Tourism Geographies 2018

https://doi.org/10.1080/14616688.2018.1457076

From Central Place to Central Flow Theory

-----An Exploration at the City Scale of Urban Catering Industry, Nanjing, China

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Abstract

The research shift from Central Place Theory to Central Flow Theory has demonstrated the influence of information technology on cities. The study explores this shift at the city scale of urban catering industry in Nanjing, China. A comprehensive set of indicators of E-WoM for the catering industry has been established. Based on this, the spatial distribution patterns of catering industry in Nanjing, China have been discussed to examine the relationship of restaurants distribution and the Central Place Theory or the Central Flow Theory using a data analytical approach. The results revealed that the spatial distribution of restaurants' density in Nanjing follows a traditional Central Place Theory, but the spatial distribution of restaurants' E-WoM in Nanjing rather follows the Central Flow Theory. In addition, different characteristics could be found in different types of restaurants' E-WoM distribution. Mainstream cuisine follows Central Place Theory but is inconsistent in urban business districts, which demonstrate some characteristics of Central Flow Theory. The distribution of E-WoM of non-mainstream cuisine is similar to the E-WoM distribution of overall restaurants, showing a central flow pattern. Finally, the implications of the study are drawn.

Key words: Central Place theory; Central Flow theory; catering industry; spatial distribution; data analytical approach; Nanjing

1. Introduction

Central Place Theory indicates that residents tend to visit the nearest city to buy goods and services when they are restricted by market, transportation, and administration (Christaller, 1933). Urban development presents a strict hierarchal distribution. However, the development of regions and cities has no longer been analyzed in a closed system because of globalization. Cities became closely

linked due to the development of a comprehensive transportation network, therefore leading to the formation of a complicated urban network. In this process, the development and extensive use of information communication technology (ICT) have accelerated the exchanges of information, population, capital, goods, and other elements among cities (Zhen et al., 2012a). Castells (1989) focused on the emergence of a new technology paradigm with the influence of ICT and proposed the concept of "flow space". He also distinguished flow space and place space, as well as expanded the flow space from pure virtual technology space to geographical space and social network scale (Castells, 1996). Taylor et al. (2001, 2008, 2010) further found that the level of spatial distribution of "Central Place" theory has evidently been changed by "Central Flow" theory. They suggested that the vibrant city is the center of the spatial flow, and the complexity of the flow is evident in non-local characteristics of the city population, goods and ideas. The hinterland of the city may not be adjacent to a certain range of space, but the distribution tends to be fragmented.

In order to adapt to this trend of fast change, scholars have gradually found the new breakthrough in paradigm, content and method of research, which outstandingly uses network information data to study flow space and place space (Zhen et al. 2015). They focused on the regional urban network and their flow patterns by analyzing the Network infrastructure data (e.g., backbone network bandwidth and network number, internet domain name or IP address) (Zook, 2001; Wang et al, 2003; Wang et al, 2006; Zook and Graham, 2007), social network data (e.g., Twitter, Weibo) (Naaman et al, 2012; Zhen et al, 2012), and mobile phone data (Krings et al., 2009; Kang et al., 2012). However, these theories and methods were mainly used to explain interactions between the cities, and research on the spatial distribution of production factors within the city is limited. Several questions remain unexplored. Do the spatial patterns of production factors within a city follow the rules of central place theory? Can the central flow theory be used to explain new phenomenon? Does the new phenomenon demonstrate the features of central flow theory at regional scale? Can traditional data on urban interior space support and explain the new phenomenon? Is there any new dataset to explain these phenomenon? Therefore, these research questions need further exploration.

Due to the fast development of information technology, especially the ICT platforms such as dianping.com (a Chinese website that allows users to buy coupons and post review comments on food and dining experiences), consumers' behavior of dinning in restaurants based on the Central Place Theory has changed (Lien-Ti Bei, et al., 2004). On one hand, the information about restaurants on the platform has given consumers more choices, providing more dining flexibility and expanded the scope of their activities (Qin, et al., 2014). On the other hand, comments made by other consumers on the review websites (positive or negative) also change the spatial and temporal behavior of consumers' dining activities. It is precisely these forces (Eckardt, 2008) that may lead to the change of distribution of those restaurants that traditionally followed urban business districts, creating more mobility for consumers. As can be seen, after the emergence of new internet platforms, the spatial distribution of the traditional catering industry might change. Traditional central place theory that reflect the rule of spatial distribution of urban catering industry might change the decision making and consuming behavior, and the spatial distance between organizations might increase. Therefore, this paper uses urban catering space which has significantly been influenced by new technology as a study object, and explores Nanjing, China as the case area. The paper tries to explore the application of central place theory and central flow theory in production elements within

the city with the influence of new technology. Current studies on catering industry mainly adopt traditional methods, which include the use of spatial and statistical data such as catering location, scale, price, spatial and statistical data and explore the spatial distribution pattern and its determinants at urban macro level; or the use of consumer word of mouth information through questionnaires to evaluate the service quality of catering providers with a relatively limited sample. However, these types of data, which reflect the spatial information, lack information on catering flow space, which is actually reflected by consumers' and catering providers' behavior with new platforms. In recent years, E-WoM which refers to electronic word of mouth (King, Racherla and Bush 2014) has gradually become an important factor influencing consumer behavior (Berger, 2014), and can be used to reflect urban catering providers' attractiveness to consumer behavior without the constraint of spatial distance.

This paper uses Nanjing, China as a case study, using E-WoM from online reviews, to discuss the spatial pattern of urban catering industry and to explore the application and new features of central place theory and central flow theory at urban scale. To be specific, the research questions include: 1) what is the E-WoM of urban catering industry in Nanjing? 2) What is the spatial pattern of urban catering providers and its relationship with central flow theory in Nanjing? 3) What is the spatial pattern of E-WoM of urban providers and its relationship with central place theory, and whether it fits with the features of regional urban network of central flow theory in Nanjing? 4) Do different types of catering providers' E-WoM reflect the providers distribution pattern?

2. Literature review

2.1 From Central Place Theory to Central Flow Theory

Since Christaller's Central Place Theory was proposed in 1933 (Christaller, 1933), location and spatial distribution pattern of urban service industry have always been a research focus. The research scope mainly involves Commercial Service Industry and Productive Service Industry. Christaller (1933) suggests that customers will travel only to the nearest central place that provides goods and services that they demand, and goods are purchased from the closest place. Yuan, Wei and Chen (2010) conclude that classical location theory emphasizes on economic factors and suggest that labor costs and market opportunities are critical. Ohlin (1933) suggests that the Neo-classical trade theory introduces exogenous factors such as natural resources, labor and technology to the location selection. New economic geography theory suggests that connections to other businesses and traffic costs lead to a cluster of businesses (Krugman, 1991).

