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International review for spatial planning and sustainable development, Vol.8 No.1 (2020), 59-93
ISSN: 2187-3666 (online)
DOI: http://dx.doi.org/10.14246/irspsd.8.1 59

On the Applicability of a Western Bikeability Index in the Chinese Context

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Received: May 18, 2017; Accepted: January 15, 2019

Key words: Urban Cycling, Bikeability Index, Bikeability Parameters, Bikeable City, China

Abstract: Following the evolutionary pattern already observed in western countries, China is now witnessing a tremendous growth in car ownership that is reshaping the urban environment. Despite the surge in motorised traffic, the remaining high level of bicycle usage and the rapid development of dock-less app-based bicycle-sharing systems highlight the urgent need to assess the bikeability level in Chinese cities. However, this unique setup renders obsolete most of the western tools used to rank cities with respect to their bike-friendliness. Following a multidisciplinary approach, we compare the results of our survey to the commonly accepted western views and isolate indicators suitable to urban cycling in China. While refining and sometimes reformulating the goals commonly pursued in bicycle planning, we also provide recommendations for measurements and effective improvements of bikeability when western solutions fail to meet the needs specific to the Chinese context.

1. INTRODUCTION

1.1 The need for tailored bicycle performance measures

As a practice, cycling can be found everywhere. Yet, despite its global character, its concentration varies according to time and context. Today's governments and localities acknowledge cycling as an effective vehicle for socio-economic, public-health and environmental improvements. Planners and engineers are increasingly eager to expand cycling infrastructure within the urban environment. To ensure the effectiveness and appropriate development of pro-cycling policies, decision makers and stake-holders need to base their actions on solid conclusions drawn from a reliable assessment of the cycling infrastructure demands, needs and quality. This concern has led to the implementation in the past few years of a broad range of measurements and methods to evaluate to what extent investments, activity, and impacts relate to the goals targeted by communities and planners (Semler et al., 2016; Sen et al., 2011; Sheikh, 2017; Mekuria, Appleyard, & Nixon, 2017). These methods and approaches, often focused on the transportation demand, seldom address the need for comprehensive

sets of measures that cover the physical, economic, socio-demographic and socio-cultural aspects of the cycling environment. The concept of *bikeability*, as a measure of how friendly an area is to cycling, aims at filling the gap, usually providing a wider perspective including societal and/or cultural preconditions. When the objective is to implement long-term solutions based on accurate judgements and realistic forecasts, these elements are of major importance since they act as powerful moderators in behaviour change (Bartholomew Eldredge et al., 2016).

Performance management techniques support informed decision-making by relating the goals to the measurable effects of transportation policies. A prime objective in performance management is to define reliable measurements able to capture the current state of the system. The following step is to improve those measures that in turn could be compared and used to evaluate the effectiveness of the policies currently implemented. In this process, the goal provides the overall orientation. As such, different goals imply different strategies and thus different measurements.

1.2 On the specificities of the Chinese context

As today's western governments strive to reverse the trend of automobility, the greatest difficulty resides in the extremely low level of the bicycle mode share. Because bicycle usage has become a marginal practice, their goal is to remodel the city to render bicycling more appealing. In turn they hope this will contribute to an adjustment of the population's travelling habits. In this regard the circumstances differ widely from the Chinese context: despite tremendous economic growth and wide motorisation, walking and cycling still account for almost half of all trips in urban areas, and in a modern city such as Shanghai, more than one in two people are bicycle owners (Pan et al., 2013). Due to its ubiquity in China, cycling induces strong interactions and acute perceptions with direct impacts on the ultimate goal to be pursued. Indeed, while inexperience in cycling was recognized as a restraining factor in many western studies (Rondinella, 2015), most Chinese people have been or are currently cycling. In this specific situation the goal shifts from helping people "set (back) in the saddle" to "remain in the saddle".

However, even in a specific context, variations still exist. Although within a same country, cities share the same ultimate goal – in China, it is maintaining (if not increasing) the bicycle mode share – auxiliary targets may greatly differ according to local circumstances. With the goal of supporting objective planning and prioritizing investments, the evaluation and comparison of cities has already proven the achievement of tangible results in bicycle usage[1]. As such, a city-level evaluation based on a performance indicators index would be most helpful in implementing adequate pro-cycling policies in China. However, most of the tools and solutions available in bikeability evaluation assume a sociological landscape with a high level of car ownership and a very low bicycle mode share. The specificity of the Chinese context motivates the following research as it implies the necessity to develop new sets of performance indicators able to establish cycling in the fast-paced and competitive realm of Chinese urban transportation.

[1] Many studies at the city-level prove that sharing knowledge and experiences accelerates the implementation of effective solutions Pucher and Buehler (2008, 2007).

This study is the first step in the definition of a new bikeability index that fits the Chinese context. To this end, we first examine the current state and organisation of performance measures (Section 2). After exposing our methods developed within a multidisciplinary scheme (Section 3), we explain our dual approach based on the confrontation of western and Chinese facts while including the results from the data analysis of our structured questionnaire survey (Section 4). Beyond their simple enunciation and assessment, we thoroughly investigate each category of the western indicators. Finally, we conclude about the significance of our work, observing how it can be applied in order to measure the bikeability level in Chinese cities (Section 5).

2. BICYCLE PERFORMANCE MEASURES

2.1 Goals and toolbox

Due to its positive evaluation in terms of sociological and environmental effects, cycling is located at the intersection of the two notions *liveable cities* and *sustainable transport*. Hence, the goals in *bikeability* often result from the fusion of two main streams: community goals and transportation goals. Community goals – defined as the goals usually resulting from community development planning – are often instrumental in formulating refined objectives for cycling as a socially inclusive and sustainable transportation mode. These goals can be gathered into seven categories: health, safety, equity, liveability, connectivity, economy, and environment.

The transportation goals as defined in this study are viewed as broad orientations that form the means by which objectives can be achieved. We organise them under five categories: accessibility, compliance, demand, mobility, infrastructure, and LOS (Level of Service) (Semler et al., 2016). As such, each transportation goal refers to specific performance measures. These data sets and measurement tools applied to community goals provide a framework for the evaluation of the cycling environment with various levels of relevance exposed in Table 1.

Table 1. Applicability of transportation measures related to community goals

Community Goals	Accessibility	Compliance	Demand	Infrastructure	Mobility	LOS
Health	High	Low	High	High	Low	Low
Safety	High	High	High	High	High	High
Equity	High	Low	Low	High	High	High
Liveability	High	Low	Low	High	Low	High
Connectivity	High	Low		High	High	High
Economy	High			Low	High	High
Environment	High		High		Low	Low

• Accessibility: Refers to programs, services, and activities to ease access for all kinds of people.
• Compliance: Conforming to a requirement (e.g., a statute or regulation).
• Demand: The amount of existing and potential use in the various transportation modes.
• Infrastructure: Elements of the built environment in which a transportation system operates; it includes roads, signals, transit, bike facilities, shared-use paths, or side-walks.
• Mobility: The ability to travel or move easily from place to place.
• L.O.S. (Level of Service): Refers to the conditions in a specific mode from the users' perspective; it evaluates speed, density, congestion, reliability, and levels of comfort, convenience or safety.

Source: Based on "Guidebook for Developing Pedestrian and Bicycle Performance Measures"(Semler et al., 2016).

This framework is most useful in associating measures to actual progress towards a specific goal, thus informing decision-making in the practice of planning. Performance management in transport planning displays a multiplicity of approaches highlighting the various ways in which a bicycle metric can be used according to formulated goals. However, these measures are usually selected to serve objectives specific to localities, in a fashion seldom expandable to wider, more complex and heterogeneous urban structures. To overcome this limitation, bikeability indices aim at providing a range of performance indicators that could capture the characteristics of an entire city. In turn, this tool could be used at a city level to prioritize, compare, and plan for the effective implementation of bicycle policies and projects at the community level.

2.2 Bikeability index

Following the relatively recent interest in cycling, *bikeability* benefits from relevant but limited literature and evaluation tools compared to its neighbour field *walkability*.

Here it is worth to illustrate the discrepancy also clearly felt in the general public interest. *Walk Score* was founded in 2007, and its aim was "to promote walkable neighbourhoods" in the context of a growing worldwide interest. The company's namesake, and flagship product, is a walkability index. Bikeability finds its counterpart in the more recent *Copenhagenize Index* which remains less popular and does not extend to neighbourhood scoring[2].

Another enlightening fact is the existence since 2007 of an article about walkability on *Wikipedia*, while bikeability as a general concept has just been recently included among the entries that can be found by the search engine, the related article still being at a preliminary draft stage.

As a reliable tool providing accurate scoring for western cities, the *Copenhagenize Index* was instrumental in expanding research methods. This is the bikeability index taken as a reference by the TDM Encyclopedia (2018). This set of performance indicators is designed in a framework to facilitate the comparison of cities through an overall rating in bikeability. First, we suggest examining the criteria (Table 2) according to the definitions given by the *Copenhagenize Index* (Copenhagenize Design Co., 2017).

Then, we relate the fourteen parameters of the index to the framework developed around the community goals to evaluate the potential impact of using such a tool in performance management (Table 3). The purpose is to determine to what extent it could help develop sets of measures that can fully integrate bicycle planning into ongoing global policies and practices. The results of this comparison highlight the gaps in the usual approach of elaborating local strategies, that is to say taking the community level as the scale of reference in interventions. Since some of the bikeability parameters are hardly included in the current performance management framework (Table 3), it also demonstrates how providing a global picture can avoid overlooking major assets or obstacles in pursuing goals.

[2] *Walk Score* recently enlarged its scope by featuring the level of bikeability in some specific areas of western cities. The fact that bikeability is treated as an actual subsection of walkability also shows its perceived lower level of importance.

