

# Mobility and beyond: explore the spatial-functional effect of cycling ban on Huangpu, Shanghai through crowd-sourcing data

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## Abstract

*Cycling is regarded as one of the most sustainable transportation methods in cities. However, under the need to improve motor traffic conditions in dense street space, the importance of cycling accessibility is often overlooked. This research takes Huangpu District, the cradle of modern-day Shanghai but is currently also the most restricted street segments for cycling activities, in order to explore the effect of cycling curb on urban space. Through emerging crowd-sourcing data that precisely reflects users' activities, this article aims to explore the mobility as well as functionality aspects of the cycling curb policy influence. It is found that current policy didn't provide enough cycling accessibility and route choice to an area with various cycling purpose, even though the streets with restrictions for non-motorized vehicles don't significantly deprive cyclists of their connectivity with urban vitality. Moreover, metro stations function as a key role in local cycling activities. Finally, authors provide a revision framework for the policy and planning making process in Huangpu District under the view of 'cycling-first' agenda.*

## Keywords

*Cycling, Mobility, Urban Functionality, Data-informed Planning, Shanghai*

## 1. Introduction

Walking and cycling are widely considered as two of the most sustainable, healthy, affordable and barrier-free transportation methods. If the provisions of infrastructure are running well, the surging demands of short-distance travel linking to people's daily activities can be met through greener ways (UN Habitat, 2018). It features safety, convenience, and comfort and is influential to the vitality of cities. Despite the long history of bicycle use, more negative outcomes are associated with it as it has long been criticized for considerably contributing to transportation disorder.

The emergence of dockless shared bicycles has greatly changed the mode of bicycle travel and the value of urban traffic management (Shen et al., 2018). Since 2015, as the striking initiatives of two companies of Ofo and Mobike, shared bicycles first appeared in China. Integrated with the Internet, mobile payment and positioning systems, it can be much more convenient to use. The vigorous development of a new generation of shared bicycles in China has brought about a change in the city's perception of non-motorized vehicles. It is used as an important means of green travel and fulfils the demands of travel in minimum distance (Zhang and Mi, 2018), and gradually focuses on suitability (Chen et al., 2018, Guo and He, 2020).

Although cycling as a mode of travel presents many advantages, due to the randomness and spontaneity of its travel characteristics (Buehler and Dill, 2016), in the process of coordinating different flows including automobiles, non-motorized vehicles, and pedestrians, there are often situations where it is necessary to restrict bicycle. At the same time, the prevalence of shared bicycles has brought an unprecedented large number of non-motorized traffic in cities, and the negative impact on urban traffic has further fuelled the demands for government control. Taking Shanghai as an example. around 2017, as to the management of shared bicycles, different districts have proposed multiple guidelines linking to its travel and parking networks (Shanghai, 2016, 2017).

However, in the transportation policy-making process, motorized vehicle travel is often given priority, ignoring the demands of non-motorized vehicles. With more people choosing to cycle, unrestricted cycling behaviour has instead brought about a decrease in the quality of cycling space. A large number of unknowing violations (Shanghai, 2018). On the contrary, good transportation facilities can enhance the cycling experience and further increase green travel (Hull and O'Holleran, 2014). Therefore, it is necessary to evaluate the spatial effects of the non-motor vehicle prohibition policy, so as to put forward effective optimization suggestions.

This research hopes to understand how does the effect of the prohibition policy affect urban space and bicycle travel? Based on this research question, this research sets the following hypothesis:

Hypothesis 1: the prohibition policy does not affect bicycle travel, therefore there is no significant difference between the time and space characteristics of bicycle travel in the prohibited area and the general area.

While affecting the characteristics of bicycle travel, the accessibility characteristics of space will further affect the distribution of urban functions and vitality. It is necessary to evaluate them, and then the second hypothesis of this study is generated.

Hypothesis 2: the implementation of the policy has no effect on the functional vitality of the city, the roads subject to traffic restrictions will have no significant difference in the representation of urban vitality from the general area, and the prohibition of traffic will not significantly affect the accessibility of the vital area.