Globalization has made the cities no longer a closed local system separated from others, as a comprehensive transportation network has made cities and facilities closely linked, forming a dynamic regional urban network (Zhen et al, 2007). Researchers have now modified the ideal hierarchical central place model. Through a study on Northeast America, Gottmann (1961) finds 'horizontal and non-hierarchical, polycentric' network pattern in urban areas, which contains two or more than two separated cities, and is connected with fast and convenient traffic corridors, emphasizing the node role of cities in the network rather than the central role（Batten, 1995）. Camagni and Salone（1993）suggest that different from critical factors in Central Place Theory,

such as economic scale, production scale, demand and market scale; the micro economy and local enterprises network is the driving factor of urban regions (Camagni and Salone, 1993; Batten 1995; Knaap 2002; Meijers 2006).

In recent decades, the rapid development and wide application of ICT has brought the speedy exchange of factors at spatial and temporal levels, such as information, population, capital and goods in the city (Schwanen et al., 2006), which has continuously expanded the scope of urban production and residents' activities, as a result the urban network model is continuously improved. Castells（1989）was one of the first who focused on the emergence of new technology paradigm under the influence of information technology, emphasizing the importance of information processing and process innovation, and put forward the concept of 'flow space' based on information technology. Castells（1996）further distinguishes flow space and place space, and expands the flow space from pure virtual technology space to geographical space and social network scale. Therefore, based on theories of Camagni and Salone (1993) and Castells (1996), Taylor et al. (2001, 2008, 2010) further use the interlocking network model to evaluate the relationship between cities. They find that the level of spatial distribution of 'Central Place' theory has obviously been changed by the 'Central Flow' theory, such that the vibrant city is the center of the spatial flow, and stress the complexity of the flow, which is non-local characteristics of the city population, goods and ideas. The hinterland of the city may not be adjacent to a certain range of space, but the distribution tends to be fragmented.

However, urban network model or Central Flow Theory cannot replace Central Place Theory, as the former represents the spatial characteristics of urban regions in the service economy while the latter explains the relationship of cities in industrial economy (Camagni and Salone,1993; Batten,1995; Knaap, 2002; Meijers, 2006). To be specific, with the background of globalization and informatization, the following features appear in regional space: 1）The role of the central area has not disappeared, and the urban or regional space still has a certain hierarchy； 2) cities with large population and commodities might not have a high grade in the region, while cities that act as the hub or important node function of regional population and commodity flow network will become a higher grade center; 3) the spatial gathering effect of the traditional geographical factors is weakened, the dispersion effect is enhanced, the regional center develops independently, and the fragmentation of the urban hinterland becomes obvious.

The urban network model and Central Flow Theory originate from Central Place Theory, and both are expansions and improvements of Central Place Theory at different stages of urbanization and technology development, and explore the relationship of urban production factors and spatial distance in a certain region (Smith, 1985). However, these theories are mainly used to explain interactions between the cities, and research on the spatial distribution of production factors within a city is limited or in other words, there is need to study further these features of Central Flow theory which can be found within cities.

2.2 The spatial distribution of the catering industry

First, a definition of the catering industry is provided before any further discussion. Catering refers to "the provision of food and beverages away from home" (Davis et al.,1998). Smith and West (2003)

and Fusi (2016) divide catering sectors into profit and non-profit activities. Bourlakis and Weightman, (2004) suggest that the profit catering sectors include restaurants, fast-food chain outlets, cafes, takeaways, pubs, leisure and travel catering outlets, while the non-profit sectors refer to catering outlets for business, education and health care (Fusi, 2016). In this research, only the profit sectors have been considered, therefore the study objects in this research website include restaurants, cafes, fast-food chain outlets, cafes and takeaways which are available from the online platform of dianping.com.

With the guidance of traditional Central Place Theory, the spatial distribution of food and beverage industry is a research topic that scholars pay close attention to. Similar to the spatial distribution of other service industries (Zhou et al., 2010; Zhen et al., 2012), most scholars believe that the distribution of urban restaurants follows the rule of falling from the city's Central Business Districts (CBD) to the periphery areas. There are aggregated clusters and territorial distribution within each area (Gwohshiung et al. 2002; Zhang and Xu, 2009), and generally speaking, these are closely related to traffic routes (Hu and Zhang, 2002). Meanwhile, the level of restaurants and the development level of business districts show high coupling (Zhang and Xu, 2009). Muller and Inman (1994) believe that urban restaurants mainly scatter in the urban retail areas, and are customer oriented. Restaurants that are located near each other form a broad central system, and are linked with urban retail and residential areas. Many factors have been found critical to the spatial distribution of restaurants at the city level, such as traffic accessibility (Melaniphy, 1992； Austin et al., 2005), urban spatial pattern, economic development (Liang, 2007； Zhang and Xu, 2009; Shu et al, 2012), population density (Liang, 2007; Shu et al, 2012), infrastructure (Hu and Zhang, 2002; Austin et al., 2005), market demand (Smith, 1995; Hu and Zhang, 2002), cultural factors (Liang, 2007; Zhang and Xu, 2009), land availability (Shu et al, 2012), density of competitors (Litz and Rajaguru, 2008), number of complementary stores (Schaefer et al., 1996)， land price (Hu and Zhang, 2002) and urban tourism activities (Liang, 2007). Other factors at the restaurant level include; scale and cost (Smith, 1995; Timor and Sipahi, 2005; Shu et al., 2012), type of restaurant (Teller and Reutterer, 2008; Zhang and Xu, 2009), parking facilities (Tzeng et al., 2002) and identity (Schaefer et al., 1996; Melaniphy, 1992).

It can be seen that current research on restaurants' spatial distribution pattern mainly focus on scales and levels of restaurants, and the distribution patterns of 'circular diminishing, closely related to traffic arteries, coupling with retail trades' can be explained by Central Place Theory. However, there is very limited research on restaurants' distribution and Central Flow Theories considering the influence of ICT. Researchers mainly discuss the factors that influence restaurants' location at the city level, but hardly consider the restaurants quality. Indeed, except the factors such as scale, cost, type, parking facilities and identity, other factors such as customer preference, type of food, atmosphere, service, decoration, reputation, brand, value, may all influence the choice of restaurants (Kivela, 1997; Yuksel and Yuksel, 2003; Baek et al., 2006; Kincaid et al., 2010). These are critical factors influencing the spatial distribution of urban restaurants.

2.3 E-WoM

Hospitality is part of the service industry. Researchers suggest consumers often rely heavily on

friends and family when they try a new type of service, and therefore, word of mouth (WoM) as an influential factor can influence consumer decision making (Anderson, 1998; Brown et al, 2007).

