Car Sharing from a Chinese Perspective

Yichao Chen

A thesis submitted to Auckland University of Technology in partial fulfilment of the requirements for the degree of Master of Creative Technologies (MCT)

2022

Auckland University of Technology

School of Future Environments

Primary Supervisor: Dr Sangeeta Karmokar

Secondary Supervisor: Assoc. Prof. Andy Connor

Abstract

As a consequence of China's strong economic growth and urbanization, residents' travel needs have become increasingly diverse, and the number of private cars and motorists has increased. This has led to more severe issues with traffic congestion and environmental damage. Car sharing is a new mode of transportation that can effectively reduce traffic congestion and air pollution, as well as contribute to reducing private car ownership, increasing vehicle usage, resolving supply and demand conflicts, and reducing travel costs for residents. Car sharing has become more prevalent in overseas countries, and its benefits have been demonstrated to some extent. Over the course of the last few years, there has been a gradual shift toward car sharing in the Asian market.

More greenhouse gas (GHG) emissions and poor air quality have resulted from China's fast urbanisation and inhabitants' high degree of reliance, among other negative consequences. Car sharing can greatly facilitate urban development by promoting sustainable transport patterns and serving as a viable alternative to car ownership. However, car sharing in China is still in its early stages of development, despite its widespread adoption worldwide. Consequently, there is limited academic literature that interprets and addresses its related topics. By using a single mixed research strategy, this dissertation intends to offer a contribution to the investigation of the current development status of car sharing in China. The research strategy involves interviewing Chinese car sharing stakeholders. According to the findings of the research conducted for this dissertation, the sustainable transportation mode of car sharing can contribute significantly to China's sustainable transportation development. The car sharing mechanism can reduce car use and car ownership, thereby reducing transportation congestion, the need for parking space, and daily greenhouse gas emissions. In addition, the dissertation demonstrated that the characteristics of the target group of car sharing mechanism users in China are comparable to those of overseas car sharing users. The user groups consist primarily of younger generations, apartment residents, and occasional car users who do not need to possess vehicles. This dissertation also emphasizes the close relationship between modern technology and car sharing. According to the conclusions of the research, vehicle-sharing operators encounter a variety of obstacles, such as the availability of public parking and financial support. There have been advancements in reducing obstacles to vehicle sharing, however, more assistance for car sharing would allow China to maximise its potential.

Table of Contents

Table of Figures

Attestation of Authorship

I hereby declare that this submission is my original work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

20 September 2022

Yichao Chen

Acknowledgement

Time always seemed to pass by fast. The years have flown by in what seems like the blink of an eye, and I really wish that time could move more slowly.

Despite the reality that the Coronavirus pandemic has presented unprecedented obstacles to my research. First and foremost, I would like to express my gratitude to my supervisors, Sangeeta and Andy, for their help in completing my research. My supervisors supported me with patient guidance as I completed this thesis. Not only were my supervisors Sangeeta and Andy academically rigorous, scientifically savvy, and knowledgeable, but they also helped me with a complete commitment. When I was confused, my supervisors were patient and offered me many valuable suggestions and support, as well as assisted me to organize the logic of my research and expand my research ideas. In addition to being rigorous scholars, my supervisors have also served as a guiding light in my life. I would also like to thank the Secretariat of the Auckland University of Technology Ethics Committee (AUTEC) for approving the Ethics application. On this arduous path to higher education, I was not alone because of the companionship of my family and friends. Therefore, I am so grateful to everyone who has supported and encouraged me throughout this journey. All of my accomplishments are the culmination of your compassion and love.

As students at Auckland University of Technology, we are expected to serve as leaders and advocates for the communities for which we care. We are taught at Auckland University of Technology to be compassionate and open toward ourselves and others. Here, we are brimming with confidence and humility. We are inspired to be courageous and exceed expectations. I can realize my dream here: to stay curious and ambitious. Let's dream big and seize the day. Let's step forward and face new challenges with courage.

Finally, it is an honour to be able to stand on the shoulders of the authors of the references used in the writing of this thesis, allowing me to see further and to think and research more effectively.

Although my master's thesis is complete, it does not signify the conclusion of my research. I will continue to study and conduct research to enhance, perfect, and broaden myself. This is only the beginning, not the end. For my next journey, may I remain brave, fearless, and humble.

Ethics Approval

Ethics application approval was granted by the Auckland University of Technology Ethics Committee vide 22/37 – Sustainable Development of Car Sharing in China dated 07 March 2022.

List of Abbreviations

CO_2 : Carbon Dioxide

GHG: Greenhouse Gas

VKT: Vehicle Kilometers Traveled

P2P: Peer to Peer

MNC: Multinational Corporation

EV: Electric Vehicle

MNL: Multinomial Logit

NL: Nested Logit

MPV: Multi Purpose Vehicle

TMD: Transport Design Manual

NEV: New Energy Vehicle

List of Appendices

[1] The approval letter can be found in Appendix A.

[2] A copy of the online survey can be found in Appendix B.

[3] The participant consent information can be found in Appendix C at the start of the online survey.

[4] The Online advertisement can be found in Appendix D.

[5] The response rate (or nonresponse) is calculated by dividing the number of individuals who receive the email invitation to complete the survey but fail to participate by the total number of potential participants invited to complete the survey. This cannot be determined for this study as the total number of potential participants is unknown (Sue & Ritter, 2012).

Chapter 1. Introduction

Over the last 20 years, car sharing has gained popularity as a new form of transportation. Its quick expansion in China has drawn a variety of users and created several issues. User happiness and service effectiveness are the major priorities. This research aims at collecting the user characteristics according to various user kinds and examining their satisfaction with station-based one-way vehicle sharing service in order to investigate potential service improvement and management intervention. Also, the possibility for alternate mobility options, such carsharing (short-term vehicle usage), utilised in growing megacities like Shanghai, is called into doubt by China's increasing motorization. The need for automobiles is rising quickly, but Shanghai and China as a whole differ from other metropolitan areas where carsharing has historically flourished in many ways when it comes to urban mobility.

Rapid urbanisation is a global phenomenon that is altering the lifestyles of the general public. It is expected that by the year 2050, more than 60% of the world's population will live in urban areas, up from more than 50% at the present time (IPCC, 2014). This extraordinary urbanisation raises significant concerns as it will lock in patterns for decades to come that rely heavily on energy-intensive transportation and urban design (Floater et al., 2014; Rode et al., 2014). Over 70% of the world's energy-related carbon dioxide (CO_2) emissions occur in urban areas (IPCC, 2014). Cities are the largest source of carbon dioxide (CO_2) emissions from transportation and have the worst local air quality (Rode et al., 2014). Sustainable transportation systems are essential for combating global climate change and urban air pollution (Rode et al., 2014).

According to the IPCC (2014), more than 70% of all energy-related CO_2 emissions occur in urban areas. The metropolitan regions are the world's largest source of CO_2 from transportation and have the worst air quality due to pollution (Rode et al., 2014). Globally, sustainable transportation systems are essential to combating the effects of climate change and can effectually reduce urban air pollution (Rode et al., 2014). The relationship between urban development and transportation infrastructure is inextricable. Constructing urban areas can be centred on selecting two alternatives of development paths: compact or scattered development. In China's major cities, sprawling urban expansion and high levels of vehicle reliance have

resulted in quite a few negative consequences, including increasing greenhouse gas (GHG) emissions and air pollution.

The scattered development is comprised of low-density, vast-shaped urban structures and is reliant on cars (Rode et al., 2014). It is possible for the urban development's growth rate to exert an adverse impact on the total amount of economic output due to rising costs of transportation and decreased accessibility (Floater et al., 2014).

Moreover, the practice of scattered urban development can have a detrimental effect on the happiness, health, and social integration of citizens. This can exacerbate energy waste, greenhouse gas (GHG) emissions, as well as air pollution (Floater et al., 2014; The New Climate Economy, 2014; Racioppi, Dora, & Rutter, 2005).

In contrast, compact urban development is typically characterised by high density, mixed-use urban structures, and environmentally friendly transportation options, such as cycling, walking, and extensive public transit (Floater et al., 2014). The compact urban development, along with a single sustainable transportation system, has the potential for boosting the economy, enhancing economic productivity, promoting public health and well-being, boosting energy efficiency, raising social fairness, reducing GHG emissions and air pollution, and strengthening energy efficiency (Floater et al., 2014; The New Climate Economy, 2014).

Car sharing is a transportation innovation that, by providing an alternative to private vehicle ownership, can enable compact living and sustainable transportation patterns. Car sharing is also a new aspect of transportation that can help people live and travel more sustainably by providing an alternative to purchasing and owning a single vehicle. The car sharing mechanism is a single system in which cars are shared among multiple users per day. The underlying assumption of such a tool is that users share costs and car usages (Barth & Shaheen, 2002).

In addition to the aforementioned advantages, car sharing can assist users in reducing car purchase volume, car ownership, and car consumption, thereby reducing car the vehicle kilometres traveled (VKT), traffic volume, the demand for packaging, and GHG emissions in urban areas (Shaheen & Cohen, 2013; Martin & Shaheen, 2010).

The mechanism of car sharing has directly increased the number of transportation options available to users or travellers by facilitating the application of an additional mode of transportation (Martin & Shaheen, 2011b; Litman, 2000). Individuals and businesses can save a substantial amount of funds by opting for a car sharing model rather than purchasing their own vehicles (Litman, 2000). Consequently, car sharing has become widespread and popular worldwide in the last few decades due to its many advantages. According to the data provided by Shaheen and Cohen (2016), car sharing has been available in 33 countries across five continents and 1,531 cities since 2014, with 4.8 mission users sharing more than 104,000 vehicles.

Despite the popularity and obvious advantages of vehicle sharing, China remains in the initial stages of car sharing growth. In all regions of Shanghai and Beijing, car sharing is neither prevalent nor well-known.

In tandem with the steep increase of the Chinese economy over the last 20 years, automobile sales and ownership have seen a quick and steady increase. By the end of 2021, the number of privately owned cars in China will have surpassed 300 million, a 6.32% (23.5 million) increase over 2020. motorists have surpassed 481 million (Pangbo, 2022).

A growing corpus of international literature on car sharing emphasises the benefits the programmes have brought to communities throughout the world. It reduces congestion, parking demand, and GHG emissions, encourages the use of alternative modes of transportation, saves money, provides transportation options, etc.

Cities are the largest source of CO_2 emissions due to transportation and with the most polluted local air quality. Globally, sustainable transportation systems are required to combat climate change and local air pollution in urban areas. Car sharing is a practice that helps people live and travel more sustainably by providing an alternative to car ownership. The underlying premise of such a mechanism is that costs and automobile use are shared among users.