Based on above hypothesis, this research will be conducted in the following parts: Firstly, we would like to introduce the current non-motor vehicle travel policy in Huangpu District of Shanghai as well as data and methods used in this research. Secondly, from the dimensions of travel time and distance of shared bicycles, this paper discussed the similarities and differences between bicycle travel characteristics in Huangpu District and Shanghai under the context of there being many and scattered prohibited roads. Through space syntax we would compare non-motorized roads with general urban roads to discuss whether the prohibition policy hinders the accessibility of non-motorized travel. Thirdly, from the dimension of the vitality of the urban space, the similarities and differences in the openness of streets and crowd vitality between the non-motorized roads and general roads are compared, and the non-motorized travel prohibition and urban vitality are analyzed as well as impact imposed on the accessibility.

## 2. Materials and Methods

### 2.1. Study Area

The study is carried out in Huangpu District, Shanghai. As one of the most historically distinctive districts in Shanghai, Huangpu contains an abundance of historical resources and tourist attractions, including the Bund, the Old Town and People's Square, and is regarded as one of the areas with the most distinctive characteristics of Shanghai.

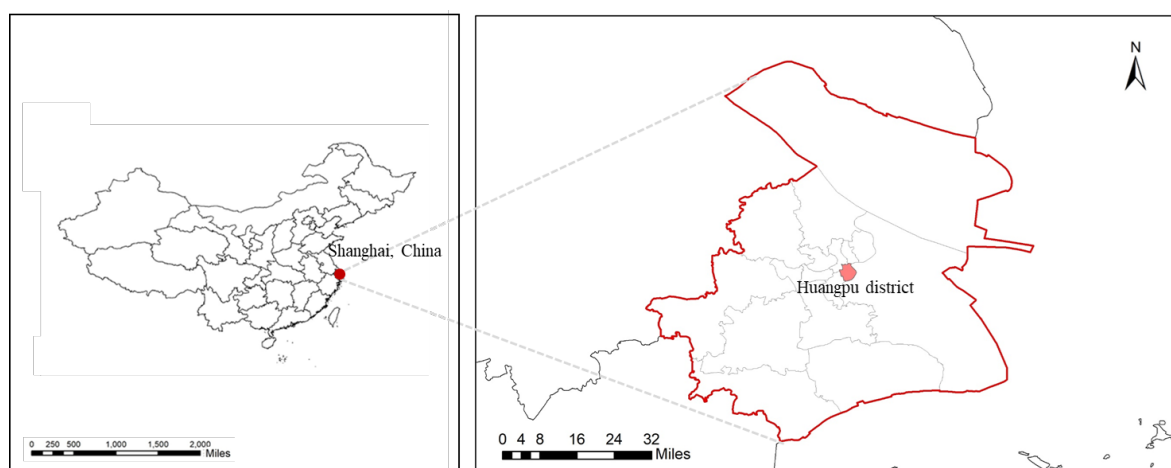


Figure 1. Study area and its location in Shanghai, China. Source: author.

Although Shanghai is among the first cities in the country to promote the spatial optimization of streets (Shanghai, 2018), the implication has not been effective enough, as the city core still suffers from difficulties in non-motorized traffic accessibility, typical of which is the Huangpu district. Within it exists the largest number of restricted road segments for cycling activities in Shanghai, with almost all major roads including restricted sections and a fragmented cycling network that could affect the accessibility of non-motorized traffics (Shanghai, 2018).

However, this policy development is not entirely ungrounded. Due to its historical development, street spaces in the Huangpu are narrow and insufficient to accommodate motorized, non-motorized and pedestrian traffic all at the same time, thus resulting in poor quality of cycling access on many streets. However, as the areas where non-motorized traffic is banned are often artillery roads in the city, which are generally considered to be areas with higher spatial openness and vitality along the streets and banning non-motorized traffic will greatly affect the spatial vitality and accessibility of the area.

In the price of prioritizing motor traffics, the self-organization and connectivity of road network as well as its role in vitalizing public spaces are undermined. As a public policy, it is of significance to identify its impacts in a holistic viewpoint. Based on the emerging data combined with the spatial form and functional configuration in the city, it is possible to effectively explain the spatial pattern of city and lead to a precise planning and policy intervention (Shen et al., 2021). This study will thoroughly assess the effectiveness of this policy from this perspective and make precise recommendations.