Traditionally, marketing communication is passed and benefited through family and friends (Brown and Reingen, 1987). Nowadays, the internet is regarded as the most innovative technology over the last few decades (Beldad et al 2010). With the fast development of internet, particularly the web 2.0 which allows customers to share their experiences and comments online, WoM has now shifted to E-WoM, expanding networking from family and friends to people who are connected online. Hart and Blackshaw (2006) suggest that compared with traditional word of mouth, "Word of Web" can include a social network that spans globally. E-WoM provides browsers with wider information, their views on the tangible products based on their memories of past time leisure experiences in tourism cities, hotels, airlines and restaurants (Yoon, 2009). Senecal and Nantel (2004) suggest that consumers show a tendency of making purchases following online recommendations. Zhu and Zhang (2012) also suggest that online recommendations significantly influence sales. Gretzel and Yoo's (2008) research suggest that three-quarters of travelers have taken consideration of online consumer reviews when planning their holiday journeys.

E-WoM has become popular and become a key source of information about specific products (Litz and Rajaguru, 2008; Hollenstein & Purves, 2010). Beverly and Browning (2010) indicate that consumers prefer easy-to-access and easy-to-process information online.

Catering is the sub-industry of commercial industry, its commercial tenant is a significant part of urban entity space, and a necessary and fundamental link of urban space units. Although there are many studies on spatial distribution features of urban catering tenants, research methods and data collection used are straightforward, and not enough attention has been paid on flow space and its spatial distribution pattern. With the popularization of network information technology, e-commerce is gradually changing the way of traditional marketing. It has increasingly become a significant factor that influence consumer decision-making, it may also influence catering provider's spatial distribution. E-commerce can be used to reflect the mobility (flow) of consumer dinning behavior without the limitation of spatial distance. Therefore, understanding spatial distribution pattern of urban catering industry and its E-WoM will be good explorations of Central Place Theory and Central Flow Theory.

2.4 Study Area

Nanjing is one of the core cities of the Yangtze River Delta urban agglomeration, and its spatial pattern shows a typical multi-center hierarchical structure. According to the Nanjing Statistical Yearbook (2016), as at the end of 2015, Nanjing has a total population of 8.23 million people. Nanjing has 27 business districts which include Xinjiekou, Hunan Road/Shanxi Road area, Confucius temple area, the Zhujiang Road area, the Taiping road area, the Ruijin Road area, Nanjing University/Nanjing Normal University area, Caochangmen/Longjiang area, Xuanwu Lake Park area and the Sanpailou area. According to the Master Plan of Nanjing (2011-2020)[①], which provides the overall evaluation of a trading area according to its population scale and density, economic output, land price, infrastructure etc., Xinjiekou is regarded as the highest grade trading area in the city, the

second highest grade areas include Hunan Road/Shanxi Road area, Confucius temple area, and the Zhujiang Road areas. Areas along the Taiping road, the Ruijin Road, Nanjing University/Nanjing Normal University area, Caochangmen/Longjiang and Xuanwu Lake Park area are district business centres.

Established in April, 2003, Dianping.com is the earliest established third-party review website in China. The website establishes its pattern mainly with reference to Zagat Survey of the US. Registered members are able to post their comments freely on the website after their consumption in a restaurant, to provide objective and precise commentary information for potential customers. Till the third quarter of 2015, active users of dianping.com were over 200 million every month, the number of comments were over 100 million, the number of restaurants providers were over 20 million and it covered more than 250 cities in whole China, and had almost 20 billion monthly page views[1]. The website mainly includes information of services in the city such as food, leisure and recreation, and shopping, together with related activity sections such as coupons, groupons, and check-in deals. The section on catering, has the most comment information, forming an enormous database of E-WoM that can influence decision-making in dining.

3. Methodology

Big data method is a full sample method based on data mining, and the data processing of relevant information recorded on the object, and the analysis of patterns is at a larger scale (Zhen et al. 2015). Applied to the studies of catering industries' spatial pattern; on one hand, big data can be used to understand urban dining space and distribution pattern in real time through restaurants location, reduce the limitation in slow data updating, and small sample restrictions of traditional research methods such as questionnaires or interviews. On the other hand, consumers can also use the evaluation score of each restaurant, to understand the overall development of the quality of the catering industry, compensating the missing information of restaurants such as quality, reputation, user preference in a traditional method.

3.1 Data collection

Firstly, based on the internal standard of dianping.com, namely, "overall evaluation star level", we removed comment information of 10, 520 catering providers that haven't acquired evaluation star level. This is because 1) the restaurants may have low reputation, invalid information, and repeated registration; therefore, scored 0 on many indicators, making it hard to make calculations in the final model; 2） these restaurants have less attention and comments from consumers mainly because they are usually small in scale. As a result, 3, 645 valid catering providers remained. Both customer reviewers and restaurant data were collected. Such as reviewer's comments data include: Dish score (1-30 points), Atmosphere score (1-30 points), Service score (1-30 points), Per capita consumption, Star-levels of overall comments (1-5 stars). The score was given by customers and calculated by the website itself. The restaurant data include: the Number of web page visitors, Number of comments, Number of comments (credible), Number of comments by group buying, Number of interested

[1] http://www.dianping.com/aboutus

people, Number of check-ins, Number of recommended dishes, Number of atmosphere comments, Number of special service (e.g., WiFi, parking space) comments, Number of branches. These data were collected from the website. Secondly, we quantized text data, such as 'average spending 50 RMB', "three star" in the overall score, and number of franchises. Information such as 'average spending 50 RMB' 'three star' were calculated by the website itself (usually the average mean score) based on review scores. Data was then entered into EXCEL 2007, SPSS 20 and ArcGIS. Then, on the basis of catering providers' detailed address we built up a database of catering providers' spatial location combined with Google Maps. It is important to note that no star evaluation does not represent poor service quality, but mainly indicates that lower attention was paid by customers on such catering providers. There is no secondary comments that were excluded from the data analysis. All data was collected from the website. The time range for the comments were collected from 2003 (since the website was created) to 30 Aug, 2016.

