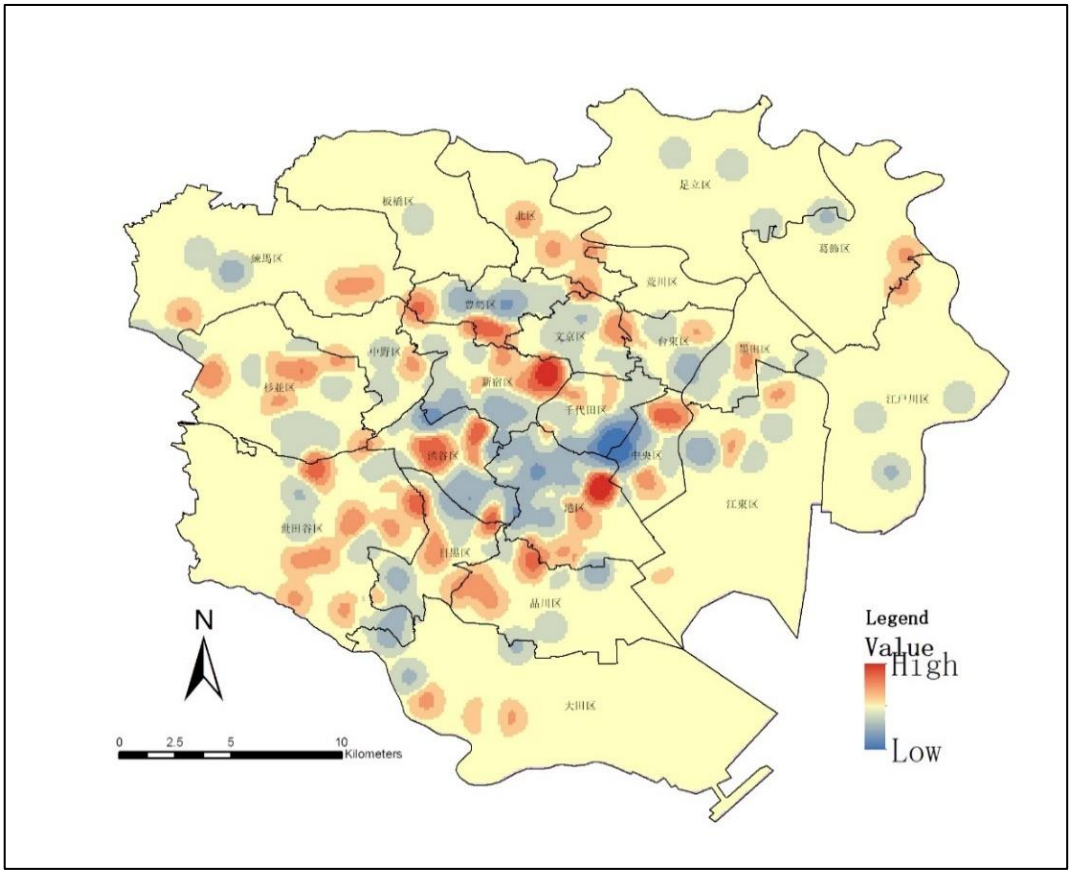

Figure 4.24 Change of French Restaurants from 2009 to 2017

According to the Figure 4.23, Ginza is the place where has the most of newly opened French restaurants. Then Kagurazaka, Roppongi and Hamamatsucho have also opened many French restaurants in recent years. However, these districts are considered as places where French cuisine was already concentrated in 2009. From the result of the change of number, the numbers of French restaurants in Kagurazaka and Hamamatsucho are on the rise, and the number of that in Ginza has not increased significantly. Kagurazaka is a place with French style atmosphere and Hamamatsucho is near Tokyo Tower. It suggests that compared to the traditional bustling business areas such as Ginza, French restaurants prefer to open in modern, fashionable and artistic places.