## 2.2. Data Source

With the advance of information and communication technologies (ICT) and the widespread use of mobile devices in recent years, new types of data are being generated, and the emergence of multi-source urban location data based on 'social sensing' (Galesic et al, 2021) provides a solid basis for fine-grained descriptions of the functional as well as spatial form of cities, which enables precise planning responses to various urban problems (Shen et al, 2021).

### 2.2.1. Bike-Sharing as Mobility

As a product of combining traditional urban facilities with ICT technology, bike-sharing can obtain real-time and full-sample spatial data to build up the spatial and temporal characteristics of bicycle trips (Shen et al., 2018). The data used in this study is based on a randomly selected sample of dockless bike-sharing usage during a week, and further filtered to obtain bicycle travel trajectories with origin/destination points located inside Huangpu District, including attributes such as order ID, bicycle ID and travel time, and connected to the real spatial road network through spatial connectivity and trajectory mapping.



Figure 2. Roads with different types of cycling restriction in Huangpu District. Source: author.

### 2.2.2. Road Networks as Spatial Accessibility

Road networks can effectively characterize the built environment of cities and, through a combination of analytical methods, can further represent the socio-economic characteristics behind space and travel (Hillier, Hanson, 1989). In this context, the concept of Space Syntax provides a well-established and widely recognized analytical methods that quantifies the accessibility of space as an 'economy of movement'.

Therefore, this study uses road network of Huangpu District from OpenStreetMap with a series of simplifications (removing duplicate roads, merging multiple parallel roads, etc., and deleting internal roads in gated communities) to derive two indicators, Choice and Integration as quantitative metric of accessibility through syntax analysis.

### 2.2.3. Points of Interest (POI) as Functionality

Points of Interest (POI) is a new data type that has emerged in recent years and has been used on a large scale in urban research and planning practice. It has higher accuracy and larger sample size than traditional data types, while enabling high frequency update features (Long and Shen, 2015).

This study uses two dimensions of POI data: city entrance data based acquired from one of the largest map platforms in China and social media check-in data. The former is a representation of the openness of the critical urban space interface, as entrance usually act as the interaction between urban function and human activities (Touya et al., 2017), which is closely related to the urban space from the perspective of bicycle travel, while the latter indicates the "social-sensing" dimension, as it is mainly generated through the actual usage which can effectively represent the distribution of human dynamics (Shen and Karimi, 2016).

### 3. Results

#### 3.1. Mobility

Huangpu District has a significantly higher density and activity due to its longer history of urban development than other areas in the municipality of Shanghai, resulting in a higher number of traffic control policies. Therefore, in terms of non-motorized vehicle prohibition policies, Huangpu District has the largest number of restricted road segments from non-motorized traffic. Based on the first hypothesis, it is necessary to examine the exact impact of the curbing policy on cycling travel characteristics in Huangpu District, in order to obtain an all-rounded conclusion on the influence of cycling curb on local mobility.

##### 3.1.1. Usage Pattern of Bike-sharing in Huangpu and Shanghai

In the existing literatures on bike-sharing, two indicators, travel time and distance, are widely adopted by scholars (Shen et al., 2018; Xu et al., 2019). By comparing the similarities and differences in the spatial and temporal characteristics of cycling trips between Huangpu District and other regions in Shanghai, it is possible to develop some knowledge of the impact of the curbing policy on non-motorized travel.

After excluding abnormal trip, it was found that trips with Huangpu District as the origin/destination point accounted for approximately 10% of the total sample size of trips in Shanghai as a whole. In terms of the distance of shared bicycle trips (Figure 3 a.), the selected samples showed relatively similar characteristics between Shanghai and Huangpu District, with a large number of trips distributed at distances below 7,500 m, and the largest number of samples with travel distance between 2,000 - 3,000m; This similarity is also reflected in the length of travel time(Figure 3 b.), where the majority of trips takes less than 50 minutes, and 0-15 minutes is the most frequent length, but the frequency of long-distance trips is relatively more in Huangpu District than in Shanghai as a whole, which is more evident in the spatio-temporal characteristics of trips (Figure 3 c.), although in terms of the spatio-temporal relationship of cycling trips, Huangpu District and Shanghai share a similar degree of correlation, but Huangpu District has a higher richness of spatio-temporal distribution.