3.2 Establishment of E-WoM evaluation index system

Based on the availability of the data and the previous studies (Kivela, 1997; Yuksel and Yuksel, 2003；Baek et al., 2006; Kincaid et al., 2010; Tao et al., 2011), we establish an E-WoM evaluation index system for classifying and screening data we obtained, from 6 aspects of comments on restaurants, namely; popularity, dish quality, atmosphere, service quality, scale and grade, and level (Table 1). There are 15 indicators at the second level: X_1 is the total visit by customers, referring to the total number of visits, customers have made to the website of a restaurant;；X_2 is the total number of comments, referring to the total number of comments made by customers；X_3 is the default number of comments, referring to the reliable comments through web screening; X_4 is the number of group comments, meaning the number of comments from those who bought group coupons from the website；X_5 is customer favorite rate, referring to the number of customers who rate the restaurant as their favorite; X_6 is check-ins, referring to the number of customers who visit the restaurants through the website of dianping.com；X_7 is the overall rating of dishes by customers (scored 1-30)；X_8 is the total number of recommended dishes, referring to the total number of recommended dishes in a restaurant by customers（the website provides rating buttons for all dishes in the restaurant, and customers click on a particular dish to recommend it）；X_9 is the general atmosphere, referring to the score of general atmosphere in the restaurants by customers（1-30）；X_{10} is the total number of atmosphere type rating,（the website provides voting buttons of atmosphere type such as business gathering, friends gathering, family gathering, etc., each time a customer clicks on a certain atmosphere and is supposed to be evaluated once）；X_{11} is the total score of services, referring to customer rating of restaurant service（1-30）；X_{12} is the total number of comments on special services，thus the total number of comments by customers (the website provides rating buttons for special services such as WIFI, parking etc., each time a customer clicks on a certain atmosphere and is supposed to be evaluated once）；X_{13} is the average consumption per person；X_{14} is the number of branches, referring to the number of branches of this restaurant in Nanjing；X_{15} is the general star rating of customers，thus the total rating of the restaurants by customers. We believe that E-WoM should not only include the direct comments (scores or star rating on the web by users) on food, service, environment etc., but also include the attention from consumers. Generally speaking, restaurants with good E-WoM would attract more attention from consumers (such as, websites browsed, comments made, dishes recommended, service

recommended etc.). Ideally, indexes should be set up according to theory. Due to the limited studies on evaluation of restaurants' E-WoM score, the evaluation index was selected mainly based on data availability of the website while considering previously suggested elements of restaurants, such as dish quality, asmosphere, service quality etc. (Kivela, 1997; Yuksel and Yuksel, 2003; Baek et al., 2006; Kincaid et al., 2010; Tao et al., 2011). The 6 indexes at the first level were a combination of previous literature and current data on the website, the 15 indexes at the second level were the data from the website and then put into each of the 6 different categories according to the nature of the index. A combination of these indicators can be used to measure restaurants' E-WoM in a more comprehensive and complex way. Each of the 3,645 catering providers include review data of those 15 indexes. The data size (number of reviews) is 54,675(3645x15).

Table 1 E-WoM evaluation index system of catering industry in Nanjing urban area

First-class index	Second-class index
Popularity	X_1 Number of web page visitors
	X_2 Number of comments
	X_3 Number of comments (credible)
	X_4 Number of comments by group buying
	X_5 Number of interested people
	X_6 Number of check-ins
Dish quality	X_7 Dish score (1-30 points)
	X_8 Number of recommended dishes
Atmosphere quality	X_9 Atmosphere score (1-30 points)
	X_{10} Number of atmosphere comments
Service quality	X_{11} Service score (1-30 points)
	X_{12} Number of special service (e.g., WiFi, parking space) comments
Scale and grade	X_{13} Per capita consumption
	X_{14} Number of branches
Level evaluation	X_{15} Star-levels of overall comments (1-5 stars)

4 Results

4.1 Comprehensive assessment of the catering industry's E-WoM in Nanjing urban area

4.1.1the E-WoM score of the catering industry in Nanjing varies widely

E-WoM scores vary widely in Nanjing. First, according to the E-WoM evaluation index system established earlier and the data of the 3,645 catering providers from Daiping.com, a dataset was established in SPSS20. Then KMO and Bartlett test was conducted. Results showed that the KMO value was 0.839, Bartlett test of spericity's P value was 0.000, which indicates a remarkable

difference between correlation coefficient matrix and unit matrix. According to KMO metrics (generally, KMO value above 0.7 is suitable for Principal Component Analysis), the data was suitable for Principal Component Analysis. In order to illustrate interpretive degree of each principal component more clearly, the varimax rotation was used in our analysis. From Table 2, we can see, the eigenvalue of the 4 principal components were 5.594, 2.859, 1.992 and 1.035, all are greater than 1, and the cumulative contribution reached 76.531%. The first and the second components contribute a total of 56% to the E-WoM evaluation, while the third and fourth components only contribute 20%. Based on the principle of eigenvalue of principal component greater than 1 or cumulative contribution greater than 75%, it shows that the 4 principal components after Varimax rotation could well explain the E-WoM evaluation of catering industry in Nanjing urban area.

Table 2 Total variance explained

Main Component	Rotation Sums of Squared Loadings		
	Eigenvalue	Variance contribution rate (%)	Cumulative variance contribute rate (%)
1	5.594	37.293	37.293
2	2.859	19.062	56.355
3	1.992	13.279	69.634
4	1.035	6.897	76.531

According to Table 3, the highest loading of the first component is the number of recommended dishes, with a co-efficient of 0.907 and this indicator suggests the popularity of dishes. The second component loading is the customers' overall rating, with a co-efficient of 0.932， showing residents' overall impression of the restaurant. The third component is average spending per customer, with a co-efficient of 0.722，showing the level of a restaurant; and the fourth component is the number of branches of the restaurants, with a co-coefficient of 0.981，showing the scale and brand of a restaurant.

Table 3 the factor loading matrix with orthogonal rotation

Indicators	Factor loading matrix with orthogonal rotation			
	1	2	3	4
Total number of customer browses	0.866	0.11	0.327	-0.046
Number of total comments	0.905	0.075	-0.025	0.009
Number of defaulted comments	0.865	0.134	-0.014	-0.019
Number of group comments	0.353	-0.119	0.516	0.003
Number of customer rated favorite	0.777	0.236	0.193	-0.1
Customer check in	0.783	0.162	0.395	0.002
Overall score on dish quallity	0.215	0.883	-0.132	-0.109

Number of recommended dishes	0.907	0.063	0.004	0.005
Overall score on environment	0.09	0.613	0.659	0.119
Number of comments on atmosphere	0.807	0.063	0.053	0.017
Overall score on services	0.082	0.793	0.462	0.049
Number of comments on special services	0.614	0.063	0.458	-0.019
Average spending per person	0.002	0.247	0.722	-0.174
number of branches	-0.039	-0.032	-0.089	0.981
Overall star rating of customers	0.144	0.932	0.134	-0.018