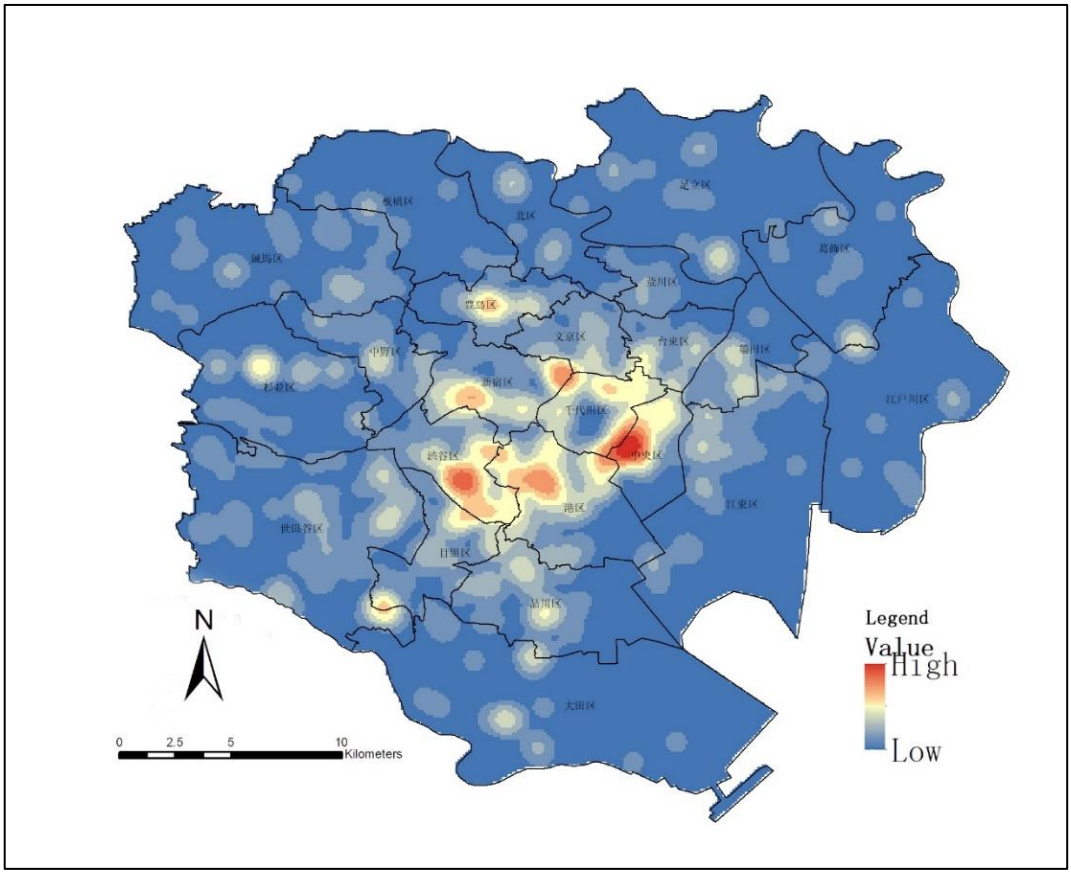

Figure 4.25 Distribution of Newly Opened Italian Restaurants from 2009 to 2017

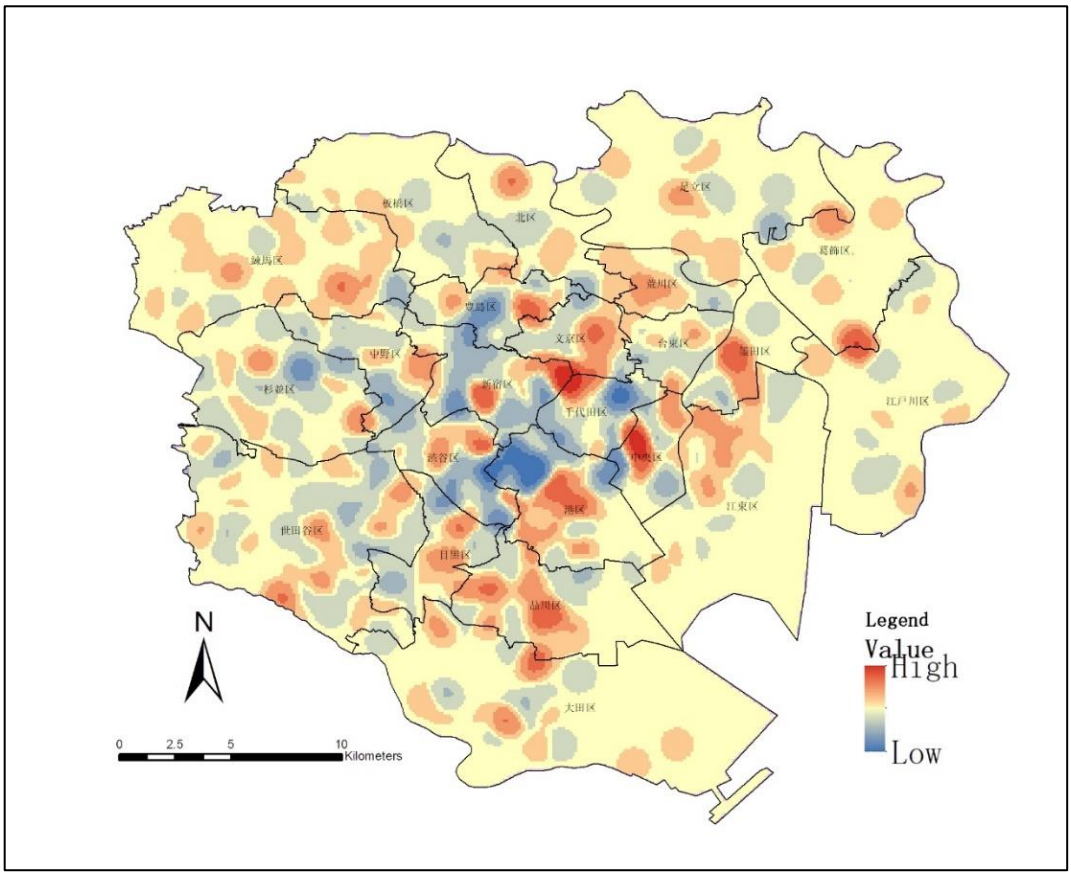

Figure 4.26 Change of Italian Restaurants from 2009 to 2017

As for Italian restaurants, the newly opened Italian restaurants opened in Ginza are the most which is same as other foreign restaurants. The number of openings of Italian restaurants in Shibuya is relatively large, followed by Roppongi and Kagurazaka. From the change map of Italian restaurants, the number of Italian restaurants has increased mostly in Ginza and Kagurazaka. Different from the French restaurants, the number of Italian restaurants in Roppongi has not increased significantly. In addition, we also find out that openings and closures of Italian restaurants in Shibuya are frequent as well.

The clusters of openings districts and increasing districts are summarized in Table 4.7.

Table 4.7 Changed Areas of Foreign Restaurants

	Openings Distribution	**Increasing Distribution**
Chinese	Ginza and Kanda	Hongō and Ebisu
Korean	Shin-Ōkubo and Akasaka	Shin-Ōkubo
Indian	Ginza, Akasaka and Asakusabashi	Ginza, Asakusabashi, Machiya, Naka-Itabashi, Kameido, Shin-Koiwa and Gotanda
French	Ginza, Kagurazaka, Roppongi and Hamamatsucho	Kagurazaka and Hamamatsucho
Italian	Ginza, Shibuya, Roppongi and Kagurazaka	Ginza and Kagurazaka

As a whole, there are three phenomena in the consequences of the evolution of foreign restaurants spatial distribution. One phenomenon is that there are both a lot of openings and increasing of restaurants from 2009 to 2017 in the districts, such as Korean restaurants in Shin-Ōkubo, Indian restaurants in Asakusabashi, as well as French and Italian restaurants in Kagurazaka. These places could be divided into two types. The places represented by Ginza had already gathered many foreign restaurants in 2009 and continued to gather more foreign restaurants in 2017. The other places, such as Asakusabashi where Indian restaurants are gathering, have developed new concentrations through openings of new foreign restaurants. The second phenomenon is that although there is just a relatively low increase of new restaurants in the area, the number of foreign restaurants has grown. This phenomenon mainly occurs in the case of Indian restaurants. It also happened in the case of Chinese restaurants in certain areas, such as Hongō and Ebisu. The third phenomenon is that even

though there are plenty of newly opened foreign restaurants in the area, the total number of foreign restaurants maintains. It indicates that openings and closures of restaurants in these districts happened frequently.