This research intends to add to the existing body of knowledge by examining automobile sharing in China. The purpose of this study is to determine if car sharing has potential benefits

in China, primarily in terms of supporting compact living and sustainable transportation patterns in the urban core. The research issue here is to examine the impact of high population density, alternative modes of transportation, and current technology on the success of car sharing in China is a component of this study. This study mainly focus on the benefits from the car sharing to solve the environment issue and the further, the sharing of electrical cars will also promote the eco-friendly car sharing to support this study for highlight the significance of this study.This study contributes to the existing body of knowledge by investigating how to develop sustainable car sharing in China and exploring ways to promote car sharing in China.

The rapid increase in the number of automobiles owned in China is closely related to and significantly contributes to urban traffic congestion, packing difficulties, and air pollution. This is one of the reasons for conducting this study. Due to the low sharing ratio and the air pollution caused by the significant traffic volume, China's current transportation infrastructure struggles to accommodate the increasing traffic volume, which has a negative impact on China's social and economic development.

A number of Chinese cities have enacted a series of restrictions on the purchase and demand for automobiles in an effort to reduce automobile ownership, alleviate urban traffic congestion, and kerb environmental pollution.

Many of China's major cities have attempted, with varying degrees of success, to build more compact, resilient urban modalities (Early et al., 2015). Car sharing can facilitate the transition to a more compact lifestyle and greener transportation. There is an increasing variety of literature on vehicle sharing that emphasises the positive impacts the service has had on communities throughout the globe. Comparatively, relatively little is known about car sharing in China. This study aims to contribute to the literature by investigating car sharing in China. The purpose of this study is to determine if car sharing has potential benefits in China, primarily in terms of supporting compact living and sustainable transportation patterns in the urban core. Examining the impact of high population density, alternative modes of transportation, and current technology on the success of car sharing in China is a component of this study. This research adds to the body of knowledge by evaluating the barriers to automobile sharing in

China and possible solutions. The significance of this research is to design survey to investigate the potential of car sharing in China and facing problems and questions when promoting car sharing in China according to China's unique situation and environment.

Chapter 2. Literature Review

2.1 Introduction and Overview of the Car Sharing

Car sharing has been available in China for around six years. Nevertheless, the program is not yet extensively utilised or well-known, particularly in places other than Beijing and Shanghai. As a consequence, little study has been conducted on car sharing in China, and there is minimal information available concerning car sharing operators and customers in China. Nevertheless, car sharing is undergoing rapid expansion and a significant experimental phase. Its future development is deemed quite promising and necessary for mitigating environmental damage, and its users utilise more economical modes of transportation.

Chapter 2 reviews the international literature on car sharing, including the definition of car sharing, the benefits of car sharing for users, the car sharing policies in China, the existing car sharing service providers in China, car sharing and compact living, car sharing and sustainable transport, car sharing and modern technologies, and the obstacles facing car sharing. Sections 2.2 to 2.7 will respectively elaborate and clarify these elements.

2.2 Car Sharing's Definition, Benefits and Usage

This segment will define car sharing and describe its benefits and users.

2.2.1 Definition of Car Sharing

Car sharing is exemplary of the development of the sharing economy, and sharing in the economy is a new phenomenon that arose with the emergence of the "Internet plus" economy. There is no standard, precise definition of "car sharing" (Le Vine, Zolfaghari, & Polak, 2014). In its broadest sense, the term "car sharing" refers to a mode in which a variety of individuals collaborate to share a fleet of vehicles.

Car sharing is a novel, intensive, and environmentally friendly mode of transportation that resembles a rental car service. Utilizing advanced Internet technology and relying on member-based shared car travel, the limited number of electric vehicles can be effectively and reasonably configured and scheduled to allow multiple people to drive the same electric vehicle in different time slots in order to maximise shared car utilisation. Members can swipe their membership card to obtain access to the vehicle in the designated parking lot or schedule an appointment in advance. The mileage driven and the amount of time spent will each be taken into consideration in the calculation of the service fee. As part of the extensive service that is offered to them, they have the option to return the vehicle to the parking spot that is situated in the region that is geographically closest to the conclusion of their journey. The shared car service provider will be responsible for vehicle acquisition, parking, and maintenance.

The proposal and implementation of a shared car mode of transportation play a significant role in reducing the ownership and use of private cars, bringing substantial benefits, as such a reduction in ownership and use of private cars is beneficial to both society and users. Car sharing decreases the number of people who own their own cars, which in turn improves flow of traffic, reduces the amount of energy that is consumed, and lowers the amount of pollution that is produced in the community.

Vehicle sharing comprises a range of economic and operational models on a global scale, including programmes operated by for-profit enterprises, community groups, and non-profit organisations (Dowling & Kent, 2015). Car sharing is an innovative method of consumption (Zhang, 2001). Car sharing is an innovative way of commuting involving private vehicles and public transit. Switzerland and Germany are the origins of car sharing (Zhou, 2013). In 1948, car sharing started in Zurich, Switzerland, as a collaboration named Sefage. Sefage ceased operations in 1998 (Shaheen, Chan, & Micheaux, 2015). It consists of a club in which members share automobiles to reduce the expense of vehicle ownership. Sefage is an informal car sharing business that relies on friendship as opposed to a formalised contract. In the 1970s and 1980s, many car sharing programs were attempted in North America and Europe. Typically, these preliminary ideas include short-term demonstration initiatives. Its objective was to showcase car sharing operations and technology, the majority of which were ultimately replaced by

permanent car sharing services. As a consequence of the 1997 merging of two regional cooperatives, The Swiss Mobile Cooperative became one of the first and most successful car sharing operators.

In the 1920s, a large number of automobiles entered households. Currently, cars are primarily privately owned means of transportation, except for occasional sharing among family members (Rabbitt & Ghosh, 2013). In an effort to maximize efficiency, numerous European countries have run a variety of car sharing experiments since the 1940s. In 1948, Zurich, Switzerland, experimented with a car sharing scheme. France, Britain, Germany, the Netherlands, and Canada all tried out various versions of automobile sharing in the 1970s. During the 1980s, many nations in Northern Europe and North America conducted practical research on automobile sharing. Nonetheless, the majority of exploration was conducted by non-profit organisations, so the scale of practical exploration was typically modest. It was constrained by the social environment and the technical conditions of that time, both of which led to the failure of the majority of the experiments. However, these efforts have provided valuable insight for the subsequent innovation of the car sharing business model (Rabbitt & Ghosh, 2016).

In the 21st century, the United States leads the car sharing boom (Acheampong & Siiba, 2020). In 2000, Zipcar, Flexcar, and City Car Club were launched simultaneously, and car rental companies in North America and Europe. In 2010, the peer-to-peer car sharing system represented by Uber came into being. Uber has become the most prominent third-party ride-sharing platform in the world as a result of its promotion of the ride-hailing business model. As Uber has 110 million existing clients and operates in more than 70 countries and 400 cities globally as of 2018. Uber boasts a 69% market share in passenger transport in the United States and a 25% market share in food delivery, far exceeding established transport services, thus becoming a standard example of shared travel and the sharing economy as a whole (Perri, 2021).

The practice of car sharing is rapidly gaining popularity all over the world. Car sharing runs in 33 countries, five continents, and about 1,531 cities as of October 2014, with approximately 4.8 million people sharing over 104,000 automobiles (Shaheen & Cohen, 2016). Europe and North America are the major locations for vehicle sharing around the globe. In 2014, 46% of

the global membership and 56% of the fleet were based in Europe. 34% of the worldwide membership and % of the fleet are based in North America (Shaheen and Cohen, 2016).

In recent decades, car sharing has attracted significant attention as a mobility innovation (Barth & Shaheen, 2002). Technology advancements such as automated booking and smart card vehicle access make this process simpler and more convenient. Integration of electric cars (EVs) and plug-in hybrids into car sharing operations is set to perform an important role in the growth of car sharing (Shaheen & Chan, 2015; Shaheen & Cohen, 2013). Future driverless vehicles are anticipated to present car sharing companies with a number of options. The capacity of self-propelled cars to shift to locations and times when demand is anticipated to be greatest without the need for a motorist might be a game-changing aspect of car sharing (Le Vine et al., 2014).

Recently, a number of the world's largest auto equity operators have evolved into large multinational corporations. Shaheen and Cohen (2013) believe that this trans nationalization and mainstreaming of vehicle sharing will persist. In addition, they believe that conventional rental vehicle companies and manufacturers will increase their presence in the car sharing sector (Shaheen & Cohen, 2013).

2.2.2 The Benefits of Car Sharing

Car sharing has brought several social, economic, and environmental advantages on a global scale (Shaheen & Cohen, 2013; Münzel et al., 2018). Car sharing services provide customers with on-demand, short-term access to an automobile for a fee. A platform firm owns shared automobiles, therefore this service supports new types of car usage wherein drivers are not required to shoulder expenses associated with car ownership. Much like free-floating services operating inside a limited region, these mobility services have risen significantly over the last few years, notably in Europe (Münzel et al., 2020). Car sharing has significantly altered aspects such as automobile ownership and trip planning and execution. Consequently, the implications for municipalities, urban communication, and the automobility business strategy are enormous. Free-floating vehicle sharing, also known as point-to-point or one-way carpooling, is

frequently viewed as a step toward more environmentally friendly transportation. Several researchers have highlighted the beneficial influences of car sharing in e.g., minimizing car ownership (Firnkorn & Müller, 2015; Liao et al., 2020), and encouraging mass transit (Martin & Shaheen, 2011b; Münzel et al., 2018), reducing air pollution (Martin & Shaheen, 2011c; Firnkorn & Müller, 2015) or facilitating traffic problems (Shaheen & Cohen, 2013; Perboli et al., 2018). These benefits include reducing congestion and parking requirements, lowering emissions of greenhouse gas, encouraging the adoption of alternative modes of transportation, enhancing public health, saving money, and expanding people's transport options. Many of these benefits have been corroborated by an ever-expanding body of empirical evidence.

As vehicle ownership and travel decline, car sharing has the potential to alleviate traffic and parking needs. Automobile sharing is a substitute for car ownership since it allows users to get a vehicle without owning one. Shaheen and Cohen (2013) evaluated a number of studies on the effect of vehicle sharing on automobile ownership. They discovered that a shared vehicle may lower the need for 4 to 10 private automobiles in Europe, 9 to 13 private automobiles in North America, 7 to 10 private automobiles in the United States, and 7 to 10 private automobiles in Australia (Shaheen & Cohen, 2013). 15% to 34% of car sharing participants in Europe and 11% to 29% of car sharing participants in North America sold their own vehicles after joining car sharing services, according to research (Shaheen & Cohen, 2013). Automobile sharing may considerably decrease car ownership among families with one or more vehicles. Nevertheless, car sharing programs are also a crucial means of preventing car-less families from purchasing vehicles (Martin & Shaheen, 2011a; Martin, Shaheen, & Lidicker, 2010). Research performed in North America revealed that around 25% of car sharing members would contemplate buying their first vehicle if the program were discontinued (Martin et al., 2010).