By calculating the overall score, a comprehensive Principle Component Calculation model was obtained after the factor score of all restaurants (F_1, F_2, F_3, F_4) and taking the proportion of each principal component corresponding to the sum of the total eigenvalues of the extracted principal components as weights:

$$F=A_1F_1+A_2F_2+A_3F_3+A_4F_4,$$

F is the score of Comprehensive Principle Component, and A_i is the weight coefficient of each principal component (variance contribution rate). It could be seen that E-WoM of the catering industry in Nanjing urban area varies widely, with a highest score reaching 119, 572.64 while the lowest only 49.03. As can be seen from the value of each principal component, F1, F2 and F3 were all positive while F4 was negative, which indicates a strong correlation between restaurant's comment popularity, level evaluation, service quality and its overall degree of E-WoM. A weak correlation between restaurant's scale and grade and its overall degree of E-WoM was found, but it did not represent negative correlation. From another aspect, after testing and verifying data, it was seen that most catering providers with high overall score in E-WoM had high customer rates on overall star assessment on dianping.com, but catering providers with low E-WoM score did not necessary have low customer rates on overall star assessment on dianping.com, because of the low level and small amount of comments on these providers, which affected the evaluation of star level. Therefore, catering providers' degree of E-WoM cannot be fully represented only by Dianping website’s overall assessment star level.

4.1.2 The catering industry’s E-WoM can be divided into four groups

We conducted k-means cluster analysis on Nanjing urban catering industry's composite degree of E-WoM. According to the overall degree of E-WoM distribution curve in Fig.1, 4 clusters were found. As such the catering industry's degree of E-WoM can be divided into 4 groups. The first group consisted of 5 catering providers, whose E-WoM degree ranged between 119, 573 and 84, 672. The number of catering providers in this group was very small, and the slope of score was nearly 90°. This suggests that there are very limited restaurants of high E-WoM in Nanjing; and

there is a large difference among restaurants' E-WoM score, showing an uneven development. The second group has 38 providers, whose E-WoM degree ranged between 75, 974 and 30, 484. The number of catering providers in this group was larger than the first group, and the slope of score was nearly 90°. The third group consisted of 198 providers, whose E-WoM degree ranged between 29, 706 and 9, 003. The number of providers in this group obviously larger than the first two groups, and the slope of score was relatively flat, but still decreasing in large amplitude. The fourth group has 3, 404 providers, whose E-WoM degree ranged between 8998 and 47. The number of providers in this class was the largest while degree of E-WoM was the lowest. But the slope of score was quite gentle, and was of little decrease. This means that there is little difference among restaurants' E-WoM score, showing an even development.

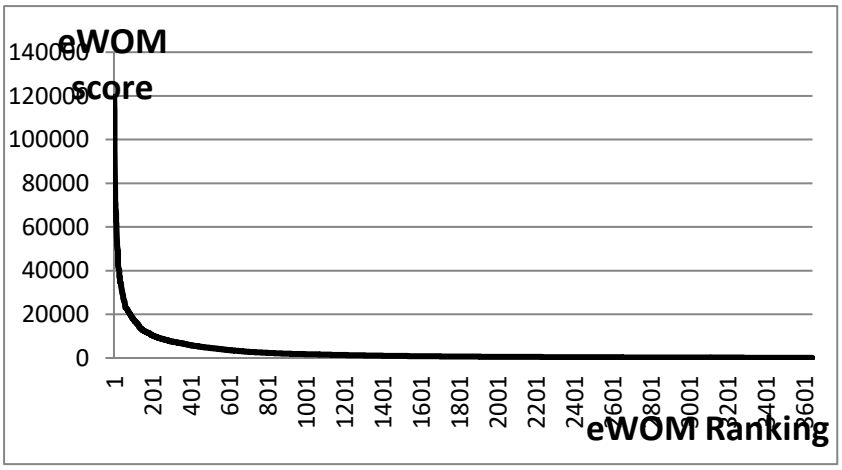

Fig.1 Distribution curve of catering providers' eWOM scores

4.2 Spatial pattern of catering industry in Nanjing urban area

4.2.1 General spatial distribution patterns of catering providers

Using the detailed addresses of registered catering providers in Nanjing urban area on dianping.com, a spatial distribution figure of the 3,645 catering providers was generated in ArcGIS software based on Google maps. It can be seen that catering providers are mainly located in the centre of the urban area and 4 suburbs; however, a large difference exists between the number of catering providers in central urban area and suburbs. We obtained kernel density of catering providers in Nanjing urban area's distribution by using kernel density analysis tool in ArcGIS, setting search radius of 500m. It can be seen in Figure 2, the catering providers mainly spread around vital urban business circles. Among which , Xinjiekou has the highest distribution density with far larger cluster range compared to other areas while the distribution density and range of Hunan Rd./Shanxi Rd., Confucius Temple and Zhujiang Rd. area takes the second place. The distribution density of Taiping Rd., Nanjing University/Nanjing Normal University and Caochangmen/Longjiang area is also high, but the range is relatively small; Only low density and small range clusters of catering providers can be found

across Hexi Wanda Plaza, Zhongshan North Rd./Yunnan Rd., Ruijin Rd. and Gulou Park areas. Overall, following the scale and market proximity as the core indicators of the Central Place Theory (Christaller, 1933; Krugman, 1991)，these distribution differences of restaurants in amount and density are highly related to the class of business circles (Zhang and Xu, 2009). Xinjiekou is the center of the city, providing a comprehensive function of business, finance, shopping, entertainment and hotels, and is regarded as the first tier urban business circle. Hunan Road, located north of the Xinjiekou circle, is the sub business circle, and mainly includes shopping and business. Confucius temple, located south of the Xinjiekou circle, is a commercial centre with tourism, shopping, local snack shops mainly serving both tourists and residents. Zhujiang road area is a shopping district for computers, and has its distinct features. Other business centres mainly provide shopping, business and entertainment, but mainly serve local residents. Meanwhile, Xinjiekou, Zhujiang Road, Taiping Road, Nanjing Uiversity/Nanjing Normal University areas have gathered contiguous development.

