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Resilience of virtual and real shops under the impact of Covid19 epidemic:

an empirical study on the distribution of breakfast service in Beijing

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ABSTRACT

The breakfast service is an important part of local vitality which are traditionally provided by restaurants and street vendors in real space. The booming virtual economy and delivery service provide alternative type. With the outbreak of COVID-19, both the temporary lock-down of many streets and the reduction of travelling have great impact on breakfast service at the beginning of 2020. During this epidemic period, what kind of breakfast service suffers more, if the location matters, these became interesting questions. This paper presents a comparative study on the central city area (160km^2) of Beijing before and after the impact of Covid19. Based on two site surveys in 2019 July and 2020 September, over 3000 breakfast service are mapped in 6 categories (Chain restaurant, subcontracted breakfast service, fixed vendor stance, mobile vendor stance, supermarket and bakery) in real space. Cell phone data of 2018 and 2020 are also used to provide other factors such as employment/residential densities and distances of commuting. Additionally, social media data of breakfast distribution from Dazhongdianping.com are collected to study how service in real and virtual space overlap. In general, it can be found that the space with dominant accessibility has stronger resilience. Breakfast services in an advantageous position are more likely to expand new opportunities through the network platform in virtual space.

KEYWORDS

Breakfast service, Space Syntax, Epidemic, Cell phone data, Social media data

1 INTRODUCTION

Breakfast service is a vital part for contemporary urban life. Under the impact of epidemic from 2019, the changing breakfast shops can serve as an indicator for the resilience of local places. Generally speaking, the research on the morphology of breakfast in cities has the following values: first, many breakfast services are running on informal economies such as street vendor or kiosk subleased from formal restaurant. Therefore, its spatial distribution could reflect the self-organized spatial pattern better than those formal restaurants. Second, breakfast services depend actual visit in very limited time during weekdays. The booming on-line shopping in last decades has strengthened attractiveness of trip destination at the cost of neglecting trip passage. On this line of thinking, buying breakfast is spatially restricted nearby the two edges of its origin and destination of a commuter's every day trajectory. This makes breakfast a good case study to understand the future commercial spaces in the informational age.

Most literatures are using questionnaire to analyse the usage pattern of breakfast shopping. Guo' s recent survey on elderly people in Beijing shows the percentage of breakfast shopping in central city is higher than that in suburb (Guo et.al 2021). Shanghai Customer Evaluation Centre's survey shows the most visited types of breakfast service are kiosk and supermarkets, only on-line purchase only accounts 12.7%. Because many breakfast services are informal, it is very hard to get data from street view map or other social media such as Dazhongdianping.com (a well-used website in China to post reviews for restaurants or other shops). There are very few literatures study the spatial distribution of breakfast service.

However, many literatures address this topic through assessment on spatial coverage of community amenities. In this field of study, Two Step Floating Catchment Area (TSFCA for short) and other gravity model are often used. Ding's study in Wuhan (Ding et.al 2016), Wu's study in Guangzhou (Wu et.al 2017), Wang' s study in Yangzhou (Wang et.al 2020). finds the residential-service distribution ratio is affected by the distance to centre, income level and the age of buildings. Using cell phone data, Wang's study on daily life circle in Shanghai shows dramatic difference with the 15 minutes coverage proposed by municipality. The distance to centres and the residential density are factors (Wang et.al 2019). Zhang' s study on the relationship between community amenity (22 types) and housing price shows little relationship between distribution of breakfast and housing price (Zhang et.al 2018). Using Point Of Interest (POI for short) data, Chen's study on Guangzhou shows the distribution of supermarket (mostly provide breakfast) tends to agglomerate on the hot spot of all other type of commercial functions (Chen et.al 2016).

Many literatures' findings suggest that the central city-suburb have clear differences in community amenity coverage. However, most of studies stop at pointing out this imbalance as a problem for planners or designers to solve without analysing the underlying mechanism. In another word, the resolution of spatial analysis frequently used today (say, 15min's circle or 1km

grid) is enough to illustrate the demand from residence (normally measured by number of household or floor area for housing at certain radius). But it is not enough to describe the potential for profits (measured by individual trajectories superimposed on street networks). Space syntax has provided a useful theory and method at street scale and there are increasing number of researches on the distribution of commercial function in China (Yang et.al 2015, Wang et.al 2015). The correlation between spatial configuration and the total number of all kinds of shops could be very stable if the data are aggregated in a standard way (Sheng et.al 2018). However, when analysing certain type of shops such as food market (Sheng et.al 2018) or bicycle repair (Hu et.al 2020), the correlation will be compromised. But in all of these cases at neighbourhood scale, the topological order proved to be more clearly presented than the metric order. These finds suggests that the street pattern itself are mediating the demand from residence and the supply provided by shop owner or vendors.

Recently new data such as check-in data of social media opens up new possibilities for space-time trajectory analysis. Shen' s research in Shanghai tested the space-time co-presence potential using check-in data (Shen et.al 2019). He proposed a possible framework for a dynamic syntactical analysis. In this sense, distribution of breakfast shops could be studied as the actualization of a space-time co-presence potential. It could help us understanding whether and how this potential could be consolidated into actual urban functions.