Moreover, we must highlight that all the elements of comparison are primarily designed to fit the western context. As this study aims to test the applicability of the bikeability criteria in the Chinese context, applying them individually to evaluate the city of Shanghai will be a solid starting point from which to identify the level of relevancy of each performance indicator.

Table 2. Categories of bikeability performance indicators

Category	Description
Advocacy	Perception and influence of the city (or region/country) advocacy NGO(s). Rated from none to strong, with political influence.
Bicycle Culture	Cycling re-established for all or only sub-cultures. Rated from no bicycles or sport bikes only to mainstream acceptance.
Bicycle Facilities	Bicycle accessibility, e.g. bike racks, ramps on stairs, space on trains/buses, road signs. Rated from no bicycle facilities to widespread and innovative facilities.
Bicycle Infrastructure	Rating of the city infrastructure. Rated from cyclists sharing car lanes to high level of safe, separated cycle tracks.
Bike-sharing Programs	Existence of comprehensive and well-used bike-sharing programs. Rated from none to comprehensive, high-usage program.
Gender Split	Gender share among cyclists. Rated from primarily male to an even split or more women than men.
Modal Share	Modal share represented by cyclists. Rated from under 1% to over 25%.
Increase since 2006	Increase in modal share since 2006 (when urban cycling started to kick off in western countries). Rated from under 1% to 5%+.
Safety Perception	Perception of safety by the cyclists. Rated from mandatory helmet laws with constant promotion of helmets to low helmet-usage rate.
Politics	Political climate regarding urban cycling. Rated from the bicycle being non-existent on a political level to being active and passionate.
Social Acceptance	Drivers and community view on urban cyclists. Rated from no social acceptance to widespread acceptance.
Urban Planning	City planners' knowledge of the best international practices and emphasis for bicycle infrastructure. Rated from car-centric urban planners to bicycle/pedestrian first.
Traffic Calming	Efforts to lower speed limits (e.g. 30 km/h zones) and calm traffic to increase safety for pedestrians and cyclists. Rated from none to extensive traffic-calming measures prioritising cyclists and pedestrians in traffic hierarchy.
Bonus Points	Maximum of 12 bonus points awarded for particularly impressive efforts or results towards re-establishing the bicycle as a feasible, acceptable and practical form of transport.

Source: Based on the *Copenhagenize Index* (TDM Encyclopedia, 2018).

Table 3. Correlation of bikeability performance indicators and community goals

Index Parameters	Health	Safety	Equity	Liveability	Connectivity	Economy
Advocacy			X	X		
Bicycle Culture				X		X
Bicycle Facilities	X		X	X		X
Infrastructure	X	X	X	X	X	X
Politics	X	X	X	X	X	X
Urban Planning	X	X	X	X	X	X
Modal Share	X	X	X	X	X	X
Increase since 2006	X	X	X	X	X	X
Shared-bikes	X		X	X		X
Safety Perception		X	X	X		
Traffic Calming		X	X	X		

Index Parameters	Health	Safety	Equity	Liveability	Connectivity	Economy
Social Acceptance			X	X		
Gender Split			X			

Source: Based on the *Copenhagenize Index* (TDM Encyclopedia, 2018) and the "Guidebook for Developing Pedestrian and Bicycle Performance Measures" (Semler et al., 2016).

3. METHODS

3.1 Applications in practice

In general, transportation goals relate to measurable outcomes in the physical environment, focusing on inputs (such as the investments) and outputs (such as the amount of facilities and infrastructure). In fact, mainstream transport research and policy is based primarily on the conclusions drawn from western studies where urban mobility benefits from limited sociological insights mostly focusing on automobility. Though a growing interest for changes in travel behaviour has led to an increasing number of individual behaviour studies, the downfall of this approach could be the overlooking of changes and processes observable at a societal level (Cairns et al., 2014).

From the perspective of social practice theory, measures in transportation are often focussed on materials – such as vehicles and urban forms – or competencies – such as driving skills – rather than meanings – rules and norms that define the practice (Shove, Pantzar, & Watson, 2012). In the western evaluation of bikeability, these symbolic meanings, ideas and aspirations, although critical in cycling, are often neglected as a way to measure and forecast its development within an urban mobility context. This alternative orientation has been mainly applied to understanding dependence on the car. A more sociological approach could be a valuable addition helping practitioners to comprehend the complex dynamics involved in cycling by considering bicycle usage as a social issue, rather than the exclusive result of individual behaviour (Spotswood et al., 2015).

Although evaluations in transportation include several elements related to individual perceptions – such as the user's satisfaction in the level of service – or behaviour change – examining the series of factors influencing travel behaviour – these components are seldom integrated in a comprehensive framework to inform global orientations for transport policies and interventions (Hong, Shen, & Zhang, 2014). The research in mental and physical health clearly establishes the association between depressive symptoms or various forms of physical pathologies with the features of the built environment, and various methods have been developed in this area to identify pertinent environmental components (Steg, van den Berg, & de Groot, 2013). But this assessment of physical features related to health, while providing a reliable inter-methodology, is often focused on pedestrian activity. Similarly, the specific area investigating the link between cognition, behaviour and built environment is well-documented, and provides valuable guidelines in defining research methodology and evaluation tools that have been largely applied in the realm of walkability (Emo, Al-Sayed, & Varoudis, 2016)[3].

[3] Another notion, connected to cycling as a social practice, is the restorative quality of the built environment. In contrast to walkability, bikeability evaluation seldom includes

A consistent and ever-growing body of evidence links the built environment to physical activity and stresses its potential benefits in health and quality of life (Jensen et al., 2017). However, this orientation in research tends to systematically group walking and cycling together as a core entity called "active transportation" or "active mobility". In fact, only a few of these studies have focused on cycling as a specific practice. An increasing literature addresses the limitations of the *active transportation* approach and calls for a clear distinction between walkability and bikeablilty measurements (Muhs & Clifton, 2015; Moran, Plaut, & Baron Epel, 2015).

Like walking, cycling extends beyond public spaces into private facilities much further than any other transportation tool. This singularity calls for studies, development, and implementation of local and microlevel processes. However, the bicycle allows travellers to go three to four times faster and access a territory ten to fifteen times larger than a person on foot. Therefore, a study in cycling cannot ignore the macro level and will gain in relevance by associating quantitative and qualitative studies.

Hence, to acquire a global perspective on bikeability we widen our scope of research to other fields such as geography, history, economics, sociology, anthropology, psychology, and medicine. This multidisciplinary approach allows us to better evaluate bicycle facilities, infrastructures, and related policies in the light of historical, ethnological or sociological insights. Moreover, while focusing on the outcomes, performance evaluation as a monitoring and analytic process is always based on actual measurements and data. Therefore, to support our theoretical evaluation of the existing bikeability performance indicators in the Chinese context and to test our hypothesis, we gathered some empirical measures through a survey of the Shanghai population.

3.2 Data collection and sample validity

In order to gather relevant bicycle measurements that take into account both perceptions and practice, a questionnaire was carefully designed with the goal of collecting appropriate data to test the current assumptions in western bikeability. A survey of more than 400 respondents was carried out in the Shanghai city centre. People were randomly selected in public spaces, or on the street without discrimination of age or of any other kind. The sample includes 55 westerners living in Shanghai for over a year and 351 Chinese citizens[4].

The questionnaire was composed of three parts in order to define: (i) the respondents' profile – such as general socio-demographic information or transportation usage and preferences; (ii) the perceived barriers and level of bikeability in Shanghai – namely the individual perceptions of cycling as a practice and cyclists as a figure; and (iii) only for cyclists, the appraisal of the cycling environment and the respondents' typical biking journey (see Appendix A).

perceptions as performance measures, investigating the level of cyclists' attachment to a typical life-style as well as its impact at a community level.

[4] When necessary, the data was analysed separately in order to provide a comparison between the perceptions of Chinese and foreign populations.

After collection, a basic analysis was performed in order to evaluate the quality of the sample. In particular we extracted some key aspects and compared them to well-established facts about the Shanghai population.

A first indicator is provided by the average door-to-door commuting time of the sample, 39 minutes, which matches the figures announced in China's New-Urbanization Report. Indeed, Shanghai residents spend an average of 38 minutes commuting to their workplace (Niu, 2012). The car ownership, 32% in the sample, corresponds to the 32.5% announced by the Shanghai Bureau of Statistics (Shanghai Bureau of Statistics, 2017). Moreover the 54% bicycle ownership displayed in the sample is close to the official statistics of 55% (Pan et al., 2013). Regarding the gender parity of the respondents, men are slightly more represented than women. In fact, this corroborates the imbalanced ratio observed over the city (113 males for every 100 females) (World Population Review, 2017). As for the age of the respondents, this ranged from 15 to 72, following a right-skewed normal distribution with a median of 30 years old and a mean age of 33.8. Although this differs slightly from the official statistics, our sample fits the purpose of the study. While the elderly may be less inclined to cycle due to their physical condition, middle-aged people are more likely to provide an accurate vision of what the future of cycling could be in the city (Table 4).

Although the size of the sample does not allow an in-depth understanding of the phenomena related to bikeability, it is still possible to observe emerging patterns. In particular, since the aim of this work is to offer new directions for refined studies of bikeability in China, the size of the sample should not represent a major hindrance.

Table 4. Descriptive statistics of the sample

Category	Sample	Shanghai official figures
Population (n)	406	24.15 million
Foreigners (n)	55	*over 150,000
Gender (Male %)	54.1	53.0
Commuting time (min)	39	39
Mean age	33.8	36.9
Bicycle ownership (%)	54.0	55.0
Car ownership	32.1	32.5

Source: Shanghai Bureau of Statistics, *number of foreigners officially registered.