The results prove that although with the emergence of internet platforms, the role of the central area has not disappeared, and the distribution pattern of urban catering providers reflects that the urban space still has a certain hierarchy. This is a typical reflection of Central Place Theory (Christaller, 1933)

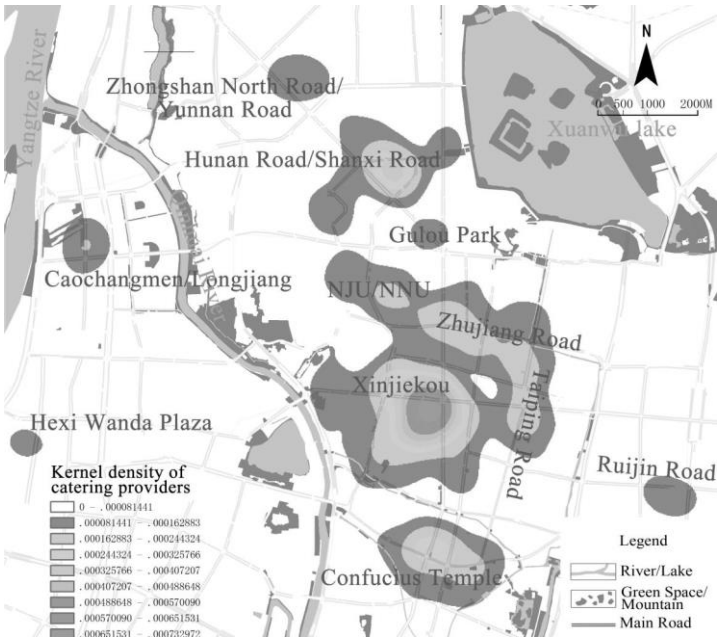

Fig.2 Distribution of catering providers in Nanjing City

4.2.2 Spatial distribution features of catering providers' E-WoM

4.2.2.1 General distribution features of catering providers

Generally speaking, the E-WoM distribution and density distribution of catering providers appear to be overlapping, with a tendency of 'one core multi-heart'. In ArcGIS software, we set overall score of E-WoM as a calculating condition and set search radius of 500m, and simulated the spatial distribution of E-WoM of catering providers in Nanjing urban area. As can be observed in Figure 3,

E-WoM reaches the peak in Xinjiekou region which is the district with highest E-WoM group, whose range includes Hanzhong West Road., Chaotiangong, Zhongshan South Road. and other regions. Hunan Road./Shanxi Road. region has the second highest E-WoM peak and cluster scale, and becomes the second centre. The Taiping Road. area has the third highest E-WoM group while the Zhujiang Road. and Confucius region has quite a large cluster of high E-WoM, whose score is lower and scale is also smaller compared to the first three regions. Xuanwu Lake Park, Jiangsu Road., Gulou Park, Nanjing University/Nanjing Normal University and Caochangmen/Longjiang region has high E-WoM, but its scale is quite small. The catering providers spreading near regional business centre are not connected with large regions of high E-WoM like Hunan Road.

We found that, different from the spatial distribution of the catering industry in Nanjing, which follows Central Place Theory, the spatial distribution of E-WoM of the catering industry shows the features of Central Flow Theory (Castells, 1989, 1996; Taylor et al., 2001, 2008, 2010). Firstly, there is a distinct hierarchal distribution of E-WoM, in which Xinjiekou forms the highest level, with Hunan Road, Taiping Road, Zhujiang road, and Confucius temple areas gradually decreasing. Secondly, low grade business circles do not necessary mean low grade E-WoM; for example, the level of business circles, the density of restaurants along Taiping Road are both lower than Confucius temple and Zhujiang Road area, but shows a higher grade in E-WoM. This may be because Taiping road area is a famous leisure area which has many western restaurants, pubs, cafes, Japanese and Korean restaurants which are popular among young people. This area has a large population mobility and strong ability to gather popularity, therefore, acts as an important node in the spatial network of the catering industry in Nanjing. In addition, although the Nanjing catering industry shows contiguous distribution of levels (Figure 2), Figure 3 shows that the E-WoM in Xinjiekou, Hunan Road/Shanxi Road, Taiping Road, Confucius temple, and Zhujiang road areas is rather a relatively independent and scattered in distribution, showing the characteristics of fragmentation.

To a large extent the development of information technology, coupled with the fast development of internet, breaks the traditional impact of distance on urban residents dining behavior. Information search engines and review platforms such as dianping.com, facilitate residents' choices of dining places from a wider area thereby making their dinning behavior more flexible. It also promotes the areas with ability to provide better or characteristic catering services and become the main areas of residential dining options, and the centre of high grade E-WoM, such as areas along Taiping Road.

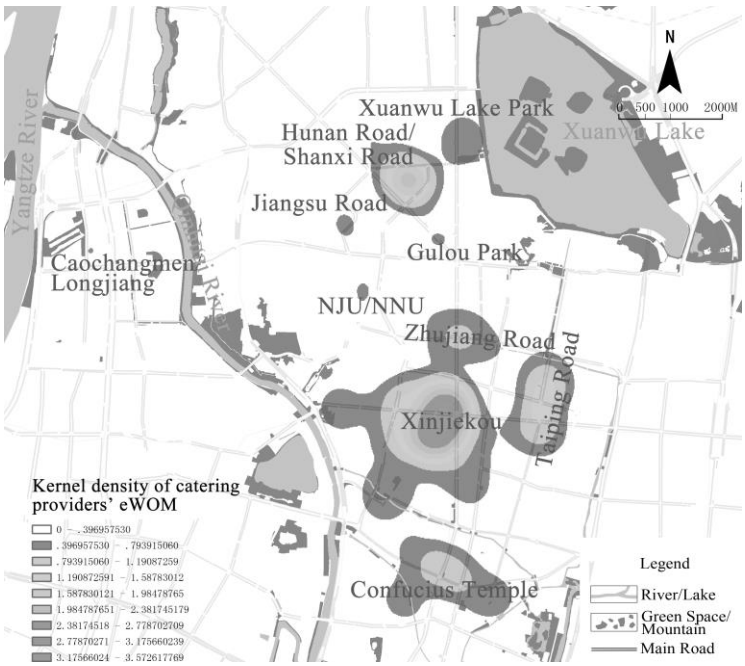

Fig.3 Distribution of catering providers' E-WoM in Nanjing City

4.2.2.2 Distribution features of different types of catering providers

Different types of catering providers have different degrees of consumer participation on E-WoM comments because they aim to differentiate consumer groups, and therefore should reflect a different spatial distribution feature of E-WoM. According to the business categories on dianping.com, two groups of catering providers were found: 1) mainstream cuisine which mainly includes Nanjing local cuisine, Huaiyang cuisine, Northern Jiangsu local cuisine, Sichuan cuisine, Cantonese cuisine, Hunan cuisine, and North-east cuisine; 2) non-mainstream cuisine which mainly includes western food, Japanese and Korean cuisine, hotpot, snack and fast food, pastry and buffet. Data shows that there are 1, 199 mainstream catering providers and 2, 446 non-mainstream catering providers in Nanjing urban area on dianping.com. Among the 241 providers that are of the top three E-WoM grades, the number of mainstream cuisine category is 2, 10 and 94 respectively in the three grades, while for the non-mainstream cuisine category, 3, 28 and 104 respectively, showing approximately the same proportion in both categories. While for the fourth grade, the amount of non-mainstream providers (2, 311) is far larger than the mainstream ones (1, 093); mainly because the non-mainstream catering includes more restaurants, whichattracts a consumer group full of young people who often use dianping.com.