Schemes of car sharing have the potential to bring numerous advantages to a city on a variety of fronts, including the social, the economic, and the environmental. The key benefits of developing car sharing in China were called into question by the stakeholders involved in this study. The objective is to compare these benefits with those described in the literature. As shown in Figure 1, the advantages recognised by stakeholders have been categorised into seven thematic groups. This section describes each of these topic categories.

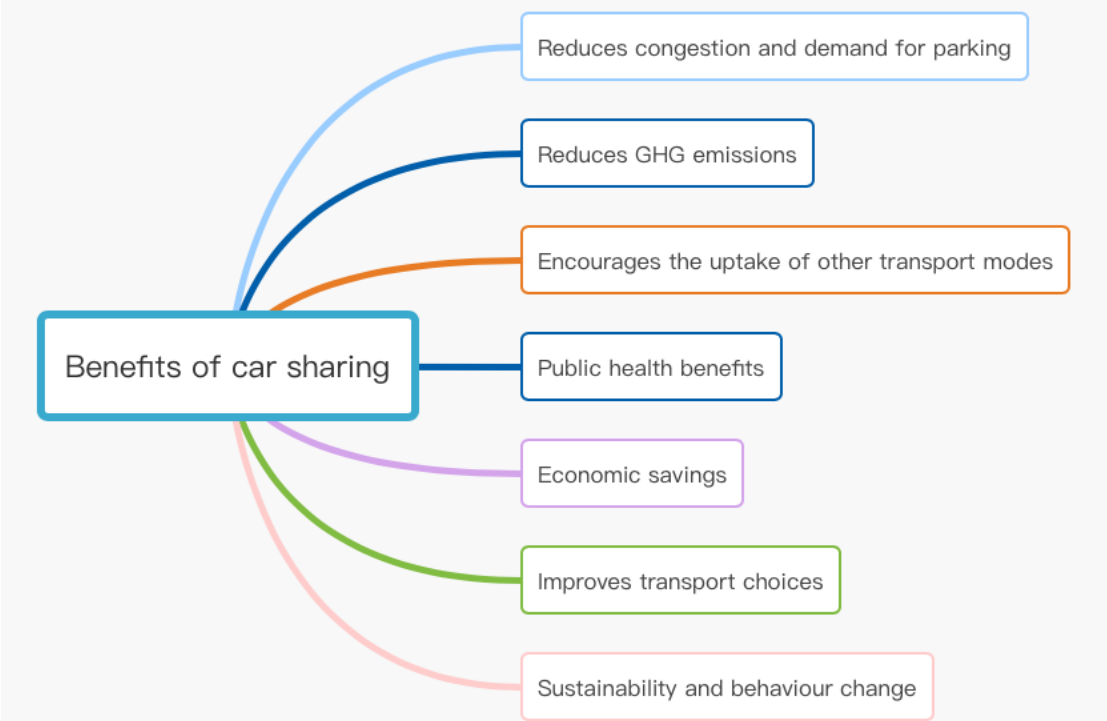


Figure 1 Benefits of car sharing. (Shaheen & Cohen, 2013; White, 2022; Firnkorn & Müller, 2015; Liao et al., 2020; Martin & Shaheen, 2011b; Münzel et al., 2018; Martin and Shaheen, 2011c; Perboli et al., 2018)

Reduces congestion and demand for parking

The primary advantage of car sharing is the decrease of traffic congestion and the number of vehicles on the road. This was due to the ability of car sharing to reduce parking demand in the city while freeing up vital public spaces.

Reduces GHG emissions

Car sharing's capacity to minimise greenhouse gas emissions is a fundamental benefit of the programme. As part of a debate on the larger advantages of eliminating vehicles off the road, many participants emphasised the decrease of greenhouse gas emissions, pollution, and the enhancement of air quality.

Encourages the uptake of other transport modes

Car sharing encourages the use of alternate methods of travel, such as public transit, walking, and biking. They discussed how those who carpool and do not own cars do not have an intrinsic

preference for driving. Rather, they choose to examine which type of transport is optimal for every trip, which may result in more eco-friendly travel options.

Public health benefits

Carpooling may also be beneficial for public health. These benefits are generally accompanied by an increase in active modes of transportation when customers forego automobile ownership in favour of car sharing (such as walking and cycling). Typically, car-sharing and rental cars are brand-new automobiles equipped with the most advanced safety features. This decreases the probability of automotive collisions and injuries. In this way, car sharing may help not just companies concerned with safety and health, but also individual drivers who can run safer automobiles.

Economic savings

Car sharing is an economical substitute to owning a vehicle and the purchase of new cars for both people and corporations. Individuals and organisations may profit from car sharing by having the opportunity to sometimes utilise a vehicle while avoiding many of the expenses associated with automobile ownership.

Improves transport choices

Car sharing may increase the transportation options and mobility of individuals. Users may pick from a range of automobiles depending on their requirements, making car sharing more adaptable than car ownership.

Sustainability and behaviour change

Car sharing for environmental sustainability and behaviour change. Car sharing may promote discussions about sustainability since it renders financial, societal, and ecological rationale and is not contentious politically.

Individuals who are members of car sharing programmes have a greater propensity to make use of vehicles owned by car sharing companies rather than their own personal vehicles (Shaheen and Cohen, 2007). In addition, Shaheen and Cohen discovered that car sharing

reduced the number of miles travelled by 28% to 45% in Europe and by an average of 44% in North America. Nevertheless, there is a possibility that car sharing will increase the rate of automobile usage among households that did not previously own a car.

People who previously relied on their own private vehicles may find that participating in car sharing programmes helps them become more conscientious drivers and reduces their overall carbon footprint. Common alternate means of transportation used by these folks include public transit, walking, bicycling, and automobile sharing. The effect of car sharing on GHG emissions has been examined in a number of studies. However, they frequently find inconsistent results as a result of various evaluation methods and sample sizes.

By reducing the number of miles driven, car sharing services can help alleviate urban road congestion (Litman, 2000). Reducing urban congestion can have a variety of positive effects, including increased productivity and decreased fuel consumption (Litman, 2017). Additionally, decreasing automobile ownership and mileage relieves parking room, thereby reducing the demand for vehicle parking and freeing up valuable urban development space (Litman, 2000).

Sharing cars has an additional impact on greenhouse gas emissions because it reduces both the number of cars owned and the total mileage driven. Additionally, car sharing can reduce carbon emissions and encourage individuals who previously relied on private vehicles to use them more responsibly. These individuals often rely on a variety of alternative means of transportation, namely public transportation, walking, cycling, and vehicle sharing (Martin & Shaheen, 2010). Multiple investigations have examined the effect of car sharing on greenhouse gas emissions. However, as a result of varying assessment methods and sample sizes, results are frequently inconsistent (Baptista, Melo & Rolim, 2014; Cairns & Harmer, 2012; Firnkorn & Müller, 2011; Martin & Shaheen, 2010; Nijland & van Meerkerk, 2017; Rabbitt & Ghosh, 2016).

Martin and Shaheen (2010) authored one of the most exhaustive analyses. In late January 2008, the authors surveyed roughly 6,300 members of 11 North America (2010). The survey results assessed the yearly home greenhouse gas emission rates prior to and after the introduction of vehicle sharing (Martin & Shaheen, 2010). The research examined "observed

consequences" and "global impacts on greenhouse gas emissions. "Avoided emissions" makes reference to emissions that might happen in the absence of vehicle sharing but do not as a result of the availability of car sharing. In this instance, saved emissions are calculated predicated on the quantity of relinquished automobile sales due to car sharing (Martin & Shaheen, 2010).

The authors discovered that 71% of participants elevated their emissions due to reported impacts, whereas 29% decreased their emissions according to observed effects. To maximise its influence, the balance was more fairly spread, resulting in a 53% increase in emissions and a 47% decrease in emissions. This emphasises the need of examining the whole effect of automobile sharing, which involves pollution reduction.

The vast majority of car sharing companies primarily use automobiles powered by internal combustion engines. Nevertheless, the incorporation of plug-in hybrid and electric vehicles into car sharing fleets is a significant global trend (Shaheen & Chan, 2015; Shaheen & Cohen, 2013). This might have a major effect on the quantity of greenhouse gases released by vehicle sharing, especially in nations with strong renewable energy levels (Shaheen & Chan, 2015; Shaheen & Cohen, 2013).

Car sharing has the potential to influence individuals' commuting habits in a variety of ways. When using a shared vehicle, members of a car sharing service are required to pay a fee in addition to the membership fee. There is a solid argument for reducing their urge to drive and using public transportation, walking, and cycling wherever feasible. In addition, research indicates that car sharing has attracted a sizeable number of households that do not own a vehicle and that these households now have access to additional mobility options (Martin & Shaheen, 2011b). As car sharing becomes more widespread, it is likely that more car-dependent families will switch to car sharing. This may foster the development of other forms of transportation and increase car-sharing capabilities (Martin and Shaheen, 2011b).

The adoption of the reform and opening-up strategy in China has resulted in a daily betterment in the populace's living standards. A private vehicle is now a prerequisite for a wealthy family. According to the 2018 China National Statistical Yearbook (Figure 2), the number of private automobiles in China reached 193,579 million by the end of 2018. Many exhaust gas emissions

from fuel vehicles produce pollutants that can directly invade the respiratory organs of humans, and the city's air pollution is also severe. Exhaust gas emissions from fuel vehicles are one of the primary sources of pollution in the city. Therefore, the key issue at hand is the resolution to address the air quality issue brought on by automobile traffic.

