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ANALYSIS

STATUS AND OPPORTUNITIES **OF SHARED MOBILITY SYSTEMS IN CHINA**

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A study commissioned by the Volvo Research and Educational Foundations

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1.0 Background

In response to the challenges of both COVID-19 and climate change, the public transport needs to be redefined. Traditional "public transport" ridership – mainly bus and metro systems – dropped in many Chinese cities during the peak of pandemic but has recovered to pre-pandemic levels. During the peak of the pandemic, shared bicycles served as one of the few resilient and safe ways in which citizens could move around and were important for providing essential mobility needs. As cities begin to reopen, transport culture may shift from collective modes to individualized and customized transport modes.

There is a strong growth trend in the use of informal public transport modes (mostly referred to in China as shared mobility) throughout 300+ cities in China. These modes are either integrated with traditional mass transit catering to first/last-mile demand or used to fully replace private cars. Public transport is being re-defined as systems that integrate buses and metros with other modes, particularly shared and active mobility (i.e., cycling and walking). However, many informal and shared-mobility markets (e.g., bike sharing, 2/3-wheeler for urban delivery) are still not well regulated, and some markets are unhealthy for employees (e.g., 2/3-wheelers). Meanwhile, most Chinese cities are still facing major challenges with respect to safety, equity, environmental, and many other issues related to the growth of shared-mobility services.

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2.0 Objective and Scope

The **objective** of this research is to contribute to the new theme – Informal/paratransit Public Transport (IPT) – under the Future Urban Transport (FUT) program of the Volvo Research and Educational Foundations (VREF). The main goal was to identify knowledge gaps and to better assess overall IPT landscape in China and provide suggestions. This was done through a systematic analysis of findings available in Chinese publications. The scope of the research was limited to China. China is one of the largest IPT countries, but little in-depth investigation of IPT trends and developments in China have been performed.

In China, **IPT** is most commonly referred to as **shared mobility**.[1] However, most terms used in this field (e.g., IPT, shared mobility, new mobility, smart mobility, paratransit) lack clear definitions. We have consistently adopted the term shared mobility in this report and have applied a definition based on the *"Annual Report on the Development of Shared Mobility in China (2020-2021)"* (the Blue Book of Sharing Economy) (CEPF; NCUT; CATARC 2021). Shared mobility is a new mobility service that is based on Internet technologies and meets demand with high efficiency. In China, shared mobility includes: bike sharing, e-bike sharing, ride sharing, ride hailing, car sharing, carpooling, car rental services, demand-responsive transport, and courier network services (CNS).

In this report, we apply a broad definition of shared mobility that includes the most common modes in Chinese cities:

- ***Passenger:*** dockless bike sharing (e.g., Meituan Bike (formerly Mobike), public bike sharing (docked), ride sharing and ride hailing (e.g., Didi), demand-responsive microbuses, shared e-scooters, shared e-bikes, and mobility-as-a-service (MaaS)[2]
- ***Courier network services:*** 2/3-wheelers (mainly for last-mile package delivery, e.g., Meituan Waimai), and 3-wheelers (mainly for urban fast-food delivery and/or intra-city express, e.g., SF rush, Shansong)

The following definitions of the six dominant shared-mobility modes in China have been applied in this report:

- **Shared bikes:** A bike-sharing system is a shared transport service in which bicycles are made available to individuals on a short-term basis through a paid service where transactions occur via Internet-based platforms. Users can use mobile phones to locate, unlock and pay for the use of bikes. A dockless bike sharing system (DBS) does not require a docking station. With dockless systems, bicycles can be parked within a defined district at a bike rack or along the sidewalk (ALTA n.d.; Jiang et al. 2020).
- **Shared e-bikes:** *It is a two-wheeled bicycle that uses the on-board battery as an energy source, also has the function of pedal. Users can use mobile phones to unlock the bike. It relies on Internet technology-based operational platform, and operates in the form of time-sharing leases, and serves single-person short-distance travel in the city area.* (CNR 2020; CUPTA 2020)
- **Ride hailing:** An Internet-based platform through which users can access ride services provided by qualified drivers (using qualified vehicles). Unlike taxis, ride-hailing service providers do not circulate or wait at specific locations to be hailed visually by riders. (China's Ministry of Transport 2016)
- **Mobility-as-a-Service (MaaS):** Unlike individual forms of shared mobility (like bike sharing and ride hailing), MaaS is provided through Internet-based platforms that integrate on-demand access to a variety of mobility services (ERTICO-ITS Europe 2019; MaaS Alliance 2017). Maas is included in this report because it is a new, promising and innovative mobility solution in China's transport strategy.
- **Courier network services (CNS):** Collection and delivery services provided using two- and three-wheeled vehicles for last-mile urban delivery of freight, such as express and parcel (CEP), food, and other light-duty cargo. In the Chinese market, two-wheeled vehicles are commonly used for package and food deliveries. Two- and three-wheeled vehicles are electrified in most Chinese cities.
- **Demand-responsive transport (DRT):** Demand-responsive transport (also known as demand-responsive bus or on-demand bus services) is a form of shared private or quasi-public group transport where vehicles determine their routes for individual journeys based on passenger demand and do not operate according to a fixed timetable (Steinfeld and Steinfeld 2018).

1 The term **new mobility is also used in China, synonymously with shared mobility.**

2 (ERTICO-ITS Europe 2019; MaaS Alliance 2017): *"MaaS is the integration of various forms of transport services into a single mobility service, accessible on demand. For the user, MaaS offers added value through the use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations."* Although MaaS is not a single form of shared mobility (such as bike sharing and ride hailing), but rather an integration platform of a variety of mobility services, it is worth mention in this report since it is a new and promising innovative mobility service in China's transport landscape.

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3.0 Methodology and Approach

The research team from WRI China elaborated two anticipated outputs from this project: 1) state-of-the-art knowledge of shared mobility in China, and; 2) a review of recent Chinese research on shared mobility. The methodological approach applied and key tasks performed are described below.

3.1 State of the Art

The objective of this effort was to provide the state-of-the-art knowledge of shared mobility in China. Under this task, we relied primarily on a literature review, stakeholder dialogues, and data collection with quantitative and qualitative analysis. Chinese literature on operation and services, policy, regulations, and governance, society and environment, business sustainability, and resilience for all kinds of shared mobility services that are commonly seen in China were reviewed. The scope of the review included shared bikes and e-bikes, ride sharing and ride hailing, mobility-as-a-service, courier network services, and demand-responsive transport.

The output includes the latest data, knowledge, and trends related to shared mobility. The aspects of shared mobility that were explored included but were not limited to:

- ***Operation and service:*** The current status of level-of-service for each shared-mobility mode, including their characteristics and pros and cons, fleet information, rider behavioral change (e.g., transport mode shift), connectivity to other modes, and accessibility.
- ***Policy, regulations, and governance:*** Summaries of current the policies and regulations by shared-mobility mode, including the key status and trends, key policy/regulatory actions, and the their impacts (if any).
- ***Society and environment:*** Road safety, equity, parking issues, battery recycling, packaging materials and waste, health improvements, emissions and air-pollution exposure.
- ***Business sustainability:*** Financial sustainability, employment, oversupply and low costs/salaries, and business models.
- ***Resilience:*** Climate resilience (chronic and incidental, e.g., heat, flooding), pandemic (e.g., COVID-19) resilience. The collective ability of shared-mobility systems to cope with the negative impacts of external disruptions caused by, for example, COVID-19 and climate change.

The topics listed above were selected because they address all key elements of shared-mobility systems, such as operation, regulation, internal (business) and external (society and environment) considerations. We attempted to address the entire shared-mobility ecosystem of stakeholders, including government decision-makers, service providers, users, and the general public. The topics also address external impacts from outside of the ecosystem, such as the influence of climate change and the COVID-19 pandemic on shared-mobility systems.

The literature review was based primarily on literature identified using CNKI (www.cnki.net), China's largest online publishing platform that was developed by the China Academic Journals Electronic Publishing House.3 CNKI is the largest Chinese academic publication platform. Most of the publications available on CNKI have been authored by researchers based at universities and research institutes. The platform provides peer-reviewed publications, patents, proceedings, standards, and non-peer-reviewed articles. In this report, we included both peer-reviewed non-peer-reviewed publications to avoid bias, because shared mobility is not considered a pure scientific topic in China but rather a market and application/practice issue. Many grey-literature publications provide valuable information. In this report, we only examined publications from the most recent three years (2019 – 2021) to ensure that the information and research trends included are the most up to date. Our intention was: 1) to collect the most updated information as possible, and; 2) to include publications from before and during COVID-19.

3.2 Research activities in China

A detailed review of currently ongoing research activities was conducted under this task. Key Chinese researchers in the field of shared mobility were interviewed, with the aim of providing a detailed overview of ongoing research activities at leading Chinese research institutions and universities. The scope of the study covered both national- and city-level research, which is published mainly in Chinese. The research team also conducted a series of stakeholder consultations in the form of interviews, workshops, and informal dialogues. Under this task, the five most influential Chinese universities in the field were identified, to highlight the latest thinking and research trends. The five most influential Chinese universities are: Tongji University, North China University of Technology, Tsinghua University, Southeast University, Beijing Jiaotong University. One Professor from each of the five universities were interviewed. We also spoke with experts from the China Academy of Transportation Sciences (CATS, a key research institute affiliated with China's Ministry of Transport), which are studying on MaaS and other shared mobility modes.

3 https://www.cnki.net

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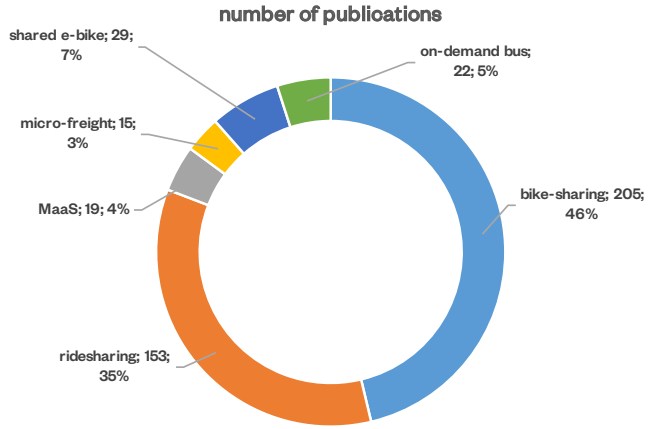
4.0 State-of-the-art: Informal Public Transport in China

As mentioned in the methodology section, we investigated literature and the state-of-the-art of China's shared mobility in the following fields: operation and services; policy, regulations, and governance; society and environment; business sustainability; and resilience. In addition, we selected the following new mobility services, since they are mostly popular in China: bike sharing (esp., the dockless bike-sharing system, DBS4), ride sharing/ride hailing, mobility-as-a-service (MaaS), courier network services (2- or 3-wheeler for last-mile delivery), shared e-bikes, and demand-responsive micro-buses.

Figure 1: Number of publications examined in this report



We have reviewed about 450-500 publications from cnki.net that cover various topics of the shared mobility solutions mentioned above. The general findings and more details are presented in Table 1 and the following subsections:

- Chinese researchers focus more on the fields of bike sharing and ride sharing/ride hailing than research on shared e-bikes, demand-responsive buses, courier network services, and MaaS.
- The knowledge gap in MaaS might be due to the lack of basic know-how of MaaS implementation, multi-stakeholder collaboration, financing and governance in Chinese cities. The knowledge gaps in research on shared e-bikes and demand-responsive transport might be because the informal and small market attracts less research interest. Opposite to their active market for the last-mile urban delivery, the gaps in the courier network services might be due to the lack of awareness of the field, and an irregulated market and/or less funding on research.

4 Starting with the Chinese market, DBS start-ups put the idea of dockless bike sharing into action, offering apps to help riders locate bicycles and unlock and leave them wherever their rides end. Unlike public bike (docked) systems, due largely to the freedom of movement and the added convenience that they offer, there has been a huge demand for dockless shared bikes in Chinese cities for short-distance trips (Jiang et al. 2020).

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Table 1: Summary of the key findings from China's shared mobility research

Shared mobility solutions	Topics and trends	Knowledge gaps	Number of publications examined
Bike sharing	– Demand modeling for better fleet size control and parking management – User-experience survey to support impact assessment (incl. CO_2, health) – DBS is good solution for last-mile mobility, and the connectivity with PT makes the PT system more attractive. – DBS replaced walking and bus rides – DBS has limited potential to reduce CO_2, but significant effect to increase health – Policies, regulations, and governance focus on fleet size control, parking, and road safety, as well as the assessment of key performance indicators (KPIs) – DBS has been the key mode during COVID-19	– Limited Chinese quantitative studies on health impact assessment of DBS – Limited studies on business models (may not be necessary, since DBS does not seem to be cost-effective and the biggest DBS services are combined with TNCs and large Internet companies, e.g., Meituan) – Limited knowledge on the life-cycle environmental impacts of DBS' materials – How to integrate with MaaS – Lack of research on equity	205
Shared e-bikes	– Supply and demand analyses – Studies of niche markets – User-satisfaction analyses – Fleet-size control and parking – Level of services and accessibility, and integration with subway and bus systems – Market entry and e-bike restrictions – Road safety: safety issues for drivers, for other road users, and due to the built environment and driver behavior – Policies and regulation on shared e-bikes – Battery safety	– Lack of quantitative impact assessments on road safety and other externalities – Need to improve and enforce legislation, policies, and regulations – Lack of studies on niche-markets, business models, and on e-bike and battery technology – Lack of research on equity	29
Ride sharing/ ride hailing	– Demand modeling and influencing factors to support operational management of fleets – Level of Service (LoS) studies (reliability, accessibility, etc.) – Dynamic pricing based on congestion level, demand, and time (peak hours, night) – Relationship with PT and other modes of transport – Environmental impact assessments – Congestion assessments – User experience surveys – Fair markets in terms of fair competition and others. – Studies on driver (employee) welfare – EV and the vehicle design relationship with the auto-industry	– Conflicting conclusions on environmental impact (CO_2, $PM_{2.5}$) of ride sharing/ride hailing – Conflicting conclusions on congestion impacts of the ride-sharing system – Lack of equity studies – Lack of studies on privacy protection – Still need to improve and enforce legislation, policies, and regulations – How to integrate with MaaS – Lack of research on employment and labor welfare – Lack of research on equity	153

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Shared mobility solutions	Topics and trends	Knowledge gaps	Number of publications examined
MaaS	– Most studies focus on the basic concept of MaaS (e.g., what is MaaS, the key elements, business models, frameworks, ecosystems) – Both national and local governments are interested in this topic and address it in white papers – The integration of PT and other modes (esp., cycling systems) is a trend in Chinese cities – Existing literature is mainly translations of international practices – Existing candidates for local ecosystems are active, e.g., Didi, Gaode, Meituan, Baidu, other TNCs, etc.	– Lack of basic knowledge of MaaS – Lack of local practices. Only Beijing (piloted by Gaode and BTI) and Guangzhou (piloted by Guangzhou bus and Didi) cases. – No concrete implementation framework from either government (top-down) or the industry (bottom-up) – Lack of knowledge of collaboration models in MaaS ecosystems, such as data-sharing protocols and other policies – Lack of studies on existing legislation and regulation and their development – Lack of data-sharing and standardization frameworks – Lack of research on equity	19
Courier network services	– Courier network services (2/3-wheelers) is a popular mode for quick last-mile urban delivery (packages, food, etc.) in Chinese cities – Road safety and riding/driving behavior – Battery safety – Market governance and regulations – Welfare of 2/3-wheeler drivers (delivery people) – Green packaging	– The market is still not well regulated (both in terms of the delivery operation and employment) – Lack of knowledge on all aspects of this industry due to limited awareness and funding of the scholars – Lack of legislation and regulation studies and development – Lack of research on employment and labor welfare – Lack of research on equity	15
Demand-responsive transport	– User demand and preference analyses and characteristics – Niche-market studies and the relationship with other modes – User-satisfaction surveys and analysis – Determination of pick-up and drop-off locations – Route optimization of DRT bus services – Cost vs. LoS analysis – Cost effectiveness vs. optimized supply	– Lack of niche-market and business-model studies – No impact assessments of externalities compared with other modes (e.g., buses) – Lack of legislation and regulation studies – Lack of research on equity	22

Figure 2 shows the number of Chinese publications on cnki.net addressing the topics of bike sharing, shared e-bikes, rides haring/ride hailing, MaaS, courier network services, and demand-responsive transport. It includes publications on each topic from 2011 to 2021, and to some extent represents the trends of academic focus on each topic.

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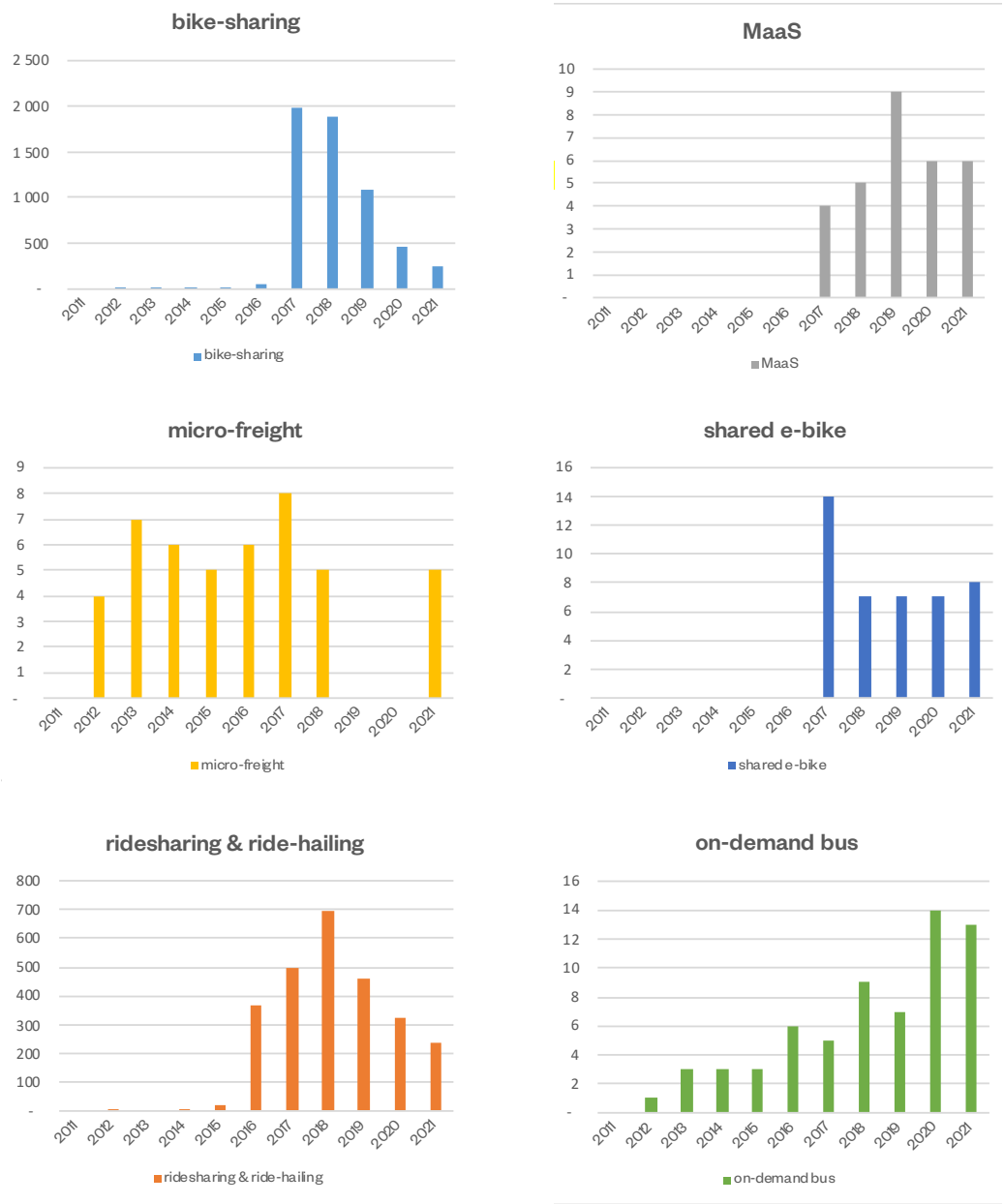
The number of the publications for each type of shared mobility varies significantly. There are thousands of publications on bike sharing and hundreds on ride sharing/ride hailing. However, there are only a few for other services such as MaaS, shared e-bikes, demand-responsive transport, and courier network services. There are multiple potential reasons for the disparity:
1) bike sharing and ride sharing/ride hailing are the dominant shared mobility types in China and attract more attention from researchers;
2) some bike-sharing and ride-sharing/ride-hailing companies are willing to share data with scholars, therefore to help the company improve services;
3) MaaS is still new to researchers and the market;
4) markets for shared e-bikes and demand-responsive transport are not stable;
5) discussions on the courier network services have not been explored in the academic field.

The research and publications are imbalanced among different shared-mobility modes with respect to the number publications, the depth of analysis, and coverage of sub-topics. This is unavoidable due to differences in the development status of each mode, the levels of awareness of researchers, industry and government, and accessibility of research-funding on each mode.

Figure 2: Number of Chinese publications on shared mobility, by mode (2011-2021)



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Note that the number of publications relate to when each shared mobility type first appeared and later began to boom. The first appearance of DBS in China was around 2015, ride sharing/ride hailing began in 2012, MaaS in 2019, shared e-bike in 2016, and demand-responsive transport in 2013. The first appearance of courier network services cannot be clearly defined, because the early market was informal and irregular (or illegal). It could be around 2012 or 2013 but may have been much earlier in some places in China.

As mentioned, due to the large amount of literature in the cnki.net database, we only examined the publications from 2019 to 2021. Restricting the literature to recent publications also ensured that the information and research trends analyzed were up to date.

4.1 Bike sharing

Photo credit: Hui Jiang

Price incentive (free ride for 0.5 hour during peak-hour in Beijing) promoted by Beijing government, Meituan Bike (formerly Mobike), Didi Bike, and Hello Bike. Source: Yangtse.com.
Photo credit: Guibin Wang.

There are 1,821 publications on bike sharing (excluding e-bike sharing) in the cnki.net database. We selected and examined 205 of these publications (cnki.net) and summarized the key topics relevant to bike-sharing studies.[5] 77 are on shared bikes, 20 are on shared economies and there are very few publications on the other topics addressed in this paper.