By analyzing the kernel density of 1,199 mainstream catering providers' E-WoM, setting search radius of 500m, we simulated the spatial distribution of mainstream catering providers in Nanjing urban area. From Figure 4, the amount of E-WoM peak of mainstream catering providers is smaller than that of all catering providers in Nanjing with a great difference. Xinjiekou is still the core region of E-WoM peak area；Hunan road/Shanxi Road area becomes the second tier of high grade E-WoM, while Confucius temple, Taiping road, Xuanwu Lake areas become the third tier of E-WoM, while the Caochangmen/Longjian, and Gulou Park areas become the regional peak area of E-WoM. From

the distribution of mainstream cuisine E-WoM, the following features can be found: 1）a distinct hierarchical distribution of E-WoM, showing a similar distribution with the urban business district （Batten, 1995）; 2）although Taiping road and Xuanwu Lake area shows a lower grade in business districts than Confucius temple area, the distribution of mainstream cuisine E-WoM shows the same grade, suggesting a strong popularity; 3) However, different from overall restaurant E-WoM distribution, the E-WoM distribution of mainstream cuisine is not independent or scattered, such that Xinjiekou, Confucius temple and Taiping Road areas have been joined contiguously, following a rule of traditional geographical gathering and distance reduction.

Therefore, it is suggested that the E-WoM distribution of mainstream cuisine follows both rules of Central Place Theory (Christaller, 1933), and Central Flow Theory (Taylor et al., 2001, 2008, 2010). On one hand, internet platforms can help dinners to choose more flexibly (Lien-Ti Bei, et al., 2004) and restaurants with a higher E-WoM could attract more visitors, thereby improving the E-WoM of the area. On the other hand, mainstream cuisines are usually chosen in formal occasions. High level business districts, such as Xinjiekou area, have advantages due to their geographic location. They have more restaurants, higher mobility, better public facilities and transport accessibility, which make them popular areas for dinners. As a result the high-level business district and the surrounding areas have high E-WoM restaurants, gathering a contiguous development.

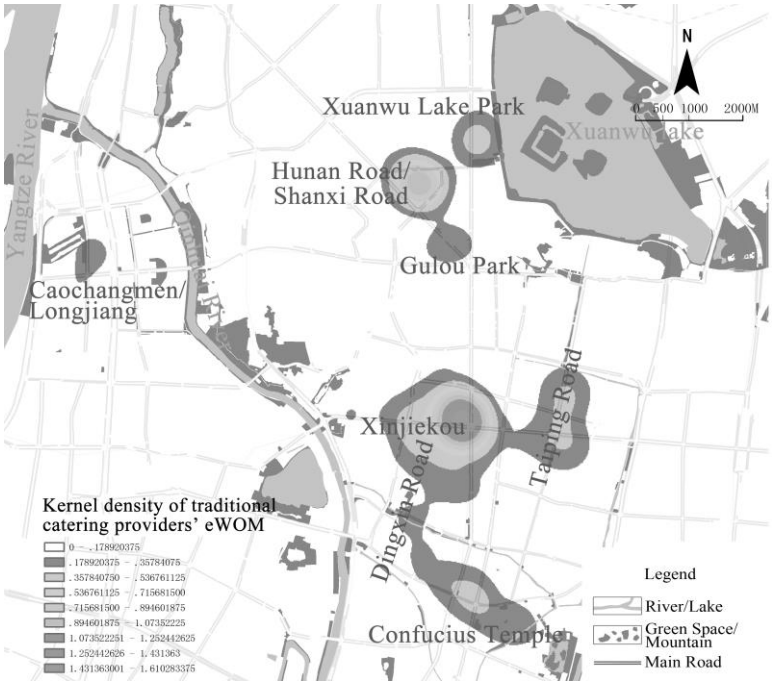

Fig.4 Distribution of mainstream catering providers' E-WoM in Nanjing City

By analyzing the kernel density of 2,446 non-mainstream catering providers' E-WoM value, setting search radius of 500m, we simulated the spatial distribution of non-mainstream catering providers in Nanjing urban area. From Figure 5, there is not much difference between the spatial distribution of E-WoM of non-mainstream catering providers and that of all catering providers in Nanjing urban area. Xinjiekou and Hunan Road/Shanxi Road areas form the first and second peak E-WoM of modern cuisine, Taiping Road and Zhujiang Road areas become the third peak E-WoM, while the

Confucius temple and Chaotiangong areas are the forth peak centre. Other areas such as Nanjing university/Nanjing Normal University, Jiangsu Road, Xuanwu Lake are the regional peak E-WoM. The Zhujiang Road area shows a great difference between the E-WoM of overall restaurants and non-mainstream cuisines, demonstrating a higher score in non-mainstream cuisines E-WoM. This is the largest trading area for electronic products and services, and has a large number of young employed people and a shopping population, who prefer non-mainstream cuisines, which results into a higher grade in E-WoM for the area. In addition, different from the E-WoM distribution of mainstream cuisines, many consumers would choose snacks, western food, buffet, café in an informal occasion, and would prefer to choose restaurants with a good E-WoM via online platforms, resulting in more flexible and mobile dinning choices. This is reflected by the independent and scattered E-WoM distribution of non-mainstream restaurants.