5. Analysis of Influencing Factors

5.1 Analysis of OLS Model

From the chapter 4, we could find out that foreign restaurants gathered in some places that have formed foreigner residential areas or foreign style street, such as Korean town in Shin-Ōkubo, “Little India” in Nishi-kasai and “Small Paris” in Kagurazaka. It is also found out that western restaurants prefer to open in modern, fashionable and artistic places where land prices are relatively high. To explore the correlation between these factors and foreign restaurants, the commercial land price of each ward and foreign population of each ward in Tokyo are collected. The study selects the ratios of each foreign population and the ratios of business land price in each ward as independent variables and selects the ratios of each kind of foreign restaurants as dependent variables. The study conducts five multiple linear regressions for foreign restaurants. The multiple linear regression model is written as:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

Where y is the ratio of each kind of foreign restaurant, x_1 is the ratio of each kind of foreign population; x_2 is the ratio of commercial land price to average commercial land price in Tokyo ward area. β_0, β_1 and β_2 are calculated by Ordinary Least Squares (OLS). In each regression of foreign restaurants, y and x_1 represent the ratios differently. For example, as the regression of Chinese restaurants, y is defined as the ratio of Chinese restaurants to all restaurants and x_1 is defined as the ratio of the Chinese population to all population. Similarly, y and x_1 represent the corresponding ratios.

The OLS regression model is utilized to conduct the global estimation and the results are shown in Table 5.1.

Table 5.1 OLS Results of Foreign Restaurants

	R^2	Adjusted R^2	sig. of F	coefficients		sig. of t-test	Tolerance	VIF
Chinese	0.262	0.188	0.048	population	0.201	0.386	0.999	1.001
				land price	-0.007	0.020		
Korean	0.578	0.535	0.000	population	0.427	0.000	0.979	1.022
				land price	-0.001	0.350		
Indian	0.318	0.250	0.022	population	-0.007	0.973	1.000	1.000
				land price	-0.002	0.006		
French	0.707	0.678	0.000	population	5.008	0.000	0.594	1.685
				land price	0.002	0.229		
Italian	0.373	0.310	0.009	population	31.422	0.018	0.667	1.500
				land price	0.001	0.383		

From the results, we could find out that the significance of Chinese restaurant regression is 0.048 with an R^2 of 0.262. The test of significance of regression coefficients shows that correlation between Chinese restaurants and the Chinese population is not so significant. Based on Tolerance and Variance Inflation Factor (VIF), there isn't multicollinearity between population and land price. As for Korean restaurants, the test value of significance of linear regression is 0 with R^2 of 0.578. The test of significance of regression coefficients shows that it is not significant of land price on Korean restaurants. According to Tolerance and VIF, there isn't multicollinearity between population and land price. The significance of Indian restaurant regression is 0.022 with R^2 of 0.318. The test of significance of regression coefficients shows that there is no significant correlation between Indian restaurants and Indian population. According to Tolerance and VIF, there isn't multicollinearity between population and land price. The linear regression of French restaurants with R^2 of 0.707 is significant. The result of test shows insignificant effect of land price on French restaurants. On basis of Tolerance and VIF, there isn't multicollinearity problem between population and land price. With regard to Italian restaurants, the test value of significance of regression is 0.009 with R^2 of 0.373. The test of significance of regression coefficients shows that correlation between Italian restaurants and land price is not significant. According to

Tolerance and VIF, there isn't multicollinearity between population and land price. Therefore, we could know that for Korean, French and Italian restaurants, foreign population is more important than land price, while for Chinese and Indian restaurants land price is more important compared with the foreign population. Furthermore, there is a positive correlation between land price and French, Italian restaurants, while for Chinese, Korean, Indian restaurants, coefficients of land price show the negative correlation.

5.2 Analysis of GWR Model

However, in the spatial autocorrelation analysis, it is found that there is the spatial autocorrelation in some foreign restaurants. The global OLS regression model that ignores spatial relationships may misinterpret the geographical and economic phenomena of the real society. Therefore, this study also uses the Geographic Weighted Regression model (GWR) model to analyze spatial non-stationarity. Geographically weighted regression was proposed by Fotheringham in 1996 and is a local version of spatial regression. The geographically weighted regression model uses a local weighted least squares method to perform point-by-point parameter estimation by assuming that the regression coefficient is a position function of the geographic location of the observation point, where the weight is the distance function between geospatial location of the regression point and other location of observation points. It allows assessment of the spatial heterogeneity in the estimated relationships between the independent and dependent variables. In addition, the estimated coefficients of the geographically weighted regression model can be visually shown in the map.

As an extension to the global linear regression model, GWR incorporates the geospatial position of the data into the regression parameters. The model expression is as follows:

$$y_i = \beta_0(\mu_i, v_i) + \sum_{j=1}^{i} \beta_j(\mu_i, v_i)x_{ij} + \varepsilon_i \, , i = 1,2, \dots \dots n$$

where (μ_i, v_i) is the location of the sampling point $i, \beta_j(\mu_i, v_i)$ is variable x_{ij} its own

regression coefficient, ε_i is a random error term.

This study utilized the AICc (corrected Akaike Information Criterion) for Bandwidth Method parameter. The formula is:

$$AICc = 2n\log_e(\hat{\sigma}) + n\log_e(2\pi) + n(\frac{n + tr(S)}{n - 2 - tr(S)})$$

where n is the number of observations in the dataset, $\hat{\sigma}$ is the estimate of the standard deviation of the residual, and $tr(S)$ is the trace of the hat matrix. GWR will find out the optimal distance with AICc. Table 5.2 shows comparison of results of OLS and GWR.