Our research team started on surveying all kinds of breakfast inside the central area of Beijing (159 km2) since 2019. Another round of survey in the same area was made in 2020, about one year after the outbreak of Covid19. Home-work and commuting pattern in these two years are extracted from cell phone data. Together with space syntax model, the distribution density of breakfast shops will be analysed through multi-variant regression model. The questions of this research are: How do street pattern affect the distribution density of breakfast service? How do street connectivity affects change of different kind of breakfast under epidemic period? Furthermore, to study the potential impact of on-line shopping and delivery in breakfast, we also compared the data from survey with two well-used websites, analysing the different spatial patterns.

2 DATASETS AND METHODS

2.1 Main Data Set: Breakfast service data in real space

This research focuses on breakfast service inside the urban area of Beijing's 3rd ring road, covered 160 square kilometers. The population in this area is about 4.054 million, accounting for 18.8% of the total population of Beijing. The main data set is the location and number of breakfast service before and after COVID-19. The data collected in 2019 July and 2020 September is based on fieldwork mapping of all breakfast service on each streets inside the 3rd ring road before 9 am. Figure 1 shows that over 3000 breakfast service in real space are mapped

in six categories-chain restaurant, subcontracted breakfast service, fixed vendor stance, mobile vendor stance, supermarket and bakery. Among them, chain restaurant and subcontracted breakfast service provide seats for customers. Supermarket represents a chain of convenience stores that provide breakfast, such as 711. Bakery represents Chinese and Western pastry chain stores. A small number of supermarket and bakery have seats. In addition, No seats were provided in fixed vendor stance and mobile vendor stance.

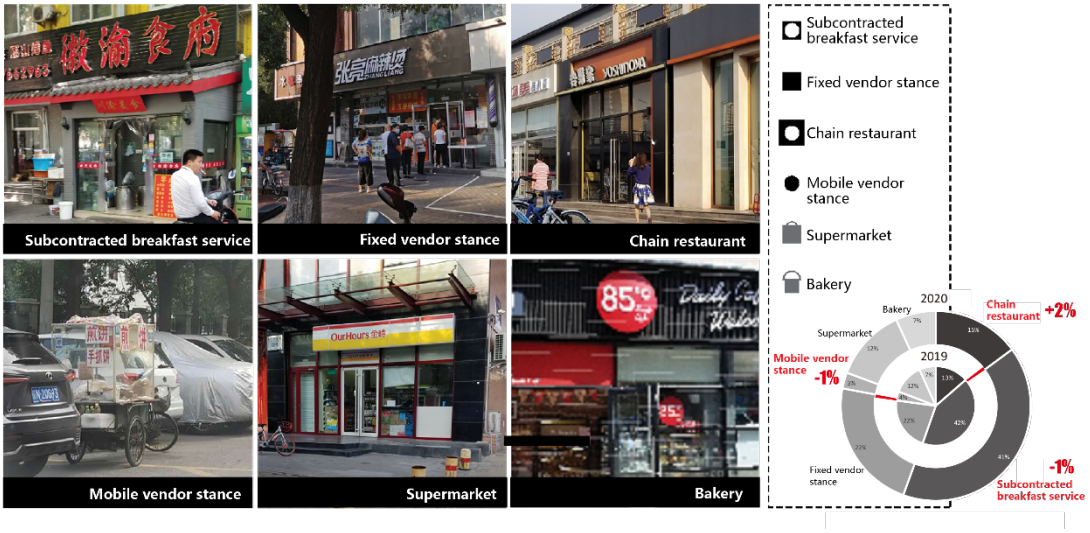


Figure 1: the six categories of breakfast service date from site surveys

2.2 Social Media Data Set: Breakfast service data in virtual space

Dazhongdianping.com is one of the first Chinese web forum and service platform which provides information based on users' feedback on the quality of the restaurants. In the last few years Dazhongdianping developed into a leading website reviewing the catering service. To a large extent it also changed the way Chinese people use catering functions in big cities. A user can make his choice based on many characters such as the style of flavor, quality of environment and service. It shows the reviews from other customers and the average rank of certain restaurant based on the their feedback. Meituan.com is one of Chinese largest living services e-commerce enterprises, which is also known as a typical O2O platform for takeaway restaurants. Therefore, the data of Meituan.com are very representative and have high value of scientific research. Many scholars have applied it to e-commerce research (Shi et.al 2016a, Shi 2017, Shi et.al 2018), which shows interesting results on a larger research scale.

In this paper, we also collected online breakfast stores data of Dazhongdianping.com and Meituan.com, adopting spatial statistics methods such as Kernel Density to explore how breakfast service in real and virtual space overlap. After excluding the online stores that do not exist in the site survey, breakfast service are divided into 3 categories - reality type, comment type and takeout type. Based on that, Figure 2 shows the spatial distribution difference of breakfast service in virtual and real space.