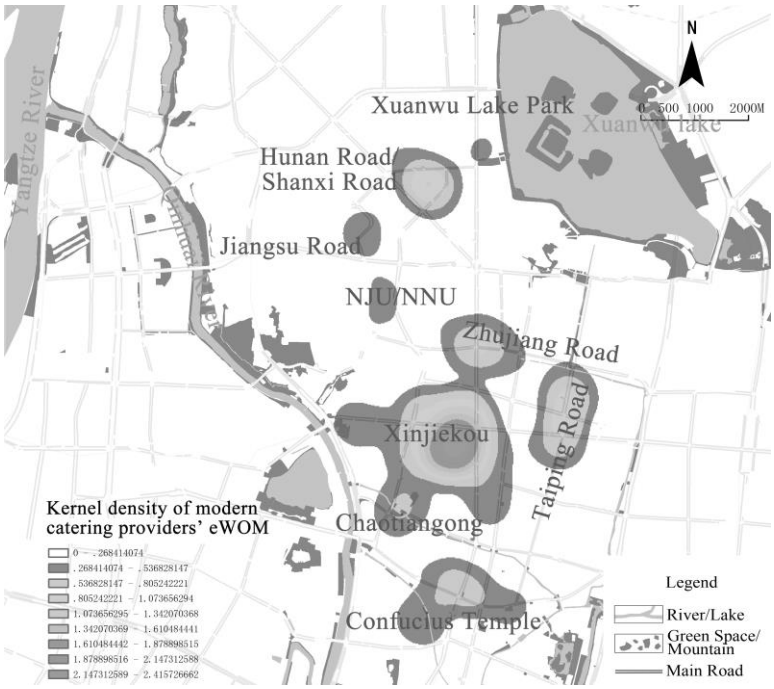

Fig.5 Distribution of non-mainstream catering providers' E-WoM in Nanjing City

5. Conclusions

With the fast development of internet and information technology, traditional Central Place Theory has shifted to Central Flow Theory, which focuses on "flow space". Although many studies have been conducted on the regional urban network and their flow patterns to explain interactions between cities (Zook, 2001; Wang et al, 2003; Wang et al, 2006; Zook and Graham, 2007; Naaman et al, 2012; Zhen et al, 2012), research on the spatial distribution of production factors within the city is still limited. Whether the features between regional organizations can still be found at the urban scale is not clear. In other words, how information technology has changed the flow space within the city and whether this type of change can be explained by Central Flow Theory or Central Place theory needs further exploration.

In the catering industry, due to the fast development of information technology, especially the ICT

platforms such as dianping.com, consumers' dinning behavior has become more flexible and mobile rather than being limited by distance (Lien-Ti Bei, et al., 2004; Qin, et al., 2014). This trend of change has also brought new trends of research for urban geography, and the integration of internet data and urban geographic spatial information has provided a new research content, method or research direction of urban geography (Graham & Shelton, 2013).

This research uses urban catering space in Nanjing, China as a study object, which has significantly been influenced by new technology, and explores the application of central place theory and central flow theory in production elements within the city. After establishing a set of index of restaurants' E-WoM from dianping.com (Nanjing), we calculated the complex score and ranking of catering providers' E-WoM, and conducted kernel density analysis and a comprehensive evaluation on spatial distribution of the E-WoM of the urban catering industry and compared this "flow space" with the general distribution patterns of catering providers (place space). The main conclusions are as follows:

1) The spatial distribution of restaurants' density in Nanjing follows a traditional Central Place Theory (Christaller, 1933; Krugman, 1991; Zhang and Xu, 2009), showing a high overlapping of business districts. Xinjiekou is the centre of the highest grade, Hunan Road/Shanxi Road, Confucius Temple, and Zhujiang Road areas are the second highest grade while Taiping Road, Nanjing University/Nanjing Normal University, Xuanwu Lake areas are the regional centres. Furthermore, the high grade centers show the development trend of contiguous gathering. The results suggest the role of the central area has not disappeared, and the urban or regional space still has a certain hierarchy.

2) The spatial distribution of restaurants' E-WoM in Nanjing follows the Central Flow Theory (Castells, 1989, 1996; Taylor et al., 2001, 2008, 2010). On one hand, a clear hierarchy can be found in E-WoM distribution, but is not fully consistent with the level of urban business districts. For example, low-level business districts such as Taiping Road area are high grade in restaurant's E-WoM due to their high popularity. On the other hand, due to the rapid development and usage of the urban network information platforms, the influence of distance on residents' consumption has weakened, and the dinning choice and activity space has been expanded, which makes the distribution of the restaurants' E-WoM relatively scattered and independent.

3) Different characteristics can be found in different types of restaurants' E-WoM distribution. Mainstream cuisine follows Central Place Theory (clear hierarchy, contiguous development) but is inconsistent with urban business districts (such as, Taiping Road and Xuanwu Lake areas), demonstrating some characteristics of Central Flow Theory. The distribution of E-WoM of non-mainstream cuisine is similar to the E-WoM distribution of overall restaurants, showing a central flow system pattern. Therefore, our study finds that Central Place Theory and Central Flow Theory are still useful in explaining the spatial distribution of the catering industry and its E-WoM at the city scale.

The findings contribute to the following areas:

Firstly, it explores the application of Central Place Theory and Central Flow Theory at the city scale, an aspect which was previously ignored by many researchers. It discusses the spatial distribution patterns of the catering industry considering network space, and examines whether the E-WoM reflects Central Flow Theory with the influence of ICT. Previous research on Central Flow Theory mainly considers the relationship of cities at the regional level. However, our research applied it to the urban level, and found that with the influence of information technology, urban internal dining shows a feature of Central Flow Theory (clear hierarchy, grading is influenced by mobility and popularity, scattered and independent). However, a feature of traditional Central Place Theory can still be found in the results such as 'clear hierarchy and contiguous development', mainly in the E-WoM of mainstream cuisine. It is obvious that information technology has provided more dinning flexibility and expanded the scope of dinning activity, and accelerated the dispersion of urban space elements. However, high level urban business districts can still attract a variety of quality restaurants aggregation due to their advantages in scale, population mobility, facilities, and transport accessibility, such that the aggregational development of spatial elements is still evident. As such, a mixture of features of Central Flow Theory and Central Place Theory can be found at the city scale.

Secondly, the paper is a welcome addition of data analytical approach exploration into the hospitality industry, providing a more holistic understanding of catering industry in Nanjing. The integration of E-WoM scores from data mining and urban geographic spatial information (GIS method) has made it possible to examine the quality of restaurants at a larger scale.

The results have some practical implications as well. Studying urban service facility's quality and spatial distribution patterns is useful in decision making for government's service facility planning. City governments should adopt various measures to optimize the space layout and minimize the unbalanced distribution of popular catering providers. For example, in order to balance the spatial distribution of different types of catering, priority can be given to non-mainstream cuisine in traditional business areas(such as Xinjiekou area) while mainstream cuisine can be encouraged in new business areas(Such as Zhujiang Road) when planning catering facilities. In particular, the number and popularity of catering providers in the low-grade business centers may be increased, and the quality of catering needs to be improved.

Our research also has some limitations. Usage of massive data on websites to some extent reduces the influence of fake information cast on total sample, improving the accuracy of research data, and can generally reflect the spatial patterns of urban catering providers. But internet users are mostly young people who tend to consume and comment on non-mainstream catering, which restrains the age range of the sample in this research. On the other hand, traditional Central Place Theory lacks explanation on spatial distribution of urban catering industry. Establishing spatial structure pattern of urban catering industry based on E-WoM also needs comparison with other cities. Further research is still needed on the influencing factors, details and mechanism of information technology to the spatial distribution of urban catering industry.

Note

① "Master Plan of Nanjing (2011-2020)" is the latest master plan of Nanjing prepared by the Nanjing Municipal Planning Bureau, and is used to determine the hierarchy of business

centers in Nanjing.

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