Table 5.2 Comparison of OLS and GWR

	OLS			GWR		
	R^2	**Adjusted R^2**	**AICc**	**R^2**	**Adjusted R^2**	**AICc**
Chinese	0.262	0.188	-133.2757	0.262	0.188	-133.2728
Korean	0.578	0.535	-205.5347	0.607	0.549	-205.7112
Indian	0.318	0.250	-194.7540	0.319	0.250	-194.7440
French	0.707	0.678	-185.7263	0.795	0.739	-188.2775
Italian	0.373	0.310	-138.6650	0.504	0.394	-140.2059

From Table 5.2, it could be seen that R^2, adjusted R^2 and AICc of Chinese restaurants and Indian restaurants are almost same between OLS and GWR. Although R^2 and adjusted R^2 of Korean restaurants in GWR are a little greater than those of OLS. AICc in OLS and AICc in GWR are similar. As for French and Italian restaurants, R^2, adjusted R^2 and AICc of GWR are greater than those of OLS. It indicates that there is no difference between OLS model and GWR model for Chinese and Indian restaurants, while the GWR of Korean, French and Italian restaurants fit better than OLS.

5.3 Visualization of Regression Results

To understand the spatial heterogeneity among foreign restaurants, the study visualizes the results of residual, standard deviation of coefficients, coefficients of foreign population and commercial land price. Residual represents the difference between prediction and

observation, which could reflect the particular ward in this Tokyo. Standard deviation of coefficients shows coefficient reliability and standard deviation which over 2.5 times should be checked. Parameter estimation of coefficient of foreign population and commercial land price is shown to display the spatial heterogeneity among 23 wards.

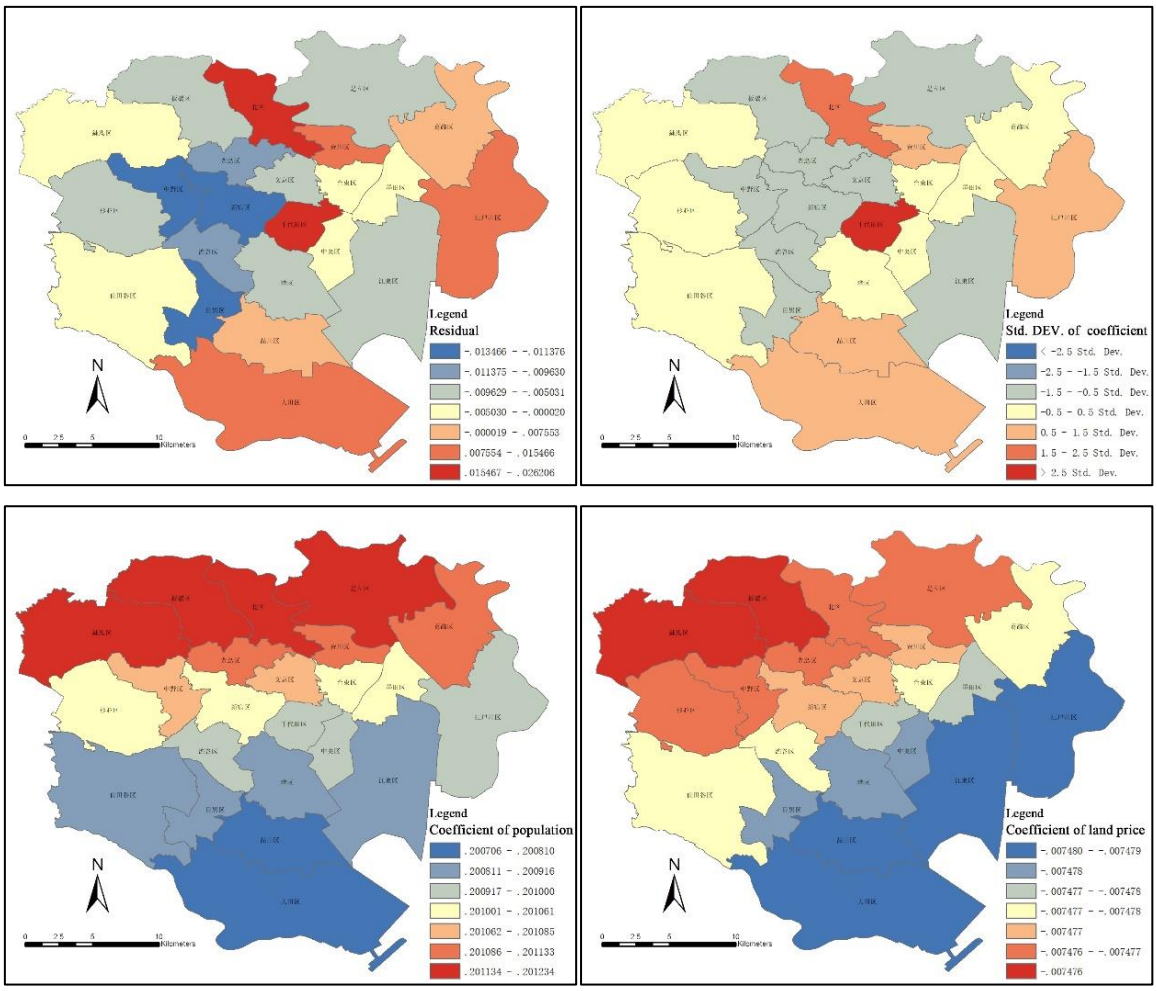

Figure 5.1 Visualization of Regression of Chinese Restaurants

In Figure 5.1, the residuals of Chinese restaurants in Chiyoda and Kita are the highest, which indicates the observations are bigger than the predictions. The standard deviation of coefficients in Chiyoda is over 2.5. It is assumed that it might because the Tokyo Imperial Palace is located in Chiyoda and there are few residential areas. Meanwhile, Yūrakuchō area is one of the biggest commercial areas with high land price and Yūrakuchō area has a large number of Chinese restaurants. Therefore, regression using Chinese population to predict the number of Chinese restaurants is less than the real situation. It also could be found out

that the residuals of Chinese restaurants are small in Shinjuku, Meguro and Nakano. These wards have lower land prices than Chiyoda, Chūō and Minato, while having more Chinese population than other wards. Despite the fact that the coefficients of the northwest of Tokyo wards area is bigger than the southeast, the spatial heterogeneity is weak because of the small difference of coefficients.