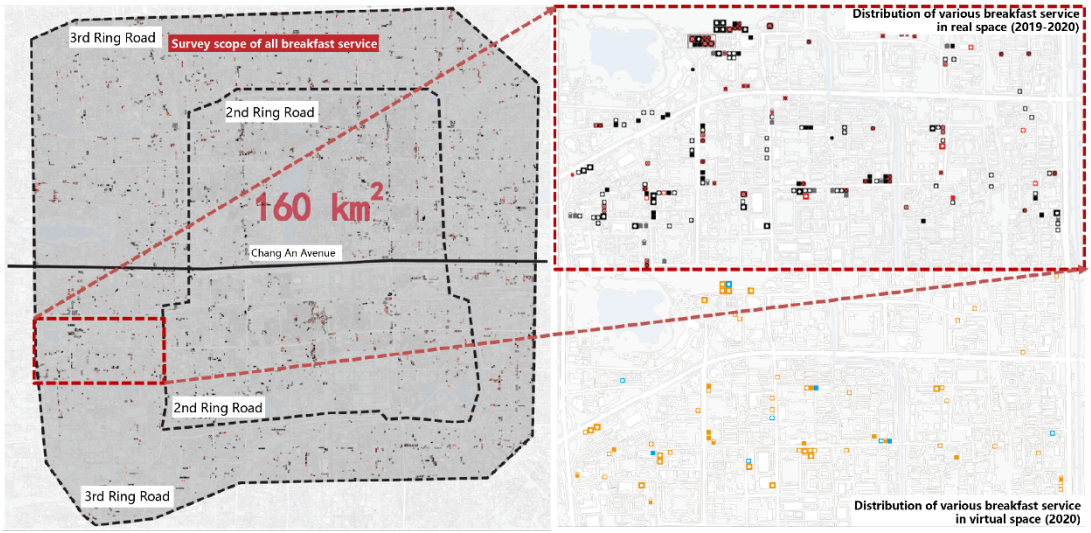


Figure 2: survey scope and the spatial distribution difference of breakfast service in virtual and real space

Before and after the epidemic, in terms of the changes in the number of breakfast service in the real space, there were 3597 in the 3rd Ring Road in 2019, of which subcontracted breakfast service accounted for the most and mobile vendor stance the least. In 2020, there were 3230, a decrease of 10.2%. The proportion of various types of breakfast service remained stable, and the chain restaurants increased slightly. It can be seen that the chain restaurants suffered less impact. The proportion of newly opened restaurants was high and the recovery was rapid, which was mainly due to the chain of domestic breakfast stores, such as Huatian and other brands. In terms of the location characteristics of the change in the number of breakfast service, Figure 3 shows that the central area within the 2nd Ring Road recovers faster than the area between the 2nd and 3rd Ring Road.

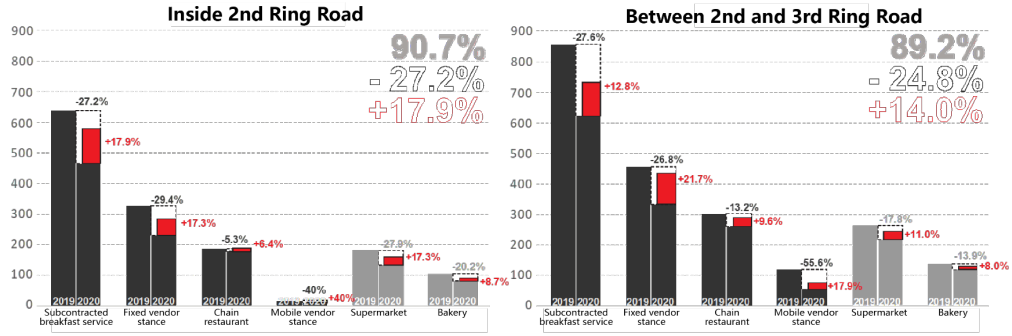


Figure 3: the changes in the number of various breakfast service in the real space

2.3 Cell Phone Signalling Data

This research explores the spatial law behind the distribution and change of breakfast service before and after COVID-19 from the urban scale and street scale. At the level of city scale analysis, the cell phone data of China Unicom in June 2020 were collected. The user's stay in a place for more than 30 minutes is recorded as a stay. The signalling data is processed by

determining the work or residence (the working population is additionally limited by the age of 18-59 years) for more than 10 consecutive days during the day and night of the month.
In this paper, compared with the GPS positioning data, although the accuracy of the applied cell phone signalling data is not high, it has a large number of data samples. The problems caused by the insufficient accuracy of the samples can be reduced through data processing. As Figure 4 shows, the application of cell phone signalling data helps to describe the relationship between residence, work and commuting in various areas, which is of great significance to the research of breakfast service.