4.1.1 Operation and service

Dockless bike sharing has expanded rapidly in China since 2016 and has been replacing docked public bike-sharing systems. By October of 2020, the number of DBS bikes in China had reached 19.45 million and the number of users had reached 287 million (周小松 2021) (Zhou, 2021). The development of bike sharing in China went through four stages (周小松 2021) (Zhou, 2021):

- 2007-2010: government-led public docked bike sharing;
- 2010-2015: companies such as Youon started providing bike-sharing services (docked bikes) to the public;
- 2015-2018: the market of the dockless bike-sharing experience explosive growth, enabled by the rapid development of Internet companies and influx of capital. Toward the end of this period, the market saturated and many smaller players failed, leaving three major players in the market;
- 2018 to present: three main players dominate the market: Didi bike, HelloBike, and Meituan bike (formerly Mobike).[6] They are all backed by large e-commerce or Internet companies. The bike-sharing market is now orderly and more sustainable. Government-funded docked public bike-sharing systems have been largely replaced by DBS. The funding amount of Didi, HelloBike, and Meituan Bike are 23.2 billion US$, 2 billion US$, and 828 million US$ (under Meituan, 17.3 billion US$), respectively.[7]

5 Selected the publications only from 2019 to 2021, and focused on core journal articles and excluded publications on e-bikes, etc.

6 Meituan, China's large on-demand shopping platform, acquired Mobike in 2018 (Cadell C. 2018).

7 Information from crunchbase.com.

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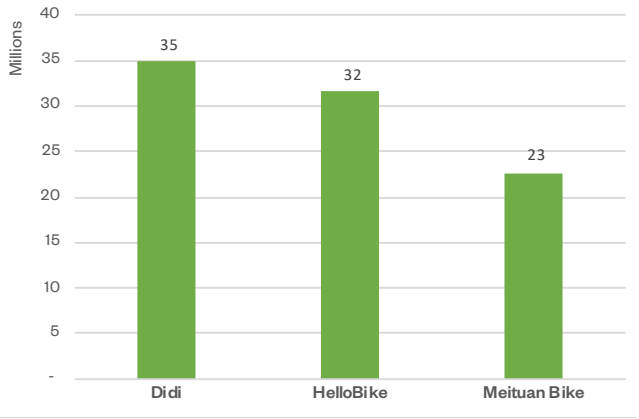
Figure 3: Number of active users for the three dominant service providers for October 2020



Source: (易观 2020)

Operator	Description	Lead investors
Didi	The company provides app-based transportation services, including taxi hailing, private car hailing, social ride sharing, and bike sharing; on-demand delivery services; and automobile services, including sales, leasing, financing, maintenance, fleet operation, electric vehicle charging, and co-development of vehicles with automakers.	SoftBank Vision Fund
HelloBike	Hello TransTech (formerly HelloBike) develops "smart-sharing" bikes for short-distance travelers in China.	Alibaba Group Ant Group Primavera Capital Group Fosun International
Meituan Bike	Meituan Bike (formerly Mobike) is a Chinese fully dockless bicycle-sharing system.	Tencent Line

Source: wikipedia.org; www.crunchbase.com

Potential opportunities:

- First-and-last mile solutions for users, and better accessibility
- Alleviate rush-hour traffic congestion
- For trips that replace car use, bike sharing is a greener transportation mode
- DBS can increase the physical activity of users, and thus providing health benefits
- Good connectivity to public transport systems
- Better affordability and equity.

Potential challenges:

- Oversupply of DBS burdens city management and materials recycling.
- Conflicts with other road users. For example, the parking zones take up sidewalk space (inhibiting pedestrians); some cyclists ride in bus lanes or on motorways, increasing congestion and accidents.
- Bike-sharing companies and local administrations can find identifying and managing the parking zones challenging.
- Potential competition with public transport.
- Parking chaos and potential challenges to regulatory policy and city management.

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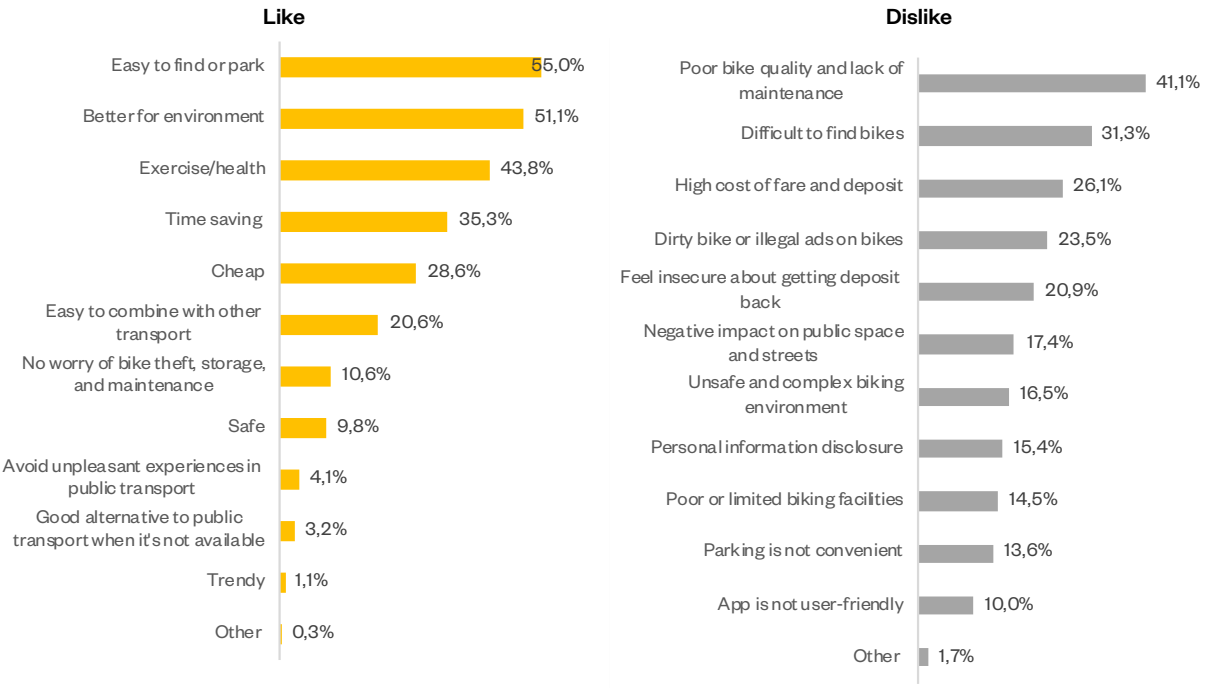
Figure 4: Why people like and dislike DBS (survey by WRI)



Source: (Jiang et al. 2020)

In the publications that we have reviewed, we found that the key research topics focus on user demand and preference, level of service and user satisfaction, accessibility and connecting with public transport, and development barriers. Most studies are based on a methodology that combines user-experience surveys with modeling and data analysis. All studies can be categorized into the demand-side and supply-side issues. Our findings are summarized in Table 2.

Table 2: Research on operation and services – Bike sharing

Operation and Services	Topics and trends	Key findings/recommendations
Demand-side studies[8]	– Factors influencing user demand and points of interest (POIs) to support fleet-size management and parking allocation – User demand and preference analysis – User-satisfaction analysis	– Influencing factors that are recommended for demand-side studies: purpose, time, convenience, cost, safety, health, parking, accessibility, maintenance, etc. – Users are active during peak-hour commuting. – POIs are mainly in offices, restaurants, PT stations, and residential areas. – Users prefer dockless over docked bike sharing. – Deposit, maintenance, safety, and privacy influence user demand. – Users prefer bike sharing, due to health and low-carbon benefits.
Supply-side studies[9]	– Fleet-size control and parking – Level of service and accessibility – Integration with subway and bus systems	– Bike-sharing services have high operational costs and low cost-efficiency. – Working with government is highly recommended. – DBS is a good solution for last-mile transit and PT connections and is considered an integral part of PT systems. – Both over-supply of and parking chaos are common in most cities with bike-sharing systems. – Bike sharing mixed with other traffic modes leads to road-safety issues.

4.1.2 Policy, regulation, and governance

The growth of bike sharing brought with it serious curb-management and safety issues in cities. City governments in China have come up with various policies and regulations to manage bike-sharing services. In the WRI report "*How Dockless Bike-Sharing Changes Lives: An Analysis of Chinese Cities,*" Jiang et al. find that these policies mainly cover issues such as fleet-size management, parking management, facilities planning and implementation, and road safety (Jiang et al. 2020). The different policies and regulations are grouped as follows:

- Fleet size management addressed in policies and regulations related to market entry, KPI-based performance assessment. Many cities' fleet sizes have decreased significantly. In Beijing, Chengdu, and Shanghai - the three largest DBS markets - have experienced decreases in fleet size of 62, 61, and 71%, respectively, compared to their peak fleet size (Table 3).
- Policies and regulations addressing facilities planning and implementation include the designation of bike lanes, bike-only expressways, parking lots for bikes, and policies prioritizing bikes over cars.
- Policies and regulations addressing road safety relates to both shared-bike and other road users.

8 References: (刘珈琪;柯湾;刘春 2019; 李红昌,崔金丽 2021; 李胜定 2021; 沈蕾 2019; 王振坡,康海霞 2019; 王馨,白凯 2021; 袁晓芳;方颖;金紫薇 2019; 马新卫;季彦婕;金雪;徐洋;曹睿明 2020; 高枫,李少英,吴志峰,吕帝江,黄冠平,刘小平 2019; 高楹, 宋辞, 郭思慧 2021) (Liu et al., 2019; Li & Cui, 2021; Li, 2021; Shen, 2019; Wang & Kang, 2019; Wang & Bai, 2021; Yuan et al., 2019; Ma et al., 2020; F. Gao et al., 2019; Y. Gao et al., 2021)

9 References: (李盼道 2019; 李雪娇 2021; 陈康, 李佳骏, 王骜 2019) (Li, 2019; Li, 2021; Chen et al., 2019)

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Table 3: Comparison of current and peak fleet sizes in Chinese cities

City	Peak fleet size (Thousands)	Date	Most current fleet size (Thousands)	Date
Beijing	2350	2017,08	900	2019,11
Shanghai	1700	2017,09	500	2019,1
Guangzhou	1000	2017	400	2019,02
Shenzhen	890	2017,12	480	2019,06
Wuhan	1030	2018,06	750	2019,04
Hangzhou	770	2018,03	390	2019,01
Xiamen	460	2017,12	150	2019,02
Xi'an	730	2017,11	450	2019,03
Chengdu	1800	2017,09	700	2019,01
Nanjing	638	2018,03	317	2019,04
Jinan	180	2018,01		
Lanzhou	290	2018,12		

Source: (Jiang et al. 2020)

The WRI report contains the following findings regarding policy, regulation, and governance:

- **Fleet-size management.** Urban policies have evolved from a laissez-faire approach to proactive regulation of fleet size by applying stringent management measures to cap the DBS fleet size. Despite these efforts, cities still need to develop science-based methodologies for forecasting the influence of incentive schemes on DBS fleet size, in order to optimize policy and regulatory design and to encourage DBS as a green and healthy mode of transportation.
- **Performance-based evaluation.** Setting up a KPI system to determine permit renewal/termination criteria based on operators' performance not only allows the public sector to have a strong regulatory framework on fleet-size management but also provides a strong incentive for operators to provide quality service.
- **Regulated parking.** Cities should set up DBS parking design standards, creating clear rules on how curb space should be used, especially at critical locations like intersections, public transit stations, schools, etc.
- **Standardized technologies.** To enable users to better follow the rules, cities should encourage standardized technology applications on parking management, since these could enhance the efficiency of parking management and save time and effort for both the public-sector workforce and private operators.
- **Dedicated cycling facilities and safety design.** Cities should introduce DBS with expanded dedicated cycling infrastructure and higher safety design standards to improve accessibility and use of cycling, by upgrading their Comprehensive Transport Plans, Non-motorized Transport Plans, and Street Standards.
- **Road-safety awareness and targeted education.** Road-safety awareness and targeted education should focus more on enabling a safer and healthier cycling environment.

We have also examined other publications on cnki.net regarding the social and environmental impacts of DBS (Table 4).

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Table 4: Research on policy, regulation, and governance related to social and environmental impacts – bike sharing

Policy, regulation, and governance	Topics and trends	Key findings/recommendations
Fleet-size control[10]	– General discussions and management methods for fleet-size control, such as dynamic fleet-size management, KPI-based fleet-size quotas	– Cities are managing the overall fleet size through caps and performance-based evaluations. – Jinan and Guangzhou's exercise of controlled entry may shed light on cities where DBS fleets are not yet saturated. – There is KPI-based system to support fleet-size management: KPI systems are introduced to evaluate operator performance. The evaluation results will affect permit renewal and fleet-size adjustments. In general, the main KPIs include vehicle quality, operation and distribution, parking management, and public satisfaction.
Parking management[11]	– Discussion of parking management methods – Geofencing for smart parking – Incentives and disincentive – KPIs for operators	– Guangzhou, Shenzhen, and Beijing have adopted more comprehensive and clear regulatory solutions for parking-area management for sidewalks and public spaces. These cities have dedicated technical standards limiting parking areas on sidewalks and applying parking-area design specifications at individual locations. – Clear parking regulation enforcement responsibilities and penalties are important. – Reasonable distribution charges should be determined by the government. – Standardized technologies should be applied.
Road-safety management[12]	– User-experience surveys	– Road-safety awareness and targeted education should focus more on enabling safer and healthier cycling environments. – There is a general lack of strong enforcement of road-safety regulations.
KPI assessments and management[13]	– Selection of KPIs for city administrators to monitor the performance of bike-sharing operators	– KPIs: fleet size, parking, bike-safety design, price/safety-deposit, IT, privacy, bike condition and maintenance, material, insurance, etc. – KPI-based systems are being used to evaluate operator performance. Evaluation results can be used to affect permit renewal and make fleet-size adjustments. In general, the main KPIs include vehicle quality, operation and distribution, parking management, and user satisfaction.

4.1.3 Social and environmental impacts

In China, studies the social and environmental impacts of bike sharing come mainly from the gray literature published by NGOs and DBS operators. A few studies have been written by authors based at universities have been published in scientific journals in English. Due to limited data and awareness, there is little research on road safety and equity. This situation applies to other shared mobility topics, i.e., ride sharing/ride hailing, MaaS, e-bikes, demand-responsive transport, and courier network services. This is explained in more detail and discussed in Section 5.2.4 (Research weakness).

10 References: (Jiang et al. 2020)

11 References: (Jiang et al. 2020; 陈康, 李佳骏, 王骜 2019) (Jiang et al., 2020; Chen et al., 2019)

12 References: (Jiang et al. 2020)

13 References: (Jiang et al. 2020; 吴继英 2019) (Jiang et al., 2020; Wu, 2019)

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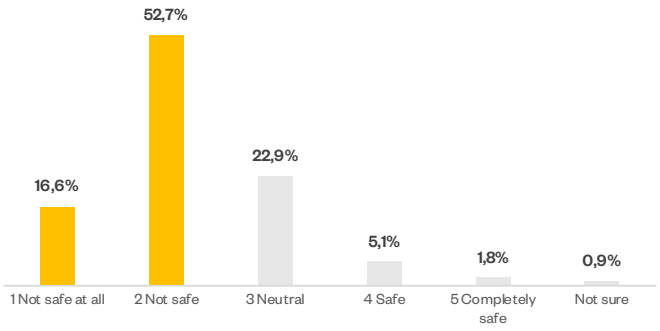
Greenhouse-gas emission reductions, congestion and parking management, health, green transport, and recycling are the primary topics addressed in publications on bike sharing. In the WRI report "*How Dockless Bike-Sharing Changes Lives: An Analysis of Chinese Cities,*" (Jiang et al. 2020) provide a comprehensive review and quantitative analysis of the impact of DBS (positive and negative) on greenhouse-gas emissions, physical health and road safety in 12 Chinese cities (Jiang et al., 2020). The report contains the following findings:

- **Health benefits:** Based on this research, the health benefits from DBS cycling outweigh the risks associated with exposure to polluted air while cycling. Therefore, cycling should be encouraged. The net mortality avoided annually among 235 million Chinese DBS users would be about 59,635 in WRI's recent study (Jiang et al., 2020). For most Chinese cities (which have the average PM2.5 concentration within 50–60μg/m^3), the maximum health benefit can be achieved with one-hour of cycling per day. Cycling more than 30 minutes per day at a $PM_{2.5}$ level above 160μg/m^3 is not recommended.
- **Carbon mitigation:** DBS can reduce total CO_2 by 4.8 million tonnes annually for the transport sector in China, due to reduced use of private motorized vehicles. However, actual emissions reductions are not large, because most trips are short-distance (first/last mile) and replace walking and the use of public transport.
- **Road-safety impacts:** The perception of safety was found to be generally low among DBS users in the 12 cities. Only seven percent of respondents reported feeling safe while cycling. The infrastructure for cyclists is not improving fast enough to accommodate surging DBS usage. However, existing academic and commercial studies in China have not quantified the difference in road safety risk between using DBS and other types of bikes. Based on the DBS share of total cycling mileage, WRI' study have estimated that of the 20,751 bike fatalities in China in 2018, 15,556 could be attributed to DBS.[14]

Figure 5: Do you feel safe when cycling? (from 1 to 5, where 1 = not at all and 5 = completely safe)



Source: (Jiang et al. 2020)

We have also examined other publications on cnki.net regarding the topics of social and environmental impacts of DBS (Table 5). We found that the key research topics are for road safety and carbon-reduction assessments. However, most studies used qualitative methods. Quantitative assessments of road safety and health benefits for DBS are severely rare, partially due to insufficient data and expertise in China. Research on equity is non-existent. More research is also needed on research on social and economic improvements, e.g., access to employment opportunities, education, and economic opportunities.

14 It is worth noting that we used data from an empirical study on users' preference of DBS over other modes in the first/last-mile connection to approximate the share of DBS among all cyclist trips (Fan et al. 2019). However, other studies show that DBS is the most appealing mode for transfer compared with other situations (Li et al. 2019). Therefore, the share of DBS might be overestimated, as are DBS fatalities. These results could be updated when more empirical data are available.

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Table 5: Research on social and environmental impacts – bike sharing

Social and environmental impacts	Topics and trends	Key findings/recommendations
Road safety[15]	– Legislation and insurance for bike-sharing accidents – Bike design, bike condition, and regulations for user safety – Impact assessments	– Relevant legislation and insurance policies for road accidents are lacking. – There is a lack of quantitative impact assessments, due to lack of data. – Parking, bike-maintenance, and travel-behavior impacts on road safety should be assessed. Data to support such assessments is limited. – User-experience surveys show that the 3 most dangerous aspects of DBS trips are: 1) complicated intersections, 2) lack of dedicated bike lanes, and 3) conflict with e-tricycles for logistics use.
Equity	N/A	N/A
Carbon dioxide[16]	– Assessments of emission reductions	– Bike sharing can reduce emissions of carbon dioxide and other air pollutants. – Integration with PT systems can reduce carbon dioxide emissions further.
Health[17]	– Health impact assessments	– Bike sharing can improve physical and mental health.
Congestion	N/A	N/A
Recycling[18]	– Recycling: waste materials, products, service – Life-cycle assessments	– Multi-sector collaboration is needed to promote green development. – Whole-supply-chain assessments and management are needed.
Green transport[19]	– Connectivity with public transport	– Co-benefits of green transport include: reducing emissions, increasing mobility efficiency, and increasing last-mile accessibility. – Bike sharing could not be verified to be environmentally friendly when assessed using life-cycle environmental impact assessments (lack of data).
Privacy	N/A	N/A
Increased access to jobs, education, and economic opportunities	N/A	N/A

15 References: (Jiang et al. 2020; 任捷 2020; 李磊 2020; 李胜定 2021; 祁芮如 2019; 郝亚丽 2020) (Jiang et al., 2020; Ren, 2020; Li, 2021; Qi, 2019; Hao &Dong, 2020)

16 References: (Jiang et al. 2020; 肖倩冰, 陈林 2021) (Jiang et al., 2020; Xiao & Chen, 2021)

17 References: (Jiang et al. 2020)

18 References: (司红运, 施建刚, 吴光东 2020; 吕杰锋,徐文静 2019; 吴怡 2020) (Si et al., 2020; Lyu & Xu, 2019; Wu, 2020)

19 References: (张敦福 2019; 高斌 2019) (Zhang, 2019; Gao, 2019)

4.1.4 Business sustainability

Current studies show that DBS are not profitable in China. For example, HelloBike is still far from making a net profit. HelloBike experienced net losses from 2018 to 2020 of 2.28 billion, 1.5 billion and 1.133 billion CNY (about 0.36 billion, 0.24 billion and 0.18 billion USD).[20] The three major players (Didi Bike, HelloBike and Meituan Bike) are not profitable for several reasons:[21]

- Price limitations: Bike sharing as a substitute for public transit and walking makes the willingness to pay very limited.
- High maintenance costs.
- Heavy depreciation of value of the bikes: nearly half of the operation cost of HelloBike is depreciation cost, which is over 2.5 billion CNY (about 0.39 billion USD) based on their gross transaction value of 5.8 billion CNY (about 0.91 billion USD) in the year of 2019-2020.
- High distribution costs: In the large cities, more labor is needed to redistribute the bikes, therefore, causes the high operation cost on bike distribution. In 2018, the operation cost per bike was 1.0 CNY (about 0.152 USD) per day for Mobike (later Meituan Bike)[22], because Mobike operated mainly in metropolitan cities with a tidal demand (i.e., rapidly increasing demand in peak hours) for bike sharing, and that requires intensive labor for redistribution after peak hours. On the contrary, HelloBike operated initially in the less developed cities with limited coverage of public transportation service and a lower labor cost. The operation cost per bike for HelloBike was only 0.3 CNY (about 0.047 USD) per day[23].
- Tragedy of the commons: The nature of shared bikes resembles the public goods, and like other common resources, shared bikes are being severely damaged through careless use and vandalism. In the US, vandalism may come from people who target shared bikes because they view them "designed for the affluent."[24] In China, there have been incidents of broken chains and pedals. In some cities, there have also been cases of private locks being put on the bikes.[25]

While there are number of gray-literature publications (such as commercial reports, news, blogs, short comments on the Internet and social media) on business sustainability (e.g., business model, financing model, cost, pricing, etc.) for the bike-sharing sector, we did not find any relevant publications in China's journal database cnki.net.