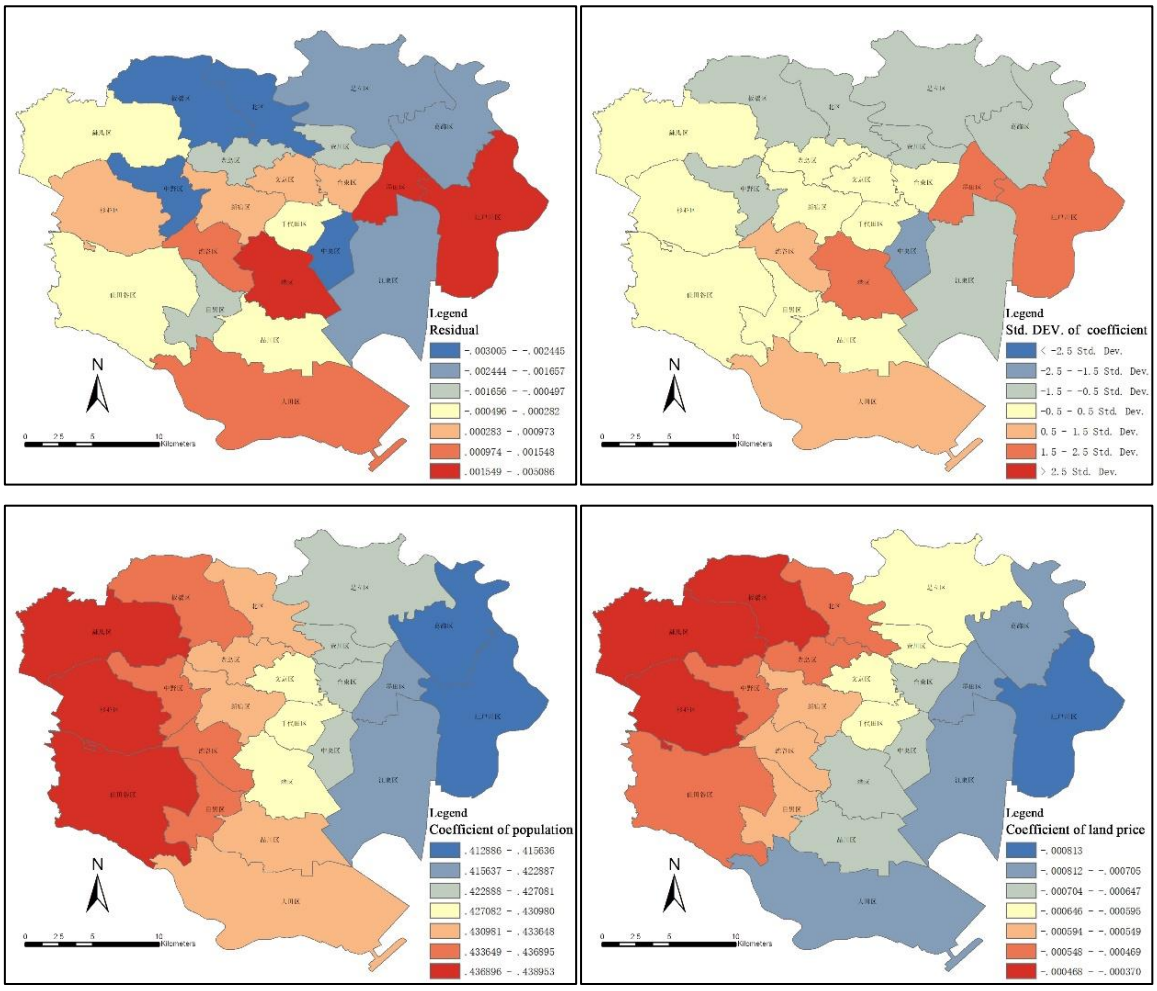

Figure 5.2 Visualization of Regression of Korean Restaurants

From Figure 5.2, the residuals of Korean restaurants in Minato, Sumida and Edogawa are the highest, while the standard deviations of coefficients in these areas are relatively high. In Minato, there is Akasaka area gathering quite a few Korean restaurants. Because of the high land price of Minato, the regression with a negative coefficient of land price will reduce the prediction of Korean restaurants. It could be observed that both the residual of Korean restaurants and the standard deviation of coefficients are insignificant in Chūō. It indicates

that the phenomenon of Korean restaurants gathered in Chūō is not obvious than the other areas. It could be found out that the coefficient of land price and the coefficient of the Korean population in the west of Tokyo wards area are higher than the east of Tokyo wards area. It agrees with the fact that most of Korean restaurants are located in Shin-Ōkubo and affected significantly by the Korean population.