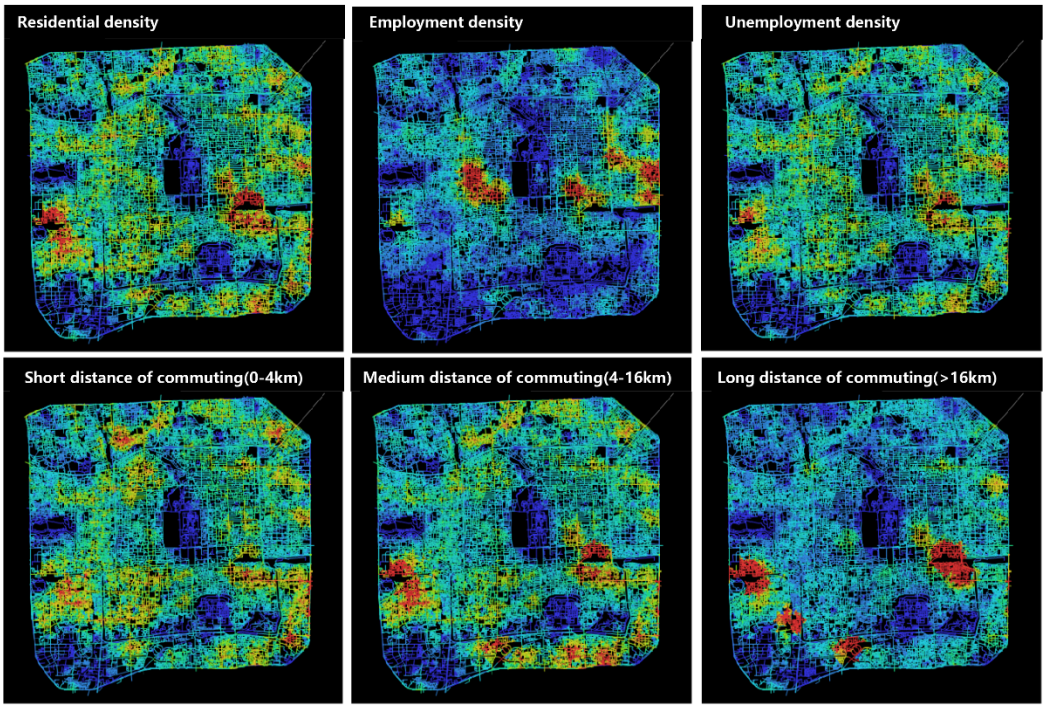


Figure 4: the cell phone signalling data is processed by determining the work or residence and physical distance between commuting.

2.4 Space Syntax Model

Space syntax model is used in street scale analysis, which provides a rational quantitative method for studying the relationship between spatial form and function. The detailed street network within the 5th Ring Road of Beijing and the urban road model of surrounding areas are established in the space syntax software Depthmap, with a total of 347832 street segments. It also reserves sufficient buffer area for this study and leaves room for further research and scope expansion, shown in Figure 5. The breakfast service data obtained from the site survey are input into the model to analyse the differences in the spatial distribution of different types of breakfast service, and to explore whether it depends on the spatial connectivity of the location to a great extent.

The analysis mainly focuses on two kinds of parameters: Integration and NACH. NACH values of different radius used in this study can further exclude the influence of the number of line segments to express the carrying capacity of space for different scale through traffic.

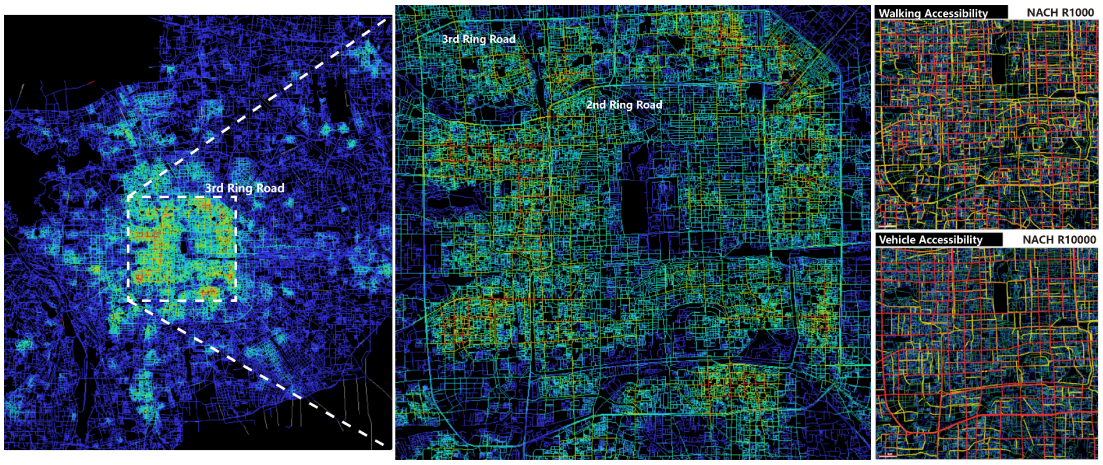


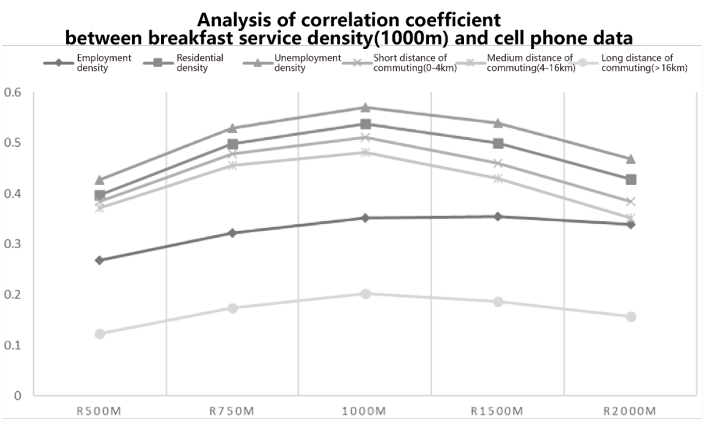
Figure 5: the range and resolution of space syntax model used in this research

Subway has become an indispensable part of urban transportation because of its fast, safe and punctual characteristics. With the expansion of Beijing, various subway routes have been gradually opened in recent years. More and more people choose to commute by subway. There are also a variety of supporting facilities near the subway station, including breakfast service. According to the location and number of subway station entrances and exits in Baidu map, a total of 89 subway stations and 402 entrances and exits are entered into the space syntax model. Metric Step Depth is calculated to analyse whether the location of breakfast service distribution is affected by the location of urban basic function distribution such as subway station.