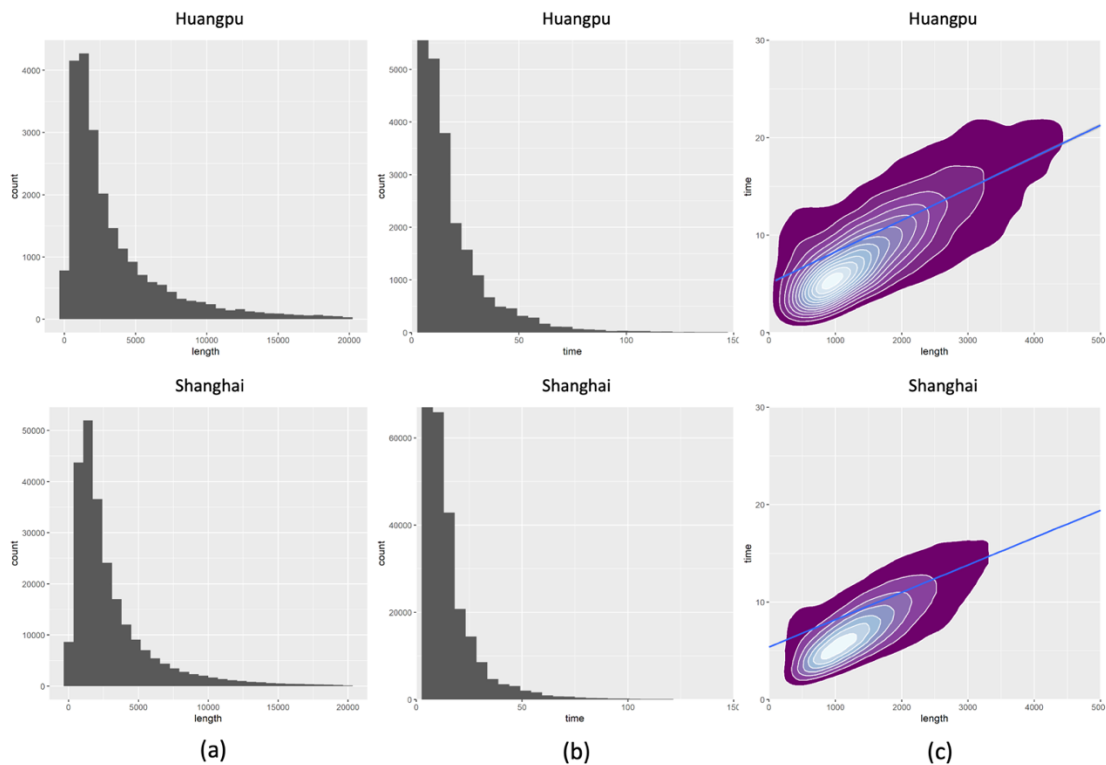


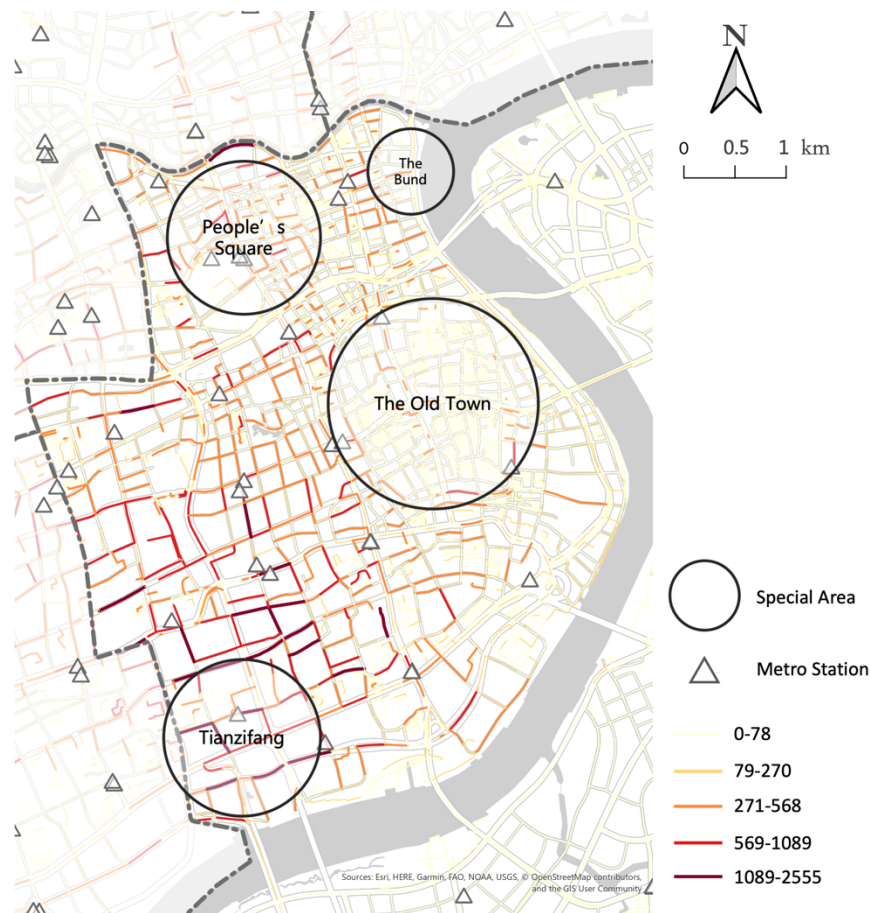
Figure 3. Usage Pattern of Bike-sharing in Huangpu and Shanghai. Source: author.



It indicates that despite the adoption of a more stringent non-motorized travel policy in Huangpu District, bike-sharing trips have not been significantly affected due to the abundance of facilities and resources in this area, but instead show a higher trip variety in comparison, potentially more non-commuting cycling trips.

### 3.1.2. Spatial Pattern of Bike Travel and Accessibility

By spatially correlating bicycle trajectories with street segments, it is observed that the trajectories of shared bicycle trips are significantly more on the western side of Huangpu than on the eastern side of the district, even though the eastern side includes renowned urban spaces as well, such as the Bund and the Old Town. Furthermore, the strong correlation between the spatial distribution of bicycle trips and rail stations further emphasizes the importance of bike-sharing service as the solution to short-distance travel for metro station. Despite the clarity and enforcement of the cycling curb, there are still illegal cycling activities on the west side of the Huangpu district, but overall, the curb has effectively reduced the amount of non-motorized traffic on roads that are not suitable for it.



**Figure 4. Spatial Pattern of Bike-sharing Trajectory in Huangpu. Source: author.**

Under the theory of spatial syntax, Choice and Integration are two indicators adapted in the analysis of street segmentation. Choice tends to represent the 'through' movement of space, while Integration is more likely to attract 'to' movement (Turner, 2007). In this study, a distance of 5,000m, which is a high probability of bike-sharing trip distance, was used as the analysis of accessibility from the perspective of bicycle trips. Based on this, road segments were further divided into two categories: general roads and roads subject to policy restrictions, and the levels of Choice and Integration were compared.

It is found that most of the roads restricted by said policy are ones with high accessibility potential and are more likely to be considered as a route or destination choice during a cyclist's trip. Although it is founded that the policy did not change the overall travel characteristics of bike-sharing, the analysis based on Choice

and Integration Index suggests that this policy will have an impact on the route choice of travel. In a context where non-motorized vehicles are banned on roads with higher accessibility, cyclists may choose to travel on roads with less accessibility, which could propose adverse effects on human interaction with urban space and on the cycling experience.