4. DISCUSSION

We turn now to the examination of the bikeability index criteria and assess each of the performance indicators with respect to their relevance in usual quantification – measurement tools or types of data – and applicability of the solutions commonly associated with these parameters. In other terms, we evaluate the pertinence of these indicators by transposing them directly into the Chinese context. As displayed in Table 3, some of these parameters are seldom included in performance management goals. Such indicators can only be associated to a very limited number of tools able to assess them. Therefore, some of the criteria will be apprehended from various angles to expose the characteristics allowing to define effective measurements.

4.1 Cycling advocacy and bicycle culture

4.1.1 Politics and official support

It is probably no accident that *bicycle culture* and *cycling advocacy* are on top of the criteria list in the *Copenhagenize Index*. Indeed, a mainstream culture that supports cycling may be the strongest element to define a bikeability level. It is, however, important to consider whether *bicycle culture* is a result or the cause of a high level of practice.

The comparison between different western countries is highly clarifying in this regard. From the democratisation of the car up to the 1970s, urban mobility followed a similar pattern in almost all cities; it was marked by a wide adaptation of the urban fabric to allow the dramatic increase in speed and number of motorised vehicles. The result was the general collapse in utilitarian cycling. During the 1980s and 1990s however, the bicycle mode share started increasing in various European countries, introducing a great separation in terms of both practice and approach among cities. In the early 2000s, utilitarian cycling was back in favour in a large part of western Europe and North America. However, this revival increased the gap between the different levels of practice. While Northern Europe consolidated its growth, cycling in other countries remained a marginal practice or was limited to specific locations (Héran, 2014).

Within western countries the Netherlands is regarded as the leading country in utilitarian cycling and thus a model to follow in terms of bikeability. It is therefore of great importance to understand the various components of this success. Although in the Netherlands, the general conditions prior to the resumption of cycling in the 1980s were not as extreme as in some other countries, cultural determinism cannot fully explain the current popularity of the bicycle as a transport mode, accounting for almost a third of all urban trips in many Dutch cities (European Platform of Mobility Management (EPOMM), 2016). Throughout the world, there are cities where the bicycle culture has been an integral part of the landscape for generations, even without much official support, however in the Netherlands, one striking fact is the constant interest of the ruling classes in cycling.

At the end of the nineteenth century, in order to counteract the recently unified power of neighbouring Germany, Dutch people built their own identity around the bicycle and its geographic convening power, being among the first to popularise cycling excursions (Ebert, 2004). In the following century, the bicycle became a mode of mass transportation for the working class everywhere in Europe, while the car was the bourgeoisie's prerogative. Dutch people however did not follow that trend. Very early, the royal family found in the bicycle a way to display the image of a monarchy close to the people. This historical specificity surely played a great role in the construction of the Netherlands's bicycle culture (Stoffers, 2012).

In the 1970s, the Netherlands enthusiastically rediscovered a declining practice and soon cultivated the image of a "biking country" (Carstensen & Ebert, 2012). The Dutch government even gathered a wide range of experts together (consultants, engineers, researchers, industrials, associations and decision-makers) within a network – *The Dutch Cycling Embassy* – that sells its know-how to other countries through marketing an export brand. In comparison, the Chinese bicycle culture's development reveals a different perspective for the future evolution of bikeability.

4.1.2 Cultural determinism and bicycle mode share

Interestingly, the bicycle had a very difficult start in China. As a foreign invention, it was not quickly embraced by Chinese people. In the end of the nineteenth century, while the western world became rapidly infatuated by the *safety bicycle*, it struggled to supplant the pulled rickshaw (人力车) recently introduced into China. This lack of enthusiasm can be explained by social factors; the resistance in shutting down the rickshaw industry was bipartite.

On one hand, the higher classes could not resolve themselves to accept the degrading labour of powering their transport by their own physical efforts. On the other hand, the rickshaw represented a substantial source of income for the lower social classes. It both generated employment and served as an instrument in the migration process for workers (Strand, 1993). The reluctance to shift from the rickshaw to the bicycle was therefore the result of pressures issued from both ends of the social hierarchy.

In Shanghai, the importation of rickshaws started more than a decade before the rest of mainland China, reinforcing its image of an avant-garde city. It was also in Shanghai, in 1868, six years before the arrival of the rickshaw, that the first importation of a bicycle was recorded (Xu, 2012). But at first the bicycle remained the preserve of foreigners living in Shanghai and did not arouse public interest since it was viewed as incompatible with Chinese cultural and social conventions.

During the first half of the 19th century, the bicycle's popularity progressively increased among urban residents. First viewed as a leisure tool, it later developed into a common mode of transportation. In the context of revolution, manual rickshaws became a negative symbol of the working class's oppression. Thus, after its founding in 1949, the People's Republic of China started its suppression. The Party advocated the bicycle as the "people's vehicle" and started to produce it on a massive scale. This implied a great turn in the Chinese bicycle industry (Mikkolainen, 2016). Its inclusion into city planning, as well as specific measures undertaken by the communist government, accelerated the bicycle's development exponentially[5]. China's first Five-Year Plan lead to a 60 percent growth of the bicycle industry. By 1958, China was producing more than a million bicycles annually and has remained in a leading position in terms of bicycle production ever since.

Today, despite a significant decrease in the modal split, China still holds to its image of a cycling country, the legacy of the once given title "Kingdom of Bicycles" (Wang, W., 2014). Nevertheless, though the omnipresence of the bicycle in China often leads to the assumption of a cultural inclination for cycling, the investigation of pre-1949 Chinese history reveals that rather than cultural predispositions, economic and modern infrastructural reasons are more likely to explain the country's development into the "bicycle nation of the 20th century" (Esfehani, 2003).

From an empirical point of view, the results of our survey reveal the difficulty of assessing Chinese bikeability according to western standards. As the respondents were asked whether or not Shanghai is a bikeable city, we observed a gap between the perception of the Chinese and westerners. While only 62% of the Chinese viewed Shanghai as bikeable, westerners

[5] For example, Chinese citizens using bicycles to travel to and from work were given additional benefits.

living in Shanghai are much more positive, as 80% perceived Shanghai as bikeable.

Due to a high bicycle mode share coupled with a booming e-bike industry, cycling is "normalised" in China to an extent generally not found anywhere else in developed economies. This can explain the positiveness of western respondents as they often come from cities where the modal share is extremely low. On the other hand, the more critical view point of Chinese people can be explained by a failure to fully integrate the bicycle demand in transport planning. Therefore, when evaluating bikeability in a Chinese city, the category of bicycle culture should be redefined in order to provide a proper rating. For now, according to the western standards, almost all Chinese cities would obtain a maximum score in categories such as bicycle culture and modal-share despite a declining practice and the absence of effective political support to cycling. The ambiguous approach of today's Chinese urban planning – vindicating bicycling in theory but doing very little to encourage it in practice – is expanded on in Section 4.3.

4.2 Social acceptance

4.2.1 Automobility versus bikeability

The "automobility culture" is developing worldwide and China is recognised as the most significant example currently undergoing this process (Urry, 2004). The rise in income, surge in motorised vehicles and expansion of the highway system in this country are pointed out as major factors responsible for the sharp decrease in bicycle usage (Zhang, Y. et al., 2014).

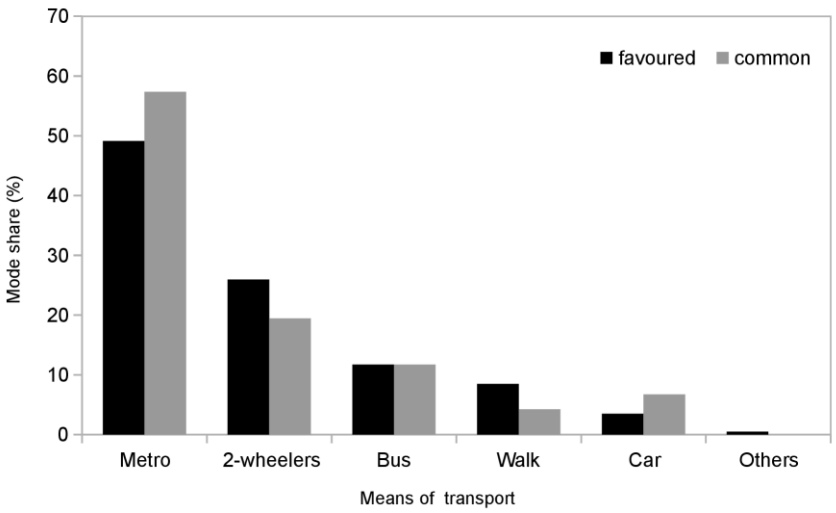


Figure 1. Favoured versus common transportation

At first glance, China follows the phenomenon already observed in western countries where the bicycle became increasingly popular and later was perceived as obsolete when the car developed into an emblematic object of individual consumption (Banister, 2005). However, our investigation draws alternative conclusions regarding the perception of cars and bicycles.

When asked what was their favourite means of transportation in Shanghai, 85% of car owners picked public transport or soft-mobility

(namely walking or cycling). Moreover, among all kinds of transportation, 20% of the car owners prefer riding a two-wheeled vehicle. Therefore, the comparison between favoured and common means of transportation highlights a shift of perception in mobility. The car does not appear to be as attractive as it seems when looking only at the dramatic surge in car ownership (Figure 1).

In fact, among the car owners who choose the bicycle as their favourite mode of transport, 33% justified their choice by convenience, and over 40% of them expressed a perception of enhanced freedom when cycling. Another interesting point is the notion of "enjoyment" expressed only when walking and riding two-wheeled vehicles, especially when considering that only the ones choosing bicycle enjoy cycling as both favoured and common transportation (Figure 2).