3 ANALYSIS

3.1 City-Scale Analysis

At the city scale, this research first analyses the correlation between the density of breakfast service and the number of residents obtained from cell phone signalling data. The result in Figure 6 (left) shows that the density of breakfast points (1000m radius) is most related to the density of unemployed and residents, and less related to the employment density. In addition, in terms of commuting distance, it can be seen that the distribution of breakfast points is more affected by the starting point of commuting. Based on this, the independent variables such as cell phone signalling, subway station distance (Metric Step Depth) and space syntax Integration were normalized and analysed by multiple regression with breakfast service density. The result in Figure 6 (right) shows that the Integrated Model with the above three variables has the best correlation with breakfast service. It followed by Cell Phone Data Model, and the worst is Space Syntax Model.



Regressive Analysis		Cell Phone Data Model		
R Square	0.33393217			
Adjusted R Square	**0.33391491**			
	Coefficients	Standard error	t Stat	P-value
Intercept	35.4641094	0.057266	619.2899	0
Residential Density	-8.02102	0.265516	-30.2092	2.6E-199
Employment Density	18.9619951	0.265516	71.41559	0

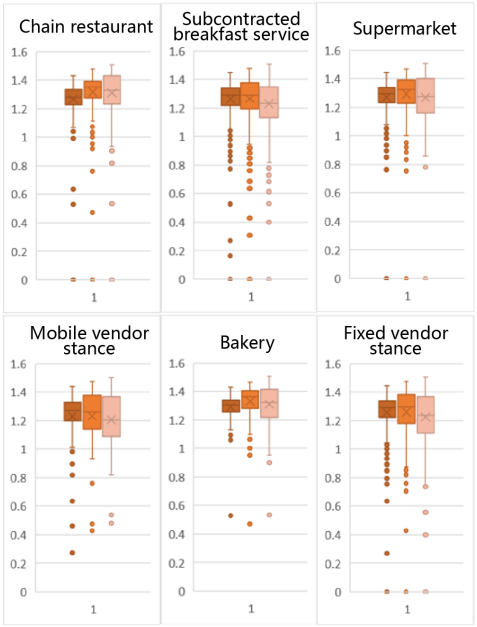
Regressive Analysis		Spatial Accessibility Model		
R Square	0.29038013			
Adjusted R Square	**0.29036174**			
	Coefficients	Standard error	t Stat	P-value
Intercept	35.4641094	0.059108	599.9849	0
Subway Station Distance	-6.0764183	0.060515	-100.411	0
INT R1000m	7.36301898	0.060515	121.6717	0

Regressive Analysis		Integrated Model		
R Square	0.38997826			
Adjusted R Square	**0.38995455**			
	Coefficients	Standard error	t Stat	P-value
Intercept	35.4641094	0.055461	639.4465	0
Employment Density	6.92799261	0.067659	102.3954	0
Subway Station Distance	-4.6538237	0.058456	-79.6126	0
INT R1000m	3.95100665	0.065836	60.01256	0

Figure 6: correlation analysis between breakfast service density of the site survey and various residents of cell phone signalling data (left) and multiple regression analysis of breakfast service density (right)

3.2 Street-Scale Analysis

At the street scale level, in order to obtain the difference of placement demand of 6 types of breakfast service on the street, the topological accessibility is counted. The different radius in the space syntax model is used as the standards to measure the accessibility of walking (1000m radius), riding (7500m radius) and driving (10000m radius). Firstly, this research makes a statistical analysis of breakfast points in 2019, and compares the three accessibilities through the box diagram. It can be seen in Figure 7 (left) that walking accessibility is more concentrated in various breakfast service. In terms of comparison of various types, it can be seen in Figure 7 (right) that chain restaurants and bakery have the highest demand for accessibility. Compared with other types, chain restaurants obviously rely on vehicle accessibility, and the average demand of mobile vendor stance is the lowest.



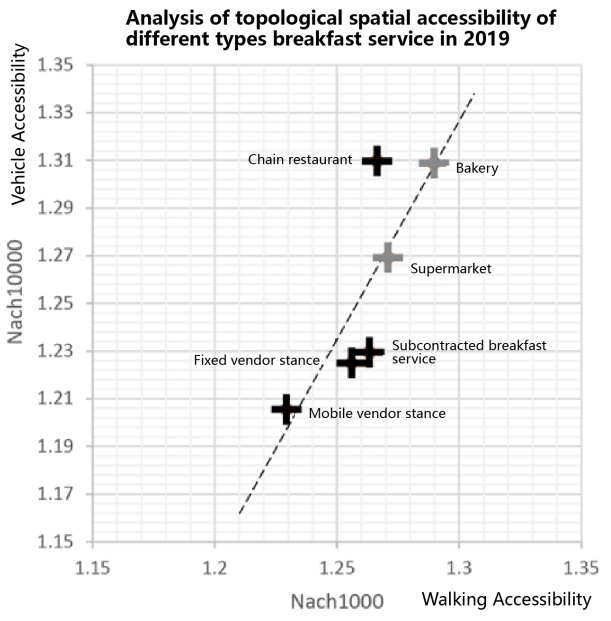


Figure 7: the box diagram shows the walking/riding/driving accessibility of 6 types breakfast service (left) and analysis of topological spatial accessibility of different types breakfast service in 2019 (right)

Secondly, our team analysed the topological accessibility of breakfast service before and after the epidemic. Through the statistics of breakfast service that disappeared after the epidemic, it can be seen in Figure 8 that during the epidemic, breakfast service with poor accessibility were eliminated first, especially the service with high vehicle accessibility but low walking accessibility. It shows that the epidemic is equivalent to a round of reshaping, cleaning the commercial functions in the relatively inferior space. According to the statistics of the increased breakfast service after the epidemic (Figure 8), the streets with good accessibility are restored first. The chain restaurants turn to the streets with high walking accessibility, but the bakery and supermarket expand in the direction of low accessibility. While the subcontracted breakfast service is still filling the losses. In general, it can be seen that the space with dominant accessibility has stronger resilience.