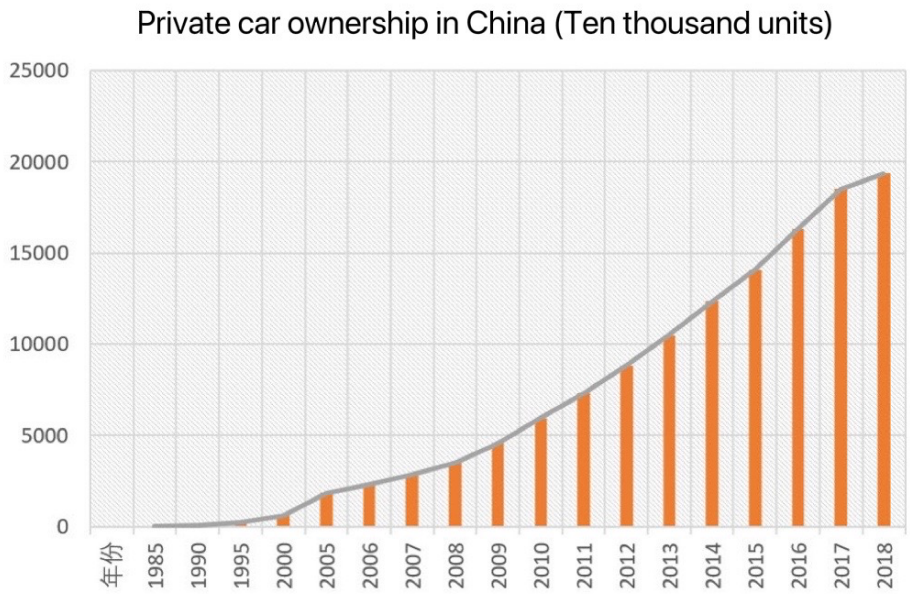


Figure 2 National Private Automobile Ownership in China 1985-2018 (China National Statistical Yearbook, 2018).

Additionally, car sharing has the possibility of improving the well-being of the general public. As was mentioned earlier, travellers' commuting travel habits might change if they had access to shared cars. (Martin and Shaheen, 2011b) discovered that automobile sharing encouraged a rise in walking and biking. Following an analysis of several pieces of research on the implications of car sharing, (Kent, 2014) came to the conclusion that a reduction in the total number of kilometres travelled would encourage more people to walk and ride bicycles as a means of transportation. Shifts in travel habits may have positive health effects. Decreased mileage reduces vehicle-related pollutants, notably nitrogen dioxide, carbon monoxide, and particulates, hence reducing respiratory disease mortality and morbidity (Kent, 2014). Reductions in GHG emissions may ameliorate the consequences of climate change and associated health implications, such as susceptibility to natural catastrophes, if sufficiently

implemented (Kent, 2014). Increasing physical movement by walking and biking lowers the incidence of mortality and morbidity associated with obesity (Kelly et al., 2014; Kent, 2014).

People choose car sharing for a variety of reasons, one of which is the potential for financial savings when compared to the expense of car ownership (Katzev, 2003; J. Kim, Rasouli, & Timmermans, 2017; Steininger, Vogel, & Zettel, 1996). The costs of owning, operation, and upkeeping private vehicles are rising in a great number of cities around the world. The majority of these fees are fixed because the majority of vehicle fees are paid regardless of the number of vehicles driven (Litman, 1999). Those who only infrequently use a vehicle may find car sharing to be a more cost-effective option than automobile ownership. Car sharing is a less costly substitute for car ownership for those who travel fewer than 10,000 kilometres per year (Barth & Shaheen, 2002; Littman, 2000). This service offers an inexpensive method for individuals to utilise their automobiles, making car sharing the preferred transport choice, and incurs no fixed costs that may promote car ownership (Littman, 1999). This allows users to experience the advantages of private automobile usage without the expenses and responsibility of car ownership (Shaheen & Cohen, 2013).

One of the various transportation choices that cover the void created by the lack of flexibility, expense, restricted carrying capacity, and scheduling of other modes is vehicle sharing (Kent & Dowling, 2013). It is also possible that this will lead to a wider variety of cars being made available to users. Car owners usually purchase vehicles that have higher levels of performance and capacity than they require on a day-to-day basis so that they can make use of those vehicles when they are required to do so. Some car sharing companies provide a variety of vehicle types, allowing customers to choose the vehicle that best suits their requirements for a specific trip (Litman, 2000). Some auto stock businesses also provide more fuel-efficient or "green" automobiles, which some consumers may not find reasonable (Wappelhorst, Dobrzinski, Graff, Steiner & Hinkelding, 2016).

Car sharing may promote equality by offering an additional programs to those disadvantaged by existing transportation alternatives (Kent, 2014; Littman, 2000). In this sense, "equality" indicates to the allocation of expenses and benefits in a fair manner (Litman, 2002). People's

socioeconomic possibilities are affected by traffic. For instance, a significant number of families living on a low income either are unable to drive or spend a significant portion of their income on automobiles that are only occasionally used. Car sharing, which provides less expensive transportation options than personal vehicle ownership, may increase equity (Kent, 2014; Littman, 2000).

Car sharing may also expose the public to current technologies and promote their acceptance (Litman, 2000: Wappelhorst, Dobrzinski, Graff, Steiner & Hinkelding, 2016). The most recent electric car technology and operating approaches, such as automated reservation, invoicing, and vehicle access, are components of modern technology. There have been efforts made by some countries to broaden public support for electric vehicles by providing funding for car sharing programs that make use of the technology, and supporting consists of investments, refunds, and subsidies, including subsidised public street parking (Shaheen & Chan, 2015). The endorsement of plans to promote the adoption of electric cars is largely motivated by their ability to decrease emissions of greenhouse gases and air pollution.

Incorporating electric vehicles into car sharing fleets can raise awareness of electric vehicle technology and provide members with driving experience in electric vehicles. According to German research, there are two significant barriers to the personal adoption of electric vehicles: the limited cost and range of electric cars compared to conventional vehicles (Wappelhorst, Dobrzinski, Graff, Steiner & Hinkelding, 2016). The research discovered that the majority of users of car sharing electric cars have no specific issues with the "electric" components of their vehicles, which is a rationale for most users to utilise the service. Car sharing provides an ideal platform for introducing electric vehicle technology, according to research (Wappelhorst et al., 2016).

2.2.3 Uses of Car Sharing

The sharing programs are utilised for individual and business reasons. Neverthless, there is minimal accessible documentation on the personal and company users of indicator sharing

programs, while extensive data is readily accessible for private users of conventional round-trip vehicle sharing. Multiple worldwide studies have identified the typical features of those who utilise round-trip vehicle sharing (Burkhardt & Millard-Ball, 2006; Le Vine et al., 2014; Loose, 2010; Martin & Shaheen, 2010; Millard-Ball, Murray, Ter Schure, Fox, & Burkhardt, 2005). This shows that users who use car sharing have the following characteristics:

1. Well-educated with an open mind to learning new things.
2. Young adults (mainly between 25 and 45 years old).
3. A member of a couple without children or a family where only one person lives alone.
4. Car free family.
5. Lives in an urban community without parking spaces.
6. A sizable percentage of people who use non-automotive urban transportation methods such as walking and biking.

From the literature, it also discovered that participants of car sharing programs share several opinions (Burkhardt and Millard-Ball, 2006). These include a high emphasis on ecological and societal issues: they regard themselves as pioneers and oppose the complexities and expenses of automobile ownership. They are also more practical about automobile usage, less concerned with model/brand, and more cost-conscious regarding mobility.

According to the Chinese Ministry of Transport, there were 342 million licenced drivers in the country as of the end of 2017, but only 310 million motor vehicles (Hui et al., 2019). This distinction is an inherent motivation for forming the target user base, and the fact that having a licence but not a car is the major reason that users choose car sharing. Currently, car sharing services in China are designed for short-distance self-drive trips, and the user base for taxis and online cars overlaps significantly with that of car sharing services. Individual users and organisational users can be divided into two categories using anthropological and participatory design research techniques.

The first category is the individual user, who is further subdivided based on motivation and requirements:

(1) Low-income individuals: represented by students and fresh workers, who are unable to afford to purchase and maintain a vehicle but frequently require one for short trips.

(2) Short-distance self-drive tourists: many tourist resorts are distant from the city and online car sharing is inconvenient. Car sharing has become the preferred mode of transportation between the city and the resorts.

(3) Residents of central cities: they decide against getting a car because their daily commute is rather convenient, but they occasionally need to make purchases or travel to locations that are difficult to reach by mass transit.

(4) Middle-class families: in most cases, a single private vehicle is sufficient to meet the requirements of the entire family. However, on occasion, one of the spouses will require a second car in order to transport the children or to attend to other matters.

(5) Experience pioneers: travellers who are interested in new travel methods and are willing to test out various models and services.

The second category consists of organisational users, which are categorised as follows.

1) Office commuting: a partnership with a car sharing platform can provide a convenient service for those with multiple office locations in a city whose frequency and the number of commuters does not lend themselves to shuttles.

2) Short haul commuting: departmental dinners or a few people travelling within the same city to another organisation.

3) High-frequency business trips: cities where company employees travel often have a fairly well-developed car sharing network, which is more efficient and less expensive than renting a car for the whole day.

According to the findings of (Acheampong and Siiba, 2020), students and office workers with relatively low incomes make up the majority of the current car sharing user population across all categories. Through observation, interviews, role-playing, and perception, it is possible to collect personal information regarding typical users in terms of social attributes, lifestyle habits, and consumer behaviour, and thus derive the characteristics of the user profile, including age concentration between 20 and 40 (mostly male); monthly income concentration between 8,000 and 15,000, with an average monthly consumption between 4,000 and 8,000 RMB; and low asset accumulation capacity. In addition to high-frequency applications for daily consumption, they are also heavy users of various travel and social applications; they have an avant-garde outlook on life and are open to new experiences.

2.3 Car sharing in China

2.3.1 Car sharing policies in China

Car sharing is the result of the era of the sharing economy, and it is a six-year-long mode of car rental under the new travel concept. The utilisation of big data, which can integrate socially unused resources, is tremendously beneficial to the practice of car sharing. The effectiveness of promoting car sharing can break the barrier between car usage rights and car ownership, thereby increasing the allocation efficiency of social resources. Essentially, the utilisation rate of the vehicles can be increased. Consequently, a platform for car sharing that integrates and visualises information can provide users with a greater level of convenience and travel variety. However, as a non-traditional mode of transportation that has developed rapidly in recent years, the car sharing field in China remains largely unregulated.

General car rental and time-sharing car rental may be used to implement car sharing. One of the most significant and essential differences between generations is the inability to share cars and use the internet to make reservations for taxis. As part of the sharing economy, peer-to-peer (P2P) car sharing is a form of person-to-person lending or collaborative consumption (Fishman, 2019). A P2P car rental is a form of private car rental in which individuals can rent

a vehicle through the P2P platform's integration of transport demand and resources in order to realise vehicle rental on both sides of the docking station. Eventually, a leasing contract relationship is reached. Car rental timeshare leasing, also known as instant sharing, is comparable to conventional car rental. In a time-sharing pricing model, users receive the right to use the car for a period of time and pay for the rental service. Nevertheless, time-sharing leasing is predominantly used for short trips, and it typically has numerous branches throughout the city. Through the integration of Internet data, users are able to borrow and return cars in close proximity, utilising advanced terminal payment, identity authentication, and platform information technology to eliminate cumbersome borrowing and returning procedures. Time-sharing leasing typically obtains vehicles through financial leasing and typically collaborates with conventional automakers to reduce dependence on fixed capital and maximise the utilisation of the resources of all parties. Consequently, time-sharing leasing has more obvious advantages than private cars and conventional car leasing.