4.1.5 Resilience

Meituan Bike (formerly Mobike) employee sanitizing bikes under COVID-19 in Beijing.

Photo credit: Guibin Wang. Source: Yangtse.com.

COVID-19:
During the COVID-19 pandemic, bike-sharing systems have proven to be a good alternative to motorized transport systems. They provide more flexibility, accessibility and convenience for citizens compared with other modes of transport. Studies show that bike-sharing services have rebounded sharply during the pandemic.[26]

20 https://www.163.com/dy/article/G8GC0O660539M9HP.html
21 https://36kr.com/p/1445929821464713
22 https://www.tmtpost.com/5778846.html
23 https://m.ebrun.com/238568.html
24 https://www.theguardian.com/us-news/2017/aug/21/bike-sharing-scheme-san-francisco-gentrification-vandalism
25 http://www.nbd.com.cn/articles/2019-04-08/1318726.html
26 https://www.36kr.com/p/1725247127553

- **Safety**: Public transportation limitations resulting from COVID-19 lockdowns or partial lockdowns have resulted in bike sharing becoming a major mode of commuting in many cities around the world[27] In China, there was also a surge of bike-sharing usage when the lockdown policy was lifted. People chose to use shared bikes instead of riding buses or subways in order to maintain social distancing as much as possible[28] Bike sharing was also a leading option (or only option) for emergency trips when the cities were in lockdown.
- **Resilience**: During the 50-day public transportation lockdown in Wuhan, Meituan Bike (formerly Mobike) provided 2.3 million trips in the city. As China's economy re-opens, bike sharing appears to be back on the rise. According to Meituan and the two other major bike-share companies, Hello-Bike and Didi Bike, ride volume in Beijing has increased 120-187%, compared to before the pandemic. However, whether demand for bike sharing will continue to increase and eventually exceed before-COVID-19 levels in the long run remains to be seen.

Two publications found on cnki.net regarding resilience to COVID-19 are listed in Table 6. We found no publications on climate-resilience issues for bike-sharing systems in China.

Table 6: Research on resilience – bike sharing

Resilience	Topics and trends	Key findings/recommendations
COVID-1929	– COVID-19 impacts on bike-sharing ridership – Solutions for reducing COVID-19 risks for riders, and fleet management during COVID-19	– Bike-sharing (esp., point-to-point) ridership increased during COVID-19. – DBS operation has been resilient during COVID-19. – Awareness, sanitization, smart parking, and good cycling facilities have positive health impacts and support an active mobility culture.
Climate	N/A	N/A

4.2 Shared e-bikes

Shared e-bikes in Kunming, with helmets in baskets. Photo credit: Xiaotian Fu.
Photo source: http://www.cnr.cn/gsgb/2015yw/20200908/t20200908_525245658.shtml

There are not many publications on shared e-bikes in China, due to lack of local implementation in Chinese cities. We have examined 29 publications (found on cnki.net) and summarized the key topics relevant to the shared e-bike and/or e-scooter studies.

27 https://www.wri.org.cn/en/blog/biking-provides-critical-lifeline-during-coronavirus-crisis

28 https://www.sohu.com/a/378498806_114930

29 Reference: (惠英 et al. 2020) (Hui et al., 2020)

Table 7: Top topics on shared e-bike publications

Topics	Number of publications	Topics	Number of publications
Shared Electric Moped	7	Group Standard	1
Bike Share	2	Alipay	1
Uncertainty	1	Bicycle Share	1
Stakeholders	1	Feature Analysis	1
Municipal Bike Share	1	Users' Travel Behavior	1
Medium-small Cities	1	Issues and Solution Analysis	1
Lithium Battery	1	Geofence	1
Development Status	1	Share Moped	1
Consumers	1	Countermeasures Inquiry	1
Sharing Economy	1	Qunaer.com	1
Evolutionary Analysis	1	Taiyuan City, Shanxi Province	1
Urban Construction	1	Chizhou City, Anhui Province	1
Development Status	1	Reasonable Using	1
Legends of the Three Kingdoms	1	Moped	1
User Behavior	1		

Source: Data from China Academic Journals Electronic Publishing House (cnki.net)

4.2.1 Operation and service

Shared e-bikes emerged in China around the same time as shared bikes (WHTDSI; Meituan Bike 2020). In 2019, the number of shared e-bikes in China exceeded 1 million, and their use generated revenue exceeding 3 billion yuan (0.47 billion USD). Some key features of the shared e-bike market are as follows:

Potential opportunities:

- Market size is large and still expanding: According to the China Urban Public Transportation Association, by 2020 there were about 5 million shared e-bikes in operation. Shared e-bikes are serving nearly 500 million people in China, which is more than 50% of the urban population in China (CEPF; NCUT; CATARC 2021). While bike-sharing services enjoy a large proportion of megacity markets, shared e-bikes dominate the market in third- and fourth-tier cities.[30] The small to medium-cities have scattered urban cores with less-dense public transportation networks. Shared e-bike systems can enhance the accessibility of PT systems and provide a "last-5-to-10-miles" solution in such cities (CEPF; NCUT; CATARC 2021). In mid- and east-China provinces, over 70% of the counties within each jurisdiction have e-bikes, with some even reaching 100% coverage.
- Popular in medium and small-sized cities: According to data from iiMedia research, a market research organization in China, only 1.8% of the shared e-bike users are from tier-one cities (i.e., Shanghai, Beijing, Shenzhen, and Guangzhou), while there are 27.4%, 36.2%, and 34.6% of the users from tier-two, tier-three, and tier-four cities and rural areas, respectively.[31]
- Longer trip distances: The average e-bike trip is 3-10 km, which is significantly longer than shared bike trips. Instead of being a first and last mile solution like bike sharing, shared e-bikes provide a complete commuting option for many users.[32]

30 The Chinese city tier system is a hierarchical classification of Chinese cities. Cities in different tiers reflect differences in consumer behavior, income level, population size, consumer sophistication, infrastructure, talent pool, and business opportunity. Tier 1 represents the most developed cities in China, while Tier 5 represents the less developed cities. There are 4 Tier 1 cities (Shanghai, Beijing, Shenzhen, and Guangzhou), 15 New Tier 1 cities, 30 Tier 2 cities, 70 Tier 3 cities, 90 Tier 4 cities, and 128 Tier 5 cities in China as defined in Yicai Global. https://baike.baidu.com/item/%E4%B8%AD%E5%9B%BD%E4%B8%80%E7%BA%BF%E5%9F%8E%E5%B8%82/2343234?fr=aladdin; https://en.wikipedia.org/wiki/Chinese_city_tier_system

31 https://www.iimedia.cn/c400/75039.html, https://www.jiemian.com/article/6078646.html

32 https://news.cgtn.com/news/2020-10-08/New-wine-poured-into-the-old-bottle-of-shared-economy-in-China-UqwtpW2nNm/index.html

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Potential challenges:

- Multiple market players cause strong competition: There are more than 200 shared e-bike companies in China. Each of the three major players – Meituan, HelloBike and Didi - have large fleet sizes (over 1 million e-bikes). Mid-sized companies such as Songguo Travel have e-bike fleet-sizes of several hundreds of thousands. Small operators usually operate in fewer cities, from one to ten locations, and have fleet-sizes of hundreds to tens of thousands of e-bikes.
- Road safety issues and driving behaviors.
- Battery safety issues.

There are plenty of publications on the shared e-bike market, addressing both demand-and supply-side issues (Table 8). Similar to publications about bike-sharing systems, most of the research is focused on user preference analysis, influencing factors, operation and services, and fleet-size control. Some publications also address niche-market analysis, since e-bikes provide service over longer distances than bikes.

Table 8: Research on operation and services – Shared e-bikes

Operation and services	Topics and trends	Key findings/recommendations
Demand-side studies33	– User demand and preference analysis and characteristics – Market niches for shared e-bikes – User-satisfaction analyses – Examining factors influencing user demand and POIs, to support fleet-size management and parking allocation	– Shared e-bikes have development advantages and opportunities (larger market demand) in medium- and small-scale cities in China. – Shared e-bikes are in demand as a "last-5-to-10-miles" solution. – E-bikes enhance the accessibility of PT systems and are a "last-5-to-10-miles" solution, especially in small-/medium-cities with less-dense PT networks. – Some cities have more e-bike users than bike users. – Demand should be controlled or regulated by both private operators and the government. – Influencing factors used for demand-side studies include: purpose, time, convenience, cost, safety, health, parking, accessibility, and maintenance.
Supply-side studies34	– Fleet-size control and parking – Operation performance – Level of services and accessibility – Integration with subway and bus systems	– Shared e-bikes are a good solution for last-mile transportation and PT connections. They are considered a good and integral part of PT systems. – Over-supply and parking chaos are found in the market. – There are road-safety concerns regarding mixed traffic. – Working with government is highly recommended. – Shared e-bikes have high operational costs but are cost efficient.

33 References: (刘松洋 2018; 周若兰,郑琰 2021; 柳键,张晋莉,谢军 2021; 王丹 2019, 2020; 黄辛旭2019; 阮钊 2021) (Liu & Lan, 2018; Zhou & Zheng, 2021; Liu et al., 2021; Wang, 2019, 2020; Huang, 2019; Ruan, 2021)

34 References: (刘松洋 2018; 柳键,张晋莉,谢军 2021; 王丹 2019, 2020; 黄辛旭 2019; 阮钊 2021) (Liu & Lan, 2018; Liu et al., 2021; Wang, 2019, 2020; Huang, 2019; Ruan, 2021)

4.2.2 Policy, regulation, and governance

There is a lack of academic publications regarding policy and regulation of shared e-bikes. However, there is plenty of gray literature published for non-academic purposes on this issue, such as news, blogs, short comments on the Internet and social media, etc. Polices and local-government attitudes regarding shared e-bike systems are changing, from being highly restrictive to gradually deregulating with respect to market entry. The most common concerns of local governments are always road safety (e.g., speed, mixed traffic), battery safety (e.g., fire accidents during charging, battery quality), parking governance, and fleet size control.

Some "no development" attitudes toward shared e-bikes in some tier-one and tier-two cities include:[35]

- Beijing: The regulations in Beijing Municipality regarding the administration of non-motorized vehicles adopted in October 2018 clearly stated that "electric bicycle leasing shall not be developed" due to generally tightening regulations for electric bicycles, because electric bikes were aggravating urban traffic problems.[36]
- Shanghai, Hangzhou, and Guangzhou have published similar government documents expressing "no development" attitudes toward shared e-bikes.[37]

"One helmet and one belt" policy

- In April, 2020, China's Ministry of Public Security adopted a national helmet requirement for e-bike and motorcycle riders (one helmet, one belt) to help address the road safety issue. The market strategy of focusing on lower-tier cities is a result of the "one helmet one belt" policy. Tier-one cities like Beijing and Shanghai made it clear that local governments do not support shared e-bike operation.[38]

Fleet size control:

- Many cities have instituted strict quotas on the number of e-bikes allowed to be in operation.
- Rapidly-growing fleet sizes have caused many problems for city management. In November 2020, relevant departments in Changsha demanded that six shared e-bike companies remove and recycle unlicensed e-bikes within three days. These six companies removed a total number of 217 thousand e-bikes from service.[39]

Table 9: Research on policy, regulation, and governance – Shared e-bikes

Policy, regulation, and governance	Key findings/recommendations
Market restrictions[40]	– Most large cities restrict (or ban) shared e-bike operation due to safety (battery and speed) concerns.
Fleet-size control[41]	– Cities should implement fleet-size controls and license plates for e-bikes. – Closer monitoring and restrictions (e.g., via market-entry regulation and criteria) on fleet size are needed. – Operation standards are needed. – There is significant over supply in the market.

35 https://www.thepaper.cn/newsDetail_forward_14202520

36 Not for Beijing, but the overall problems with electric bikes are similar. https://www.sohu.com/a/367856797_100151087

37 http://www.xinhuanet.com/politics/2020-09/10/c_1126474394.htm

38 五环外的共享电单车，无法内卷 https://www.tmtpost.com/5434266.html

39 https://hn.rednet.cn/content/2020/11/30/8661765.html

40 References: (周若兰,郑琰 2021; 罗紫宇 2021; 聂帅钧 2019; 阮钊 2021) (Zhou & Zheng, 2021; Luo, 2021; Nie, 2019; Ruan, 2021)

41 References: (中国城市公共交通协会标准化委员会2020; 周若兰,郑琰 2021; 李永华 2021; 罗紫宇 2021; 阮钊 2021) (Standardization Committee of China Urban Public Transportation Association (hereafter referred to as CUPTA), 2020; Zhou & Zheng, 2021; Li, 2021; Luo, 2021; Ruan, 2021)

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Policy, regulation, and governance	Key findings/recommendations
Parking management[42]	– Parking chaos can be alleviated through monitoring and restrictions. – Geofencing and planned/regulated parking areas should be considered. – Operation standards are needed.
Data sharing[43]	– Platforms for sharing data between government and operators are useful. – Shared e-bikes, like other shared-mobility services, required data and privacy protection.
Road safety management[44]	– Helmet and belt requirement are needed. – Lights and mirrors are needed. – Standards and regulations for e-bike design and speed regulations are not well enforced. – Design standards to control e-bike speed are needed.
Battery safety management[45]	– Appropriate battery-replacement intervals are important. – Charging and battery-swapping standards, and station design standards, are needed. – Recycle method of battery is unclear – Standards and regulations for battery safety are enforced weakly .
Built environment[46]	– Mixed traffic (with both pedestrian and vehicles), lack of dedicated lanes, etc. are challenges – Built environment for e-bike users should be considered.
Standards on e-bike design[47]	– Technology design and regulations are addressed many studies.

4.2.3 Social and environmental impacts

Shared e-bikes complement underdeveloped public transport systems in county-level cities:

- The public transportation systems of county-level cities provide low levels of service (LoS) in terms of infrastructure/networks (e.g., road and station accessibility) and operation performance, and the costs of taxis are relatively high. Shared e-bikes serve the public as a complement to public transportation systems.

Safety when charging batteries:

- The hazards associated with e-bike batteries have been alarming in China (中国证券报 2021) (China Securities Journal, 2021). According to the Fire and Rescue Department, over 2000 cases of fire are reported annually. In 2020, 421 fires were caused by e-bikes, resulting in 20 deaths and 19 injuries.
- Shared e-bike operations are a good alternative to private ownership of e-bikes and reduce the risk of battery-charging accidents.

Publications on the social and environmental topics related to shared e-bikes mainly focus on road-safety and battery-safety issues (Table 10), which are major concerns. Equity issues have not been addressed in this research field. Research on social and economic improvements, e.g., increased employment, educational, and economic opportunities, is insufficient.

42 References: (中国城市公共交通协会标准化委员会 2020; 周若兰,郑琰 2021; 罗紫宇 2021; 阮钊 2021) (Standardization Committee of CUPTA, 2020; Zhou & Zheng, 2021; Li, 2021; Luo, 2021; Ruan, 2021)

43 References: (阮钊 2021) (Ruan, 2021)

44 References: (中国城市公共交通协会标准化委员会2020; 周若兰,郑琰 2021; 罗紫宇 2021) (Standardization Committee of CUPTA, 2020; Zhou & Zheng, 2021; Luo, 2021)

45 References: (中国城市公共交通协会标准化委员会2020; 周若兰,郑琰 2021; 罗紫宇 2021) (Standardization Committee of CUPTA, 2020; Zhou & Zheng, 2021; Luo, 2021)

46 References: (周若兰,郑琰 2021) (Zhou & Zheng, 2021)

47 References: (中国城市公共交通协会标准化委员会2020) (Standardization Committee of CUPTA, 2020)

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Table 10: Research on social and environmental impacts – Shared e-bikes

Social and environmental impacts	Topics and trends	Key findings/recommendations
Road safety[48]	– Safety issues for drivers – Safety issues for other road users – Safety issues due to infrastructure characteristics and driver behavior	– E-bikes (including shared e-bikes) are the source of road-safety issues in mixed traffic. – Standards and regulations address e-bike design and speed regulation, but are poorly enforced. – There is a lack of quantitative impact assessments due to lack of data. – Parking, bike maintenance, and travel behavior impact road safety (but with limited quantitative evidence).
Battery safety[49]	– Battery standards regarding safety	– Fire and recycling issues are significant. – Standards and regulations of e-bike battery safety exist, but are poorly enforced.
Equity	N/A	N/A
Carbon[50]	– Quantification of carbon emission reductions	– Shared e-bikes could reduce Tank to Wheel (T2W) emissions, but there are no quantitative results.
Health	N/A	N/A
Congestion	N/A	N/A
Recycling	N/A	N/A
Privacy	N/A	N/A
Access to employment, education, and economic opportunities	N/A	N/A

4.2.4 Business sustainability

E-bike sharing is more profitable than bike sharing:[51]

- The number of trips per vehicle per day (TVD) for shared e-bikes is about 5 to 10 times that of shared bikes in the same region.
- The price of shared e-bikes is also twice that of the price of shared bikes. Adopting a business model that includes battery swapping reduces capital and operational costs. Operators can achieve profits within 15 months (Table 11).
- Overall, the operational efficiency of 1 shared e-bike is similar to that of 20 shared bikes, which results in higher profitability.
- According to Cheng Liang, general manager of Supply Chain Management at Hello Bike, "If e-bikes are managed precisely and effectively, the cost over the full life cycle of the bike can be reduced, and of course the price for an e-bike is higher. And compared to the usual shared-bikes, there is less chance for us to lose them. Since users are required to park their e-bikes in designated places, we have to move them around less, and that has reduced our overall costs."[52]

48 References: (Jiang et al. 2020; 周若兰,郑琰 2021; 罗紫宇 2021) (Jiang et al., 2020; Zhou & Zheng, 2021; Luo, 2021)

49 References: (周若兰,郑琰 2021) (Zhou & Zheng, 2021)

50 References: (阮钊 2021) (Ruan, 2021)

51 https://www.tmtpost.com/5434266.html

52 https://news.cgtn.com/news/2020-10-08/New-wine-poured-into-the-old-bottle-of-shared-economy-in-China-UqwtpW2nNm/index.html

E-bike sharing creates opportunities for mid- and small-sized operators:

- Unlike the oligopoly market of bike sharing, the shared e-bike market offers greater opportunities for smaller operators. Through more refined operational management, smaller operators can work to gain a greater market share if meet cities' requirement on safety, parking, etc.
- China's county-level cities are currently the largest market for shared mobility such as shared e-bike services. The large market in lower-tier cities provides smaller operators space to operate. For example, Songguo Travel - a company that focuses on lower-tier cities - has been able to achieve a profit two years in a row. Songguo Travel is now planning to go public.

Table 11: Research on business sustainability – Shared e-bikes

Business sustainability	Topics or key findings/recommendations

Business model[53]	– Business models that have been explored include collaboration with
	  – Food-delivery platforms (2 wheelers for food delivery), e.g., Metituan, ELM, to expand market
	  – E-bike manufacturers
	  – Battery manufacturers
	– A model for capital investments involving battery swapping was found to lower capital and operating costs. Operators can achieve profits within 15 months.

Cost[54]	– E-bikes are, on average, CNY1000 (about 157 USD) more expensive than DBS. – Average cost of a shared e-bike: CNY3,000 (about 471 USD). – Hallo e-bike cost: CNY5,000 (about 785 USD) – Xiaoliu: cost CNY5,000 (about 785 USD)
Pricing	– Higher rental rates than DBS with better returns (seems profitable). – Longer life cycle than DBS.
Good practice[55]	Good practices are found to include: – Good e-bike design – Collaboration with e-bike manufacturers. – Fleet-size control: 150 people per e-bike (Xiaoliu case) – Regulate parking behavior of the users through penalties and register restrictions. – GPS-based geofencing systems for parking. – Collaboration with battery manufacturers. – Hallo Bike, CATL, and Ant Group are investing jointly to provide battery-swapping services for HelloBike.

4.2.5 Resilience

Similar to bike-sharing systems, shared e-bikes have been a good alternative to motorized transport systems during the COVID-19 pandemic. They provide more flexibility, accessibility and convenience for citizens compared with other modes of transportation.

The situation under COVID-19:

- Similar to situation for dockless bike sharing.
- Policies have not been consistent.
- The policies regarding shared e-bikes are changing. Various factors influence the macro-level attitude toward shared e-bikes. The development of shared e-bike markets is dependent on the production of e-bikes and

53 References: (星恒电源 2020; 姚颖超 2020; 黄辛旭 2019; 阮钊 2021) (Phylion Battery, 2020; Yao, 2020; Huang, 2019; Ruan, 2021)

54 References: (李永华 2021; 阮钊 2021) (Li, 2021; Ruan, 2021)

55 References: (星恒电源 2020; 姚颖超 2020; 黄辛旭 2019) (Phylion Battery, 2020; Yao, 2020; Huang, 2019)

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batteries.[56] From a policy perspective, e-bike markets must be regulated in the context of regarding green-transportation and other environmental policies.

Table 12: Research on resilience – Shared e-bikes

Resilience	Purpose and Trend	Key findings/recommendations
COVID-19[57]	– Shared e-bike performance during COVID-19	– Shared e-bike (esp., point-to-point) ridership has increased during COVID-19. – DBS has been resilient during the pandemic. – Awareness, sanitization, smart parking, and good cycling facilities provide positive health impacts and support an active mobility culture.
Climate	N/A	N/A

4.3 Ride sharing and ride hailing

Photo credit: TOM.com

There are 1,018 publications in the cnki.net database regarding ride sharing and ride hailing. We selected and examined 153 of these publications (from the most prominent Chinese journals and summarized the key topics covered in ride-sharing and ride-hailing studies.