Based on this observation we can reach a first conclusion related to car use. Car owners do not have a positive perception of urban automobility in terms of efficiency or personal preferences. Confronted with urban congestion and parking shortages, car owners do not appreciate driving in the city. In such a context, the notion of freedom seems to have transferred from the expected promises of the car to the practicality of the bicycle. Therefore, while car ownership seems strongly motivated by a perceived higher status, our analysis found a mitigated picture in terms of car appreciation. This observation, complying with the results of another study on bikeability perception in Shanghai (Chevalier, Charlemagne, & L., 2017) also relates to the discrepancy between car ownership and car use that will be discussed in more detail in Section 4.3.2.

This conclusion is of major importance when evaluating the level of bikeability in a city. While cycling advocacy does not benefit from a strong official support in the vast majority of Chinese cities, the aspiration of the population for soft mobility – i.e. mobility which is people-friendly and environmentally-friendly – appears as a potential trigger for future improvements in bikeability.

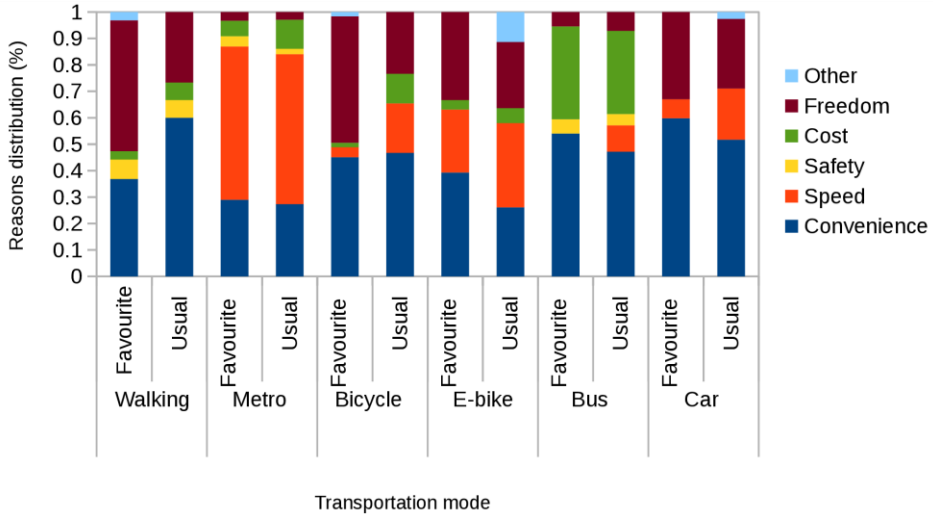


Figure 2. Reasons for favoured and common transportation mode

4.2.2 The bicycle as a part of the urban landscape

When further investigating our data, we identified a separation between the bicycle acceptance of Chinese citizens and the one of westerners living in Shanghai. The respondents were asked whether or not they think cyclists could be an issue for other road users in Shanghai. Only 22.6% of the Chinese respondents against 76.8% of the foreigners viewed bicycles as a potential problem on the roads.

As we discussed in the previous section, people seem to have a positive view on cycling as a practice. According to our sample, they also display a wide acceptance for cyclists as a figure. For those who have a negative view of cyclists, the reason explaining their opinion can offer some clarification (Table 5): Among the Chinese, the first reason was the cyclist's "disregard for traffic rules", gathering close to 60% of the people viewing the bicycle as a potential issue. Interestingly, from the westerners' view point, in half of the case cyclists were incriminated for their "lack of attention" on the road.

These differences in appreciation could rely on sociological characteristics. In a western context, even in the places where cycling is "normalised", the likelihood of meeting cyclists on the road is often occasional in comparison to the constant interactions with bicycles in Chinese cities. The "lack of attention" as well as the "unawareness of danger" pointed out by westerners could be due to a lesser ability on their part to cope with the crowdedness on the Chinese roads. Before going further in the investigation, the Chinese sociological context should be considered.

Table 5. Bicycles perceived as an issue for other road users

Nationality	No issue	Issue reason		
		Break rules	Careless	Ignore danger
Chinese	77.4%	14.8%	4.9%	1.7%
Westerners	23.2%	19.6%	37.5%	12.5%

Shanghai, as with many Asian cities, has a high population density, resulting in extraordinary crowdedness. Though often perceived as a negative experience (Bechtel & Churchman, 2003), some studies distinguish the physical condition of density and the actual experience of crowding (Stokols, 1972). In the research, this discrepancy between measurable density and level of emotion-laden crowding often results in a cultural bias, as it is widely admitted that crowding implies negative impacts on well-being, without empirical proof of such impact (Bechtel & Churchman, 2003).

In fact, crowding appears to be perceived differently in western and eastern cultures. For instance, when westerners feel an increase in risk and discomfort as streets become busier, Chinese road users seem to cope much better with the physical density, noise and action. This can be discerned in the Chinese language itself, as busy urban spaces are often described using the word "renao" (热闹), which has no exact equivalent in the English language. Only a paraphrase, such as "bustling with noise and excitement", can render the positive tone associated to the notion of frenetic activity and noise[6].

[6] The closer translation of "renao" into English could be "lively" although it often implies a festive environment and seldom relates to daily life activities. The Merriam-Webster dictionary defines "lively" as "full of life, movement, or incident" which may express the agitation but does not necessarily imply noise and density.

Furthermore, in a western context, segregation and speed on the roads reach much higher levels. In this context danger is real, leading to a necessary high level of self-awareness from vulnerable road users. Coming from such a context, westerners may tend to overestimate the danger in Chinese cities. Conversely, the concern of Chinese respondents for the "disregard of traffic rules" may reflect the progressive integration of perceived risk, similar to that of western societies. In China the rapid adaptation to motorised traffic, increasing speed and segregation on the roads, results in conflictual situations due to the still significant remaining soft mobility. The apprehension of danger and the applicability of western urban design solutions is further discussed in Section 4.4.4.

From a sociological standpoint, these observations represent an element of importance when evaluating the potential development of bikeability in China. Since this acceptance seems consensual, almost cultural, an analysis at the community level could be of great help to understand and measure the phenomenon. Therefore, when applying a western index's criteria, we could draw the hasty conclusion that *social acceptance* for cyclists is extremely high in China. A redefinition of the category could provide a refined measurement able to capture the societal evolution of a practice now still "normalized" and therefore not strictly defined by individual perceptions and behaviours.

4.3 Modal share, infrastructure and policies

4.3.1 Evolution in urban planning

In China as in the rest of the world, urban design placed cars in a central position within urban traffic and infrastructure development. While numerous western countries widely acknowledged the need for a re-orientation in urban mobility, that approach reached a quite dramatic degree in China.

In 1995, the Central Government released *The Standard of Urban Road Traffic* which initiated an era of drastic decrease in urban cycling (Zhang, H., Shaheen, & Chen, 2013). Local governments adopted more or less aggressive policies towards bicycle use, some even making it an official target to decrease the number of people cycling in the city. For instance, in 1993, the Transport Master Plan of Guangzhou established that the city would cut by almost one third the bicycle mode share in 2010 (Ma, 2004). From 2000 to 2006, major Chinese cities such as Shanghai, banned cycling traffic from the key central arteries and implemented various measures to limit the number of bicycles on the roads (Pan, 2012).

In 2002, the Shanghai government initiated a new phase in China's bicycle evolution by issuing the *White Paper of Shanghai Urban Transport Development* and ceasing the antagonistic attitude towards urban cycling (Zhang, H., Shaheen, & Chen, 2013). In an effort to solve environmental issues induced by motorised traffic, most local governments are still currently reassessing bicycle use, although initiatives in the last few years were often limited to the provision of bicycle-sharing systems. This illustrates an acceptance of the bicycle as a complement for public transportation but a persistent reluctance to promote and integrate cycling as a reliable mode of personal transportation per se (Yang et al., 2015).

In 2013, 104 Chinese cities adopted public bicycle-sharing systems (Institute for Transportation and Development Policy (2013)). These systems are under three business models and, in all of them, local

governments play a key role by providing land for stations, funding or both (Zhang, H., Shaheen, & Chen, 2013). In the large and dense transit-oriented Chinese cities, the question of the last mile problem must be addressed. As such bicycle-sharing systems appear as a reasonable solution. A study on public shared bicycles in Shanghai proved, however, that the shift to public bicycles was mainly from soft or eco-mobility, with nine users out of ten shifting from private bicycles and other sustainable transportation modes (Zhu et al., 2013). A great part of the public-bicycle users are in fact bicycle owners, so the gain in the bicycle mode share is somehow limited. In Section 4.5, we will further discuss the question of the bicycle-sharing systems in correlation with the booming phenomenon of the dock-less app-based schemes rapidly expanding in China.

Structural factors - the factors related to the conditions of town planning favourable to bicycles - have long been recognized as a measurable indicator of bikeability[7]. The discontinuous and limited character of the bicycle network in most western cities induced measures taking mostly in account the length of the bicycle lanes currently available. The examination of our data confirms the necessity to reassess this approach in Chinese bikeability. As shown in (Figure 3), when respondents were asked what could make them cycle more, while close to 40% of our respondents answered “better weather”, the following factor was the improvement of the urban environment, highlighting their desire for “better bicycle infrastructure”, “less encroachment of the lanes” and “more streets open to bikes”.

The great amount of bicycle lanes in urban China can lead to a biased interpretation that governments pay substantial attention to cycling. In reality, bicycle infrastructure was firstly developed with the objective of preventing cyclists from getting in the way of the increasing motorised traffic. Most of the existing bicycle lanes were built for the purpose of segregating bicycles to gain fluidity in the flow of cars (Zhang, H., Shaheen, & Chen, 2013).