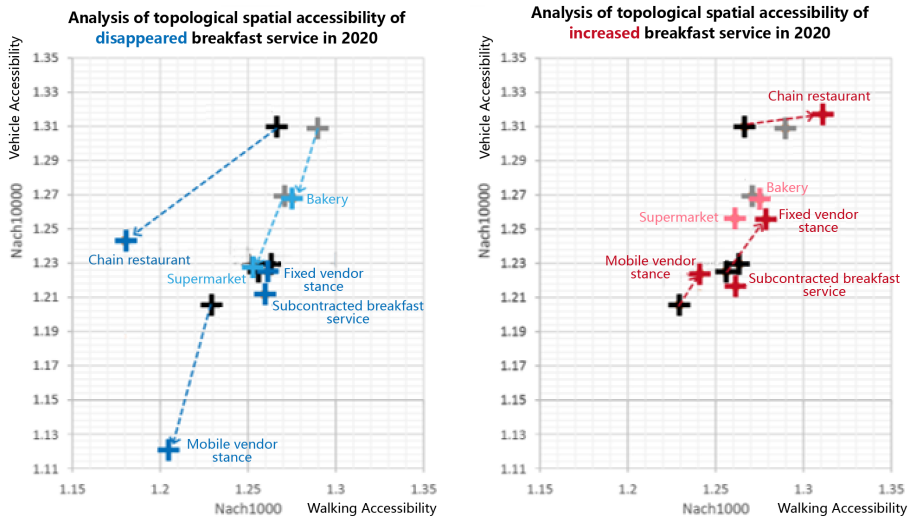


Figure 8: analysis of topological spatial accessibility of disappeared breakfast service in 2020 (left) and analysis of topological spatial accessibility of increased breakfast service in 2020(right).

3.3 Spatial distribution of breakfast service in real and virtual space

Our team also collected online breakfast stores data of Dazhongdianping.com and Meituan.com. After excluding the online stores that do not exist in the site survey, breakfast services are divided into 3 categories - reality type, comment type and takeout type. Next, our team studied the difference of breakfast points in real and virtual space. In terms of urban scale analysis, the Kernel Density method is mainly used to analyse the reality, comment and takeout breakfast services respectively, so as to obtain the spatial distribution density of each type and provide the basis for the selection of the following case areas. As can be seen from Figure 9, the spatial distribution density of breakfast services in real and virtual space is quite different. The breakfast services that only visible in reality are highly concentrated around Qianmen (Number 3), and also show a high distribution density in Xinjiekou (Number 1), Chaoyangmen (Number 2) and other areas. The breakfast services benefiting from Dazhongdianping or Meituan takeout are relatively more dispersed, showing a ‘decentralized concentration’. The comment and takeout types spread to emerging and secondary urban businesses in the breakfast service benefiting from the Internet.

As consumers no longer consume in stores, express delivery replaces consumers' personal travel, and businesses rely more on the network platform that can bring passenger flow, which means that the spatial location choice of urban life service industry represented by catering industry has changed and will reshape the urban internal spatial structure. As an urban catering industry with obvious market-oriented characteristics, breakfast needs to be close to potential consumers to the greatest extent. In urban space, it is concentrated in economically developed areas, such as business centres and densely populated areas. Therefore, the forces of diffusion and agglomeration interact with each other, and online reviews and takeout breakfast points finally show the characteristics of 'decentralized concentration' in urban space.

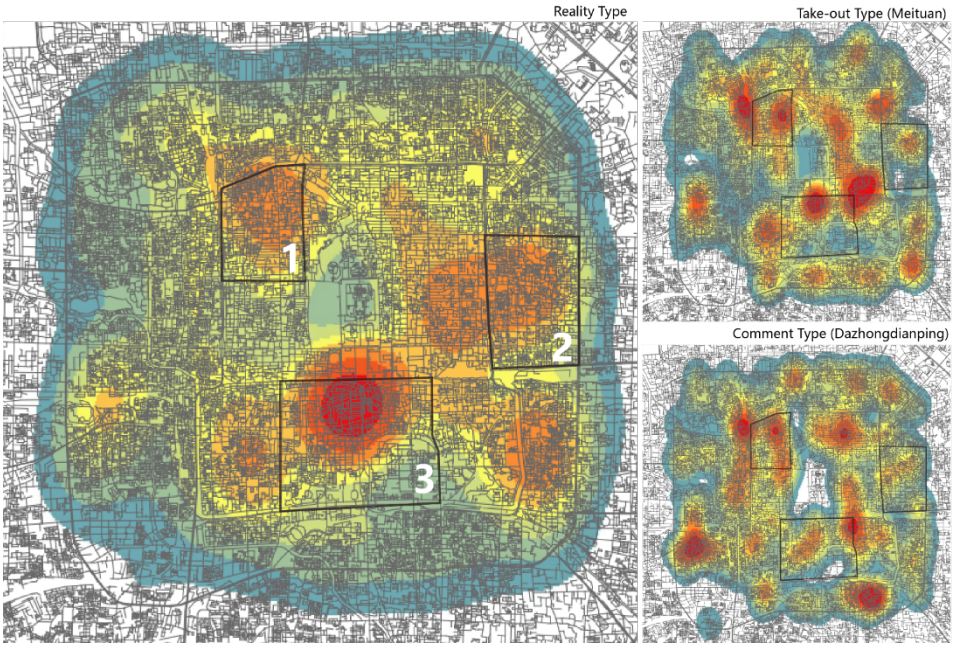


Figure 9: the spatial distribution kernel density of breakfast services in real and virtual space of reality (left), takeout (top right) and comment type (bottom right)