56 http://www.jjckb.cn/2021-04/20/c_139893913.htm

57 References: (阮钊 2021) (Ruan, 2021)

Table 13: Top publication topics regarding ride sharing and ride hailing

Topics	Number of Publications	Topics	Number of Publications
Ride sharing	61	Policy changes	2
Transport elasticity	14	Traffic jams	2
Ride-sharing platform	11	Regulatory solutions	2
Supervision of ride sharing	6	Platform economics	2
Evolutionary analysis	5	New ride-sharing policies	2
Sharing economy	5	Empirical analysis	2
Ride-sharing service	4	Competitive dynamics	2
Legal restrictions	4	Institutional entrepreneurship	2
Commuting with ride sharing	4	Traveling demand	2
Taxis	3	Adoption of Laws	2
Optimizing matching	3	Regulation	2
Shared economics	3	Pricing research	1
Evolutionary game theory	3	Ride-sharing safety	1
Price control	2	Speech recognition	1
DiDi	2	ECM-ISC	1

Source: data from China Academic Journals Electronic Publishing House (cnki.net)

4.3.1 Operation and service

Market status: Ride-sharing and ride-hailing services have been available in Chinese cities for more than 10 years. As of September 30, 2021, 248 companies nationwide had obtained platform operating licenses, and 3.595 million ride-hailing car drivers' licenses and 1.148 million vehicle-transport licenses had been issued in the country.[58] National and local governments require the ride-hailing companies to meet three types of compliance criteria on drivers, vehicles, and platforms[59], based on the regulation of the "Interim Measures for the Management of Online Ride-hailing Car Operation Services."[60] Among the online ride-hailing platforms with order volumes exceeding 300,000 units, the highest compliance rate was from the operator "Ruqi Chuxing." And among the major central cities, the highest compliance rate is in Xiamen, and the lowest is in Kunming.[61]

In Guangzhou, the average daily passenger volume of online ride-hailing services was 1.06 million in 2020, which was essentially equal to that of taxis. The average daily passenger volume of shared bicycles increased to 1.53 million during COVID-19. Both ride-hailing and bike-sharing services had become important modes of travel for Guangzhou residents. The average daily motorized travel volume was about 24.34 million trips, and the motorized travel rate of residents was 1.48 trips/day. Public transportation in the central district accounted for 61% of the motorized share.

In China, the development of the ride-hailing industry has entered a period where orders have consistently been growing, with the total number of daily orders exceeding 21 million in 2020, while the ride-sharing industry has achieved rapid growth with the average daily order volume is reaching about 1 million. The service is becoming more and more specialized. In addition to ride hailing with only one passenger, ride sharing is being explored, and the penetration rate of carpooling is increasing.

58 https://mp.weixin.qq.com/s/S0WgWJuOtuUUEYa6nu051w

59 https://www.sohu.com/a/343084577_99891879

60

61 https://mp.weixin.qq.com/s/S0WgWJuOtuUUEYa6nu051w

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Fleet Information: In 2010 Yidao launched an online ride-hailing service in China, followed by Didi entering the market in 2012. Ride-hailing services gradually began to penetrate into China. In February 2014, the U.S. company Uber entered the domestic market in China to join the competition. The shouqi app was officially launched in 2015, when Shenzhou and Caocao entered the market. However, on August 1, 2016, Didi and Uber China announced a merger. Didi acquired all of Uber's data and assets in China.

Table 14: Market share and order volume of major online ride-hailing service platforms in October 2020

Platform	Market share (%)	Order volume (10,000 units)
Didi	89.21	56,200
Caocao car	2.63	1,660
T3	2.51	1,580
Wanshun	1.41	890
Meituan	1.16	730
Shouqi	0.92	580
Xiangdao	0.70	440
Huaxiaozhu	0.51	320

Source: (CEPF; NCUT; CATARC 2021).

The monopoly pattern in the online ride-hailing industry remains unchanged, with Didi currently maintaining a nearly 90% market share in online ride-hailing travel. This effective monopoly was primarily the result of the mergers of Didi and Kuaidi in 2015 and Didi and Uber in 2016. In addition to Didi, other significant companies include Caocao, T3, Wanshun, Meituan, and Shouqi.

- Transportation network companies: Didi mainly uses a self-operating transportation network model, and in 2019 began using an aggregation model, accessing third-party travel service providers.
- Internet companies: Some IT platforms aggregate vehicles from many different platforms such as Meituan (online shopping app) and Gaode Map. As a representative company in the field of life services, Meituan has a huge Internet traffic advantage. Gaode is more compatible with online ride-hailing services in terms of map scenarios.
- Car companies (including automakers or car-rental companies that owned vehicles): T3, Caocao, and Hengdao company continue to expand the scope of their businesses. As of the end of 2020, T3 travel's cumulative business covered 20 cities, their order size and monthly active users were among the top three in the net car industry, with zero major liability safety accidents.

Potential opportunities:

- Providing individual services for people seeking convenience and cost effectiveness.
- The vehicles utilized are mainly private cars, avoiding the unnecessary operating costs that taxi cabs incur when waiting or driving without customers.
- Completely a product of market demand, complementing public transportation and reducing the load on PT resources.

Potential challenges:

- Ride hailing may increase travel demand and replace public transportation and cycling.
- Increasing demand for ride hailing may cause traffic congestion and increase GHG emissions and local air pollution.
- Road safety and passenger security issues.

We found many academic publications on demand- and supply-side studies in the Chinese literature. Because more funding (from both private and public sector) is allocated to research on operation/services compared to other shared-mobility services, there is active research activities on this subject. Many of the publications on demand- and supply-side modeling, dynamic pricing, influencing factors, etc. apply quantitative methods.

Table 15: Research on operation and services – Ride sharing and ride hailing

Operation and services	Topics and trends	Key findings/recommendations
Demand-side studies62	– Demand modeling, forecasting, and influencing factors – Driver satisfaction (see separate section)	– Influencing factors that have been assessed in demand-side studies include: purpose, price, waiting time, safety and security, speed, comfort, congestion, and vehicle condition. – Demand influences pricing and compensation to drivers.
Supply-side studies63	– Relationships with other transportation modes – Pricing and subsidies – Impacts of infrastructure on ride sharing/ride hailing	– Dynamic pricing and subsidies should be introduced based on spatial and temporal characteristics. – Ride sharing/ride hailing have reduced PT ridership by 11-13%, especially in large cities. – Ride sharing/ride hailing has reduced ridership in traditional taxis by 25%, especially, in large cities. – Ride sharing/ride hailing vs. car sharing: car sharing should be promoted for non-commuter markets. – Pricing should be based on optimal social welfare. – Ride sharing and ride hailing are price competitive compared to traditional taxi services. – Dynamic pricing could be based on congestion levels, demand levels, and time (e.g., peak and night hours)

4.3.2 Policy, regulation, and governance

The policy and regulation system in China has improved in recent years.64 Online ride-hailing-car compliance requirements continue to develop. Some cities are gradually relaxing online ride-hailing-car approval requirements and optimizing the application process. Monitoring of safety in the industry is being strengthened and standardized. The capability of governments' price and credit supervision on ride-hailing/ride-sharing markets has improved. And the promotion and use of new energy vehicles for online ride-hailing/ride-sharing services is encouraged and supported.

- In 2016, after allowing online ride-hailing companies to operate in a legal gray area for years, China passed national regulations that established ground rules for ride-hailing service operations in the country, making it the first major economy to legalize ride-hailing services on a national level.
- As of June 2017, more than 50 cities have promulgated or formally implemented interim measures for the management of online ride-hailing services.
- On November 10, 2020, the State Administration of Market Regulation issued the "Anti-monopoly Guidelines on the Platform Economy" to prevent monopolistic practices in the platform economy, guide operators in the platform economy to operate in compliance with the law, and promote sustainable and healthy development of the online economy.

62 References: (于跃 2021; 席殷飞 et al. 2020; 张政, 陈艳艳, 梁天闻 2020; 曾兰兰 2021; 钟军, 林岩 2020; 陈喜群 2021) (Yu, 2021; Xi et al., 2020; Zhang et al., 2020; Zeng, 2021; Zhong & Lin, 2020; Chen, 2021)

63 References: (丛华锋,苗瑞2021.; 于乐, 谢秉磊, 张鹃鹏 2019; 孙中苗 and 徐琪 2021; 康凯, 王旭阳 2021; 彭向 et al. 2021; 许研, 纪雪洪 2021; 赵道致 and 杨洁 2019; 赵道致, 杨洁, and 李志保 2020; 钟军, 林岩, 吴瑕 2021; 钟军, 林岩 2020) (Cong & Miao, 2021; Yu et al., 2019; Sun & Xu, 2021; Kang & Wang, 2021; Peng et al., 2021; Xu et al., 2021; Zhao & Yang, 2019; Zhao et al., 2020; Zhong et al., 2021; Zhong & Lin, 2020)

64 https://wagner.nyu.edu/files/faculty/publications/RUDIN_EHAIL_REPORT.pdf

Trends:
In the future, the Chinese market will develop in a direction that is more in line with supply and demand, and more in line with market principles. The current market is still characterized by high costs, poor driver welfare and dissatisfied users. This is related to the current monopoly pattern of the market. In the future, new companies and business models will solve key challenges and drive change and innovation. Also, the government aims to better regulate the industry and strengthen the protection and rights of drivers.

Existing academic publications are focused on fair markets, policy evolution, legislation and standards, fleet size control, and KPI assessment and management (Table 16). Studies aim to support policy and regulation for national and local government, therefore, to obtain a more regulated market and equitable market environment.

Table 16: Research on policy, regulation, and governance – Ride sharing and ride hailing

Policy, regulation, and governance	Topics and trends	Key findings/recommendations
Fair markets[65]	– Capital investment behavior (e.g., expansion pattern, etc.) – Anti-monopoly and anti-over-competition	– The public and private sectors should collaborate.
Policy evolution[66]	– Policy history and gap analysis – How do TNC markets influence policy and decision systems? – Evolution of monitoring and supervision.	– Incremental learning-type policy changes in the practice of TNC should be developed. – Technologies and regulations should be co-developed.
Legislation and standards[67]	– Legislation and regulation improvement – Regulation for market entry – Personal information protection	– Efforts to improve legislation should focus on: TNC identification, security, information protection (privacy), road safety, insurance, anti-monopoly, and property protection.
Fleet size control[68]	N/A	– Local governments should have new policies. Traditional fleet control should be improved.
KPI assessments and management[69]	– Market monitoring and supervision	– Government should monitor and supervise the platform and the platform should monitor and supervise the market.
Privacy	– N/A	– N/A

4.3.3 Social and environmental impacts

It is necessary to consider sustainable shared mobility from the perspective of the entire lifecycle, not only the maximum utilization of resources during transportation use. Electrification of vehicles and reduction of emissions and pollution, the production of vehicles and production facilities and equipment, as well as the treatment of waste, including the disposal of used batteries and vehicles, should be considered.

65 References: (黄娟 2021) (Huang, 2021)
66 References: (杨志军 2021; 郑路 2019; 陈昭 2021) (Yang, 2021; Zheng & Jiang, 2019; Chen, 2021)
67 References: (曹勇 2019; 毛俊响 2019; 胡东 2019; 郑翔 2019) (Cao, 2019; Mao, 2019, Hu, 2019; Zheng & Shan, 2019)
68 References: (阎波,武龙 2019) (Yan & Wu, 2019)
69 References: (冯骅 2020) (Feng, 2020)

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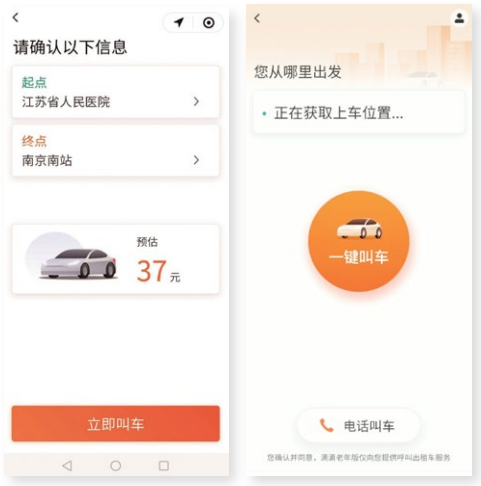
Potential benefits:

- o Provide convenient and comfortable mobility services to users.
- Increased job opportunities (drivers).
- May reduce congestion, since ride-sharing services has the potential to reduce the total number of vehicles on roads by encouraging travelers to share rides. However, there is also a counter argument that ride sharing/ride hailing can cause congestion due to the increased number of trips (negative impact).
- Individually, ride-sharing participants benefit from shared travel costs, savings in travel-time from access to high occupancy vehicle lanes and preferential parking and other incentives.70
- Convenience for the elderly: Major online ride-hailing platforms such as Shouqi and Didi have designed functions in their apps to address concerns of the elderly, such as the "one-click ride-hailing" function. The function is designed with a large button, a large font size, and clear and simple information, as well as a "one-click" button for calling the ride-hailing services.

Figure 6: "One-click" function for the elderly on Didi App

Potential challenges:



- Congestion: ride hailing may cause more motorized trips and cause congestion.
- Emissions: more emissions may be generated because of the additional trips generated by ride-hailing services, especially during peak hours.
- Equity: people with higher incomes benefit more from ride sharing/ride hailing; Some evidence shows that ride hailing is not affordable for lower-income group.
- Driver welfare
- Passenger security and safety: passenger's safety in the car is still a challenge, especially for women passengers.
- Data security: data and privacy protection and data usage.

In the academic community, there are plenty of publications on the subject of social and environmental impacts, including equity, security, road safety, carbon emissions and air pollution, congestion, privacy, etc. (Table 17). The publications use either qualitative or quantitative methods, or both. Compared with other shared-mobility services, researchers studying ride sharing/ride hailing seem to pay more attention to equity issues, such as affordability and women's safety. This may be due in part to pricing and criminal incidents in the ride-sharing segment of the market. Another trend in ride-sharing/ride-hailing research is to examine dynamic pricing, e.g., applying higher prices during peak hours and in congested areas to reduce demand and congestion (also mentioned in section 3.3.1).

Another interesting finding is that there are some conflicting results regarding the impacts of ride sharing/ride hailing on congestion and greenhouse-gas (as well as local air-pollutant) emissions. Different studies and different cases/cities draw different conclusions, finding either negative or positive impacts on traffic and the environment. This echoes findings from ITDP's Background Report (ITDP 2021). We do not know the reason for the conflicting results. However, the results could be accurate and depend on differences in case groups studied (e.g., ridership from PT or private cars). Note that many studies in China are funded by TNCs or other stakeholders. This may result in bias and/or uncertainty.

70 https://www.researchgate.net/publication/329146565_An_Overview_of_Shared_Mobility

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Table 17: Research on social and environmental impacts – Ride sharing and ride hailing

Social and environmental impacts	Topics and trends	Key findings/recommendations
Equity[71]	- Impact assessments focused on different groups - Affordability - Women's security	- People with higher incomes benefit more from ride sharing/ride hailing. - Some evidence shows that ride sharing/ride hailing is not affordable. - Legislation should be improved regarding: employment, user rights, privacy, and avoiding monopolies.
Security[72]	- Women's security - Protections and regulation to reduce violent crime	- Women's security should be enhanced.
Road safety[73]	- Legislation of and liability in road accidents	- Legislation should be improved.
Carbon and other air pollutants[74]	- Impact assessment	- There are conflicting results regarding impacts on emission reductions/increases resulting from ride sharing/ride hailing.
Congestion[75]	- Impact assessment	- There are conflicting results regarding impacts on congestion (negative or positive).
Privacy[76]	- Legislation and technology to provide private information	
Accessibility of jobs, education, and economic opportunities	- N/A	N/A

4.3.4 Business sustainability

There are two types of business development models being applied by companies (Huang 2020). The first is the Peer-to-Peer (P2P) model. The company only provides a platform, and the drivers source vehicles from rental companies or use their own cars. Driver income mainly consists of driving fees and subsidies from platforms such as Didi, Yidao, and Meituan. Although the customer-to-customer (C2C) model is simple and efficient to operate, security is one of its drawbacks.

The second model is the Business-to-Customer (B2C) model. Companies such as Caocao Car and Shouqi car service provide both vehicles and professional drivers to serve customers. The B2C model provides better customer experience by setting high requirements on vehicles, strictly managing drivers, and standardizing service processes. It has lower policy risk compared to the C2C model, but increased operating costs.

Publications in the business area focus on business-model and employment issues, as well as the adoption of electric

71 References: (刘晗 2020; 左文明, 黄枫璇 2020; 李庆功, 王震炎, 孙捷元 2020; 钟军, 林岩 2020) (Liu, 2020; Zuo & Huang, 2020; Li et al., 2020; Zhong & Lin, 2020)

72 References: (冯文刚, 鞠一铭 2020) (Feng & Ju, 2020)

73 References: (程啸 2019) (Cheng, 2019)

74 References: (袁韵, 徐戈, 陈晓红 2020; 赵鹏飞 2019) (Yuan et al., 2020; Zhao, 2019)

75 References: (杨浩雄, 张丁, and 孙丽君 2020; 林鹏飞, 翁剑成, 尹宝才, 周翔 2019; 袁韵, 徐戈, 陈晓红 2020) (Yang et al., 2020; Lin et al., 2019; Yuan et al., 2020)

76 References: (毛俊响 2019) (Mao, 2019)

vehicles (EVs) in the ride-sharing/ride-hailing industry (Table 18) in recent years.

Table 18: Research on business sustainability – Ride sharing and ride hailing

Business sustainability	Topics and trends	Key findings/recommendations
Insurance[77]	- Insurance and monitoring	Insurance and monitoring of ride sharing and ride hailing market is highly necessary.
Employment[78]	- Costs and benefits (mostly applying qualitative methods) to employees and employers - Relationships between employees and employers - Employee (drivers) satisfaction surveys - Driver welfare - Protecting driver's rights	- App-based ride-hailing and ride-sharing companies reduce employment costs and increase flexibility. - Standards and legislation should be introduced to protect worker's rights and interests. - Factors that influence driver satisfaction include: income, subsidies, insurance, and regulation. - Drivers have more physical health issues compared to the general population.
Business model[79]	- Profit and cost analysis - Relationships with other modes	- Ride sharing and ride hailing are price competitive compared to traditional taxi services.
EV[80]	- EV fleets - Charging infrastructure - Smart charging management	- Optimization of charging facilities for ride sharing/ride hailing is needed.

4.3.5 Resilience

In 2020, the ride-share market started to experience a recession due to the COVID-19 pandemic. In third-tier and smaller cities, the level of market penetration is still low. The order volume in first- and second-tier cities declined significantly. For example, in Shenzhen, Guangzhou and Dongguan, the proportion of vehicles with less than ten orders per day is over 50%, which is an increase compared to 2019.

The ITDP COVID-19 Travel Choice Survey concluded that only 34% of subway and public transportation commuters had maintained their original mode of transportation after returning to work, and 40% switched to travel using motorized vehicles (private cars (23.6%), taxi and online ride-hailing services (16.7%)). Due to the work stoppage and sharp decrease in travel demand, online ride-hailing services were suspended in over 100 cities during lockdowns.[81] Users followed the government's pandemic prevention and control strategy to avoid exposure to infection, and were less likely to choose ride sharing (ITDP 2020) as their mode of transportation.

77 References: (付淑换 2021) (Fu, 2021)

78 References: (周绍东 2021; 徐丽荣, 顾雪非, 李婷婷, 彭博 2020; 王永洁 2021; 范围 2019; 赵磊 2021; 齐昊, 马梦挺 2019) (Zhou, 2021; Xu et al., 2020; Wang, 2021; Fan, 2019; Zhao, 2021; Qi & Ma, 2019)

79 References: (赵道致 et al. 2020; 钟军, 林岩, 吴瑕 2021; 黄世忠 2021) (Zhao et al., 2020; Zhong et al., 2021; Huang, 2021)

80 References: (吴钉捷 and 李晓露 2020; 王丽丽 2019) (Wu & Li, 2020; Wang, 2019)

81 中国共享出行发展报告 (Annual Report on the Development of Shared Mobility in China)

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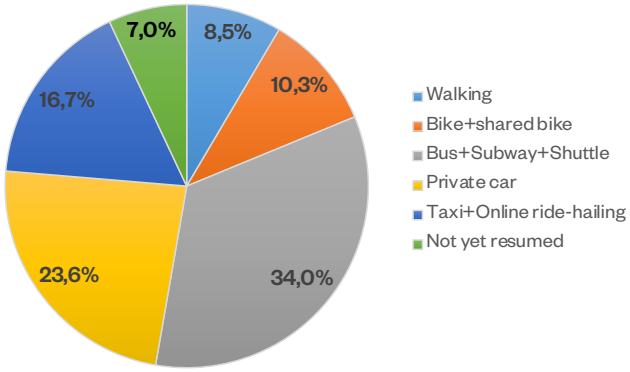
Figure 7: Survey conducted by ITDP regarding choice of mode of transportation



Source: (ITDP 2020)

Online ride-hailing platforms are currently operating well. Although some ride-hailing drivers may not have been able to work temporarily for various reasons related to COVID-19 in early 2020, the online ride-hailing fleet was still able to meet the user demand. Prices did not fluctuate significantly and were essentially the same as before the Spring Festival (when the price could be increased during the higher demand during the festival). At the same time, online ride-hailing platforms have introduced safety measures during the COVID-19 pandemic.[82] Major platforms have also actively introduced relevant preventive measures, including daily disinfection and sterilization and installation of protective film in the cars.

Didi has developed and launched more than 20 pandemic prevention measures and product functions under the guidance and assistance of relevant state departments, and continuously optimized and improved them. At the same time, the whole process of pandemic prevention and control was completed and announced to the population gradually over time. For example, Didi set up disinfection sites across the country to provide free vehicle-disinfection services and distributed pandemic prevention materials such as masks to drivers.

Shenzhou has ensured that the driver's body temperature is checked before taking orders, and that drivers wear masks throughout the service process. The vehicles are required to be thoroughly disinfected before and after each order, and the windows are opened in a timely manner to ensure air circulation. Video monitoring is also carried out, to monitor driver behavior and ensure safety.

Shouqi has ensured that the operating vehicles are disinfected thoroughly once every three days, at the disinfection-stations established by their branch offices in each city in cooperation with the franchises. Limited disinfections have been carried out three times a day, with each city's branch office responsible for specific implementation. Drivers are required to put masks on before driving the vehicle and to disinfect points of contact inside and outside the vehicle by spraying them with disinfectant and to open the windows for ventilation.

T3 has developed a traceable intelligent pandemic prevention system based on the "healthy car" and "driver + vehicle + platform" protection system to ensure the safety and health of drivers and passengers through big data and other technologies.