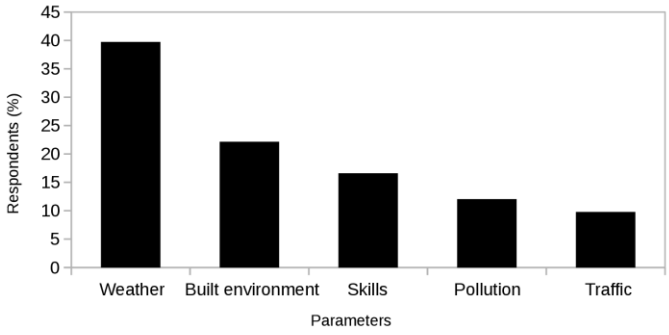


Figure 3. Reasons for favoured and common transportation mode

Therefore, while in a western context bicycle infrastructure development was undertaken with the ultimate goal to increase bicycle use, the Chinese approach renders the evaluation of bikeability even more complex when it comes to the category of *bicycle infrastructure* and *facilities*.

[7] Indeed, the existence of a bicycle network encourages cycling although some studies demonstrate that the importance of structural factors decrease as cyclists become more experienced (Broach, Dill, & Gliebe, 2012).

4.3.2 Perspectives and durability of cycling in China

As the one-child policy was relaxed, we can expect an increase in the number of children. Therefore, in order to address the future of bikeability in China the question of child transportation appears central in two aspects:

As explained in Section 4.2.1, our data analysis unveils an ambiguous duality of the perceptions in car ownership and car use. According to our sample, these perceptions appear highly connected with child transportation. In fact, in our sample less than a third of the car owners drive to commute, which highly contrasts with more than half of them using cars to transport their children. As in this half, less than 50% use it also for commuting, it means that a quarter of all the car owners only use it to drive their children (Chevalier, Charlemagne, & L., 2017). It also implies that young parents are very likely to shift from sustainable transportation to private cars.

The other aspect to be examined is the feasibility for children to cycle to school. Here, the Chinese regulation gives clear insights on the general perception of bicycle use for children. It also clearly states the orientation of the overall culture of planning, in terms of practice and regulations in this country. The Road Traffic Safety Law prohibits children under 12 years old to cycle on their own. It also forbids adults to transport more than one passenger, who cannot be older than 14 years old (People's Republic of China, 2003). These regulations, coupled with the absence of programs or legal interventions such as *Safe Routes to School*, converge with the issue of car ownership. In Section 4.4.1, we will examine the various vicious cycles in mobility that have a direct impact on bikeability since child transportation is a trigger in the implementation of these negative spirals (Horton, Rosen, & Cox, 2007). In China, the overall approach in transportation planning and the apparent lack of political support contrast greatly with the extensiveness of cycling infrastructure and the current bicycle mode share.

This ambiguous situation has led to some difficulties in evaluating categories such as *modal share*, *politics* and *urban planning*. New sets of measures in transportation sub-domains such as *compliance* and *demand* (Table 1), designed to estimate accurately the population needs and aspirations would enable authorities and decision makers to evaluate clearly the results of the actual efforts in planning towards bikeability in practice.

4.4 Safety, gender and cycling barriers

4.4.1 Safety perception

Many authors point out the correlation between perceived risk and urban cycling in western societies, especially in comparison with the perceptions in car use (Adams, 1995; Basford et al., 2002; Horton, Rosen, & Cox, 2007). Despite the diminution of cyclists and the explosion of motorised vehicles on the roads, many studies proved that the objective risk – measured by statistics – did not significantly increase over past decades (Krag, 1989). However, the subjective risk – the risk perceived by the population – is considerable. This gap between objective and subjective risk results in the disregard of cycling as a reliable means of transport which, in turn, drags the modal shift towards motorised transportation – thus increasing the actual risk for cyclists – and often leads to a biased interpretation of the problems in transport policies. The dual spiral of road insecurity is well investigated in western contexts and can be illustrated by the "cab-parents" fact; because they are scared by the increasing motorised traffic, parents no longer dare to

send kids to school on foot or on bicycle. They take them by car, thus increasing the danger to cyclists (Breton, 2004).

Another negative spiral is the one of increased distances. The boom in car traffic encourages urban sprawl, and by increasing travel distances, turns people's interest towards motorised transportation. Similarly, car traffic generates noise and atmospheric pollution highly detrimental to cycling and walking. Therefore, vulnerable road users are prompted to limit their exposure by choosing the shelter of the modes at the very source of this pollution (Gerondeau, 1993). This overestimation of danger and the resultant vicious cycles as shown in Figure 4 are recognised as having a direct impact in the bikeability level of western cities.

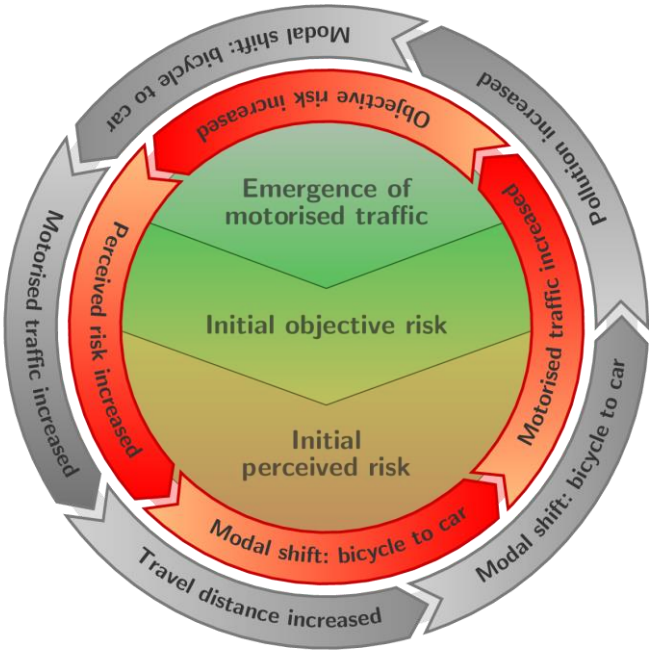
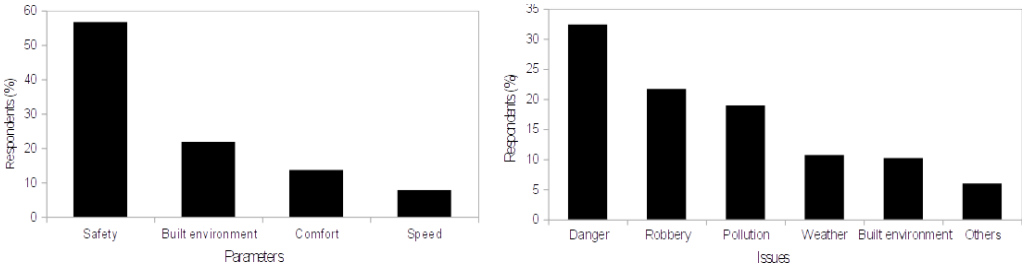


Figure 4. Vicious cycles

According to our sample, the weight of perceived danger as a major barrier in cycling can be questioned in the Chinese context. Though safety is an important element expressed by almost half of our respondents, we must put it in perspective with other formulated issues (Figure 5a). When respondents were asked to give their major concern with cycling, danger accounted for less than a third of the Chinese people as opposed to half of the westerners. Moreover, danger was largely outweighed by the addition of the fears of theft and bad weather respectively representing 22% and 11% (Figure 5b).



(a) most important when cycling *(b) major issues when cycling*

Figure 5. Perceptions in cycling

Therefore, while *safety perception* is an indisputable indicator of the bikeability level in western countries, it seems to be of lesser importance in China. If we refine its actual definition it could be put in perspective with other issues encountered by Chinese urban cyclists, namely the risk of losing your bike and the issues related to bad atmospheric conditions. These elements have been identified as powerful restraining factors by a study investigating cycling to school in Shanghai (Chevalier, Charlemagne, & L., 2018).

4.4.2 Helmet and gender

Regarding cycling barriers, another related aspect is to be considered. Gender differences in cycling are also well documented and *safety perception* is long proven to be highly gendered in a western context (Aldred, 2008; Atkins, 1986; Dalton, 2010). Surveys consistently show that men cycle much more than women. However, researchers have noted that in urban areas where the bicycle mode share is relatively high, cycling ceases to be gendered with equal or higher rates of female cyclists.

Considering our sample, however, we found no obvious relationship between the safety perception and the level of cycling (Section 4.4.1), neither between safety perception and gender[8]. Therefore, the category examining gender characteristics does not appear highly relevant for a bikeability evaluation in the Chinese context since it may not reflect an accurate perception of the cycling conditions in the way it operates in western countries.

Furthermore, to improve both objective and perceived safety, many western governments try to enforce wearing a helmet for cyclists. There is a virulent debate whether the helmet is an improvement or a barrier to cycling. Many empirical studies found that it is a restraining factor as it is viewed as inconvenient while the gain in safety is not widely acknowledged (Span & Morel, 2009). Following this conclusion, bicycle advocates often view it as a determining factor of the bikeability level (Bicycle Helmet Safety Institute, 2017). However, this question needs to be further investigated in China. Because in most Chinese cities the helmet is not compulsory, an evaluation along this parameter would provide them an excellent rating. However, the observation of the overall policies in China demonstrates that cyclists' safety and comfort is not yet central in planning. Therefore, attributing the maximum of points would be the result of a misinterpretation.

4.4.3 Fear of technology

While examining the various forms given to the "fear of cycling" in western countries, we isolated the ones relating to the "fear of technology"[9].

[8] The gender split in our sample is relatively balanced: 75% of the women and 87% of the men ride a two-wheeled vehicle.