In the street scale analysis, the dependence of the 3 types of breakfast services on walking and vehicle accessibility is analysed. It can be seen in Figure 10 (top) that the takeout breakfast service is in the street with the best accessibility. However, compared with the breakfast that can only be seen in reality, the comment type breakfast that benefits from the Dazhongdianping.com depends less on walking accessibility. It can be seen that the takeout platform (Meituan.com) does not give opportunities to shops with poor accessibility at the street level, but still follows the rules of the real world. Stores or services in an advantageous position and with a prosperous foundation are more likely to expand new opportunities through the network platform in virtual space. What is more, the number of comment type breakfast stores is the least and the accessibility is relatively inferior. Compared with the breakfast points only visible in reality, perhaps the online comment platform such as Dazhongdianping.com does benefit the small breakfast points in remote streets and lanes to continue operating. To sum up, it can be seen that the two different virtual network platforms, comment and takeout, not only have great differences in quantitative coverage, but also in the streets where the businesses they cover are located in the real world. Takeout type is in the advantage street of better accessibility.

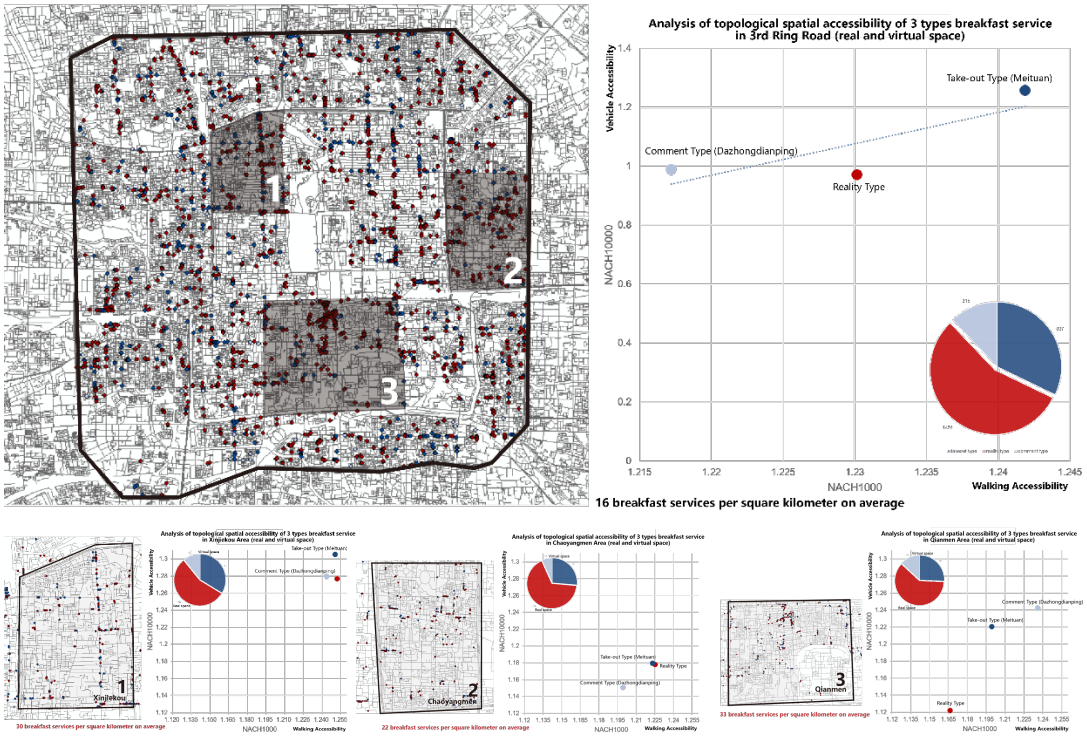


Figure 10: analysis of topological accessibility of 3 types breakfast service (reality, takeout, comment types) in 3rd Ring Road (top) and analysis of topological accessibility of 3 types breakfast service in Xinjiekou area, Chaoyangmen area and Qianmen area (bottom)

According to the above-mentioned kernel density analysis results (Figure 9), this study selected three case study areas (Xinjiekou, Chaoyangmen and Qianmen area) and statistically analysed the accessibility of three types of breakfast services. Firstly, the distribution density of breakfast services in the Xinjiekou area is worse than that of online comment and takeout type according to the kernel density analysis. Xinjiekou is a mixed residential area, including Hutong, old community, high-rise residential area and other residential types. We summarized it as a partial online breakfast case area. The second one is the Chaoyangmen case area, which is mainly a business office area, belonging to the Beijing CBD. The distribution density of breakfast services visible only in reality in this area is higher than that of comment and takeout types visible on the Internet. As a result, we summarized Chaoyangmen area as a more traditional and realistic breakfast case area. What is more, the Qianmen area is dominated by tourism services, in which the streets retain the original Hutong texture, with a large number of businesses and a rich variety of types, and the catering industry is very developed. The distribution density of real breakfast and take out breakfast in Qianmen area is large, and the comment type is slightly lower than the first two categories. It is a case area of real network hybrid breakfast.