In 2017, the Ministry of Housing and Urban-Rural Development and the Ministry of Transport issued the Guidance on Promoting the Healthy Development of Small and Micro Bus Leasing, which encouraged and supported the development of time-sharing leasing of cars, a new mode of shared transportation, and officially defined shared cars as time-sharing leasing of small and micro cars (Anonymous, 2017). It is distinct from the traditional car rental industry in that its service platform is the Internet, and its business model is fundamentally distinct from that of online car-hailing because its business operators do not offer driving services. P2P car rental in the private sector can be broken down into two categories, the first of which is car sharing rental modes that rely on car companies, and the second of which is car sharing rental modes that cooperate with car companies. These categories are determined by the various sources of equipped vehicles. China's specialised car rental industry regulation law is limited, mainly consisting of local government rules and normative documents, and the provisions of the law mainly exist in other laws, such as civil and commercial law, such as the adjustment of the legal relationship of car rental, primarily based on the provisions of the legal lease contract. However, its content focuses more on clarifying the basic rights and obligations and relevant legal responsibilities of both parties. Nonetheless, car sharing currently operates via the Internet and

mobile Internet applications, utilising an information service platform to connect private car owners or car companies with car renters; all parties are subject to legal liabilities.

Specifically, the responsibility and dominant position of the internet information platform are ambiguous, it is necessary to build charging stations and parking spaces on a large scale in order to grant it public transportation capabilities. Adjustments to the current privacy laws and regulations are restricted by a number of factors. Moreover, the regulation of the car rental industry consists primarily of local government regulations. There is also a large gap between local regulation thinking and standard access that highlights the regional characteristics of development in the form of normative documents with low legal status and insufficient enforcement. Consequently, the formation of network and scale development is challenging. In addition, the traditional car rental and taxi industries are not comparable to the car sharing industry in terms of supervision. This is because the car sharing industry breaks the geographical segmentation of evidence supervision, which limits the scale development of the car sharing industry.

2.3.2 Existing Car Share Providers in China

According to the 2017 China Car Sharing Status and Trend Report released by Price water house Coopers, the number of shared cars in operation in China reached more than 30,000. As of July 2018, 210 Chinese cities had issued comprehensive regulations for the management of online car-hailing, representing 62.1% of the total. By the end of 2018, Gofirn Travel had over 12,000 vehicles spanning 21 cities in China. People choose to share cars in order to reduce the number of trips taken by fuel-consuming motor vehicles, respond to the global call for low-carbon travel, save energy and save costs on vehicles, and promote the gradual opening up of the market for shared cars.

In China, car sharing service providers fall into three categories:

Firstly, the conventional mode of car rental. This mode adopts the rental method according to the date, generally calculated by the day, the need to go to the store or the user-designated

location to return the car and sign a car rental contract for traditional car rental companies and the emerging car rental business.

Secondly, the private car mode. The private car model involves utilising the idle time of private cars via the internet to provide the private car service, which can share the vehicle maintenance and depreciation costs of private cars and reduce the travel costs for consumers. It is a typical model of the sharing economy. This approach allows more people to travel without requiring the addition of vehicles, which is advantageous for many reasons. Among them, Didi is the most representative. This model does not require users to sign cumbersome car rental contracts, but instead typically provides users with travel services by exclusive driving vehicles, with a simple user experience and convenient payment options.

Thirdly, the time-sharing rental mode. The intelligent rental model exemplified by Car2Go encompasses the time-sharing rental services offered by traditional automobile manufacturers such as BMW and Daimler, as well as the hourly car sharing model currently being explored by domestic platforms such as Wukong Car Rental and Microbus soda (Soda) Travel.

2.3.3 Current Scenarios and Funding Obstacles of Car Sharing Model in China

Since 2015, more than 30 corporations have invested in car sharing operations and services in China, with Halo Car Sharing, one of Alibaba Group's subsidiaries, currently dominating the market (Wang et al., 2021). This is primarily due to the fact that adequate funding is a significant obstacle to the development of car sharing operations in China. It is also the reason that the most successful car sharing companies are backed by Chinese MNCs.

Figure 2 shows one illustrative example of Togo, a Chinese car sharing company that was founded in 2015, expanded from 2016 to 2018, and then ceased operations in 2019. The example of Togo has been quite representative as it shed light on a significant barrier to the development of car sharing operations in China over the course of the last decade. Such a barrier is the requirement of continuous and stable funding, as well as the need for three to five years of high-cost and low-return status.

Flexibility is an essential technology-enabled feature that users of car sharing require when selecting and utilising car rental services; however, this requires greater investments. China's car sharing companies have a difficult time balancing their profit margins and service usage (Sai et al., 2019).

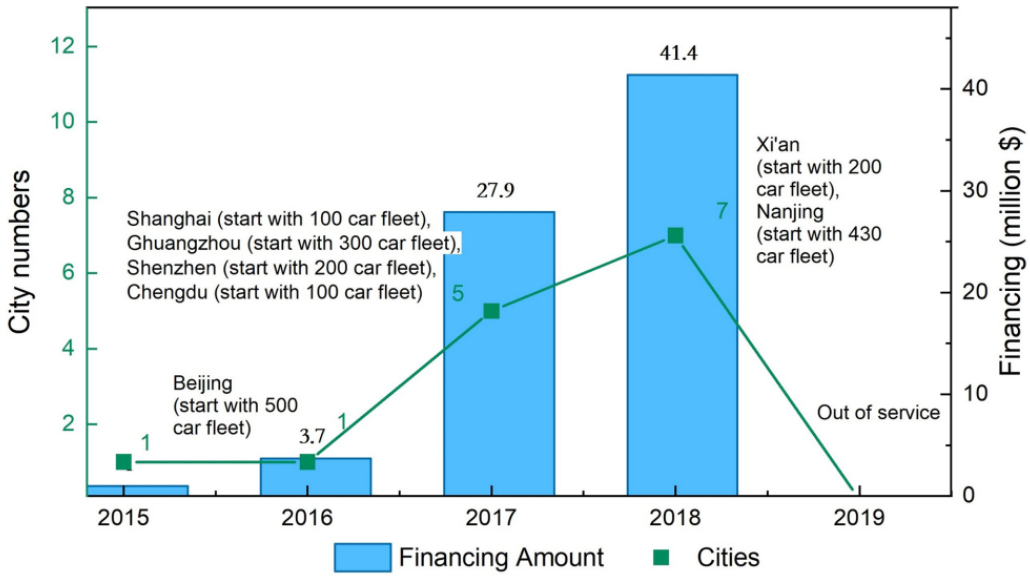


Figure 3 A Chinese Car Sharing Service Provider Togo's Establishment in 2015, Expanding from 2016 to 2018 as well as Out of Service in 2019 Due to Fund's Restraint (Wang et al., 2021).

As shown in Figure 3, Togo ceased operations in 2019 shortly after its 2018 expansion to seven cities (Beiijng, Shanghai, Shenzhen, Guangzhou, Chengdu, Nanjing, and Xi An) due to high investment issues and low user utilisation. The low utilisation led to insufficient profits. This has been the case for a number of corporate experiments in the car sharing industry in China over the past decade, and by 2022, the most successful ones will include Halo Car Sharing, Qing Ju Car Sharing, and Mei Tuan Car Sharing, all of which are supported by large Chinese MNCs that do not require profitability from the car sharing business alone.

According to Michael Porter's definition of the term "focus strategy," the car sharing businesses that are currently operating in China are primarily concentrating their efforts on a targeted specific market segment and niche market (1980). In order to survive in the long-term based on

a large user base, they must endure three to five years of high-cost and low-return crises during their early development.

Such a niche strategy has enabled car sharing companies to establish a valuable image in China's urban areas, with the result that the vast majority of citizens in Chinese major cities such as Beijing and Shanghai (more than 86.70%) are aware of car sharing services and well-known car sharing companies, regardless of whether they have used it or not (Sun et al., 2018).

Based on a review of the findings of a number of previously conducted studies, the model for car sharing in China has been encountering a number of obstacles and limitations, which prevent its further development. These challenges can be summarised below.

As shown in Figure 3, Martins et al. (2021) have posed a number of challenges for the car sharing model. Among them, battery recharging difficulty, limited location and difficulty in planning the locations of recharging stations, matching riders' demand, and dynamic traffic conditions are common obstacles for car sharing models adopted in China (Xu et al., 2021; Sun et al., 2018; Wang et al., 2021).

Additionally, a large number of shared vehicles witness a high level of intentional damage as a result of their unsupervised operation as well as the significant difficulty in supervising them (Xu et al., 2021). This negatively impacted the profitability of these car sharing companies by incurring high maintenance costs and making it difficult to identify vehicles in need of immediate repair.

2.4 Wider Public Transportation and Environmental Efficacy Enabled by Car Sharing

As mentioned previously, car sharing can encourage the use of public transportation, walking, and cycling (Martin & Shaheen, 2011b). Moreover, it broadens transport options by filling the void created by the limited carrying capacity, timetables, inflexibility, and high costs of conventional forms of transportation (Kent & Dowling, 2013). This section delves further into how car sharing fits into the overall transportation system.

Car sharing can increase the accessibility of public transportation, walking, and cycling (Martin & Shaheen, 2011b). It also broadens the range of transportation options available to people by filling the void by the limited carrying capacity, rigid schedules, lack of flexibility, and high costs of traditional forms of transportation (Kent & Dowling, 2013). This section examines in greater detail how vehicle sharing fits into the larger transportation system.

2.4.1 Car sharing and compact living

As previously stated, Car sharing programmes are usually located in densely populated places with well-developed public transportation, walking, and biking infrastructure (Burkhardt & Millard-Ball, 2006; Le Vine et al., 2014; Loose, 2010; Martin & Shaheen, 2010; Millard-Ball et al., 2005; Stillwater, Mokhtarian, & Shaheen, 2008). According to the characteristics of the success of car sharing in American communities, Millard-Ball et al. (2005) found that the majority of successful car sharing communities in the United States possessed the following characteristics:

Parking pressure: when car ownership is prohibitively expensive and parking is scarce, car sharing becomes increasingly attractive

Families may survive without a car: car sharing cannot fulfil all of a household's mobility demands; rather, it complements other modes of transportation. As a consequence, communities must have appropriate interconnections for walking, biking, and/or public transit.