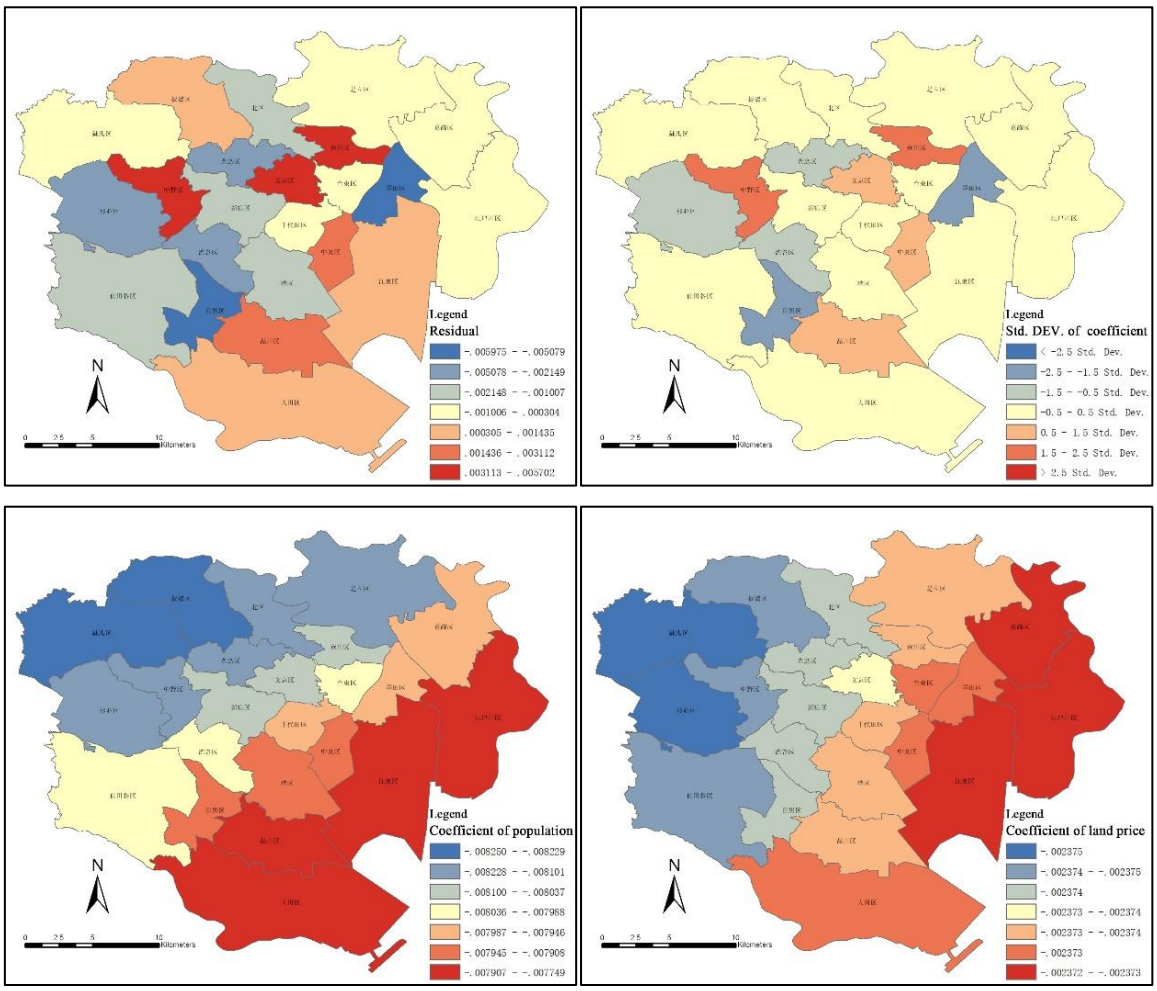

Figure 5.3 Visualization of Regression of Indian Restaurants

According to Figure 5.3, the residuals of Indian restaurants in Nakano, Arakawa and Bunkyo are high, while the standard deviations of coefficients in Nakano and Arakawa are relatively high. The OLS and GWR of Indian restaurants are similar, so the local coefficients are similar to the global coefficient. However, there are quite a few Indian restaurants opened in Nakano and Arakawa in recent years which couldn't be predicted precisely. Furthermore, the residuals of Indian restaurants in Meguro and Sumida are small. In fact, the number of

Indian restaurants in Meguro and the number in Sumida are less than surrounding wards. As the same as Chinese restaurants, the spatial difference among estimated parameters is small. Coefficient of land price and coefficient of Indian population in the west of Tokyo wards area are a little bit less than the east of Tokyo wards area.