Figure 10 (bottom) shows the spatial topological accessibility location characteristics of three types of breakfast services divided based on real and virtual space in the above three case areas. Interestingly, these three case areas show different laws, which are also different from the overall law of breakfast services in the 3rd Ring Road. Firstly, in terms of kernel density, Xinjiekou area compound residential area with virtual network type accounting for the majority. In this area, the takeout type breakfast stores occupy the streets with the best vehicle accessibility, while the

comment type is in the position with poor walking accessibility. The reality type breakfast services in the display are not very different from the comment type in the vehicle accessibility, which is the same as the overall trend. However, different from the overall situation, these three types have little difference in walking accessibility.

Compared with the latter two case areas, breakfast services are located in the streets with high accessibility. As for the reason, we think it has a lot to do with the compound living characteristics of the case area. The large population and rigid demand for community catering such as breakfast in this area lead to the coverage of up to 30 breakfast services per square kilometre in Xinjiekou area in terms of quantity. This group habit and dependence also explain the phenomenon that takeout breakfast is given priority to the development of accessibility advantage.

Secondly, for the Chaoyangmen case area, through statistics, it is found that takeout and realistic streets occupy the accessibility advantage of the area, forming a competitive relationship. Chaoyangmen is a business office area. For breakfast, office workers usually choose to eat in the hall near the office, or order takeout to the office on the way to work and eat at the station. It is the emergence of these two options that makes the reality type breakfast and takeout breakfast overlap in the accessible street, resulting in the emergence of competitive relationship. Finally, we analyse the Qianmen case area with dense breakfast stores. This area shows the research results that are very different from the above case area. Takeout type breakfast no longer occupies the streets with the best accessibility. On the contrary, comment type breakfast has become the dominant street in terms of accessibility, whether by car or by foot. At the same time, the realistic type is in the most disadvantaged accessibility position in space. This is closely related to the characteristics of Qianmen tourist area.

For the breakfast of tourists, comments have become the dominant category, while local people do not need breakfast choices with good accessibility due to their familiarity with the Hutong environment. Their habitual dining leads to the low accessibility of breakfast only visible in reality. For different groups, there is a complementary relationship between real breakfast and virtual network breakfast in this case area.

4 CONCLUSIONS AND DISCUSSIONS

Before and after the epidemic, in terms of the changes in the number of breakfast service in the real space, there were 3597 in the 3rd Ring Road in 2019, of which subcontracted breakfast service accounted for the most and mobile vendor stance the least. In 2020, there were 3230, a decrease of 10.2%, and the chain restaurants increased slightly. It can be seen that the chain restaurants suffered less impact.

At the city scale, our team found that the density of breakfast points (1000m radius) is most related to the density of unemployed and residents, and less related to the employment density. In addition, in terms of commuting distance, the distribution of breakfast points is more affected by the starting point of commuting. Based on this, the independent variables such as cell phone signaling, subway station distance(Metric Step Depth) and space syntax Integration were normalized and analyzed by multiple regression with breakfast service density. The Integrated Model with the above three variables has the best correlation with breakfast service.

At the street scale, in terms of comparison of various types, it can be seen that chain restaurants and bakery have the highest demand for accessibility. Through the statistics of breakfast service that disappeared after the epidemic, we found that breakfast service with poor accessibility were eliminated first, especially the service with high vehicle accessibility but low walking accessibility. According to the statistics of the increased breakfast service after the epidemic, the streets with good accessibility are restored first. In general, it can be seen that the space with dominant accessibility has stronger resilience.

About the difference of breakfast points in real and virtual space, the Kernel Density method is mainly used to analyze the reality, comment and takeout breakfast services respectively. We found that the spatial distribution density of breakfast services in real and virtual space is quite different. The breakfast services benefiting from Dazhongdianping.com or Meituan takeout are relatively more dispersed, showing a “decentralized concentration”. In urban space, it is concentrated in economically developed areas, such as business centers and densely populated areas. The takeout breakfast service is in the street with the best accessibility on the whole. However, compared with the breakfast that can only be seen in reality, the comment type breakfast that benefits from the Dazhongdianping.com depends less on walking accessibility. It can be seen that the takeout platform does not give opportunities to shops with poor accessibility at the street level, but still follows the rules of the real world. Stores or services in an advantageous position and with a prosperous foundation are more likely to expand new opportunities through the network platform in virtual space. Interestingly, these three case areas show different laws, which are also different from the overall law of breakfast services in the 3rd Ring Road. Firstly,in Xinjiekou area, the takeout type occupy the streets with the best vehicle accessibility, while the comment type is in the position with poor walking accessibility.

However, different from the overall situation, these three types have little difference in walking accessibility (Nach1000). Secondly, for Chaoyangmen case area, takeout and realistic services occupy the accessibility advantage of the area, forming a competitive relationship. Finally, we analyze the Qianmen case area with dense breakfast stores, which shows very different results from the above case area. On the contrary, comment type breakfast has become the dominant street in terms of accessibility, whether by car or by foot. At the same time, the realistic type is in

the most disadvantaged accessibility position in space. There is a complementary relationship between real breakfast and virtual network breakfast in this case area.

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