High population density: this implies that every vehicle sharing station is within close proximity of a large clientele (These regions also have lower automobile ownership and travel rates).

Mix of uses: throughout the day, business clients may be matched with residential users throughout the evenings and on the weekends.

All of these variables are interconnected in significant ways. For instance, parking spots are hard to come by in high-density areas, and an increase in population also makes using public

transportation a more viable option (Millard-Ball et al., 2005). Millard-Ball et al. (2005) compiled a list of locations in the United States where car sharing is most likely to be successful (Figure 4). Figure 4 shows that household type, commuting mode, and vehicle ownership are the best surrogates for the types of neighbourhoods where car sharing works. Car sharing is more likely to flourish in areas with a high proportion of single-family homes, a high proportion of the population who prefer to walk, and households without a vehicle (Millard-Ball et al., 2005).

Variable*	Level of Service	
	Low	High†
Demographics		
% 1-person households	30%	40-50%
Commute Mode Share		
% drive alone to work	55%	35-40%
% walk to work	5%	15-20%
Vehicle Ownership		
% households with no vehicle	10-15%	35-40%
% households with 0 or 1 vehicle	60%	70-80%
Neighbourhood Characteristics		
Housing units per acre	5	5

* For most variables, the values are the suggested minimums that are needed to achieve a given level of car-sharing service. For the "% drive alone to work" variable, the values are the suggested maximums.
† High service roughly equates to 10 or more car-sharing vehicles within a half-mile (800m) radius.

Figure 4 Guideline for where car sharing succeeds (Millard Ball. et al. (2015) Exhibit 3-15, p. 3-40).

Stillwater et al. (2008) examined the effect of population density on car sharing in the United States. According to them, car sharing is negatively correlated with the proportion of commuters who drive alone, whereas families with a single vehicle are positively correlated with car sharing. In addition, the researchers discovered that increased roadway width negatively affected car sharing. Since narrow streets are more pedestrian-friendly, this may demonstrate a direct correlation between walking and car sharing (Stillwater et al., 2008).

Car sharing can be effective on university campuses and rural villages outside of urban areas. However, in a rural area, success factors are likely to vary from those in a metropolitan one (Millard-Ball et al., 2005). In small communities, vehicle sharing systems are often distinguished by a high level of participation and volunteer initiatives (Millard-Ball et al., 2005).

According to worldwide studies, car sharing is more likely to be successful in a tiny city. This is caused in part by the strong correlation between rising population concentrations and the need for parking, by families with no cars or just one vehicle, and by the accessibility of alternative modes of transportation. This does not rule out the possibility of vehicle sharing being successful in areas with a lower population density if the programme receives strong support from the community.

The percentage of various transport modes, as shown in Figure 5, represents the structural adjustment of transportation. Public transportation uses less road resources and emits significantly fewer exhaust fumes while operating at the same capacity as private transit.

Transportation modes	Bicycle	Walking	Bus	Vehicle
Speed (km/h)	12	4	15	20
Horizontal width (m)	1	0.6	3.75	3.75
Vertical spacing (m)	3.44	1.46	16.35	11.13
Passenger capacity	1	1	50	1.2
Per capita spatial and temporal consumption index (m^2h/vehicle/person)	2.95	2.25	0.73	15.58

Figure 5 Guideline for where car sharing succeeds (Shuai L. et al. (2022).

Under a fixed transportation demand, boosting public transport and its share rate, lowering motor cars, and encouraging slow short-distance travel may considerably cut exhaust emissions. Adjusting the transportation system is the best option to accomplish green transportation in many major cities since supply is limited. The last two tiers are road network structure optimization and scientific transportation regulation procedures (traffic control and guidance). This job improves traffic flow and reduces vehicle emissions by reducing idle speed, low speed, and stop-and-go. These solutions only improve traffic under the given transportation supply

and demand, hence they contribute nothing to green transportation. Their cheap cost and fast effect make them beneficial.

Transportation development modalities and green transportation depend on transportation system regulation. Transportation administrators should start at multiple levels and suggest policies based on urban growth, shape, economic level, and demographic structure. In many large cities, road supply is saturated and difficult to grow. To achieve green and healthy transportation growth, management and structure should be modified. In small cities, green transportation should be integrated early in planning. All regulatory levels are unipolar. Lower-level approaches are difficult to apply to upper-level difficulties because upper-level methods strongly impact them and lower-level procedures weakly respond to them. Thus, higher level solutions are essential and beneficial for green transportation. Management-wise, these regulation levels may encourage green and efficient transportation growth.

2.4.2 The Development Status of Car Sharing in China-Taking Beijing for an Example

Sun et al. (2018) have conducted an in-depth study on the development status of car sharing in Beijing, the capital city of China, as illustrated in Figure 6.

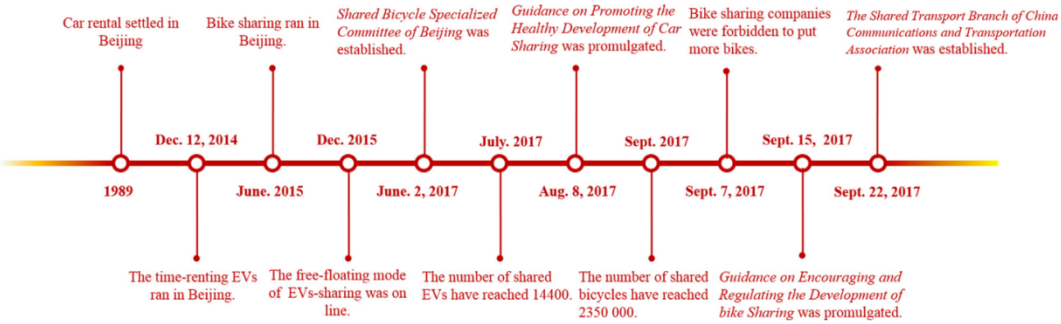


Figure 6 The Development Status of Car Sharing in Beijing (Sun et al., 2018).

Figure 6 demonstrates that by September 2017, the number of shared bicycles in Beijing had reached 2.35 million. In 2013, seven of the ten most polluted cities in the world were located

in China (China Daily, 2013), consequently, Beijing and Shanghai have implemented urban area transportation restrictions and car-purchase since 2008 and 2010, respectively.

For instance, the transportation restriction and traffic control policy that is being implemented by the Beijing Government can only allow cars with the last digit of double numbers or single numbers to commute during daily working peak hours across urban areas in Beijing (Beijing Government, 2015). This means that only cars with number plates ending with 2,4,6,8,0 or 1,3,5,7,9 cars will be permitted to commute during these specified days. In order to alleviate the severe traffic congestion in Beijing and Shanghai, a car purchase restriction policy was enacted with a monthly car purchase limit and a "lottery process" for those who wish to purchase a new vehicle. It is possible for a prospective car purchaser to participate in a monthly "lottery process" for more than three years without procuring a new vehicle. Consequently, the car sharing model is comparably crucial in China due to the vastly improved user convenience for individuals who cannot own private vehicles.

According to Sun et al. (2018), the initial development of car sharing in Beijing has been considered remarkable in terms of reducing the city's overall energy consumption as well as saving a significant amount of resources. They (Sun et al., 2018) successfully surveyed 1,029 adults in Beijing in 2018, and their survey results indicate that 58.80% of users use EV sharing services less than or equal to 10 times per month, while only 19.0% use the services more than 20 times per month. 34.30% of users use the services 3-5 times per month, while 12.70% use the services 6-10 times per month (Sun et al., 2018).

As for bicycle sharing, the percentage was significantly higher: 63.70% of users have utilised bicycle sharing services more than 100 times, and 47.10% of users have attempted to use bicycle sharing more than three times per day. This indicates that in China's metropolitan areas, bicycle sharing is prevalent while EV sharing is still in its infancy (Sun et al., 2018).

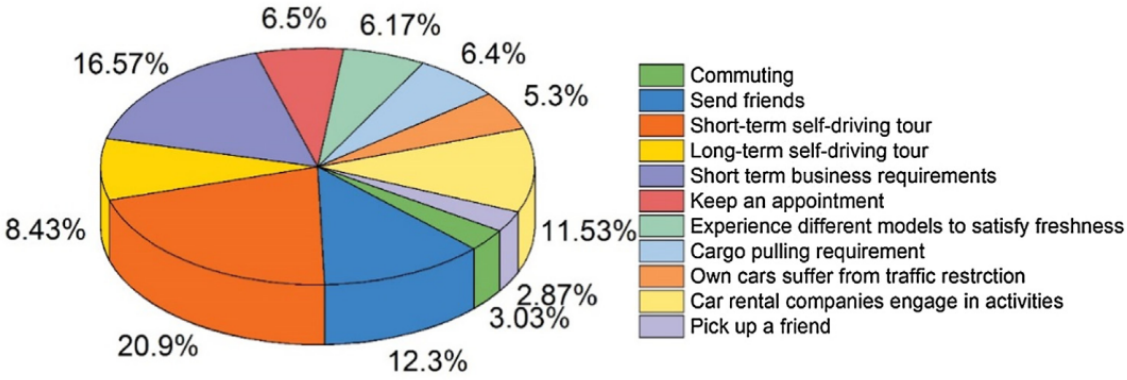


Figure 7 The Purposes of User EV Sharing by 1,029 Surveyed Beijing Citizens (Sun et al., 2018).

As depicted in Figure 7, the 1,029 Beijing residents surveyed for this study use car sharing for a variety of reasons, including meeting or picking up friends, for appointments or short-term business needs, short-term or long-term driving tours, commuting, as well as private automobiles hampered by traffic restrictions.