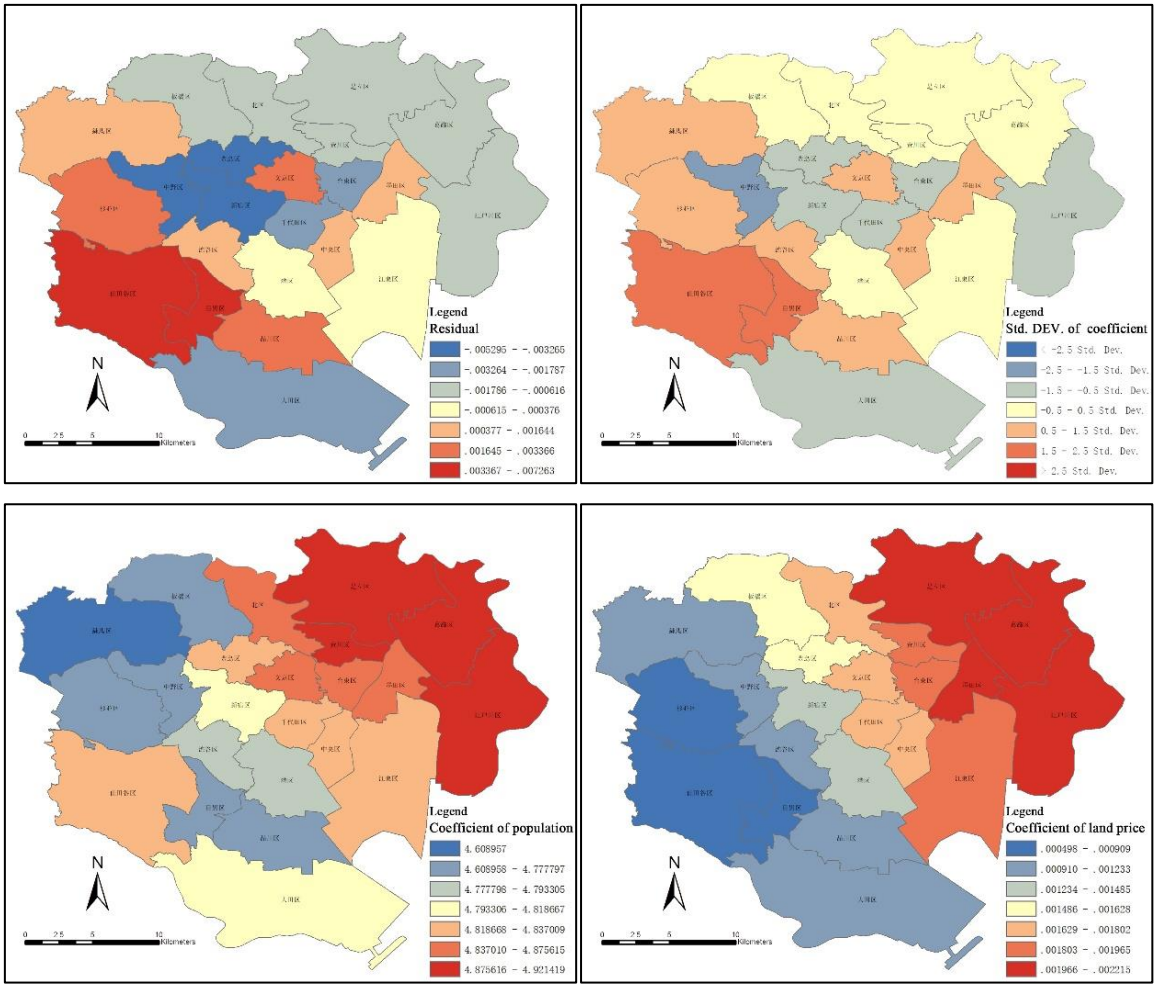

Figure 5.4 Visualization of Regression of French Restaurants

Based on Figure 5.4, we could find out that both the residual of French restaurants and the standard deviation of coefficients in Setagaya and Meguro are greater than other wards. There is little French population and many places gathering French restaurants, so the residual is high. The residuals of French restaurants in Shinjuku, Toshima and Nakano are small, and the standard deviation of coefficient in Nakano is small as well. Because of the facts that many French people live in Shinjuku and Toshima and there are few French restaurants in Nakano, the predictions are bigger than observations. The coefficient of land

price and the coefficient of the French population in the northeast of Tokyo wards area are greater than the southwest of Tokyo wards area. The coefficients are significant in the northeast of Tokyo wards area because the French population and land price are too small in these areas and increasing is more influential for growth of French restaurants.