Table 19: Research on resilience – Ride sharing and ride hailing

Resilience	Topics and trends	Key findings/recommendations
COVID-19[83]	- Measures for COVID-19 transport - Ridership	- Each online ride-hailing platform had also introduced COVID-19 safety measures (sanitation, or health reporting) during the pandemic.
Climate	N/A	N/A

82 https://new.qq.com/omn/20200215/20200215A02Y8300.html

83 Reference: (ITDP 2020)

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4.4 Mobility-as-a-Service (MaaS)

MaaS solutions in Gaode Map and the DBS+metro connection in Beijing. Photo credit: Su Song

Mobility-as-a-Service (MaaS) is an emerging type of mobility service that an integrated online platform (e.g., through app) enables users to plan, book, and pay for multiple types of mobility services. The MaaS platform integrates multiple modes of transportation, such as public transportation, shared bike, taxi, and public-private partnership. A first consensual definition among public and private organizations was provided in 2017 by the White Paper of the MaaS Alliance (ERTICO-ITS Europe 2019; MaaS Alliance 2017):

"MaaS is the integration of various forms of transport services into a single mobility service, accessible on demand. For the user, MaaS offers added value through the use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations." (ERTICO-ITS Europe 2019; MaaS Alliance 2017)

More recently, in mid-2019, the European Metropolitan Transport Authorities (EMTA) described MaaS this way (EMTA 2019; ERTICO-ITS Europe 2019):

"With Mobility as a Service (MaaS), customers fulfil and manage all their mobility needs on demand, based on their general preferences and journey-specific needs. The service is based on the seamless integration of all different public and commercial modes of transport and is delivered via a digital interface. The service must enable multimodal travel possibilities and thus allow for the planning and booking of multimodal journeys, support on the go and payment as well as alteration of the planned journey. MaaS also generates insights into demand, needs and travel behavior for cities and authorities, allowing for more targeted and effective adaptations of services and investments in infrastructure."

Potential opportunities:

- Reduce the need to use or own a car.
- Clear representation of all modes of transportation will make the real cost of mobility more transparent, and the efficient combination of modes may allow for cost-saving opportunities for users compared to private car ownership.
- Take user preference into account concerning travel aspects like speed, convenience, comfort and cost, but also journey-specific needs, such as a need to transport large pieces of luggage, baby buggies or wheelchair. This is

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particularly important for users with either temporary or permanent mobility impairments

- To make better use of existing transportation services and resources and provide better intermodal connectivity within a region.

Potential challenges:

- A risk of causing the unfavorable mode shifts, such as some MaaS platforms might encourage taxi usage instead of public transportation and cycling.
- Trust between MaaS parties, the tight competition among various stakeholders make them unwilling to share information, expose their business models and collaborate with their competitors in the same MaaS scheme.
- Data sharing, availability, and management
- The lack of standardization of data.

Barriers to MaaS development:

- Lack of: an integrated approach, trust between key stakeholders, fact-based data and information sharing. Monopolistic behavior, an unlevel playing field, market-entry difficulties and difficulty in scaling MaaS adoption.

There are a limited number of publications on MaaS in China, due to lack of local implementations in Chinese cities. We examined 28 publications (from cnki.net) and summarized the key topics relevant to MaaS in China.

Table 20: Top topics on MaaS publications

Topics	Number of Publications
Mobility as a Service	13
Experience of Traveling	2
EV Cars	1
Smart Transportation	1
Automotive Industry	1
Public Transportation	1
Smart Travel	1
Path toward Success	1
Urban Transportation Management and Service	1
Abstract of Development	1
Cases Comparison	1
Transportation Service Level	1
e-Palette	1
Research Review	1
Development Outlook	1
Service Design	1
Urban Public Transportation System	1
Mobile Payment	1
Alipay	1
Development Stages	1

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Facing Future	1
Shared Travel	1
Driving Skill	1
Developing Routine	1
Innovative Design	1
Situation Analysis	1
System Framework	1
Vision of Application	1

Source: data from China Academic Journals Electronic Publishing House (cnki.net)

4.4.1 Operation and service

Current status: Currently, the market penetration of MaaS operation is small, and the degree of connectivity between modes of travel is low, while the functions of MaaS platform service mostly on route planning and payment integration only.

Characteristics: Integrated, people-oriented, shared, sustainable. As an integrated travel service platform, Maas integrates different modes of transportation and travel functions to provide consumers with a customized integrated travel experience.

Presently there are only two MaaS trial programs in China, in Guangzhou and Beijing. Both MaaS trial programs are still in the very initial stages and have issues that require improvement. In December 2020, **Didi** and **Guangzhou YangChengTong** (YTC, Guangzhou's public transport payment system) jointly issued the "Green Pass" for Guangzhou citizens to enjoy "public transportation + shared bicycle" travel. **Gaode Map** is working with **Beijing Municipal Commission of Transportation,** Baviton Technology and others to explore the implementation of MaaS in other cities in China.

Fare pricing mechanisms, algorithm-based scheduling from big data and information sharing among different participants are the main challenges faced in MaaS implementation. In cities with a high degree of openness to developing Maas applications, more and more government departments, technology companies, public transportation units and research institutions are beginning to collaborate.

Beijing

On November 4, 2019, the Beijing Municipal Commission of Transport in collaboration with Alibaba's subsidiary, Gaode Map, launched an MaaS mobile application in Beijing, branded as the "Beijing Green Transportation Integrated Service Platform." This was the first MaaS app to be launched in China and the first MaaS platform in the world to have served over ten million users in its pilot phase.

The MaaS app integrates all modes of transportation (bus, subway, suburban railway, walking, cycling, taxis, air, train, long-distance bus, private vehicles, etc.), provides smart travel services, and offers comprehensive travel information (such as real-time traffic updates, real-time location of buses, real-time information on congestion of subway stations, etc.). It covers more than 95% of bus routes, and the accuracy rate of matching real-time information is over 97%.

On September 8, 2020, Beijing Municipal Commission of Transport and other departments launched green-travel carbon-inclusive incentives based on an MaaS platform. For the first time, the carbon emission reduction of individual's green travel is included in the carbon trading market, which realizes the sustainable incentive mechanism of green travel. As of April 2021, the cumulative number of users of this platform reached more than 24 million, with an average of three million active users per day.

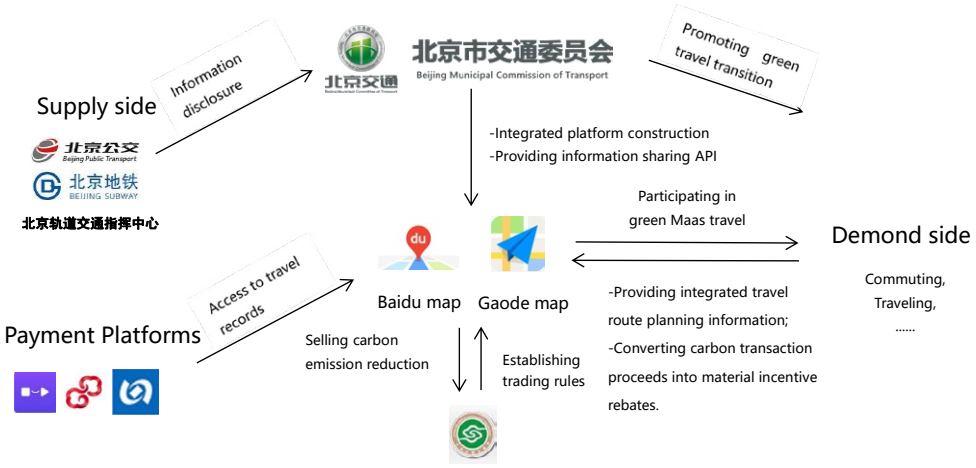
Highlights of Beijing MaaS system:

- The MaaS system integrates travel services with carbon reduction calculation. Through Beijing's low-carbon travel carbon-reduction assessment methodology, green travel behavior is monetized as the carbon credits. Beijng's MaaS system is promoting the green travel transformation, which is subsidizing users who choose public

transport and shared bike in the MaaS system. The carbon credits are then collected by the system and entered the local carbon trading system.

- The Beijing Municipal Commission of Transport released the "Measures for the Management of Open Traffic and Travel Data in Beijing" in 2019, by promoting the open sharing of traffic and travel data. To a certain extent, these measures break the data barrier between the government, enterprises, and the public, and helps enterprises to better serve travelers and enhance traveler satisfaction through high-quality real-time data sharing.
- Simultaneous construction of transportation service networks and transportation information networks support MaaS services with information technology.

Figure 8 Beijing MaaS System



Guangzhou

On December 18, 2020, Guangzhou YangChengTong (YCT, an integrated transit payment system under Guangzhou's bus company) and Didi jointly issued the "Green Pass" for Guangzhou citizens. The Green Pass is a MaaS product that integrates multiple modes of transportation to meet user travel needs such as inquiries and planning, payment and evaluation. Currently, the Green Pass focuses on public transportation and shared bikes: Guangzhou citizens can use the pass for both the public transportation and Qingju bike services.

There are two products: weekly and monthly passes. Weekly pass users only need to buy one pass to enjoy unlimited rides on Qingju bikes for a week and 14 rides on public transportation for the price of one cent. The weekly pass primarily serves tourists, commuters and students, while the monthly pass primarily serves commuters.

Highlights of Guangzhou MaaS system:

- Rely on YCT's strong technology in the field of integrated payment system and wide coverage of public transportation users in Guangzhou and other cities, Guangzhou MaaS system operates as a bus-dominated integrated travel system covering public transportation and shared bike services under one payment platform and discounting plan.
- Cooperation between private enterprises (such as online ride-hailing/ride-sharing platforms and bicycle-sharing platforms) has led to the development of a series of applications that better meet the demands of users' lives, by focusing on the transportation usage of disadvantaged groups and providing convenient travel services for the elderly and students. Similarly to the system in Beijing, the MaaS pilot program in Guangzhou is also driven by public-private partnership.
- The MaaS pilot is also seeking for more service solutions in the MaaS system, such as demand-responsive transport services, intercity transportation solutions, and the integration of city cluster development in other cities from Guangdong province, therefore to obtain more economic and social benefits.

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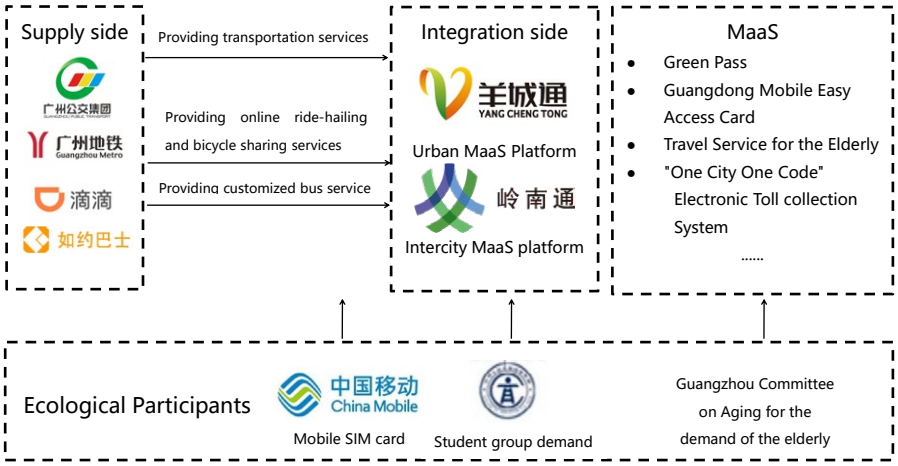
Figure 9 Guangzhou MaaS System



MaaS research in China is still in an early stage due to the lack of local initiatives. Most Chinese publications focus on 1) the definition and identification of the basic elements of MaaS systems, and 2) translating international publications (Table 21).

Table 21: Research on operation and service – MaaS

Operation and Service	Topics and trends	Key findings/recommendations
Definition[84]	- Concept of MaaS and relevant knowledge	- The definitions of MaaS are mainly sourced from international practices.
Cases from international practices[85]	- Case studies - Reviews of key elements of MaaS systems and their success - MaaS development history - Framework design - MaaS ecosystems	- Cases are mainly sourced from international literature and practices.
Demand-side study[86]	- User experience studies	- Limited findings on user-experience studies and impact studies in local context.
Supply-side study[87]	- Public transport and MaaS - Vehicle design based on MaaS - Service design	- It may be necessary to redefine and reform PT systems based on MaaS.

84 References: (王健 2018a) (Wang, 2018a)

85 References: (刘向龙 et al. 2019; 岳锦涛 2019; 张晓春 2019; 李晔, 王密 2018; 樊根耀, 高原君 2020; 王健 2018b; 王健, 胡敏翔, 管妮娜, et al. 2021; 王晶 2020; 龙昱茜, 石京, and 李瑞敏 2019) (Liu et al., 2019; Yue, 2019; Zhang, 2019; Li & Wang, 2018; Fan & Gao, 2020; Wang, 2018b; Wang et al., 2021; J. Wang, 2020; Long et al., 2019)

86 References: (唐珊, 沈天宇 2020) (Tang & Shen, 2020)

87 References: (梁罗丹 2018; 胡峰 2018; 胡飞 2021) (Liang, 2018; Hu, 2018; Hu, 2021)

4.4.2 Policy, regulation, and governance

The 19th National Congress proposed to build a modern transportation system and to achieve the integration of transportation systems. China has issued a series of policy documents to support the development of MaaS, such as the " Guiding Opinions of the State Council on Vigorously Advancing the "Internet Plus" Action" in 2015, the "Thirteenth Five-Year Plan for the Development of a Modern and Integrated Transportation System" and other major policies to support and accelerate the integration of Internet and transport systems, to promote the development of convenient transportation services using Internet-based platforms, and a proposal to build an integrated system for travel services, which provide travelers with "one ticket to home" transportation services.

Chinese publications on the area of policies and regulations of MaaS are also sparse. Most of them review international practices (Table 22).

Table 22: Research on policy, regulation, and governance – MaaS

Policy, regulations, and governance	Topics and trends	Key findings/recommendations
Challenges[88]	- International practices of challenges on policy, legislation, and governance	- Most MaaS practices studies are from other countries/cities.
Policy framework[89]	- International practice review	- Most MaaS policy frameworks are from other countries/cities.

4.4.3 Social and environmental impacts

MaaS can enhance users' travel experience and create multiple social and environmental benefits (北京交通发展研究院 2021) (Beijing Transportation Development & Research Center, 2021).

Social benefits: Guangzhou's MaaS pilot program focuses on equity in travel. For example, Guangzhou Working Committee on the Elderly, as well as the Ministry of Education are working together with YangChengTong (YCT), a bus operator and lead MaaS operator. Their work aims to implement MaaS to provide convenient travel services for the elderly and students.

YCT is cooperating with the Office of Guangzhou Committee on Aging to jointly study an implementation plan to solve the difficulties faced by the elderly when attempting to use intelligent technology. They are developing multi-level and diversified-age care models, providing reliable and convenient age-appropriate service products, focusing on optimizing taxi-travel services for the elderly, improving conditions for the elderly to take public transportation. The services is also providing solutions for the elderly to travel safely with medical services.

YCT has joined hands with the Education Management Information Center of the Ministry of Education to create an education pass. This travel pass is intended to meet the travel needs of primary- and secondary-school students, by providing relevant information and managing the student travel pass.

Environmental benefits: During Beijing's MaaS trial, which was conducted by Beijing transport authority, Alibaba/ Gaode (an Internet map company) and Baidu Map, trips shifted from private cars to greener modes of transportation (i.e., public transport and shared bikes), which can save 2.8kg of CO_2 per trip on average[90]. Based on the estimate of Beijing Transport Institute, the total CO_2 reduction from the MaaS platform (via Gaode Map app) was about 24,500 tonnes during the trial stage (the MaaS Campaign) from September 8th, 2020 to April 30th, 2021.[91] The most recent result shows that the

88 References: (王健 2019) (Wang, 2019)

89 References: (王健, 胡敏翔, 王承翔, et al. 2021) (Wang et al., 2021)

90 https://mp.weixin.qq.com/s/0LeU9vhLzzj8yANaB7aHAQ

91 https://baijiahao.baidu.com/s?id=1709943735245843186&wfr=spider&for=pc

cumulative CO_2 reduction was nearly 100,000 tonnes by the end of March 2022[92].

Due to lack of local initiatives, publications on the social and environmental impacts of MaaS are limited. The Beijing Transport Institute (BTI) and Gaode have published some studies on carbon emission reductions resulting from MaaS trial programs in Beijing. Other local studies are limited (Table 23). Since MaaS is a new mobility service, the information limitation of the complete cases is also a global issue, especially with respect to quantitative assessments. Even for WHIM (Finland), an early and one of the most complete and successful MaaS initiatives in the world, no detailed in-depth assessments have been published.

In general, there are no publications on social and environmental impacts of MaaS systems, in terms of urban space, road safety, equity, carbon impact, health impact, congestion, recycling, and green transport.

4.4.4 Business sustainability

MaaS, from the perspective of a transportation organizer, involves transportation providers that often need to secure public transportation services, such as bus and metro. However, most public transportation services are still dependent on government subsidies and have lower service quality compared to other modes in the MaaS system. Without a sustainable business model designed in MaaS, it will be difficult for the bus or metro operators to compete with other modes in the system.[93]

The Beijing Municipal Commission of Transport has taken the lead in coordinating platform construction and data sharing in Beijing. The fares for each mode of transportation remain unchanged, and travel records generated through system can be used as a basis for quantifying carbon credits for the local carbon trading system. The money from the carbon trading system will be used to subside the users who chose public transport, bikes and other green modes in the MaaS system, in order to encourage more "green ridership."

There is a lack of academic publications on the commercial sustainability of local MaaS initiatives.

4.4.5 Resilience

No publications were found on the resilience of MaaS pilot programs in China.

92 http://www.beijing.gov.cn/ywdt/gzdt/202203/t20220325_2639100.html
93 https://mp.weixin.qq.com/s/ZULtGsdbtImNUHhyTE8NfQ

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4.5 Courier network services (2/3 wheelers for last-mile package and food delivery)

2-wheeler for food delivery and/or intra-city express.

Photo credit: kuaibao *(left), Su Song (right)*

3-wheelers for last-mile package (freight) delivery normally link to DCs for intercity freight delivery services. Photo credit: Su Song

"*A three-wheeled electric vehicle that uses the onboard battery as energy, driven by electricity, equipped with a closed cabin with a unified logo. It is specially used for express collection and delivery.*" (State Post Bureau of China 2014). In China's market both 2- and 3-wheelers are used for package and food deliveries. In most Chinese cities, 2/3-wheelers are electrified (some are still internal combustion engines) and are used for last-mile urban delivery of freight, such as express and parcels (CEP), food, and other light-duty cargo. According to (Li 2018),[94] electric 3-wheelers account for about 90% of all last-mile shipments in China, with drivers delivering an average of 300-360 kg of goods every day.

There are very few publications on the use of 2/3-wheelers for last-mile urban deliveries. We have only examined about 20 publications in this field. Most of the publications studied focus on road safety, battery safety, and market governance. Some publications also mentioned driver welfare. In this section we only focus on electric 2/3-wheelers.

Courier network services seems off the radar of researchers, especially in academic communities. Possible reasons could include the fact that the courier network services 2/3-wheeler market in China is scattered and irregulated (sometimes illegal). Researchers, especially those based at universities, are not incentivized to study markets that are not well regulated. In addition, unlike ride sharing/ride hailing, which attract investments from auto-makers and high-tech companies, courier network services markets consist of informal businesses using inexpensive vehicles.

94 https://www.sustainabletransport.org/archives/5826

Table 23: Top topics on courier network services publications

Topics	Number of Publications	Topics	Number of Publications
EV Cars	4	Drink and Drive	1
Electric Tricycle	2	Li-ion Battery	1
Illegal Operation	2	Case Handling Police Officer	1
Local Legislation	1	Manufacturer	1
Helmet	1	Driver License	1
Electric Moped Management	1	Public Safety Organs	1
Three Layer	1	Non-motor Vehicle Management	1
Anti-dumping Measures	1	Displacement Map	1
Permitted Type to Drive	1	Usage Fee	1
Passenger Flow Management	1	Machinery Design	1
Secondary Responsibility	1	Undercut Tunneling	1
Lead-acid Battery	1	Beijing Municipal Bureau of Justice	1
Anti-dumping Sunset Review	1	Packstation	1
Jining City	1	PLC Control System	1

Source: data from China Academic Journals Electronic Publishing House (cnki.net)

4.5.1 Operation and services

Potential opportunities:

Two- and three-wheelers are popular for urban deliveries in Chinese cities because they are:

- Flexible and more accessible for door-to-door delivery,
- Cost-efficient due to mostly electric motors, relatively inexpensive to acquire and maintain,
- Easily maneuverable, which enables navigation of the commonly narrow roads in the older parts of Chinese towns, such as Beijing Hutongs,
- Small in size, which makes it possible for 2/3 wheelers to circumvent traffic jams, and
- Not subject to the bans on driving larger trucks in cities during the day.

Growth in the courier network services market is in response to the elevated demand from users that want faster and more flexible freight services.

- Market sizing: According to data from Southwest Securities, in 2020, the overall logistics and delivery market generated a revenue of 879.5 billion CNY (about 138 billion USD), with 83.4 billion parcels delivered in China, in response to the surge of Internet-based logistics and integration of warehouses and distribution in recent years. Real-time delivery accounted for 19% of total revenue, about 170.1 billion CNY (about 26.7 billion USD). The number of orders generated through real-time delivery was 27.76 billion, which is close to 33% of the whole logistics industry.
- During the COVID-19 lockdown, more consumers became accustomed to an online purchase + real-time delivery model of grocery and other types of shopping. In response to this demand, real-time delivery was provided by shopping platforms and other companies (e.g., delivery companies, restaurants, etc.).[95]

95 http://www.myzaker.com/article/6041f7018e9f09749243afcd

- Two- and 3-wheelers are the main vehicles used for real-time deliveries, because of their flexibility and cost-effective nature.
- "The Chinese express industry raised its concerns against the policies of the cities and called for the "right of way" for electric 3-wheelers." During the National People's Congress and Chinese People's Political Consultative Conference (NCP & CPPCC) in 2017 in Beijing, the State Post Bureau (SPB) Minister pointed out that electric 3-wheelers are a key element for the development of the express delivery industry and called for accelerating the formulation of a national standard. He also encouraged local administrations to develop regulations that set clear rules for electric 3-wheelers and provide them the "right of way."

Potential challenges:

- Operation: unregulated operation and management; unregulated terminal and warehouse management; lack of parking management; high logistics costs vs. low-cost competition.
- Road safety: lack of speed restrictions; high occurrence of road accidents in mixed traffic; low standard of quality and lack of enforcement of vehicle standards; poor driving behavior, in particular traffic-rule violations.
- Environment: packaging materials that contributing to pollution; battery recycling issues.
- Business systems: cut-throat competition (oversupply and low cost); low salary and welfare of delivery workers; lack of training and service quality; lack of labor during COVID-19.
- Economy: COVID-19 reshaped e-commerce and urban economies; lack of labor.
- Technology: standards for new technologies are required; no clear regulations and standards on autonomous vehicles, robots, and drones for urban delivery; operational chaos of smart lockers during the pandemic.