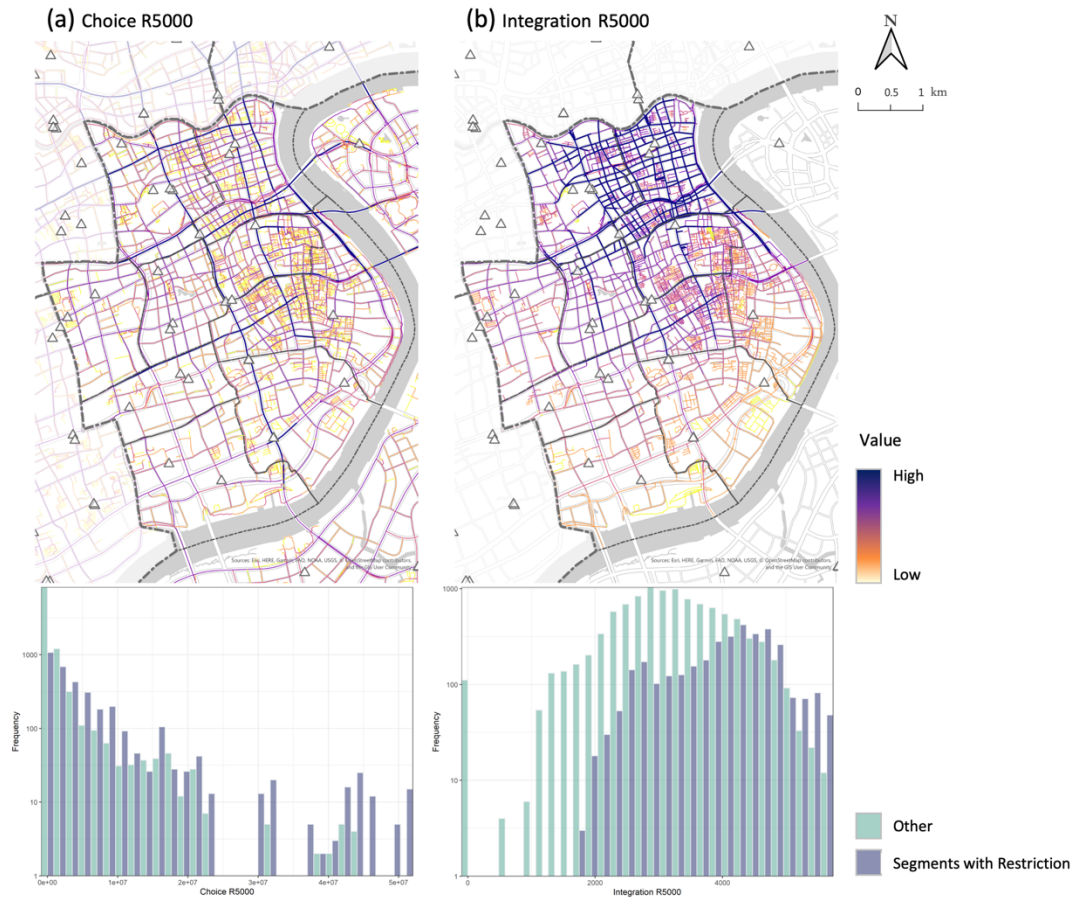


Figure 5. Spatial Pattern of Accessibility and Cycling Curb in Huangpu. Source: author.

### 3.2. Openness and Vitality

After analysing the impact of the ban on the mobility aspect of non-motorized travel, the perspective is further shifted to the functional and vitality dimensions, using data on entrances and social media check-in data, respectively, to explore the correlation of cycling curb with urban vitality in terms of the openness of urban space and human activity.

In terms of spatial distribution, a strong synergy is observed between the dense distribution of entrances and exits and the no-traffic roads in the area north of the Old Town, as well as a number of concentrated areas of crowd activity on both sides of the roads with non-motorized traffic restriction, and also closely related to the distribution of rail stations. This suggests that the roads in Huangpu District where the cycling curb policy is affected are all roads with high levels of functionality and vitality that may affect the accessibility of urban vitality for non-motorized travel groups.

All entrance/check-in function points within 30m of a street were connected to the corresponding street and categorized according to their control of non-motorized traffic in ArcGIS, and it was found that other roads have a higher level of openness compared with roads with non-motorized traffic restriction in terms of urban interface, which could be explained by the fact that segments with restrictions are usually highly

classified, heavily motorized roads with a correspondingly lower level of façade openness to the city. However, when examined from the perspective of vitality, the result show that segments with restriction are usually ones with high vitality functions in the city.