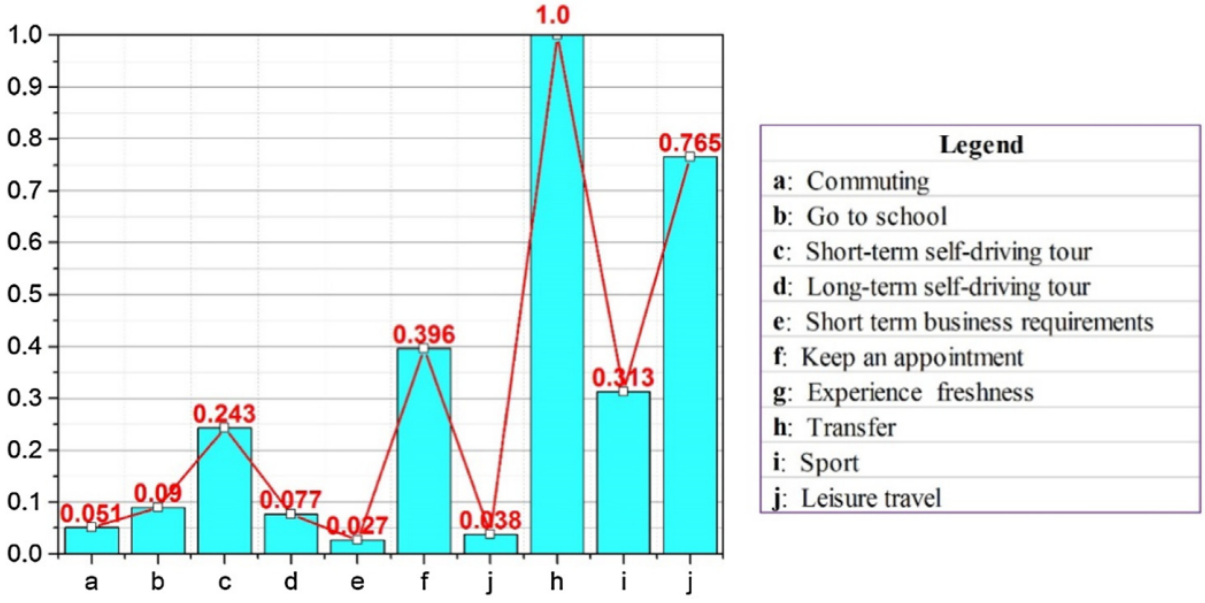


Figure 8 The Reasons for Bicycle Sharing by the 1,029 Surveyed Beijing Citizens (Sun et al., 2018).

The reasons for bicycle sharing among the 1,029 Beijing residents surveyed differ slightly from the reasons for EV sharing. Sports, leisure travel, and the need for exercise have emerged (Sun

et al., 2018). This provided evidence that shared cycling could enhance the well-being of city residents and contribute to the long-term viability of the city's environmental sustainability.

In summary, this example follows the established literature to conduct a stated choice experiment in Beijing, which provides an ideal context to test whether such types of policies can be effective to achieve the desired objective of urban sustainability. The example's stated choice experiment examines this issue and provides empirical evidence on consumer mobility choices in the context of car sharing and the lottery policy of allocating car license plates. The discrete choice analysis is then carried out, which is based on random utility maximization and is commonly used by market researchers to determine market demand. The rational behind the differences on the points of low utilization rates & intentional damages, and the uptake of car sharing in Beijing is the unrealized popularization of education and the need to improve the quality of the people. This problem exists in Beijing, a city dominated by education, so it will only become more and more serious in other areas with underdeveloped education. In particular, several discrete choice model specifications, including the multinomial logit (MNL) model and the nested logit (NL) model, are contrasted in order to determine the best choice structure to represent customers' heterogeneous preferences for various choices. We further analyze how the car-sharing and license-place lottery policies impact the usability of the mobility system as well as in various customer categories using the specified model structure.

The results of this research have two benefits. First off, as far as the authors are aware, this is the first article to evaluate the combined consequences of the automobile license plate lottery scheme and car sharing from the standpoint of accessibility in the mobility system. On the one hand, previous research on vehicle sharing have not looked at the impact of car sharing on accessibility or the combined impact of car sharing and the policy of randomizing license plate numbers for cars. The research on accessibility in a mobility system, on the other hand, often focuses on macro-level analysis with little consideration for how consumer behavior has changed as a consequence of policies designed to promote sustainable transportation. To close this gap, our research use a stated choice experiment, discrete choice analysis, and predicted consumer surplus to evaluate changes in accessibility and expose the impact of the automobile license plate lottery program on consumer accessibility to mobility.

2.5 Car sharing and sustainable transport

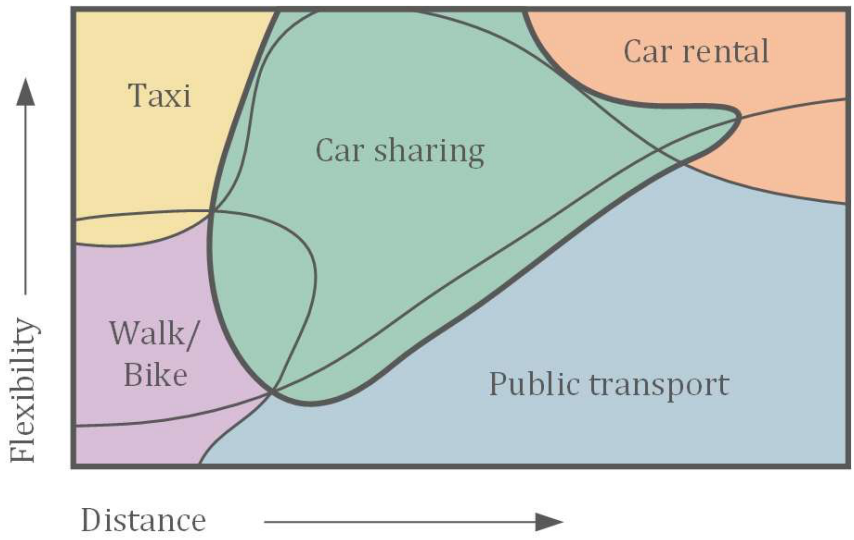


Figure 9 Car sharing's role in the transport system based on flexibility and distance (adapted from Britton (1999), Figure i, p. 9).

Although public transportation can be utilised for both short and long trips, it does not satisfy all requirements. Biking and walking are flexible modes of transportation, albeit only for short ranges. Taxis need less time and effort than walking or biking, but their range is restricted owing to their expensive cost. For multi-day trips that need flexibility, an automobile rental is an excellent option. Nevertheless, these options may not be suitable for every trip. When individuals need to go to a location that is not well-served by public transit, move items, commute at an unexpected time, or drive themselves, car sharing may serve as a bridge (Britton, 1999).

The relationship between different forms of transportation in terms of access and privacy values is highlighted by Nawangpalupi and Demirbilek (2008) (Figure 10).

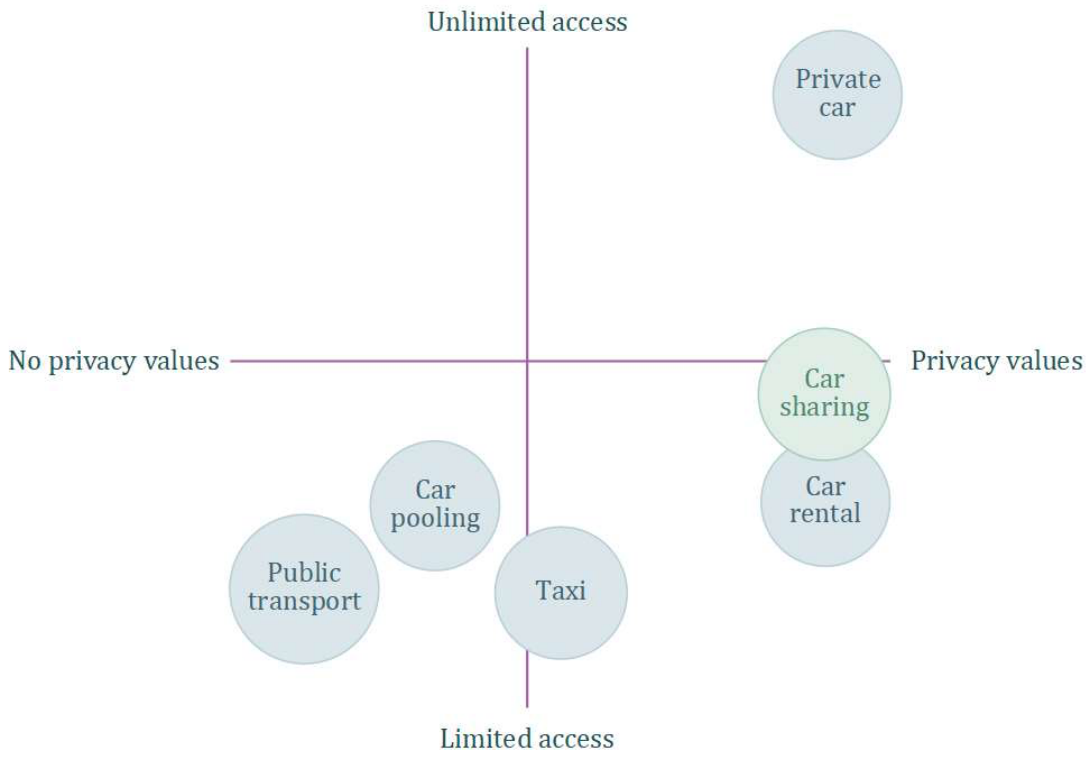


Figure 10 Car sharing's role in the transport network based on access and privacy values (adapted from Nawangpalupi and Demirbilek (2008), Figure 1, p. 3).

A private car is nearly always accessible and provides the user with complete privacy. Sharing a car offers a level of privacy while at the same time facilitating easier access. Car sharing provides its members with greater flexibility than renting a car does because they are able to keep the vehicle for as long as they require it rather than being required to rent it for the entire day. In addition, the vehicle is conveniently located in the neighbourhood and is easy to access. This is advantageous compared to the typical placement of rental cars, which is typically some distance from residential areas. Public transportation and car sharing provide restricted access due to limited operating hours, distances, and availability. Due to the fact that passengers share the vehicle with others, privacy is also compromised (Nawangpalupi & Demirbilek, 2008).

2.5.1 Car sharing and modern technologies

Car sharing and modern technologies are inextricably linked. As previously stated, car sharing can facilitate the adoption of specific technologies (Litman, 2000; Wappelhorst et al., 2016).

Several governments have offered financial support to car-sharing firms whose fleets include electric cars (Shaheen & Chan, 2015). In the 1990s, early round-trip car sharing companies relied heavily on EVs (Shaheen & Chan, 2015). It was a strategy for maximising the environmental benefits of car sharing programmes. In car sharing programmes, hybrid vehicles had replaced the vast majority of electric vehicles by 2006 (Shaheen & Chan, 2015). This may be due to a number of causes, such as the significant expense of electric cars, expensive insurance premiums, poor dependability of first-generation electric vehicles, a predisposition for hybrid vehicles, operating obstacles, dwindling consumer demand and engagement, and economic conditions (Shaheen & Chan, 2015).