Only a few publications were found in the operation and service area of the courier network services market (Table 25). Courier network services seems to be off researchers' radar, especially in the academic community. Research publications on 2/3-wheelers for last-mile urban delivery are extremely scarce in academic databases in China. Publications for non-academic purposes, such as news, blogs, short comments on the Internet, social media, and magazines on this topic are common.

Table 24: Research on operation and service – courier network services

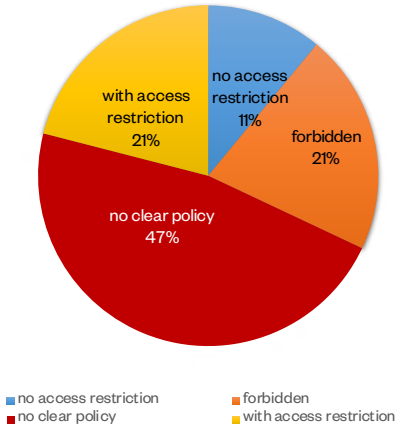
Operation and service	Purpose and trend	Key findings/recommendations
Market development[96]	- Market reviews	- The market is not well studied. - The market is not well regulated.

4.5.2 Policy, regulation, and governance

- According to (Li 2018), the development of national guidelines for electric 3-wheelers has been slow. However, several Chinese cities have taken steps to regulate electric 3-wheelers. For example, Jinan has required vehicle licenses for electric 3-wheelers since 2017 and Beijing requires that electric 3-wheelers used for delivery have standardized colors and display a unique serial number (which is distinct from a license plate). In fact, according to a China Post News, by 2017 more than 50% of Chinese cities had adopted some policies to regulate 3-wheelers, and 21% of Chinese cities outright banned electric 3-wheelers.

96 References: (刘潇 2020; 徐翔 2021) (Liu, 2020; Xu, 2021)

Figure 10: Status survey of electric 3-wheelers in 224 cities in 2017



Source: (Li 2018).

- (Li 2018) mentions that bans on electric 3-wheelers have had significant impacts on the express-delivery industry that have affected both drivers and consumers. The industry has raised concerns and fought for the rights of 3-wheeler operators. In 2017, the State Post Bureau Minister indicated publicly that electric 3-wheelers are key to success of the express-delivery industry and encouraged local administrations to regulate rather than ban their use. The industry and its employees have been bolstered by the 2018 adoption by the Chinese State Council of an article, which stipulates that 3-wheelers used for express delivery should be granted the legal right to operate and be provided with short-term parking solutions.

- In 2020, the SPB issued a policy document that aims to improve the well-being of delivery workers in the urban freight and express ecosystem (SPB China 2020). The document identifies current issues for employees and the ecosystem, including cut-throat competition, low salaries and poor welfare for delivery workers, lack of training and low quality of service, and labor shortages as a result of the COVID-19 pandemic. Chinese government aims to increase accessibility for 2/3-wheelers for delivery, secure the safety and social welfare of delivery workers, introduce training and education for employees, and improve companies´ due diligence of labor welfare.

- City-level regulations:

  - According to China Post News, by 2017, more than 50% of Chinese cities had adopted policies to regulate 3-wheelers, with 21% of Chinese cities banning electric 3-wheelers outright due to lack of license plates.

  - Jinan has required vehicle licenses for electric 3-wheelers since 2017.

  - Beijing required that electric 3-wheelers used for delivery services to have standardized colors and display a unique serial number (which is different from a license plate).

- Standards for 3-wheelers:

  - The State Post Bureau (SPB), which is responsible for regulating delivery services, released the industry standard requirements YZ/T0136-2014 "Electric-Tricycle Technical Requirements for Express Special" in June 2014. The standards outline the external dimensions, weight, speed, battery, and braking performance of 3-wheelers, and more.

4.5.3 Social and environmental impacts

Safety

- The biggest concern for 2/3- wheelers is road safety. According to a recent bike-sharing survey by WRI China, in 12 Chinese cities,[97] more than 41% of responses (out of 8,097 samples) indicated that 2/3-wheelers for urban delivery cause road-safety issues for cyclists. Enforcing speed limitations on 2/3-wheelers in China is very difficult. "In case the electric 3-wheeler is classified as non-motor vehicle, it does not need to be registered and the driver is not required to have a license. However, such a 'non-motor vehicle' electric 3-wheeler is only allowed to have a maximum speed of 15 km/h, according to article 58 of 'Road Traffic Safety Law of the People's Republic of China.' Yet, most electric 3-wheelers in use have a top speed that far exceeds that." (Li 2018).

97 Report to be published in August 2020.

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Regulation dilemma:

- Negative effects on the logistics industry: the ban of electric 3-wheelers has not only hit the express delivery industry. Couriers have had to find other jobs, which is often difficult in China due to the Chinese Hukou system (which is similar to a residence permit for particular cities). Also, customers were concerned that their deliveries would not arrive on time or that prices would increase.
- If an electric 3-wheeler is classified as motorized vehicle, it needs to be registered and the driver must obtain a driver's license, which would increase expenses for operators and could cause workers to leave the logistics industry.
- If the electric 3-wheeler is classified as a non-motorized vehicle, it is required to have its maximum speed restricted to 15 km/h, according to article 58 of "Road Traffic Safety Law of the People's Republic of China." However, most electric 3-wheelers in use have a top speed that far exceeds that.

Environment

- Most of the 2-/3-wheelers in China are electric vehicles. Many cities are advocating for a more environmentally-friendly logistics industry. For example, Beijing is promoting a greener last-mile logistics system, which includes putting more electric vehicles into operation.[98]
- Battery recycling problem.[99]
- The awareness of battery recycling is not strong among urban delivery operators
- Lack of formal recycling services: many people turn to small workshops for recycling, which tend to have higher prices than official, qualified companies.
- The qualification requirements of battery-recycling companies are strict, resulting in a limited number of qualified recycling companies.
- Battery reuse technology is undeveloped, and the recycle business model is lack of innovation.

Labor issues:

- Delivery people (couriers) are responsible for purchasing and maintaining their 2- or 3-wheelers.
- Lack of drivers licenses and proper training, which results in many accidents. According to the Traffic Control Department of Beijing, the average number of cases of 2-/3-wheelers' violation of traffic rules is high, among which, the proportion of violations committed by electric vehicles used for micro freight business such as express and takeout is relatively high.

Current academic publications focus on road safety, battery safety, packaging, and labor welfare. See the details in Table 26.

98 https://auto–time.36kr.com/p/309219806101512

99 http://www.xinhuanet.com/politics/2021-06/19/c_1127577731.htm

Table 25: Research on social and environmental impacts – courier network services

Social and environmental impacts	Purpose and trend	Key findings/recommendations
Road safety[100]	- Assessments of impacts on riders - Road-safety regulations - Rider experience with respect to road accidents and traffic-law violations - Monitoring and supervision of driving behavior and other road-safety issues - Safety design	- Reviews of local conditions are limited. - Drivers need awareness raising and training. - A large share of road users think that 2/3 wheelers cause safety issues in mixed traffic.
Battery safety[101]	- Battery-safety issues	- Some batteries are not safe.
Packaging[102]	- Green packaging	- Packaging needs to be safe and environmentally friendly
Labor welfare[103]	- Risk and safety issues during delivery - Insurance for drivers	- Labor welfare improvements are needed, related to safety, insurance, and payment.

4.5.4 Business sustainability

Cost of 2- and 3- wheelers:[104]

- A new electric 3-wheeler costs less than 3000 CNY (about 471 USD), including insurance and license plates. However, with the stricter rules and management of electric 3 wheelers, prices are going up.
- The costs of the 2- or 3-wheelers are mostly borne by the delivery people (couriers): they either purchase one themselves before getting the job or rent one from a distribution center.

Cost of changing to electric microvans:[105]

- increased costs:

Most electric tricycles currently in use violate one or more aspects of the Road Traffic Safety Law; tricycles that exceed a certain size should be regarded as motorized vehicles. All these increase the operational cost (e.g., fine, tax) of the operators.

- higher laborer cost,

An electric microvan and driver must be licensed, making microvans more expensive to use compared to the non-motorized couriers. Most of the express tricycles currently in operation are not considered to be motorized vehicles and, therefore, do not require that the vehicle or driver is licensed. Loopholes like the one just mentioned favor electric tricycles because franchise companies consider cost as a primary concern.

100 References: (Jiang et al. 2020; 吕慧, 郑雪 2021; 李卓颖, 韩佳钰 2020; 李晴 2019; 王昊喆 and 杨文庆 2021; 赵永强, 马骏, 黄靖博 2019; 陈福祥 et al. 2019) (Jiang et al., 2020; Lyu et al., 2021; Li & Han, 2020; Li, 2019; Wang & Yang, 2021; Zhao et al., 2019; Chen et al., 2019)

101 References: (刘潇 2020; 吴学安 2021) (Liu, 2020; Wu, 2021)

102 References: (吉红立 2019) (Ji, 2019)

103 References: (魏洁,丁少群 2021) (Wei & Ding, 2021)

104 https://m.jiemian.com/article/6586344.html

105 https://finance.sina.com.cn/chanjing/cyxw/2021-09-04/doc-iktzqtyt4043653.shtml

Societal costs:

- Replacing 3-wheelers with four-wheel vehicles is not simple. There are traffic issues to consider. Electric microvans cannot be driven on bike lanes, which could result in congestion. The costs also pose an entry barrier for workers and distribution centers, which could lead to a large-scale retreat from the last mile delivery market.

There is a lack of academic publications in the courier network services field.

4.5.5 Resilience

Local policies pose major constraints to the courier network services. Although there have been many proposals about using electrified microvans to replace 2- and 3-wheelers, not much progress has been made on this front. When broad-brush regulations are posed on 2- and 3-wheelers, real-time delivery and the last-mile of long-distance logistics suffer. While the industry is actively looking for a substitute, they still rely heavily on 2/3-wheelers. The lack of substitutes and the heavy reliance of the courier network services industry and sanitation workers on 2/3-wheelers have generally made past efforts to restrain the use of 2- and 3-wheelers unsuccessful.[106] There is a lack of academic publications on this topic and a lack of academic publications on resilience studies for courier network services sector in general.

4.6 Demand-responsive transport (DRT Bus)

Didi DRT bus trial in Kunming. Source: Global Times.

Demand-responsive bus services, also known as DRT or on-demand buses, is a form of shared private or quasi-public transport for collective travel. Vehicles alter their routes for each journey based on specific demand: they don't use fixed routes or timetables (Steinfeld and Steinfeld 2018). The vehicles providing DRT can include taxis, buses and other vehicles, and pick-up and drop-off passengers in locations based on passenger needs (Brake, Nelson, and Wright 2004).

There are limited numbers of publications on demand-responsive transport in China, due to a lack of local implementation in Chinese cities. We have examined 33 publications (sourced from cnki.net) and summarized the key topics relevant to the demand-responsive transport studies.

106 https://auto-time.36kr.com/p/309219806101512

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Table 26: Top topics on demand-responsive transport publications

Topics	Number of Publications
Demand-responsive Buses	6
Customized Bus	4
Responsive	4
Demand-responsive	3
Demand-responsive Shuttle Buses	2
Optimizing Research	2
Influencing Factor Research	2
EV Cars	1
Time-spatial Clustering	1
Elitist Selection Genetic Algorithm	1
Smart Bus System	1
Bus Dispatch Optimizing	1
Anti-COVID-19 Solutions	1
Demand Level	1
New Generation	1
Flexible Dispatching	1
Driverless Bus	1
Responsive Mechanism	1
Dedicated Bus Route	1
Demand-responsive Transfers/Connections	1
Mixed Algorithm	1
Route Optimization and Planning	1
DRT Stop Location	1
Coupling Network	1
Framework Design	1
Development Path	1
Pakistan	1
Karachi	1
Market Share	1

Source: data from China Academic Journals Electronic Publishing House (cnki.net)

4.6.1 Operation and service

Demand-responsive transport services have flexible routes based on real-time commuter demand, using a fleet of vehicles using a shared-ride method operating between pick-up and drop-off locations. On-demand buses are also called demand-responsive buses. They are called ***dynamic buses*** in some cities, such as Qingdao, Xi'an and Hangzhou and are also known as *Smart Buses*, etc.

Demand-responsive transport is a new model of online bus-hailing and booking service. Passengers who need to travel can make reservations online. When the bus seats are fully booked (or nearly fully booked) by people with similar (or overlapping) routes, the demand-responsive transport service starts. For example, Beijing's online bus-hailing service has vehicles that can carry six passengers but only require three passengers to meet the requirements to initiate service. There are two-vehicle models that serve larger groups of passengers, where five or ten booked passengers are needed, respectively, to start a trip.

Bus pooling costs less than ride sharing. It is estimated that the daily travel demand is around 460 million trips in China, of which 30-50 trips consist of carpooling. Nearly 200 million people travel using public transportation, so there is an extremely large potential market for bus-pooling services. It is estimated that the potential market value of DRT buses is more than 100 billion yuan (about 15 billion USD) in China (CEPF; NCUT; CATARC 2021).

In China, theoretical research on demand-responsive public transportation has been carried out for many years, but the implementation of demand-responsive public transportation has only gradually matured in recent years. The information platform companies and the bus companies jointly develop a service platform for demand-responsive buses, and cooperate with the bus operator in the implementation area. For example, the demand-responsive bus project in Chengdu was implemented by Chengdu Public Transport Group Company in cooperation with Didi. The project requires a government permit to determine the geographic area of operation. There are two operating models for implementing DRT bus services one with a single origin and single destination and another offering services with multiple origins and destinations. Passengers can choose the stations provided by the booking platform as their origins and destinations.

There are two operation models:[107]

(a) Organized by the public transportation operator

Beijing:

- Vehicles, stations, and staffing are provided by the Beijing public transportation group.
- DRT bus services are fully public transport company-owned and operated.
- Include more than 100 diversified routes such as business shuttles and special holiday lines

Shenzhen:

- Shenzhen Eastern Bus Co. Ltd launched the "Shenzhen e-Bus" service, providing new energy vehicles (i.e., electric vehicles) and route resources
- Operated a total of 860 routes, with a passenger satisfaction rate of 99.9%, in 2018.
- Users can book the bus through an app.

(b) Internet companies + public transport companies

- Public transport groups provide vehicles, bus stops and other facilities.
- Internet companies aid in data analysis, route optimization, etc.
- Customized bus services launched by Xiaoma Liancheng Technology Co. Ltd (小码联城)[108] and local public transportation groups have an average occupancy rate of over 70%.
- Tencent cooperated with Zhengzhou Bus Communication Corporation and Zhengzhou Tiamaes Technology Co. Ltd（天迈科技） to launch the Feixian Bus (飞线巴士).

107 https://www.zgjtb.com/2019-04/17/content_220861.htm
108 https://www.i-xiaoma.com/fzlc.html

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Potential opportunities:[109]

- Planning routes oriented to passenger demand, which can better meet individualized needs compared to Bus Rapid Transit systems and conventional buses.
- Small vehicle sizes, high accessibility, better flexibility and convenience, and good quality of service.
- With lower construction and operating costs, vehicles often provide better service quality and have more benefit than traditional bus services.
- Suitable for providing intensive services to passengers in low-passenger-density areas, such as suburbs and recently-developed urban areas.

Pilot programs for demand-responsive transport are new in China.

- There are hub-based demand-responsive transport at train stations such as Beijing South Railway Station and Beijing West Railway Station that combine passenger demand for transportation to different locations to generate dynamic routes, which is convenient for passengers arriving at night.
- In Nansha District of Guangzhou, demand-responsive transport provide a solution to meeting travel demand in areas with low population densities and recently-developed urban areas that cannot be fully covered by direct routes through.110
- The Qingdao Huangdao District Dynamic Bus started officially in January of 2019. Passengers only need to choose a starting location and destination on the Didi App, and the platform automatically books the nearest bus. The service area covers about 30 square kilometers.

Highlights:

- Use direct bus from any one station to any another within the service area. This reduces walking distances and eliminates the need to transfer to other bus lines.
- Shortens the time of bus travel within the service area by optimizing route planning.
- Passenger-survey results indicate, a preference for demand-responsive bus travel compared to traditional bus services for the following reasons: no transfers are required, the ride is comfortable, more seats are available, total travel time is shortened, the price is lower, , and waiting times are shorter.

Potential challenges:

- What government subsidies and other policies will be necessary to achieve full implementation after the pilot is still unclear. Demand-responsive bus projects do not currently receive government subsidies: the operator fully funds the operation and maintenance costs, including the staff cost for local bus companies.
- Demand-responsive bus operation needs to be scaled up to generate economic benefits.

Other problems:

- The smaller the service area, the lower potential passenger demand.
- The larger the service area, the greater risk that vehicles will be detoured over long distances.
- Larger redundancy capacity is required when passengers expect fast response times.
- The more passengers a single vehicle aims to serve, the more indeterminate the trip lengths are.

There are plenty of publications containing demand- and supply-side analyses of demand-responsive transport (Table 28), which focus primarily on optimizing route and stop locations, identifying niche markets, analyses of factors influencing markets, timetable design, and planning to achieve cost-efficient.

109 共享出行蓝皮书

110 http://www.7its.com/html/2021/xinwen_0202/9774.html

Table 27: Research on operation and service – demand-responsive transport

Operation and service	Topics and trend	Key findings/recommendations
Demand-side studies[111]	- User-demand and preference analysis and characteristics - Niche market studies - User-satisfaction surveys and analysis - Examining factors influencing user demand and POIs, to support fleet management, route planning, and timetables	- Optimization of route and location planning is needed. - There are many uncertainties regarding the demand side of this service. Further study is needed. - Rural areas could form niche markets for DRT. Rural areas have random transit demand but PT networks with lower densities, making DRT more suitable for providing on-demand services. - For long-term users, significant factors that influence demand include: waiting time, travel duration, detour distance, and ticket prices. - Optimization of DRT dispatch is needed.
Supply-side studies[112]	- Determination of pick-up and drop-off locations - Route optimization for DRT bus services - LoS analysis - Optimizing the cost-effectiveness of supply solutions	- Optimization of pick-up and drop-off locations of DRT bus services is needed. - Collaborative route planning is needed to optimize between DRT and traditional bus systems. - Route and timetable optimization measures are needed. - There are various models for optimizing the cost-effectiveness of supply solutions.

4.6.2 Policy, regulation, and governance

As mentioned in the General Provisions section of the Guangdong Public Transport Regulations (Draft for Public Comments), public transportation in Guangdong is divided into traditional public transportation and diversified public transportation, according to different market niche and characteristics. Traditional public transportation includes urban rail and basic public buses, which are run by the government and operated on approved routes with fixed departure times, frequencies, stations/stops, and fares. Diversified public transportation is a public service provided to meet the public's need for personalized and high-quality travel services. It is a complement to traditional public transportation and is market-driven. Demand-responsive buses are diversified transit systems. However, there are still some connections between the two. For example, there are bus companies that operate both conventional and demand-responsive buses simultaneously. This has led to some problems in governance and development of regulations.

If demand-responsive buses are to be subsidized the way conventional buses are (the general fare difference is around CNY5-10), there are no regulations that can be referred to when financial audits are conducted. Do/should demand-responsive bus companies have the authority to choose their own operating areas and pricing based on demand?

In the process of developing demand-responsive bus systems, public transportation authorities should increase their responsibilities as managers and supervisors, and laws and regulations governing demand-responsive buses need to be

111 References: (于展 2020; 冯帅 2021; 刘勇杰,李树民 2020; 张璐璐,朱欣媛,李亚男 2019; 王正武, 谭笑, 高愿 2021; 程仁辉 2021; 薛浩楠, 王佳 2021; 赵靖,葛庆红 2020; 陆百川,黄镜轶,张冬梅,李玉莲 2021; 靳文舟,胡为洋,邓嘉怡,罗晨伟 2021; 靳文舟,邓钦原,郝小妮,朱子轩 2021; 靳文舟,郭献超 2020; 韩博文 2019; 韩霜 2020; 高艺萍,高虹,彭新潮 2021) (Yu, 2020; Feng, 2021; Liu & Li, 2020; Zhang et al., 2019; Wang et al., 2021; Cheng, 2021; Xue & Wang, 2021; Zhao & Ge, 2020; Lu et al., 2021; Jin et al., 2021; Jin et al. 2021; Jin & Guo, 2020; G. Han, 2019; S. Han 2020; Gao et al. 2021)

112 References: (于展 2020; 王正武, 谭笑, 高愿 2021; 程仁辉 2021; 薛浩楠, 王佳 2021; 薛浩楠 2021; 赵靖,葛庆红 2020; 陆百川,黄镜轶,张冬梅,李玉莲 2021; 靳文舟,胡为洋,邓嘉怡,罗晨伟 2021; 靳文舟,郭献超 2020; 韩博文 2019; 韩霜 2020; 高艺萍,高虹,彭新潮 2021) (Yu, 2020; Wang et al., 2021; Cheng, 2021; Xue & Wang, 2021; Xue, 2021; Zhao & Ge, 2020; Lu et al., 2021; Jin et al. 2021; Jin & Guo, 2020; B. Han, 2019; S. Guo, 2020; Gao et al. 2021)

introduced to create a favorable market environment and to better regulate market behavior.

We found no academic publications on the topic of regulation and policy of demand-responsive transportation.

4.6.3 Social and environmental impacts

Demand-responsive bus systems can reduce urban congestion and pollution, while at the same time providing economic benefits and addressing travel inequities.

Avoid private car use

Jinan:[113]

- As of August 2021, more than 820 customized bus routes have been opened in Jinan, with an annual passenger volume of 5,518,000, encouraging nearly 4,000 people a day to stop taking their private cars and take public transportation instead.

Reduce emissions

Changsha:[114]

- There were two DRT bus lines in Changsha on trial in May 2021. During the first four months of operation, about 24.7% of passengers had switched from using private cars to DRT buses for their commute. The two pilot DRT bus lines have the potential to reduce CO2 emissions by 1,085 tons annually (compared with taking cars) when the buses are fully seated. If this DRT bus system covered the entire area of Changsha, it could potentially avoid more than 2,562 million tons of CO2 emissions.

Improved transit accessibility and coverage

Foshan:[115]

- In Foshan, regular bus stops are also used as stops for demand-responsive buses. The DRT service area contains a large number of residential neighborhoods, schools, and subway stations, and the population density is lower than that of downtown of Foshan. DRT service fills the gap in the service range of conventional buses, and direct travel can be achieved between stations in the area.