Even the previous analysis shows a seemingly contradictory results, the spatial effects of this policy are further enriched by spatial join in addition to the visualization. The result reveals that although the streets with non-motorized traffic restriction tend to show a higher value in spatial vitality, they don't coincide with areas with more of entrances, indicating that albeit influencing the vitality of Huangpu District, this policy has found a more limited impact on the accessibility of the spatial vitality side.

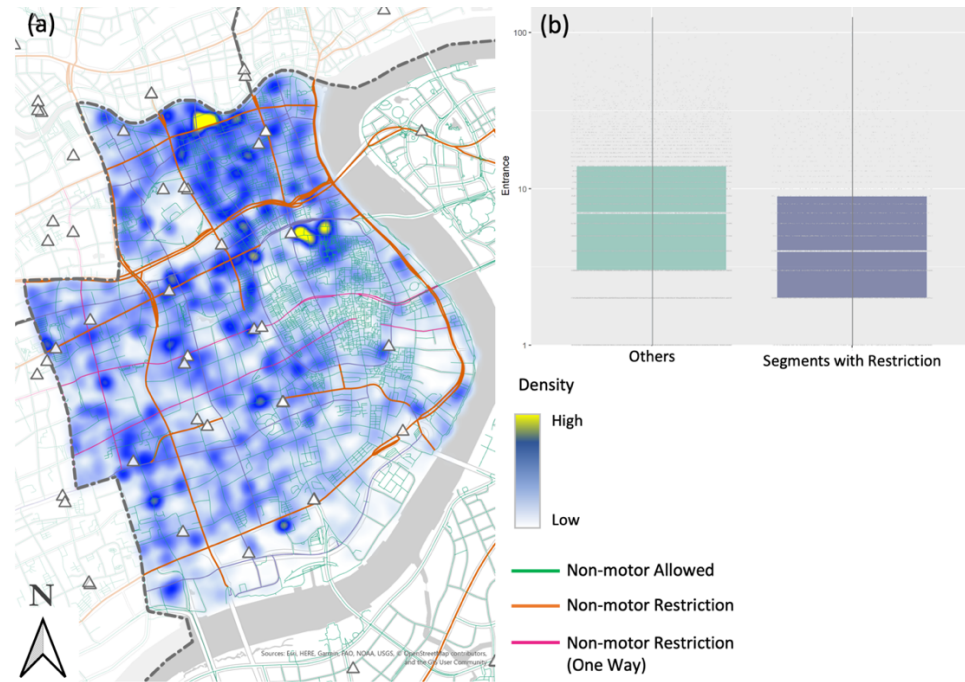


Figure 6. Openness and in Huangpu Indicated by Entrance Points. Source: author.