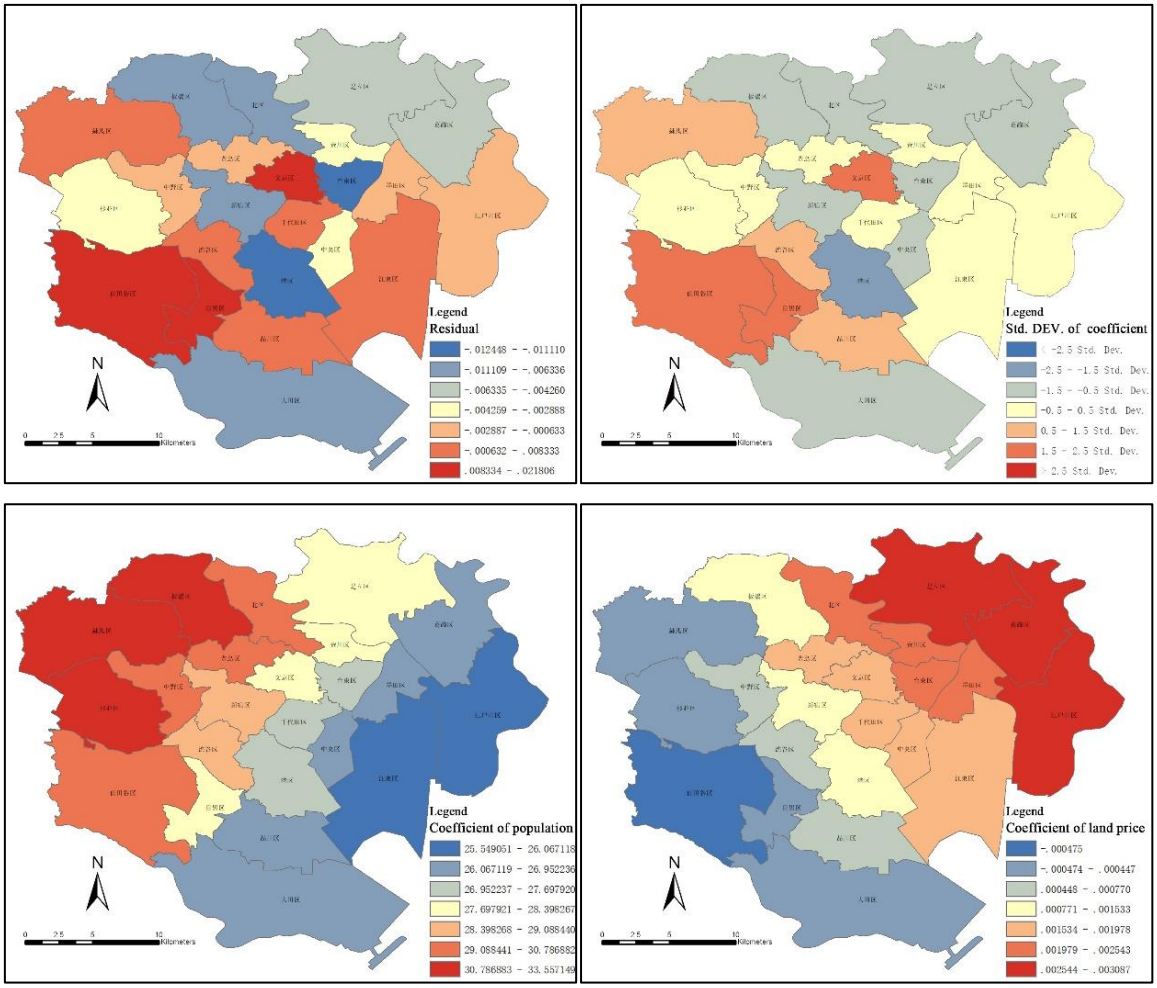

Figure 5.5 Visualization of Regression of Italian Restaurants

For Italian restaurants, the residuals are high in Bunkyo, Setagaya and Meguro. The standard deviations of coefficients are high in these wards as well. It is considered that the Italian population in Bunkyo is small, but the number of Italian restaurants is large here in fact. The situation of Setagaya and Meguro is similar to the case of French restaurants. The residuals of Italian restaurants in Minato and Taitō are small and the standard deviation of coefficients in Minato is small as well. Although the observation of Italian restaurants in Minato is highest, the Italian population in Minato is largest so the prediction is greater than the

observation. We could find out that the coefficient of land price and the coefficient of the Italian population are inconsistent in spatial distribution. The coefficient of the Italian population in the northwest of Tokyo wards area is greater than the southeast of Tokyo wards area, while the coefficient of land price in the northeast of Tokyo wards area are greater than the southwest.

From analysis of OLS and GWR, the following conclusions could be drawn. The regressions of Chinese and Indian restaurants fit only small part of data and there is no difference between OLS and GWR. There is no spatial heterogeneity of population and land price. It is supposed that Chinese restaurants are not reckoned as a kind of distinct foreign restaurants and the spatial pattern is more complex than that of other foreign restaurants, so the selected influencing factors are not significant. Form the result that the effect of factors on Indian restaurants is not significant, the cause is deemed to the inaccurate data due to the population at Kushichōson level. Based on the analysis of kernel density estimation of Indian restaurants, we could believe there is a certain correlation. It might get a more precise regression if there are a more detailed neighborhood data of Indian population. For Italian restaurants, consequences of GWR could explain more than OLS. The regressions fit the French and Korean restaurants better than the others. GWR of French and Korean restaurants fit better than OLS as well. Geographic Weighted Regression model shows spatial heterogeneity of population and land price on Italian, Korean and French restaurants.

6. Conclusion

6.1 Summary

This study explores the spatial distribution of five kinds of foreign restaurants in Tokyo wards area. Gini coefficient and Lorenz curve are used to capture the overall agglomeration degree of restaurants in 2017. Chinese restaurants and Indian restaurants show low Gini coefficient, which indicates even distribution of restaurants. On the contrary, Korean, French and Italian restaurants present uneven spatial distribution. Global Moran's I is utilized to analyze spatial autocorrelation of foreign restaurants. The results indicate that French and Italian restaurants do have spatial autocorrelation on distribution. Spatial autocorrelation of Chinese restaurants is relatively significant, followed by Korean restaurants. Indian restaurants distribute scatteredly and show no spatial autocorrelation based on the result of Global Moran's I. Method of Kernel Density Estimation is employed to visualize the spatial clusters of foreign restaurants. As shown on the map, spatial cluster characteristics of foreign restaurants are concluded as follows. Some Chinese, Indian, French and Italian restaurants gather in business area, like Ginza. It also could be found out that various foreign restaurants locate in sightseeing districts. Spatial clusters reveal the location preference of each kind of foreign restaurants as well. Foreign restaurants tend to gather with the formation of ethnic neighborhoods, such as Korean town in Shin-Ōkubo, 'Little India' Nishi-kasai and Kagurazaka with Paris style. This study also visualizes the spatial distribution of newly opened foreign restaurants and the areas where the number of foreign restaurants has grown from 2009 to 2017. The result suggests that openings and closures of foreign restaurants happened frequently in some places, like Ginza, and other places have developed into new concentrations of foreign restaurants, like Indian restaurants opening in Asakusabashi. Ordinary Least Squares model and Geographic Weighted Regression model are utilized to explain the correlation between influencing factors and foreign restaurants. Significance of foreign population and land price is different depending on the type of foreign restaurants. Geographic Weighted Regression model also demonstrates the spatial heterogeneity of the estimated parameters.

In brief, this study makes several contributions as follows. First of all, the visualization of spatial distribution could help us observe the cluster phenomenon of foreign restaurants in Tokyo wards area. Secondly, the analysis of the causes of distribution phenomenon makes us gain understanding more accurately. It could change the stereotype of position of foreign restaurants. Finally, this study contributes to the further extension of geography research content. It might help scholars to do further research of foreign culture on a macro level.

6.2 Future Research

There are still several problems and shortages in this research, and it is hoped that these problems would be solved in the future. The data of restaurants provided by Telepoint Pack are decreased gradually. Thus, these data can't be used to study closures of restaurants. Compared to the number of point data, it is assumed that ratio will solve the accuracy problem. The other problem about data is the foreigner population can only be collected by kushichōson level. It leads to the results of regression insignificant. It is expected more detailed population data would be collected to do precisely research. The study uses the same influencing factors to analyze the foreign restaurants. For each kind of foreign restaurants, there might be more factors influencing the distribution and the influencing factors might be different. However, this study only conducts the macro level analysis. The agglomeration phenomenon of each district could be studied much deeper. It is hoped that the study of foreign culture in geography will become more perfect and practical in the future.

Appendix

The Translation Table of 23 Wards

Japanese	**English**
千代田区	Chiyoda
中央区	Chūō
港区	Minato
新宿区	Shinjuku
文京区	Bunkyo
台東区	Taitō
墨田区	Sumida
江東区	Kōtō
品川区	Shinagawa
目黒区	Meguro
大田区	Ōta
世田谷区	Setagaya
渋谷区	Shibuya
中野区	Nakano
杉並区	Suginami
豊島区	Toshima
北区	Kita
荒川区	Arakawa
板橋区	Itabashi
練馬区	Nerima
足立区	Adachi
葛飾区	Katsushika
江戸川区	Edogawa

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