There were no academic publications found in the database on this topic of DRT's social and environmental impact quantification. However, non-academic publications, such as news articles, blogs, and comments on the Internet, social media, and in magazines on this topic are common .

4.6.4 Business sustainability

Business sustainability can be achieved by reducing ticket prices and/or creating new sources of revenue.[116]

Reduce ticket prices: Tickets are more expensive than those for conventional public transportation and less expensive than private cars and cabs.[117] In Chengdu, during a trial program, the cost of each DRT bus trip provided was 2 yuan (about 0.3 USD). The price per ticket was only a few cents due to subsidies provided to passengers by the DRT platform.[118]

Generate new value-added revenue: Online shopping advertisements on the DRT platform and the DRT buses can

113 https://3g.163.com/dy/article/GI8UB99A055061FK.html

114 https://hnxjxq.rednet.cn/content/2021/08/26/9851588.html

115 http://www.7its.com/html/2021/xinwen_0202/9774.html

116 共享出行发展报告 (Annual Report on the Development of Shared Mobility in China)

117 https://zhuanlan.zhihu.com/p/114452732

118 https://zhuanlan.zhihu.com/p/341053382.

attract passengers to purchase goods such as breakfast, dinner, fruit, emergency medicine, etc.. Passengers can collect items purchased when they get off or on the bus. This can effectively add value to the DRT business.

Nanjing:[119]

- The tourist DRT bus model is not-for-profit and it mainly functions as a day-trip service and traffic diversion.
- The business custom bus model: the employee and the company share costs. Only employees in the company enjoy preferential ticket prices. The cost of the shortfall is funded by the company.
- Introduces monthly rebate incentives, with each DRT bus reaching an occupancy rate of over 95%.

Most academic publications focus on business models, costs, transit ecosystems, and analyses of international practices for DRT buses (Table 29).

Table 28: Research on business sustainability – demand-responsive transport

Business sustainability	Topics and trend	Key findings/recommendations
Business model[120]	- System design - Niche markets - Technological frameworks	- Many studies focus on the basic concept of DRT. - Strategic frameworks in many studies include: research on suitable business models (MaaS concept), technologies, environmental concepts (safety, comfortable, green), target users, niche markets, main services, and improving existing PT systems. - DRT should be integrated with MaaS systems. - DRT can be used for airport connections: airport shuttle-bus services provide good niche markets for DRT.
Cost[121]	- Profit optimization - Cost vs. LoS studies	- DRT systems should balance profits and user satisfaction. - DRT systems can minimize costs by reducing congestion and waiting time.
Ecosystem[122]	- Niche markets and relationships with other modes	- DRT pricing should consider the ticket prices of other modes, e.g., DBS, to optimize the benefits of the entire mobility ecosystem and limit competition between green mobility modes. - Collaborative route planning (optimization) is needed between DRT and traditional bus systems.
Pricing		- N/A
Good practices[123]		- Nantong (Jiangsu province) is collaborating with Didi on piloting DRT buses. - There are both national and international studies. - Ningbo (Zhejiang province) recommends introducing DRT services during the pandemic and related events.

119 https://www.sohu.com/a/399142961_100008879

120 References: (刘世忠,卓亚娟,于媛媛,段和柱 2019; 刘勇杰,李树民 2020; 刘好德,钱贞国,刘向龙 2020; 滕靖,潘炜维 2020; 郝偲成 2020) (Liu et al., 2019; Liu & Li, 2020; Liu et al. 2020; Teng & Pan, 2020; Hao, 2020)

121 References: (王正武,谭笑,高愿 2021; 韩博文 2019) (Wang et al., 2021; Han, 2019)

122 References: (滕靖,潘炜维 2020; 王正武,谭海婷 2020; 赵靖,葛庆红 2020) (Teng & Pan, 2020; Wang & Tan, 2020; Zhao & Ge, 2020)

123 References: (周继彪,马昌喜,董升 2020; 缪颖 2020; 郝偲成 2020) (Zhou et al., 2020; Miao, 2020; Hao, 2020)

4.6.5 Resilience

During the COVID-19 pandemic, many cities have introduced customized bus and demand-responsive bus services, promoting the rapid development of diversified public transportation and further improved the resilience of urban transportation.[124]

Telecommuting and online education have reduced travel demand, which in turn has reduced demand for public transportation. If bus routes had continued to run at pre-pandemic levels of frequency, bus companies would have faced serious losses due to sparse passenger traffic. In contrast, running buses on demand and knowing the travel times and origin/destination of passengers in advance made the best use of resources, which was the main reason for promoting the implementation of DRT buses in China in 2020.

Between June and September 2020, some cities in China, such as Nantong City, launched DRT bus services based utilizing existing bus stops and vehicles. This also provided a good opportunity for DRT buses to fill market gaps.

However, in Nantong results during the initial stage of trial period were not satisfactory. Due to COVID-19, the public's willingness to take public transportation was low. Moreover, the university city through which the line passes was closed, reducing the number of target passengers .[125]

Table 29: Research on resilience – demand-responsive transport

Resilience	Topics and trends	Key findings/recommendations
COVID-19[126]	-	- Ningbo (Zhejiang province) recommended introducing DRT services during the pandemic, in order to increase flexibility and safety.
Climate	N/A	N/A

124 http://www.nbd.com.cn/articles/2021-04-14/1696819.html

125 http://www.cnr.cn/list/finance/20200927/t20200927_525278058.shtml

126 References: (周继彪,马昌喜,董 2020) (Zhou et al., 2020)

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5.0 Research activities in China

While the Background Report from ITDP (ITDP 2021) used some references written by Chinese researchers, our study provides a detailed overview of existing research activities by leading Chinese research institutions and universities. Our study also highlighted the latest thinking and research results. Based on publication counts and the academic reputation of transportation engineering related fields, we have identified the five most influential Chinese universities in this field and the research topics that they address:

- Tongji University: ride-sharing/ride-hailing modeling, MaaS, impact studies
- North China University of Technology: shared mobility in general, ride sharing, car sharing, bike sharing, auto industry
- Tsinghua University: robotaxis, bike sharing, MaaS
- Southeast University: shared mobility legislation, and
- Beijing Jiaotong University: MaaS, ride sharing/ride hailing, big data analysis, demand-side modeling.

A report prepared by Behrens et al. (2021) "Informal and Shared Mobility: A bibliometric Analysis and Researcher Network Mapping" identified five different leading Chinese research institutions in the field of "for-hire transport": University of Hong Kong, Tongji University, Southeast University, Beijing Jiaotong University, and Chang'an University. In the field of shared mobility, the top two are: Tongji University and Southeast University. There are no top research institutions identified in the field of "flexible transport" and "informal transport." By comparing the study with Behrens et al. (2021), Tongji University, Southeast University, and Beijing Jiaotong University are the three research institutes that should be highlighted, since they appeared in two leading studies showing strong research capacity and experience in the field of new mobility.

The research team conducted a series of stakeholder consultations in the form of interviews, workshops, and group dialogues with available experts. The results of these consultations are summarized in the following sections (Section 4.1).

In addition to universities, some government-affiliated research institutes, international NGOs, and private sector companies are also active in the field of shared mobility, in either research or monitoring operation. Although most of these organizations' research and monitoring results are published as grey literature (some are confidential), they influence the shared-mobility market and policymaking processes at both national and city levels. These institutions and the focus of their work include:

- Beijing Transport Institute: MaaS pilot with Gaode, bike sharing, ride sharing/ride hailing
- China Academy of Transportation Sciences: MaaS, bike sharing, ride sharing/ride hailing, shared e-bikes
- Research Institute of Highway: data and information technology of MaaS
- China Classification Society: ride sharing/ride hailing
- China Academy of Urban Planning and Design: bike sharing
- WRI: bike-sharing, MaaS
- ITDP: shared mobility, bike sharing, MaaS, ride sharing/ride hailing
- Meituan (formerly Mobike): bike sharing, MaaS, ride sharing/ride hailing, and
- Didi: MaaS, bike sharing, ride sharing/ride hailing,

Due to time limitations, we were unable to interview all of the institutions using the same interview format as that used for the five universities. However, we have recently corresponded with stakeholders, e.g., Didi, Beijing Transport Institute, China Academy of Transportation Sciences, Research Institute of Highway, Meituan (formerly Mobike), and China Classification Society, when we conducted a future mobility project in China. In this report, we only present the results from universities.

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5.1 Research highlight

The WRI team conducted interviews and stakeholder consultations with experts and researchers at universities, research institutes, and the shared mobility industry. All of the interview results were recorded anonymously. The key focus topics of current and future research are summarized in Table 31.

Table 30: Summary of research activities in China: key focus topics of current and future research

Organization	Key topics	Future focus
North China University of Technology	- Shared mobility: impacts on the auto industry. E.g., production, electrification, and design - Ride hailing/sharing: nexus of congestion, cities regulation/administration on TNCs, and the auto industry - Car sharing: business models, impacts on the auto industry. - Bike sharing: KPI assessments, fleet quotas and city administration	- Policy studies - Nexus of auto industry and shared-mobility applications
Chongqing Jiaotong University	- MaaS, Shared Mobility Laboratory, and Demand Response Transit in the Chinese context - Translating EU and US practices to China, including: concepts, legislation/regulation, city administration, data sharing, technological integration, and business models	- Frameworks and concrete roadmaps and measures for MaaS - Learning from EU cities' best practices on MaaS (e.g., legislation, data sharing standards, city administration, etc.)
Beijing Jiaotong University	- MaaS: integrating public-transport and shared-mobility services via MaaS platforms - Ride sharing/hailing: pricing, operational optimization (e.g., surge and dynamic pricing) - Big data analysis: the impact of ride sharing/hailing on congestion - Demand-side analysis: user-group preferences between ride sharing and ride hailing	- Macro-level modeling to support policy decisions (e.g., fleet-quota management) - Pricing packages/solutions for ride sharing/hailing and bike sharing - Big data mining: public transport and shared mobility integration and operational diagnosis and optimization - Post-COVID-19 peak crisis: DRT bus development and health/safety
Southeast University	- National-level legislation: supporting State Congress for establishing legislation systems for comprehensive transport (including shared mobility) - City-level legislation: working with cities to establish local legislation for various forms of shared mobility, especially, ride sharing/hailing and MaaS - Engagement: working with the private sector, associations, civil society, research institutes, the media, and the public sector to promote shared mobility ecosystems	- Legislation - People: employee rights and flexible contracts with TNCs - Vehicles: insurance, after-service insurance for private use - Standards: industry standards (e.g., on integration platforms, e-bike standards) - Governance: e.g., KPIs, credit assessments, car-sharing and renting models, etc.

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Organization	Key topics	Future focus
Tsinghua University	- Robotaxis (self-driving taxis): impacts on travel behavior, user-experience surveys (Guangzhou), user preferences, users characteristics, and market trends - MaaS: demand analysis and user-experience surveys (Beijing) - Bike sharing: development of shared moped services in Chinese cities	- MaaS: governance, business models, technologies, data-sharing, platform integration, financing models, policies, standards, etc. - Robotaxis: safety, financing models (e.g., public-private partnerships (PPP)), policy studies, pilots - Clear definition of terms: e.g., shared mobility, MaaS, shared bikes, etc.
Tongji University	Mainly focusing on MaaS: - Maas development models: integration of modes, business models, ecosystems, equity and sustainability, case studies, user-experience surveys (Shanghai) - Demand analysis and service design: modal shifts, service analysis, plan/package studies, affordable pricing, travel-demand preferences, value-added services, user-experience surveys, and demand characteristics - Supply and optimal operation: market positions, network planning for multi-modes, DRT bus routing, bike and ride-sharing nexus, service efficiency, emissions, LoS, and relationships with PT Other areas: - Ride sharing/ride hailing (mainly included in MaaS studies) - DRT buses - Policy recommendations to Ministry of Transport (MOT). - Auto-driving and EVs - International literature reviews and case studies	- MaaS development models, package/plan design (pricing) - Demand and potential of MaaS in Shanghai, Xiamen, and Shenzhen - MaaS Whitepaper - Theoretical study of MaaS: definition, theory and mechanism, sustainability, market level, supplier (monopoly? competition?), policies, etc. - Standardization: vehicle design, drivers, and quality of service - Market segments and solutions: equity, differentiated pricing (night, peak hours, extreme weather), etc. - Factors impacting service: economy, technology, psychology, reliability, allocating connection nodes, infrastructure retrofitting in newly-developed high-density Chinese cities - Externalities: parking, congestion, safety, emissions, equity, etc. - Safety and information security - Value-added services: e.g., with other suppliers in supply chains (coffee, entertainment)
China Academy of Transportation Sciences	- MaaS case studies and technologies - Implementation of bike sharing and shared e-bikes in China	- The national government and many local governments are highly interested in introducing MaaS and some are including MaaS in their mobility strategies. However, both national and local governments and stakeholders lack basic knowledge of MaaS. - The investment, role of government, business models, financing models, and collaboration models of MaaS are still unclear.

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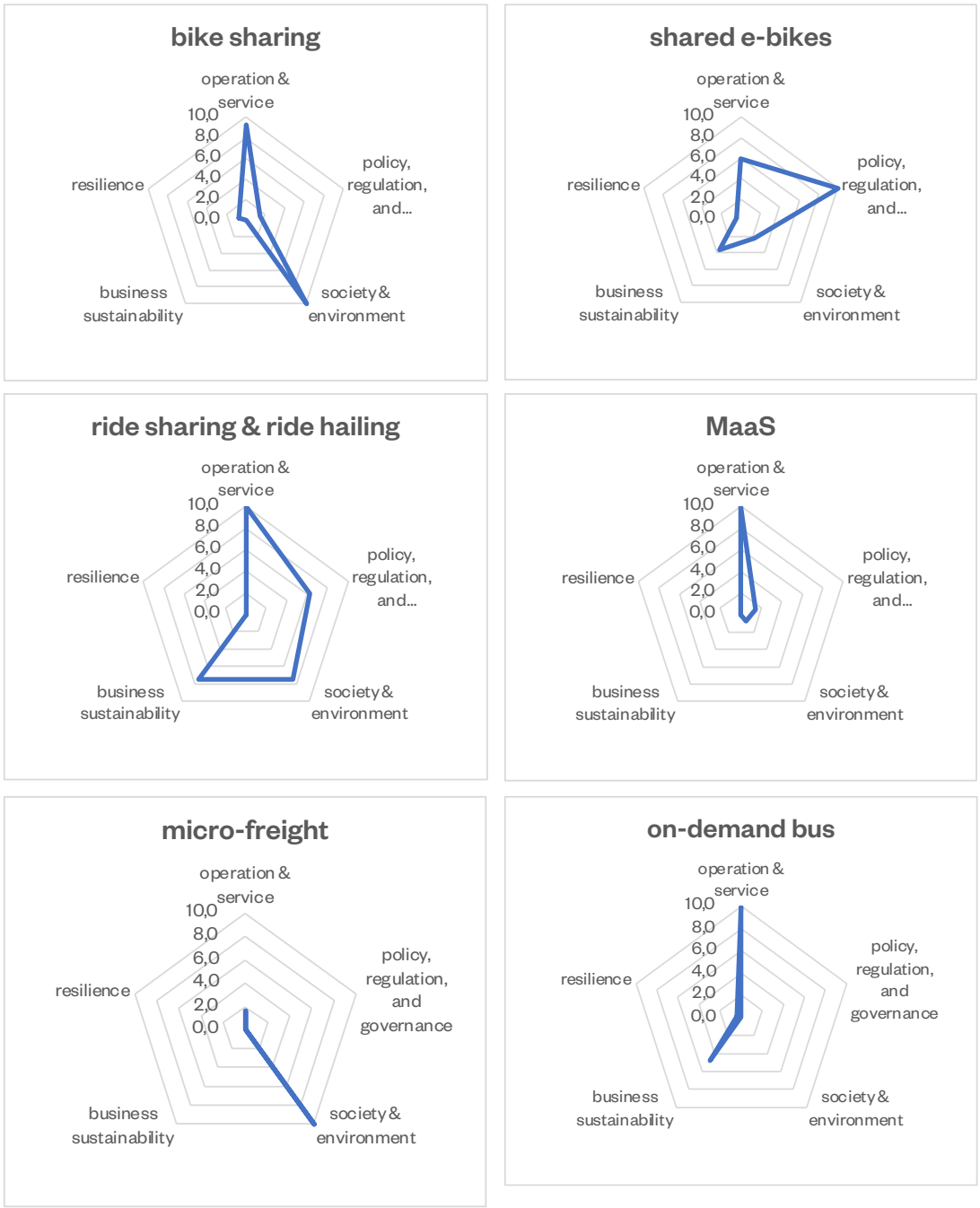
5.2 Research gaps

From the interviews and stakeholder consultations, as well as a broad examination of existing Chinese literature on the shared/new mobility sector, we have identified some gaps in existing research activities in China:

Figure 11: Research focuses and gaps in current research in China



Note: Research focuses (and interests) from publications in cnki.net, ranking from 0 to 10, where 0 = least academic focus, 10 = most academic focus.

5.2.1 Lack of research and knowledge on courier network services (2-/3-wheelers for last-mile delivery)

Courier network services to be off the radar of Chinese researchers, especially in academic communities. There are very few research publications on 2/3-wheelers for last-mile urban delivery in the academic databases in China. Publications for non-academic purposes, such as news articles, blogs, and short comments published on the Internet, in social media, and in magazines on this topic are common. Most research publications, as well as policies and regulations, focus on the topics of road safety (e.g., speed restrictions, driving and parking behavior), battery safety (e.g., battery technologies, charging behavior), and labor welfare (e.g., safety, insurance, salaries). There is almost no literature or knowledge in other areas of courier network services. There are various potential reasons for this. The 2/3-wheeler market in China is scattered and unregulated (sometimes illegal). Researchers, especially those based at universities, do not have the interest in the unregulated markets. And unlike ride sharing and ride hailing, which attract investments from auto-makers and high-tech companies, courier network services markets are made up of informal businesses and use low-end 2/3-wheelers.

Based on our observations, this situation (i.e., limited research, and focusing on battery and road safety) appears to be similar in other countries, especially countries in Asia where the 2/3-wheelers are an informal (sometimes still illegal) mode of transportation for urban freight and food deliveries. Based on ITDP's background report "Future of Paratransit and Shared Mobility: Mapping Report" (ITDP 2021), some findings in lower- and middle-income countries (LICs and MICs) show that micro freight (shared mobility) served a critical role during the COVID-19 pandemic, providing access to essential food, medicine and materials. However, our findings also highlight the need for additional research on urban freight drivers and operators and how COVID-19 has affected the sector.

5.2.2 MaaS research is still in an early stage

MaaS research in China is still at an early stage due to lack of local practices. Most Chinese literature focuses on 1) the definition and identification of the basic elements of MaaS systems, and 2) translation of the international practices. Potential business models (feasibility and selection) and pilot programs are under frequent discussions within core players, i.e., TNCs, traditional mobility operators, ITS and ICT companies, and local government, instead of within academic communities.

The gap in the literature indicates that research in China needs to move beyond international MaaS practices reviews, to address topics such as: local operation and services (including demand- and supply-side analyses, level of service); discussions and preparation of local and national level policies, regulations, laws, and governance; studies in the impacts of MaaS (or MaaS-like integrated mobility services/systems) on society and the environment; discussions on business, collaboration, and financing models, and business sustainability. These will be consistent to China's national and some city-level strategies on smart mobility and MaaS development.

In addition, our findings also indicate that for MaaS (and for all forms of shared/new mobility in modern societies), not only research (and/or technologies) is essential. Multi-stakeholder collaboration, especially collaboration and coordination between the public and private sectors on modern mobility services, is also key to successful implementation of MaaS and improving user satisfaction. Stakeholder engagement is also necessary to transfer concepts into practice.

5.2.3 Big gap between concepts and practices

There is a big gap between concepts and practice in the field of shared mobility. Researchers in China have limited real cases to support the development of shared mobility solutions. A large number of publications are just published for obtaining academic credits. They are in very low quality. It took us a long time to screen out such publications from our study. The "signal-to-noise ratio" of the publications mentioned in Section 4 is not high. This may also imply that for the shared-mobility sector, especially the most recently emerged services (such as MaaS), collaboration with other stakeholders in the transportation ecosystem, especially the large industry players, is very important.

More practical findings from the shared-mobility market, business, technologies, financial status, even policy background and social and environmental benefits assessment, can be found in the gray literature and industry reports published by industry actors (e.g., TNCs) and consulting firms. However, these publications have not been peer reviewed and lack quality control, and, from our observations, sometimes appear to be biased toward certain group interests and/or contain mistakes.