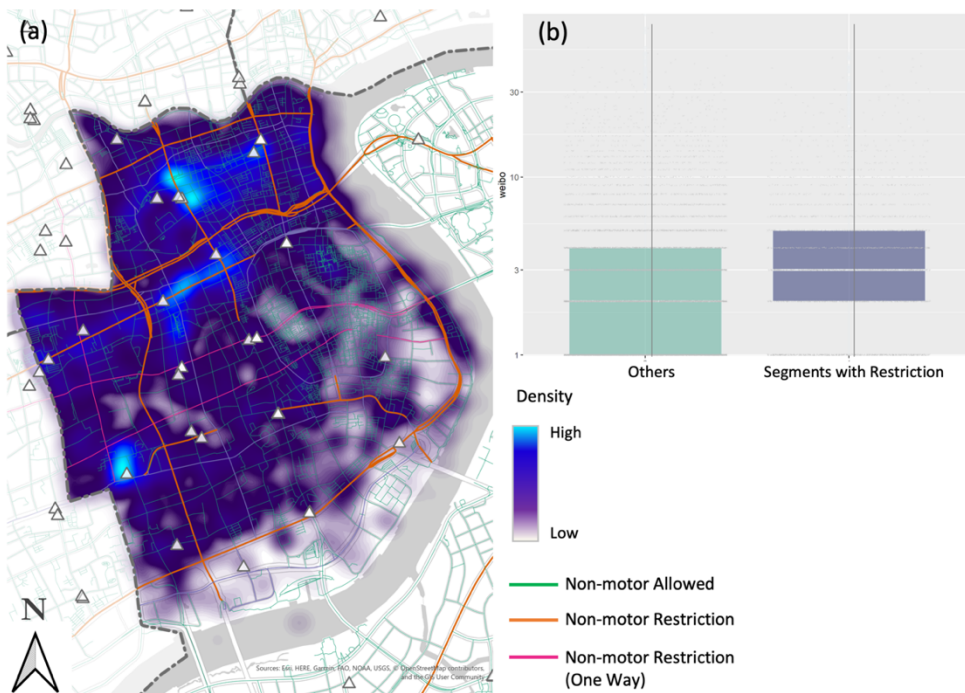


Figure 7. Vitality in Huangpu Indicated by Social Media Check-in. Source: author.



## 4. Discussion

Through analysis and interpretation based on spatial data, this paper forms a response to the two hypotheses established in the initial part of the article.

Hypothesis 1 holds partially. Within Huangpu District, there are a large number of restrictions on non-motorized travel, but the time and distance pattern of bike-sharing travel show similar characteristics to the overall sample in Shanghai, with a higher proportion of non-commuting travel. However, in terms of spatial distribution, the presence of roads with non-motorized traffic restriction makes it difficult for shared bicycles to travel in areas with high accessibility, potentially affecting the convenience of their travel, a phenomenon that is similar to Huangpu District's bicycle. There is a high degree of similarity in the distribution of trajectories.

As for the second Hypothesis, it also partially holds. It is found that non-motorized roads are generally higher than general roads in terms of functional vitality, but the corresponding spatial openness index is lower than that of non-motorized roads, implying that although non-motorized access is restricted in areas of high vitality, non-motorized vehicles still need to make detours to achieve accessibility due to the low level of openness in the aforementioned areas, therefore their travel demand and accessibility are not significantly affected.

Thus, although the ban potentially affects the spatial choice of shared bikes and other non-motorized vehicles and reduces the cycling experience, it does not have a serious negative effect on the spatial vitality and accessibility of the area. However, this does not mean that the current policy is sufficiently justified; on the contrary, press and online interviews suggest that there is currently a certain amount of criticism of the travel characteristics of non-motorized bicycles in Huangpu, and even a certain amount of deliberate violation of regulations in order to facilitate travel (Shanghai, 2016), which has a negative impact on urban spatial governance. On this basis, it is necessary to respond to existing non-motorized policies through planning and design instruments, both in terms of policy and space.

## 5. Policy and Planning Considerations

As one of the most historically and culturally influential areas in Shanghai, Huangpu District will have the possibility to undergo large-scale renewal in the future marching toward a more globalised city. In this context, it is necessary to reconstruct the transportation system, which will prioritize green commute while coordinating all the methods. It is of significant importance to build a more suitable network to encourage cycling travel. However, it should be highlighted that any policy which lacks examination through scientific method will induce more problems as it is stressed in this essay that reckless curbing policies will have adverse impact. The transportation policymaking should take local road networks and the practical needs into consideration.

Based on this thinking, the optimization of the cycling network can be started from two perspectives: First, it is critical to sort out the current status of the existing important road sections that restrict non-motorized vehicles and are not so coordinated to the network, so as to build a system that encourages cycling however not in sacrifice of the right of motorized vehicles. Secondly, more attention should be drawn to rail transit stations. The role of Shared bicycles as a strong link between rail transit stations and other spaces in the city has been widely recognized, However, the existing rail transit stations are often located in areas where shared bicycles are prohibited, which adds inconvenience to non-motorized vehicle travel and adversely impacts those links between.

At the same time, from the perspective of physical space, the existing roads are not completely impassable. There is little space left to non-motorized vehicles when motorized vehicles dominated the space. A series of space designs methods can be applied to optimize the streets, especially to enhance the efficiency of

transportation capacity and facilitate the running of non-motor vehicles, reaching balance between different travel behaviours.

Finally, based on the case study of Huangpu District, we would like to point out that in the process of urban policy-making, it is necessary to consider the interests of multiple stakeholders and take scientific and detailed analysis. At the same time, this research also shows that through big data, urban space and its internal activities can be fully understood on a larger scale, but it also requires a cross examination of finer-scale research to improve its accuracy and efficiency.

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