[9] The fear of cycling represents an important emotional barrier to initiating (or maintaining) regular use of bicycles. This fear is multidimensional; it is of course composed by the fear of risk (subjective or objective) and the fear of being judged (referring to the notions of status and identity). It can be widened to the fear of the city

We found this type of fear significantly represented in our sample. Only 34% of the respondents felt capable of maintaining or repairing their bicycle by themselves while 24% of the men and only 4% of the women were actually doing so. This situation differs greatly from the one usually observed in fully developed economies. In western countries, repair and maintenance for bicycles is mainly assured by the bicycle owners. Bike shops can provide service but it is relatively expensive. As for China, the labour cost for fixing a flat tire or any other minor repair work is extremely low and shops are easy to find. The cost is, however, rapidly increasing while the number of repair men is decreasing dramatically. These workers used to be found on the street, in hallways or in very small shops. The recent enforcement of the Chinese regulation forbidding commercial street activities outside of the tax system has resulted in the disappearance of cheap convenient services. Dianping is providing much fewer repair points than it used to only a couple of years ago (Dianping, 2003)).

This contingency generated a high dependence of Chinese cyclists on these workers' availability. We may assume that future developments in bikeability will rely on the ability of populations to adapt to new circumstances and acquire necessary skills in order to repair and maintain private bicycles. Therefore, this aspect should be addressed in a Chinese bikeability index. The development of new measurement tools in the transportation sub-domain *LOS (Level of Service)* (Table 1) would allow us to capture the actual state and impact of such factors.

4.4.4 Traffic calming

In western countries, new urban planning approaches are now considered in order to develop soft-mobility. In the context of fast-moving and well segregated traffic, governments and citizens aim to render the character of liveable spaces to the streets. As a response to the growing awareness for the social cost of car use, various kinds of *traffic calming* mechanisms have been implemented with different levels of achievement[10]. In the western context, traffic calming provides greater safety for vulnerable road users (Litman, 1999). Thus, it is often viewed as a necessary component of bikeability.

To counteract the confining effect of pedestrianisation and follow the aim for a safer environment, many cities have been reintroducing soft mobility into a pluralist traffic environment and reviving the concept of "complete streets"[11]. In this context, the "shared space" is viewed as a promising alternative approach to urban design. The notion of a multi-usage road is not really new, but the shared space innovates in its pursuit to reconcile different speed and mass transportation means, mixing and erasing the separation of mobilities. From a sociological stand point the benefits of such combinations are already widely documented[12]. *Shared space* also

itself; fear of crowds, fear of traffic, but also fear of people and places viewed as dangerous. In fact, the fear of cycling overlaps with multiple related types of fear (Horton et al., 2007).

[10] Rooted in the 1970's Dutch movement of "woonerven" or "living yards", *traffic calming* encompasses a great variety of measures to lower speed and density of the motorised traffic and alter driver behaviour (Ewing, 1999).

[11] The notion of complete streets was developed to promote streets planned, designed, operated, and maintained to enable safe, convenient and comfortable travel or access for all users regardless of their mode of transportation (www.GovTrack.us, 2009).

[12] The road user integration idea was developed in various fields and can be traced to Buchannan's environmental area philosophy (Karndacharuk, Wilson, & Dunn, 2014).

highlights the evidence that rather than improving safety, segregation by design leads to a loss of general awareness increasing hazards for the most vulnerable groups of road users (Clarke, 2006).

In fact, *shared space* could be viewed as a resurgence of the default mode, the re-establishment of the street as it was before the consensus on segregation of urban design during the last century (Hamilton-Baillie Associates, 2006). Thus, regarding Asian mobility, this development model deserves close attention. In Chinese streets, the public disregard for rules of segregation often convert the streets into kinds of "wild shared spaces".

In practice, Chinese cities have not yet fully applied the general view of segregation in transport planning. On one hand, it means that Chinese cities could be privileged settings for implementing innovative urban design. On the other hand, this hypothesis should take into consideration the extreme urgency of assessing this potential development with relevant studies and thorough investigations. Although it is tempered by an emerging concern for soft mobility from the planning authorities, China is witnessing a rapid conversion of the urban environment towards traffic segregation. Moreover, the overall traffic speed in Chinese cities is already relatively low and often self-regulated by the traffic density and level of congestion on the roads. Therefore, this question needs to be further investigated since a *traffic calming* category in a Chinese bikeability index is less relevant than in a western context. A redevelopment of transportation measures in the *compliance* category – namely conforming to specific statutes, regulations or norms – would provide a more accurate over-view of the cycling conditions in China. In turn, it could be a powerful incentive in the implementation of effective pro-cycling designs.

4.5 Shared-bike programs

4.5.1 Cycling advocacy and effects on the modal share

These past few years, the rise of bicycle advocacy groups and fashionable trends such as "fixed gear bicycles" observed worldwide has also been increasingly visible in Shanghai, proving that bikes can be an appealing object for the new Chinese generations. When correlated to the amount of bicycle usage in China, advocacy – through organisations, sport clubs or communities – could however be viewed as very restricted. The "Mobike" phenomenon, launched in Shanghai in 2016 is probably the most remarkable advocacy campaign ever seen in urban China (Mobike, 2016). Successful from its beginning, it rapidly found strong advocates even abroad (Sp and X, 2016; Smart Shanghai, 2016). A year after their introduction, these bike-sharing schemes have scaled up to an astonishing level. With massive funding from private investors, bike-sharing start-ups stormed the streets of Chinese cities. Mobike alone claimed to have 100,000 bikes just in the city of Shanghai while also being present in 50 cities across the country (Mobike, 2016). Ofo, another highly visible actor on the market, started in 2015 as a Peking University project. In 2017 it announced over 10 million users in 33 cities (Ofo, 2016). In total, within the last six months of 2016 a dozen copycats have added their fleet to a rainbow of bicycles parked along the streets of Chinese cities.

In a context of sharp decline in urban cycling, and a climate where private cars are still viewed as an icon of economic success, these new schemes have revived an appreciation for bicycles as an efficient mode of transport. According to various newspapers, they have managed to reverse a

countrywide tendency within less than a year (Van Mead, 2017). Dock-less App-based Bike-sharing Systems (DABS) have made Shanghai the world's largest bike-sharing city, with 280,000 shared bikes according to the city government in 2017 (Wang, S., 2017). The striking point of these systems is their visibility in the urban environment; bicycles can be found everywhere and are instantly recognizable as branded products. Looking at the figures released by Mobike, the mode share of pedal bicycles roughly doubled since their concept was first introduced (Mobike, 2017). Regarding their performance with car drivers, DABS also display good results. Car owners without a private bicycle who use shared bicycles represent 15% of the shared bicycle users in our sample, three times more than the estimated achievement of conventional schemes (Zhu et al., 2013; Yang et al., 2015; Karki & Tao, 2016).

These accomplishments, however, need to be put in perspective with other issues in order to evaluate the effectiveness of these schemes in overcoming major restraining factors in cycling. On one hand, the general perception of DABS users as individuals is relatively negative (Chevalier, Charlemagne, & L., 2018). In the western context, the low social acceptance for cycling is often considered as a logical follow-up of bicycle messengers and delivery men viewed as reckless cyclists (Horton, Rosen, & Cox, 2007; Héran, 2014). Thus, we could expect the negative image of DABS users to spread to all cyclists, in turn affecting the overall *social acceptance* for bicycles (Section 4.2.2).

On the other hand, the discrepancy between car ownership and car use highlighted in Section 4.3.2 and the legal restrictions towards utilitarian bicycle use exposed in Section 4.3.1 converge towards the problem of bicycle ownership.

4.5.2 Shared-bikes versus bicycle ownership

While 52% of our surveyed population use DABS, it should be pointed out that half of the users also own a private bicycle, which means that they have shifted from private to public bicycles. Their riding frequency may have increased, but they cannot be viewed as new cyclists. While comparing these new systems with conventional public-bicycles in Shanghai the situation in this regard is not drastically different (Zhu et al., 2013). Therefore, despite an indisputable success, DABS face difficulties similar to those of conventional shared-bicycles.

In fact, commuting rides represent 40% of the typical journeys in our sample. Leisure and health also represent a substantial part of the usual purpose for riding, roughly constituting another 40%. Shopping and child transport however hold a very small share in the main purpose for riding with 11% and 3% respectively. These observations show that DABS do not address major issues in daily utilitarian cycling. As constantly pointed out in the related literature, shared-bike systems need to be supported by a comprehensive set of bicycle-friendly policies making infrastructure and road safety regulations supportive to the practice of cycling.

In recent years, several studies have discussed the deterioration of the cycling environment in China, such as the continuous encroachment on bicycle lanes by the ever-growing motorised traffic, which results in a risk increase with deterring effects on cycling (Yang & Gakenheimer, 2007; Liu, Jia, & Cheng, 2012). This situation needs to be addressed to define accurate measurements of the gains and benefits provided by DABS in urban cycling.

In fact, some recent studies point to the urgent necessity to assess utilitarian cycling and child transportation in China (Chevalier, Charlemagne, & L., 2017; Carlton, 2018). Up-to-date research supports the conclusion that family obligations is a limiting factor for women's ability to cycle. Since they often need to transport children and groceries, studies highlight the importance of the bicycle as a means to fit the actual needs of family-oriented purposes in cycling. Encouraging children to cycle and promoting the use of bicycle trailers are viewed as an effective means to increase bikeability (Emond, Tang, & Handy, 2017). The lack of equipment on shared-bikes, such as the absence of a back seat, is thus a limiting factor – since parents cannot ride with their child – and reveals the necessity to support the use of privately-owned bicycles that can be properly equipped.

More especially, in the long run, regular users of shared bicycles may be discouraged to acquire a bike of their own when their personal circumstances have changed. Not being accustomed to owning a bicycle, they could encounter specific barriers such as the *fear of technology* developed in Section 4.4.3. As it was pointed out in a study about the major issues facing the biking revival in China, debates always exist about whether government resources are well-spent, especially when it comes to shared bike systems. Though the private initiatives of DABS have proven to be a successful way to revive the image of cycling as a practice, much more is left to governments in order to develop utilitarian cycling (Yang et al., 2015). Following the idea of Yang et al. (2015), one could suggest to allocate some of the substantial resources dedicated to public shared bikes to support private bike usage.