5.2.4 Research weaknesses

Compared with similar research soured globally, and referencing (ITDP 2021) and Behrens et al. (2021), we found that there are certain gaps in the research topics and activities addressed in most Chinese academic communities. The gaps are mainly in the field of human-related (or human well-being related) topics across the entire shared-mobility subsector. The gaps are summarized as follows:

- **Equity** topics are seldom touched, especially with respect to vulnerable groups (e.g., the disabled, children, the elderly, women, lower-income workers, etc.). It seems that Chinese academic communities do not think that equity is an essential concern in the shared-mobility sector, or in the mobility sector in general. Almost no Chinese publications were found on the issues of safety, affordability, accessibility, health, and employment specifically for vulnerable groups, which have been discussed extensively in literature published in the global north. The literature gaps in China echo ITDP's Background Report (ITDP 2021), which indicates that there is a lack of equity research in Asia, South Asia, Latin America, the Middle East, and Africa.
- **Climate resilience** topics are seldom covered. The shared mobility background reports from (ITDP 2021) and Behrens et al. (2021) do not cover the topic of the climate resilience of future shared mobility. From our research, there is also no literature and research activity on climate resilience/adaption vs. shared mobility in China. The report from the European Platform on Sustainable Urban Mobility Plans (POLIS and Rupprecht Consult - Forschung & Beratung GmbH 2021) provides a detailed discussion of how to plan for more resilient urban mobility (including shared mobility). The lack of literature on climate resilience (and pandemic resilience) of all kinds of shared-mobility services (i.e., bike sharing, shared e-bikes, ride sharing/ride hailing, MaaS, courier network services, and demand-responsive transport) is a key research gap in China.
- **Health impact assessments** are weak for shared mobility studies, especially assessments of the health benefits of bike sharing and other active mobility modes within shared mobility services. The World Health Organization's Health Economic Assessment Tool (HEAT) for cycling and walking (Kahlmeier et al. 2017) can be a good guide for Chinese cities. The health benefits resulting from physical activities including DBS cycling and walking as replacements for trips by private car outweigh the health risks from road accidents and exposure to air pollutants during transport. These results can be used to support local decision-making on financing green transportation modes (biking and walking) within shared-mobility services. However, there is still very limited research on this topic in China due to data limitations, weak research capacity, and lack of awareness.
- Lack of **road safety** studies due to lack of decent (real) data, such as accident/fatality and injury data. This finding is consistent with results found in an ITDP report indicating that the safety literature mainly focuses on user perceptions, with little quantitative assessment of traffic collisions, injuries, or death (ITDP 2021). The literature surrounding safety for ride hailing and shared mobility was concentrated in higher-income countries (HICs). However, the lack of access to basic data is an important barrier to performing research on shared-mobility safety issues in China.
- There is a lack of analysis on the implications and impacts of **policies and regulations** on both the shared-mobility ecosystem (especially the shared-mobility industry and users) and external groups (the general public, other road users). This is reflected in ITDP findings (ITDP 2021), which indicate that there is a shortage of dedicated research on the policy implications and impacts of shared mobility. More specifically, in China, there is lack of research on quantitative impact analyses of policies and regulations, user satisfaction surveys and investigation, data and quantitative analysis-based decision-making, the role of paratransit operators and driver integration with public transport systems (including fare structures), lack of long-term research commitments and sustained funding sources (especially in the field of bike sharing and courier network services using 2/3-wheelers), and lack of interest in the research (especially in the fields of bike sharing and 2/3-wheelers).
- Studies of the **employment** and **welfare** of employees/drivers are limited. As in the case of road safety issues, employment and employees/drivers welfare appear to be sensitive topics in China. Some findings are consistent with (ITDP 2021), which concludes that the research is mainly qualitative with a focus on drivers' quality of life, especially for ride sharing/ride hailing. More information is needed on employment conditions in other forms of shared-mobility services. In China, this research gap is mainly for courier network services 2/3-wheelers, specific topics include employment/unemployment, working conditions, cut-throat competition, low wages/costs and insurance/welfare, safety and security, labor shortages, and lasting impacts on the labor market.

Economic impact analyses of the shared mobility industry as seen from the employee's perspective are also needed, as stated in (ITDP 2021).

- Research on **social and economic improvements**, e.g., access to more employment, educational, and economic opportunities, is insufficient. For some types of shared-mobility services, such as bike sharing, shared e-bikes, MaaS, and demand-responsive transport, the potential benefits (i.e., increased access to opportunities) could be significant, and should be studied.

5.2.5 Weak private sector engagement

Promoting the development of shared mobility, as well as relevant research, requires engaging the private sector, including TNCs, automakers, traditional mobility operators (e.g., taxis), ICT and ITS companies, etc., because shared mobility by nature requires public-private partnerships. Many Chinese publications lack content obtained through communication and close engagement with the private sector, making them too theoretical and unable to facilitate the improvement of real-world mobility services. Lack of data may be one reason for this. Most universities and even government-affiliated research institutes in China cannot access data from TNCs and/or other companies (or even PT companies, even though they are operated by government). Some TNCs and other companies have invited (and/or joined with) universities and research institutes to do some specific research (e.g., on ride sharing/ride hailing, MaaS). However, these collaborations are sometimes case-based or intended strictly for commercial use or brand communication. There is not enough data sharing or sufficient transparency mechanisms among public and private shared mobility stakeholders and researchers.

5.2.6 Limited research on legislation

Based on expert consultations, we found that research on national and local-level legislation and regulation for shared-mobility services is very limited in universities and research institutes in China. Legislation, especially local legislation, is of primary importance for implementing new mobility services, especially for emerging business/financing models for MaaS systems. In addition, there is a lack of research on legislation related to labor welfare in shared-mobility markets, especially for courier network services. Without legal expertise and enough research on this topic, cities cannot introduce innovative and high-quality mobility services.

5.2.7 Lack of research on climate resilience

Publications on the climate resilience of all types of shared-mobility systems are lacking in Chinese universities and government-affiliated research institutes. This topic has not been reviewed by either (ITDP 2021) or Behrens et al. (2021). However, the European Platform on Sustainable Urban Mobility Plans, (POLIS and Rupprecht Consult - Forschung & Beratung GmbH 2021) has developed a Topic Guide: Planning for More Resilient and Robust Urban Mobility, which highlights climate-resilience issues and solutions for some shared-mobility services (e.g., MaaS, bike sharing, urban freight, etc.). We believe that it is necessary to look more closely at this topic in the near future. However, we did not find any interest from either the Chinese government (e.g., local and national), the private sector (e.g., TNCs), or philanthropic institutions (local and international) in investing in research in this field.

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5.3 Future focus

We have summarized potential future topics and opportunities in the field of shared mobility below. These should not only include the current ongoing research of Chinese organizations, but also the works need to be conducted in order to fill the knowledge gaps as mentioned above.

- Policy impact assessments for all kinds of shared-mobility services.
- Dynamic pricing for ride sharing/ride hailing and MaaS.
- Post-COVID-19 crisis-period studies: impacts and solutions.
- National- and local-level legislation design.
- Driver and delivery-worker welfare in the ride sharing/ride hailing and courier network services industries.
- Impact assessments (quantitative lifecycle assessments) for all modes of shared mobility, addressing health, emissions, safety, security, economy, congestion, the built environment, etc.
- Climate- and pandemic-resilience studies.
- Frameworks and concrete roadmaps and measures for MaaS.
- Courier network services studies.
- Equity studies.

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APPENDIX 1: POLICY AND REGULATION DATABASE

Bike sharing

Fleet size control	Market entry	Dedicated regulations/guides on market entry	
		Bidding mechanism introduced on permit granting/renewal	
	Fleet size management	Requirements on fleet size limit	
		Requirements of detailed data-sharing format	
		KPI system used to determine operator's permit renewal/fleet size	
		Penalties specified for operators due to breaches of fleet size requirement	
	Subtotal		
Parking management	Parking area regulation	Technical guides of bike parking area setting and design	
		Clarified dedicated and prohibited parking areas for dockless bikes	
		Requirements on parked bikes (e.g., number of bikes in a parking lot, upright parking)	
		Requirements on smart bike–parking facilities (e.g., dual-height racks, underground parking vaults, etc.)	
	Subtotal		
	Enforcement	Enforcement regulations for shared bike breaches	
		On operator	Penalties specified for operators due to poor distribution
			Parking management considered a major KPI of the operator's performance
			Staffing required on parking management
		On user	Operators allowed to charge additional distribution fees on users if they didn't park the bikes in preferred locations
			Geofence parking required to enable proper parking
			Personal credit system used to adjust riding fare based on user's parking behavior
	Subtotal		
Facilities	Plans for bike lanes network expansion		
	Dedicated bike facility (e.g., bike highway, underground parking vaults)		
	Cycling facilities improvement specified in street designs		
	Subtotal		
	Total		

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Ride sharing / Ride hailing

REGULATION ID[127]	CHINESE	RELEASE DATE	RELATED	ACTION
Interim measures for the management of online ride-hailing car-operation services	网络预约出租汽车经营服务管理暂行办法	Jul. 27, 2016	Ministry of Transportation	Describes the conditions for licensing online ride-hailing vehicles to conduct business, issuing transportation licenses, and issuing driver's licenses
Guidance on deepening reforms to promote the healthy development of the taxi industry	关于深化改革推进出租汽车行业健康发展的指导意见	Jul. 28, 2016	The State Council	(1) Staggered development and differentiated operation of cruising cars and online ride-hailing cars. New cabs are given priority for the use of new energy vehicles (EVs). (2) The operation of the new cabs is for a limited period and can be used without compensation. (3) Encourage carpooling.
Guidance from the General Office of the State Council on deepening reforms to promote the healthy development of the taxi industry	国务院办公厅关于深化改革推进出租车行业健康发展的指导意见	Jul. 28, 2016	The State Council	(1) Determine the positioning of the rental car industry. (2) Coordinate the development of cruising cars and online ride-hailing vehicles, implement staggered development and differentiated operation, and provide quality and diversified transportation services for the public.
Notice on the process of access and withdrawal of online ride-hailing vehicles	关于网络预约出租汽车车辆准入和退出有关工作流程的通知	Nov. 7, 2016	Ministry of Transportation	(1) Manage online ride-hailing services in accordance with the management of operating passenger vehicles. (2) Regulate the frequency of safety and technical inspections of vehicles and environmental protection inspections.
Management measures for the operation and regulatory information interaction platforms for online ride-hailing vehicles	网络预约出租汽车监管信息交互平台运行管理办法	Feb. 13, 2018	Ministry of Transportation	Requires data on operations that is received via interactive platforms for online ride-hailing services to be stored for not less than 6 months..
Notice on strengthening the joint supervision of online ride-hailing industry in and after an accident	关于加强网络预约出租汽车行业事中事后联合监管有关工作的通知	May. 30, 2018	Ministry of Transport, Central Internet Information Office, Ministry of Industry and Information Technology, etc.	(1) Clarifies the responsibilities regarding to the joint supervision of the net car industry after accidents. (2) The online ride-hailing platform company that still refuses to change after the warning, may take corresponding measures to suspend the release, shelve the app, stop the Internet service, stop networking or shut down for rectification and other disposal measures within 6 months.
Urgent notice on further strengthening the safety management of online ride-hailing vehicles and carpooling	关于进一步加强网络预约出租汽车和私人小客车合乘安全管理的紧急通知	Sep. 10, 2018	Ministry of Public Security， Ministry of Transportation	(1) Strengthens the background verification of drivers. (2) Conducts a comprehensive verification of existing drivers to achieve safety compliance of platforms, vehicles and drivers.

127 https://www.qianzhan.com/analyst/detail/220/210429-7ffc9c6a.html

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Notice on further deepening the reform to speed up the healthy development of the rental car industry	关于进一步深化改革加快推进出租汽车行业健康发展有关工作的通知	Dec. 12, 2018	Ministry of Transportation	Taxi operators should actively promote the application of mobile Internet technology to achieve changes in service modes and integration with the development of online ride-hailing vehicles, improve operational efficiency, enhance service levels and regulate the healthy development of the online ride-hailing vehicle industry.
Green Travel Action Plan (2019-2022)	绿色出行行动计划（2019-2022年）	May. 31, 2019	Ministry of Transport, National Development and Reform Commission, etc.	(1) Accelerates the compliance process of platforms, vehicles and drivers. (2) Encourages the networked and large-scale development of the car-rental industry and promotes innovation and standardized development of car-sharing.
Opinions on deepening the price reform of road transport	关于深化道路运输价格改革的意见	Oct. 30, 2019	Ministry of Transport, National Development and Reform Commission	Standardizes the price management of new formats and models of road transportation.
Guidance on strengthening and standardizing the supervision in and after an accident	关于加强和规范事中事后监管的指导意见	Aug. 25,2020	Ministry of Transport	(1) Comprehensively consolidates regulatory responsibilities; (2) Establishes and improves the regulatory system and standards; (3) Innovates and improves the regulatory approach; (4) Enhances regulatory capacity and levels; (5) Promotes industry self-regulation and social supervision;
Notice of public consultation on "Road Transport Regulations" (revised draft for comments)	关于《道路运输条例（修订草案征求意见稿）》公开征求意见的通知	Nov. 2, 2020	Ministry of Transport	(1) Clarifies the responsibilities related to the operation of rental cars, including cruising and online ride-hailing car operation. (2) Clarifies online ride-hailing car operators, vehicles, practitioners regarding to the market entry conditions, norms of conduct, etc.

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Mobility-as-a-Service (MaaS)

REGULATION ID	CHINESE	RELEASE DATE	RELATED DEPARTMENTS	ACTION
The State Council on actively promoting "Internet +" action guidance	国务院关于积极推进“互联网+”行动的指导意见	Jul. 1, 2015	The State Council	(1) Promotes the Internet-based platform for a variety of travel-mode information services; (2) Promotes cross-regional and cross-mode transportation information interoperability.
Transportation information technology "Thirteenth Five-Year Plan" development plan	交通运输信息化“十三五”发展规划	Apr. 25, 2016	Ministry of Transport	(1) Guides the development of third-party integrated passenger transport network ticketing platforms, encourages the development of intermodal transport ticketing, integrated services, the construction of national road passenger transport information networking services project. (2) Takes the lead in Beijing, Tianjin and Hebei and other key regions in starting the interconnection of transportation cards, and promotes the application of transportation cards in transportation modes such as taxis, long-distance passenger transportation and parking services. (3) Strengthens the efficient docking of regional highways around the city with urban roads, systematically optimizing road networks in and out of the cities, promotes planning and construction coordination and management synergies.
"Thirteenth Five-Year Plan" modern comprehensive transportation system development plan	“十三五”现代综合交通运输体系发展规划	Feb. 28, 2017	The State Council	(1) Promotes the interoperability of transportation cards across regions (municipalities) and modes of transportation. (2) Promotes the transformation of information technology for operation management systems and promotes intelligent cooperative scheduling： studies the conditions for open access to the railroad ticketing system and other modes of transport to form a single ticketing system for the entire country and accelerates the application of mobile payment in the field of transportation.
Guidance on accelerating the development of intermodal transportation of passengers	关于加快推进旅客联程运输发展的指导意见	Dec. 31, 2017	(1) National Tourism Administration. (2) National Railway Bureau. (3) Civil Aviation Administration of China. (4) National Post Bureau. (5) China Railway Corporation.	(1) Improves the service facilities for intermodal passenger transportation; (2) Optimizes the market environment of intermodal transportation of passengers; (3) Improves the quality of intermodal passenger transportation services; (4) Improves the level of information available for intermodal passenger transportation; (5) Improves the system of regulations and standards for intermodal passenger transportation.

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Digital transportation development plan outline	数字交通发展规划纲要	Jul. 25, 2019	Ministry of Transport	(1) Promotes the full open sharing and integrated development of various kinds of information such as transportation and tourism: platform enterprises are encouraged to deepen the integration of multi-source data, integrate online and offline resources, provide fully open access to various transportation ticket systems, build digital travel assistants, and provide "door-to-door" customized travel services for passengers. (2) Advocates for the concept of "travel as a service (MaaS)," connects travel demand and service resources with data, makes travel an on-demand instant service, and makes travel simpler: creates an "intelligent mobile space" where passenger travel is integrated with business, shopping, consumption, leisure and entertainment, and provides a new travel experience. Promotes the development of "Internet +" convenient transportation, and encourages and standardizes the development of new forms of urban transportation services, such as customized public transport, intelligent parking, intelligent public transport, vehicle maintenance, online taxi reservations, Internet bike rentals, and time-sharing rentals of small and micro buses.
Outline of the construction of a country with a strong transportation network	交通强国建设纲要	Sep. 19, 2019	The Communist Party of China Central Committee； the State Council	Vigorously develops shared transportation, creates a service system based on mobile intelligent terminal technology, and promote travel as a service.
Action Plan for Promoting Integrated Transport Big Data Development (2020-2025)	推进综合交通运输大数据发展行动纲要（2020—2025年）	Dec. 9, 2019	Ministry of Transport	(1) Promotes innovative travel-service applications： encourages all kinds of market players to cultivate the "travel as a service (MaaS)" model, with data to connect travel demand and service resources. (2) Promotes the innovative application of big data for transportation and tourism services： uses big data analysis to evaluate the development characteristics of new and old business models in the field of road-based passenger transportation, public transportation, rental cars, car time-sharing, etc., to promote the transformation of new and old business models and integration.
National comprehensive three-dimensional transportation network planning outline	国家综合立体交通网规划纲要	Feb. 24, 2021	the Communist Party of China Central Committee； the State Council	(1) Promotes the effective connection of urban and external transportation services： promotes the integration and construction of trunk railroads, intercity railroads and urban (suburban) railroads, and does a good job in coordinating with urban railways to build a unified network for operation management and services, and achieves interconnection of facilities, interoperability of ticket systems, mutual recognition of security checks, information sharing and payment compatibility. (2) Strengthens the efficient docking of regional highways around the city with urban roads, systematically optimizes the road network in and out of cities, promotes planning and construction coordination and management synergies.

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Courier network services

	Status/Issues	Key Policies & Regulations	Key Actions	Stakeholders
Operation/ Service	- Unregulated operation and management - High logistics cost vs. low cost competition - Unregulated terminal and warehouse management - Lack of parking management	- The State Council's guidance on promoting the development of Urban delivery industry (2018)	Cultivates big enterprises Promotes "Internet+" Improves service network through DCs and logistics parks Promotes integrated transport network Improves logistics security through standards	Carriers; DC operators; Governments.
Road Safety	- Lack of speed management - High road accident in mixed traffic - Low quality and lack of standards of vehicles - Bad driving manners, in particular traffic rules violations	- Electro-tricycle technical requirements for express special (2014)	Technical requirements for 3W for express use (incl. speed, weight, size, engine, battery, tires, label, etc.)	3W makers; Carriers; Delivery persons; Government.
Environment	- Polluted package material - Batteries recycling issue	Guide on Promoting Green Packages in the Delivery Industry The State Council's guidance on promoting the co-development of e-commerce and urban delivery (2018)	Improves package-related law, regulations, and standards Reduces and resources footprint of the packages Implement green package certification Conducts green package pilots Establishes green package alliance Establishes pilot cities for package recycle Promotion and education Enhances the logistics efficiency and build energy-saving protocol Promotes green freight and urban delivery, reduce empty miles, and use new energy vehicles.	Carriers; Shippers; Package producers; Governments.
Business Ecosystem	- Cut-throat competition (oversupply & low cost) - Low salary and welfare of delivery persons - Lack of training and low LOS - Lack of labor during COVID.	President Xi's Concern on the well-being of delivery persons (2020)	- Increases the accessibility of the 2/3Ws for delivery - Secures the safety and social welfare of delivery persons - Training and education - Improves company's due diligence on staffs	Carriers, Delivery persons; Government; the Public.

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Economy	- Post-COVID reshapes e-commerce and urban economy - Opportunities & high demand to 2/3W freight - Lack of labor	The State Council's guidance on promoting the co-development of e-commerce and urban delivery (2018)	- Promotes open data mechanism between e-commerce companies and delivery companies - Open market and deregulation to promote fairplay - Improves land-use and infrastructure - Improves the accessibility of delivery vehicles through urban traffic management and infrastructure - Vehicle standardization and road safety - Promotes smart lockers/boxes for the last-mile parcel delivery - Promotes the application of big data, AI, and other smart technologies.	Shippers (esp., e-commerce companies); Carriers, Governments; and other stakeholders in the entire logistics chain.
Smart Technology	- Requires standards for new technologies - No clear regulations and standards on autonomous vehicles, robot, and drones for urban delivery - Operational chaos of smart lockers during and after COVID-19.	Service regulation for smart delivery lockers (2019) The State Council's guidance on promoting the co-development of e-commerce and urban delivery (2018)	Standardizes and regulates the operational and security issue of the smart lockers Promotes the application of big data, AI, and other smart technologies Promotes data sharing and open data Standardization of new technologies and information/data accessibility.	IT/internet/network companies; Carriers; Shippers; Warehouse companies; Governments; and other stakeholders in new tech industry.

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Demand-responsive transport

REGULATION ID	CHINESE	RELEASE DATE	RELATED DEPARTMENTS	ACTION
Outline of the "Thirteenth Five-Year Plan" for the development of urban public transportation	城市公共交通"十三五"发展纲要	Jul. 18, 2016	Ministry of Transportation	(1) Improves the diversified bus service network, (2) Enriches the form of urban bus services, (3) Actively develops customized buses, community buses and other forms of special services to better meet the diverse travel demand.
Outline of the digital transportation development plan	数字交通发展规划纲要	Jul. 25, 2019	Ministry of Transportation	Encourages and regulates the development of customized bus, intelligent public transport and other new forms of urban travel services.
Opinions on a number of issues to promote the modernization of transport governance system and governance capacity	关于推进交通运输治理体系和治理能力现代化若干问题的意见	Oct. 17, 2020	Ministry of Transportation	(1) Improves the system for the development of new modes of transportation. (2) Establishes a demand-responsive travel service system such as customized bus.
Services specifications for urban demand responsive transit	《城市定制公交服务规范》（JT/T 1355-20）	Dec. 30, 2020	Ministry of Transportation	General requirements, operating routes, operating vehicles, service information systems, service requirements and service monitoring and evaluation.

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APPENDIX 2: INTERVIEW QUESTIONS ON SHARED/NEW MOBILITY RESEARCH IN CHINA

Questions:

Research topics of your organization regarding to new/shared mobility? Please provide details.

(What fields have you and your team/university/department being focusing on regarding new/shared mobility? E.g., bike sharing, shared e-bikes, ride sharing/ride hailing, MaaS, courier network services, demand-responsive transport, etc.? Please also specify some detailed projects and themes you have being performing research on in the past 3 years in the field of shared mobility.)

(In addition, please also summarize the key findings, takeaways, and lessons from these studies or projects.)

Key conclusions and gaps regarding recent research and local practices

(Please indicate the key conclusions of your findings from the research. In addition, please indicate the gaps and issues between research and local practices. For example, did your research help fill gaps in local applications/cases? Or, has the research helped/supported shared-mobility practices and implementation on the ground?)

Studies in the future?

(What is your or your department's plan for future studies in the field of shared mobility?)

(Please also let us know what you perceive to be the most important topics or trends in this field, and what should be urgently addressed in the future, both with respect to academic research and practice.)

Partners

(Who have you partnered with in the past 3 years in the field of shared-mobility research, (either organizations or individuals)?

Partners can include academic research partners, government representatives and decision-makers, and/or private-sector actors such as TNCs and automakers. What projects/research have you performed together, and what were your and your partners' respective roles?)

Post COVID-19?

(Have you performed post COVID-19 research in the field of shared mobility?)

(What do you think about the relationship between traditional public transport systems and booming new/shared mobility solutions, especially during and after COVID-19?)

Universities and/or institutions that are leading the topics of the new/shared mobility?

(What universities or institutions are leading research into which topics of shared mobility? What are they influencing, e.g., markets, decision-making, policy-making, legislation, research, technologies, urban management, PPP, business models, etc.)

- May we contact you if we have further questions?
- Can you share some recent reports/books and papers on these topics?

Thank you for your time!

--- End of interview ---


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