4.5.3 Environmental issues

With the spread of DABS overseas, an increasing literature denounces the waste of massive bicycle fleets and their hold on the public space (Campbell, 2018; Haas, 2017; Lee, 2017; Tchebotarev, 2017). Despite a very moderate collective awareness for the unsustainable character of DABS, a recent study on the social acceptance of cycling in Shanghai demonstrates that the population is highly sensitive to the deterioration of the public space due to the DABS parking (Chevalier, Charlemagne, & L., 2018). The significant number of bicycles parked in public spaces results in the hindrance of pedestrian circulation and the aesthetic deterioration of the environment, these are pointed out as major draw-backs of the DABS schemes.

The growing concern for global environmental issues is also to be taken into account. To counter the problem that results from the excessive number of bicycles in service, localities have been confiscating thousands of vehicles stored in various vacant lots across Shanghai (Figure 6). The destiny of this massive number of bicycles remains a pending question.

In fact, the organisation of the performance measures (Table 1) reveals that few tools are available for the evaluation of achievements in the *environment* category. Thus, the Chinese situation requires the development of new measurement tools able to capture the environmental impacts of DABS and relate them to the actual gains in the transportation subdomain of *mobility*. Therefore, despite undeniable positive effects on the bicycle mode share and cycling advocacy, DABS raise new sociological and environmental issues calling for adequate measures in all categories of transportation tools.

*Figure 6***.** Aerial view of one of the vacant lots where municipalities are storing bicycles confiscated from DABS providers (Hongkou District)

4.5.4 Bikeability index's assessment

As we reviewed the various criteria of western bikeability indices and related them to the Chinese context, we now apply them literally in the rating of Shanghai as an assessment of their actual definition. Here we ought to highlight the difficulties in giving an accurate score to the city of Shanghai. Due to the wide range of information necessary to cover the totality of the areas rated by the various indicators, some of the ratings are open to discussion. The very uniqueness of Shanghai's urban environment, economy and demography may also be viewed as mitigating factors in the implementation of measurement tools applicable to the whole country. This is however a solid base to theorise on bikeability measurements while providing a clearer view on the accuracy of western performance indices in China (Table 6).

*Table 6***.** Assessment of the *Copenhagenize Index* in the Chinese context

Category	Shanghai's Rating	Relevancy in China
Advocacy	1	4
Bicycle Culture	4	2
Bicycle Facilities	2	4
Bicycle Infrastructure	3	2
Bicycle Sharing Programs	4	2
Gender Split	4	1
Modal Share	4	NA
Modal Share increase since 2006	NA	NA
Perception of Safety	4	NA
Politics	1	4
Social Acceptance	4	1
Urban Planning	1	4
Traffic Calming	2	NA
Bonus points	6	4

NA = non-applicable, 0 = very poor, 1 = poor, 2 = fair, 3 = good, 4 = excellent

Total score for Shanghai = 77/100

Source: Based on the *Copenhagenize Index* (TDM Encyclopedia, 2018).

Cycling advocacy and *bicycle culture* though often related in a western context display different levels of importance in China. As a "nation of bicycles", rating different cities according to their culture may not be as pertinent as it is in other countries, especially when considering its lesser importance revealed by the historical development of bicycle practice in China. Indeed, it is only when associated with strong advocacy and official support that *bicycle culture* can have a positive and lasting effect on the modal share (Section 4.1.2). Advocacy thus appears as an efficient indicator of bikeability. However, unlike western advocacy, usually structured within a legal and administrative framework, its dilutive character in China renders it more difficult to evaluate. DABS are surely promoting the bicycle, but they remain mostly outside the scope of governmental actions (Section 4.5).

Bicycle facilities and *infrastructure* are structural factors instrumental in bikeability's evaluation. Due to the large extent of bicycle networks in China, their measurement should focus on the qualitative aspect rather than on their actual length, as it is often the case in a western context.

Bicycle sharing programs are well developed in many Chinese cities. DABS increase convenience in cycling but may be detrimental to bicycle ownership. The effects are two-fold; since young or middle-aged citizens will cease to view the private bicycle as a necessity, it may have a severe impact on bike ownership by affecting their appreciation of private bicycles, as we have seen earlier, already strongly associated with theft and difficulties in maintenance (Section 4.4). Young parents therefore will be even more unlikely to consider cycling, since of the two options, "becoming a bike owner" or "becoming a car owner", the second one will fit better actual conventions[13]. Child transportation on bicycle therefore appears as a major component to be addressed in the overall evaluation of bikeability.

Since the configuration and evolution of the modal split in China greatly differs from those in western contexts, *gender split*, *modal share* and *modal share increase* are non-applicable and need to be fully reconsidered to fit the Chinese situation. *Safety perception* as defined by the enforcement of helmet-wearing also represents an invalid indicator for China. Similarly, the *social acceptance* category calls for a redefinition. The observations gathered in Section 4.5.3 suggest that a mixed approach, encompassing both individual perceptions and global awareness, would provide an accurate view of their impacts on bikeability.

Regarding *urban planning* and *politics*, both appear as crucial elements to be measured objectively and included in the overall evaluation of bikeability in China. Our analysis noticed the importance of utilitarian cycling, that is cycling to fulfil daily purposes such as transporting children, or shopping. An answer to this pressing demand would represent a sustainable solution to the problem of urban congestion and travel efficiency as well as a substantial improvement for bikeable cities. This question, however, has not yet been addressed in the general approach of Chinese planning.

Due to the specificity of Chinese urban mobility, the importance and implications of *traffic calming* mechanisms appear mitigated. It results in a more difficult understanding in terms of assessment and measures (Section 4.4.4).

[13] Since having a child appears to be a determining factor in automobility, the above issues should be addressed in order to encourage an efficient shift from private cars to bicycles.

While expanding a bikeability index, the specificity of DABS cannot be ignored and should provide bonus points for the cities currently hosting the phenomenon. The city could be commended for such an effort in cycling revival but only up to a point. In fact, unlike conventional bike-sharing systems, DABS are the product of private initiatives and do not reflect an active political involvement. In fact, they are not purely advocating cycling. They have commercial prospects and despite a certain political influence, they do not fit the profile of NGO(s) fervently defending cycling as an individual practice. They even raise new questions related to their potential negative impact in terms of public bicycle acceptance and the environment.

Overall, Shanghai would score 77 points and be considered as one of the top three bikeable cities worldwide (Table 6). This result underscores the inadequacy of western measurement tools when directly applied into a different context. Indeed, Shanghai's rank contrasts highly with the lack of official support for cycling in *politics* and *urban planning*. Furthermore, the index only focuses on the increase of the bicycle mode share and neglects any sign of decrease. While this perfectly fits the western context, it is inappropriate in a country where more than half of the population owns a bicycle.

4.5.5 Directions for new sets of measurements

In general, the various limitations of the existing bikeability tools exposed in this study call for the establishment of evaluation systems that should be context-dependant. A simple solution lies in a revised approach when relating bikeability goals to measurement tools. Redefining the goals for each category enables us to select appropriate measures issued from mainstream transportation tools or to identify new possible measurements. Although each parameter is related to the other and often shares the same goals, it is possible to isolate significant signs of progress towards established targets.

In Table 7, categories have been associated with the relevant goals and their affiliated measurements.

*Table 7***.** Proposed sets of bikeability measures for the Chinese context

Category	Goals	Measures
Advocacy	Equity, Liveability	Awareness of social and environmental benefits, visual streetscape assessments, number of NGO(s).
Bicycle Culture	Liveability, Economic	Population's perception audits, visual streetscape assessments, quality assessments of the cycling infrastructure.
Bicycle Facilities	Health, Equity, Liveability	Level of service, bicycle facilities' counts and current level of use.
Infrastructure	Health, Safety, Equity, Liveability, Connectivity, Economic, Environment	Visual streetscapes assessments, quality assessments of the cycling infrastructure, statistics on road casualties.
Bike-sharing	Health, Equity, Liveability, Economic, Environment	Level of service, population's perception and current level of use, ratio of intermodal trips.
Gender Split	Equity	Evaluation based on bike-ownership rather than modal share with a special focus on family oriented utilitarian cycling.
Modal Share	Health, Safety, Equity, Liveability, Economic, Environment	Evolution of the bicycle mode share since 2006.

Category	Goals	Measures
Safety Perception	Safety, Equity, Liveability	Population's perception audit with a special focus on child transportation.
Politics	Health, Safety, Equity, Liveability, Connectivity, Economic, Environment	Level of official involvement in pro-cycling interventions (for instance the number of roads reopened to cyclists) and programs such as bike-sharing systems with public participation or "safe route" measures.
Social Acceptance	Equity, Liveability	State of pro-cycling regulations and level of compliance from drivers, police enforcement of pro-cycling regulations, public acceptance of bike-sharing system users.
Urban Planning	Health, Safety, Equity, Liveability, Connectivity, Economic, Environment	City planners' knowledge of the best international practices reflected in the infrastructure's design and integration of innovative solutions.
Traffic Calming	Safety, Equity, Liveability	Evolution of road speed since 2006, amount of mechanisms easing the cyclists' circulation such as early starts and turning priorities for bikes and pedestrians on traffic lights.
Urban Forms	Equity, Liveability, Connectivity	Efforts in heritage conservation and design reflecting the traditional Chinese schemes giving prevalence to human scale rather than focusing on traffic fluidity.
Micro-economies	Equity, Liveability, Economic	Efforts to maintain local businesses and small businesses.
Bicycle Ownership	Equity, Liveability, Economic, Environment	Evolution of bicycle ownership.

Most of the categories commonly displayed in western indices such as *advocacy*, *facilities*, *infrastructure*, or *gender split*, have been maintained. However, the related measurements have been refocused on perceptions rather than usage which usually provides the metrics applied in bikeability evaluation. For instance, measuring the gender split according to bike ownership rather than bicycle mode share enables us to capture specific gender-based difficulties such as maintenance of the bicycle or barriers due to family-oriented obligations that are often a woman's responsibility.

Some parameters such as *modal share* and *traffic calming* have been revisited in order to be applied in the Chinese context. For instance, we suggest evaluating the *traffic calming* category according to the evolution of the road speed since 2006 when Chinese authorities started to develop a renewed interest in cycling. This global evolution, along with an evaluation of the actual measures implemented to ease circulation for cyclists, especially on road intersections, would provide an accurate assessment of the progress made in this area.

We also suggest the addition of three new categories of parameters: *urban forms*, *parallel economies* and *bicycle ownership*. Up-to-date research consistently highlights a strong correlation of the propensity to cycle and urban forms, especially in terms of density or connectivity. In the fast-changing Chinese cities, undergoing constant reshaping and expansion, this specific matter deserves to be closely examined in a bikeability evaluation at the city level. Chinese traditional urban forms display characteristics widely recognized as beneficial to the bicycle use. As such, heritage conservation and general orientations in planning - reflected in specific measures such as limiting the size of the blocks or encouraging high density - can be reliable indicators of a city's bikeability level.

Another point that clearly emerges from the current literature is the positive association of cycling with the local economy. In fact, studies increasingly point out the inclination of cyclists to go more often to local shops with very positive economic outcomes (Carlton, 2018; Trotignon, 2014). In fact, the fate of these small shops appears related to the practice of cycling. In major cities, to counter the excess of migrant workers and solve the problem of commercial activities outside of the tax system local governments are currently undertaking measures to close down many of the small shops. While it may be unclear how much it would affect cycling as a practice, the disappearance of proximity services and sellers such as bicycle repair shops will certainly have an impact in the short term on bicycle ownership. In a fast-paced economic environment such as China, the economy aspect of cycling should not be ignored.

This consideration converges with the issue of child transportation since it requires a vehicle equipped to this end. Therefore, we suggest monitoring the evolution of bicycle ownership. In fact, the decrease in privately owned bicycles would be an effective indicator of the bikeability level in Chinese cities. Its inclusion in a bikeability index would put in perspective the information provided by indicators such as the *shared-bikes programs* since family-oriented purposes cannot fall into this domain.

5. CONCLUSION

This study established the importance of a city-level evaluation in providing tools for meaningful comparisons among different areas and how comparative approaches would allow effective evaluations and prioritisations in the development of pro-cycling policies in China. Therefore, in an effort to assess the suitability of the Copenhagenize bikeability index to the Chinese context we have thoroughly evaluated its various parameters, and investigated how it would apply to the city of Shanghai.

Our results highlighted several major limitations preventing it from being an adequate tool. In fact, one of the most critical aspects is related to the initially much higher propensity of Chinese citizens to cycle compared to any western population. As this circumstance is omitted in the current bikeability measurement, the oversight of major specificities unfolds in the Chinese context. As a matter of fact, existing tools fail to capture the influence of major socio-cultural indicators such as *bicycle culture* and *cycling advocacy* since they unveil different meanings than those commonly accepted in a western context. Socio-economic factors are also to be questioned in Chinese bikeability, for instance, *bicycle ownership* and *micro economies*, absent from mainstream bikeability parameters, would provide accurate measures of the bicycle-friendliness in Chinese cities.

In general, attitudes toward cycling in the Chinese population greatly differ from the ones displayed in western countries and call for a re-examination of parameters such as *road safety perception* or *social acceptance of the bicycle*. Therefore, new tools and methods taking into consideration the specifics of the sociological and cultural context should be developed to better understand and evaluate the bikeability level of eastern cities.

Most importantly, we reformulated the performance objectives related to inadequate parameters and provided directions for suitable bikeability performance measures. In turn such results could greatly help understand the

perceptions in cycling and open new avenues to counter the continuous decrease observed in the Chinese bicycle mode share of the past few decades.

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APPENDIX: STRUCTURED QUESTIONNAIRE

The data collection took place from February to April 2017 in the Shanghai city centre. People were randomly intercepted on the streets or in public spaces. Respondents were asked to answer the following questionnaire on paper. This investigation was conducted by the main author and all data was collected by this person alone. If respondents were foreigners, they were initially asked how long they had been in Shanghai and those living in the city for less than a year were not included in the survey. Chinese respondents were provided with a Chinese version of the following questionnaire. The purpose of this initial investigation was to draw an accurate picture of the appraisals and perceived barriers in cycling among Shanghai citizens.

Barriers to cycling & bikeability perception

A/ General profile:

How old are you? _____Years old

What is your gender? Male □ Female □

What is your nationality? _____

What is your occupation? Student □ Employee □ Self-employed □ Retired □ Unemployed □ Other □
If you work, what is your field? _____

In what district do you travel the

most?_____

How much time do you travel from home to work/school?

_____h____min

Do you use multiple means of transportation for this travel? Yes □

No □

Please specify the means of transportation:
(If you use multiple means, please choose multiple answers)
Walking □ Bicycle □ E-bike □ Bus □ Metro □ Taxi □ Car □
Other □ _____

Do you own a car? Yes □ No □

Do you have children? Yes □ No □

If yes, how do you usually travel with them?

Walking □ Bicycle □ E-bike □ Bus □ Metro □
Taxi □ Car □
Other □ _____

1/ What is your FAVORITE way of moving in the city?

Walking □ Bicycle □ E-bike □ Bus □ Metro □
Taxi □ Car □
Other □ _____

Why?
It is cheaper □ I have more freedom □ This is more comfortable □
It is quicker □ It is less dangerous □ It is more enjoyable/exciting □
It is more convenient □

2/ What is your most COMMON / USUAL way of moving in the city?
Walking □ Bicycle □ E-bike □ Bus □ Metro □
Taxi □ Car □
Other □ _____

Why?
It is cheaper □ I have more freedom □ This is more comfortable □
It is quicker □ It is less dangerous □ It is more enjoyable/exciting □
It is more convenient □

3/ Do you think Shanghai is a bikeable city? Yes □ No □ I don't know □

B/ Barriers to cycling:

4/ Do you own a two-wheeled vehicle? Yes □ No □
Please specify:
Bicycle □ E-bike □ E-scooter □ Kick-scooter □ Tricycle □ Electric Tricycle □ Electric kick-scooter □ Electric Unicycle □
Other □_____

Do you use bicycle sharing systems (such as Mobike or Ofo)**?** Yes □

No □

5/ How often do you ride a two-wheeler vehicle?
Every day □ Every week □ Sometimes □ Never □

When did you last ride a bicycle?
Within few days □ Within few month □ Few years ago □
More than 10 years ago □

If you never ride bicycle or electric-bike, what is the main reason?
It's dangerous □ I don't know how to ride □ It is too tiring □
It is too polluted □ I don't want my bike to get stolen □
The weather is often not good enough □
Other □ _____

6/ Do you think cyclists on bicycles can be an issue for other road users?
Yes □ No □

If yes, why?
They are not careful enough □ They go to fast □
They do not respect rules □ They are unaware of danger □
The bikes are not well maintained □ Other □ _____

Do you think bicycles belong to: *motorized* □ or *pedestrian* □ traffic?

7/ What do you think is a major issue for cycling in the city?
It's too dangerous □ It's not pleasant □ It's too dirty □
It's too polluted □ It's easy to get lost □ It's uncomfortable □
Bikes get easily stolen □ Poor weather □ Other □
_____

In which Shanghai district do you travel the most by bike and/or by walk?_____

8/ In the following elements, which one would make you cycle more in the city?
Less traffic □ Better bicycle lanes □
More green □ Better air quality □
More streets open to bikes □ More separation with traffic □
Safer bike parking □ Less rain / Better weather □
Other □ _____

(If you never ride bicycle or electric bike, please stop here)

C/ Cycling habits:

9/ Do you use your bicycle □ / E-bike □ during work? Yes □
No □
If yes, do you use it for: deliveries □ to transport goods/people □

If no, what is your usual purpose for riding bicycle or electric bike?
Go to work □ Shopping □ Drop off/Pick up child □

Leisure □ Physical exercise □ Other □_____

Usually how long is this ride? _____h_____minutes /_____km

10/ While biking, do you stop by for other purposes?
Always □ Often □ Sometimes □ Never □

Why do you stop? Shopping □ Drop off/Pick up child □
Leisure □
Other □
_____

11/ Do you repair or maintain your bike by yourself? Yes □ No □

If no, would you continue to use your bike if you cannot find a person to maintain it for you? Yes □ No □

D/ Perceptions in cycling:

12/ As a biker, with what kind of road users do you feel the most uncomfortable?
Cars □ Bicycles □ E-bikes □ Buses □ Taxis □ Pedestrians □

Why?
They go to fast □ They are unpredictable □ They don't follow the rules □
Other □
_____

13/ When you cycle, what is the most important for you?
Safety □ Comfort □ Speed □ Easy parking □
Easy direction □ Style □ Other □_____

For the following questions please classify the items:

14/ Please classify the elements from the most important to the less important for you when you cycle?
Lots of shops □ Lots of trees □
Lots of indications □ Lots of bike parking □
Low atmospheric pollution level □ No cars parked on the cycling lanes □

15/ Please classify the elements from the most comfortable to the less comfortable for you when you cycle?
Few motorised traffic □ Slow traffic speed □
Separation barriers from traffic □ Independent cycle lanes □
Wide bicycle lane □ Contraflow bicycle lane □
Small amount of traffic lights □ Less pedestrians □