EVs have made a return in car sharing operations in recent years (Shaheen & Chan, 2015). Vehicle manufacturers are developing EV car sharing systems in a number of cities in Europe, Japan, and North America. Existing car-sharing firms are adding or reinstating electric vehicles to their fleets (Shaheen & Chan, 2015). According to Shaheen and Chan (2015), this is due to technology developments that have cut prices and expanded battery ranges, hence lowering many of the barriers car share operators have in adopting electric cars. More than half of the nations where EVs are now accessible have included them into car-sharing schemes as of 2015. (Shaheen & Chan, 2015).

Many car-sharing organizations are shifting from manual to partly or completely automated operations in terms of operational technology. Many car-sharing firms, for instance, have automated their bookings, invoicing, and vehicle access (Shaheen & Cohen, 2013). Increasingly, automobile sharing companies are beginning with partially or fully automated systems. This reflects the improved accessibility and affordability of modern technology (Shaheen & Cohen, 2013). According to Shaheen and Cohen, current vehicle sharing technologies prioritize "advanced services" such as open-ended booking systems (no set return periods), quick access (no reservations necessary), interoperability, point-to-point, and peer-to-peer sharing.

As previously said, it is projected that car-sharing firms would implement autonomous vehicle technology in the near future (Le Vine et al., 2014). The capacity of autonomous cars to

reposition themselves without a human driver might revolutionize car-sharing services. It might assist car-sharing businesses in managing their networks by automatically deploying cars to high-demand locations. However, it is unknown when this technology will be generally accessible to the general population.

2.5.2 Car Sharing's Development as a Sustainable Travel Mode in China

According to Guo et al. (2017), the growth trend of bike sharing in China has been the same as the growth trend seen globally, which is explicitly demonstrated in figure 10 below.

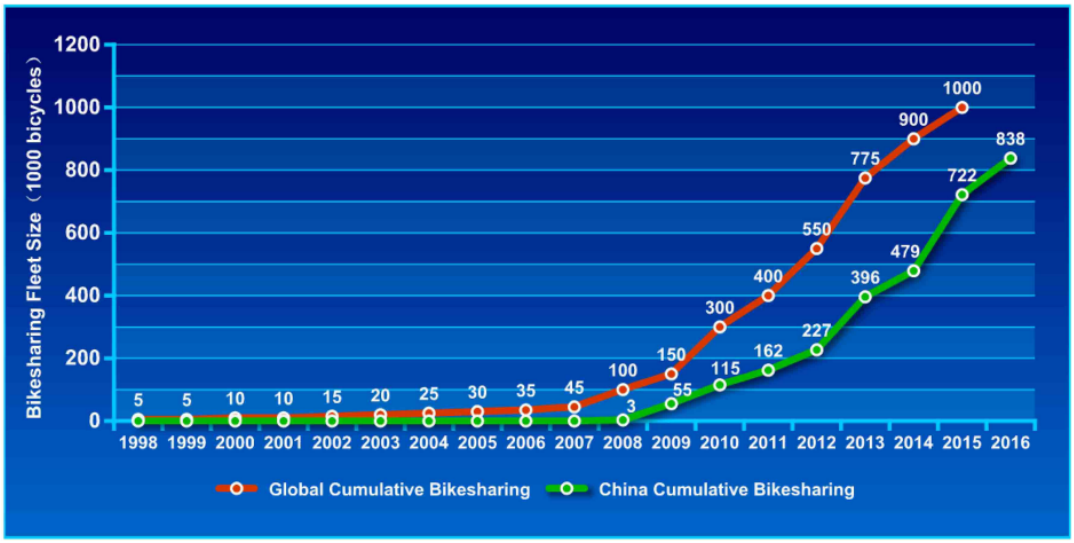


Figure 11 The Rapid Growth of Bike Sharing Projects Globally and in China (Guo et al., 2017).

In 2015, there were 772 bike-sharing programmes in China and 1000 globally, with China accounting for 77.20% of the total. In 2016, the number of bike-sharing programmes increased to 838 (Guo et al., 2017).

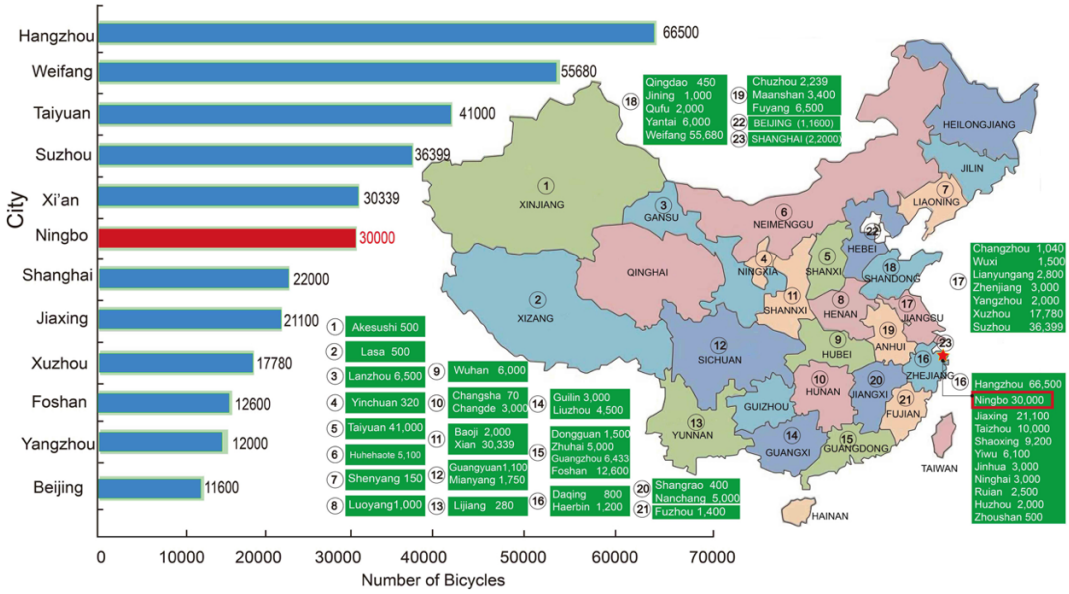


Figure 12 The Boom of Bike Sharing Programs in China (Guo et al., 2016).

The aforementioned data demonstrates the rapid expansion and distribution of bike sharing in Chinese cities (Guo et al., 2017). Surprisingly, Hangzhou, Weifang, and Taiyuan are the cities with the highest number of shared bikes, followed by Beijing and Shanghai.

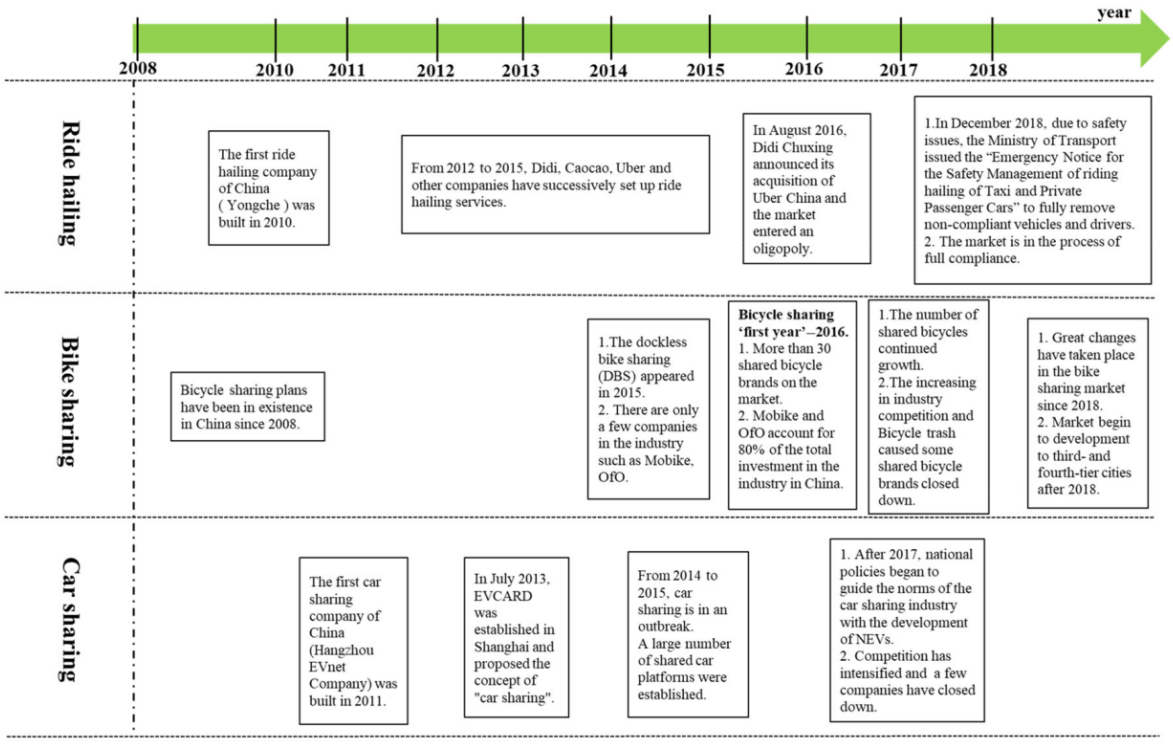


Figure 13 The Development of the 3 Shared Transports Modes in China Between the year 2008 to 2018 (Hu & Creutzig, 2022).

Hu and Creutzig (2022) conducted a systematic review of the evolution of shared mobility in China and provided a summary of the evolution and development of three shared modes between 2008 and 2018. Their categorisation is rather comprehensive, as it takes into account both ride-hailing and the rental of bicycles and automobiles. According to extensive research on car sharing, ride-hailing and car sharing are classified as single mode of transportation.

In accordance with the findings of Hu and Creutzig (2022)'s research from 2022, bicycle sharing has been on the rise since 2016 and car sharing has been increasing from 2014 to 2015; with national regulations stipulated and strengthened in 2017 and 2018 for car sharing and bicycle sharing, respectively, the development for both modes of transportation has never been halted, but has instead continued to advance.

In China, in terms of multifarious factors that impact the development of the car sharing model, consumers consider price, privacy, trust for the sharing platform, average travel distances, and are influenced by their educational backgrounds, income, gender, age, travel frequency, as well

as the familiarity level with the car sharing model when making decisions (Hu & Creutzig, 2022), as shown in below Figures.

	Consumer	Company	Government	Environmental benefit	Others
Car sharing	Price (Qu & Xiong, 2020)	Digital technology	Subsidy (Zhang et al., 2018)	Emission reduction (Ding et al., 2019; Jung & Koo, 2018)	
	Car ownership cost	Smartphones	Supervision	Pollution reduction	
	Privacy (Hui et al., 2019)	Recharge mileage of Pure Electric Vehicles (Qu & Xiong, 2020)	Propaganda (Niu & Xu, 2016)	Private cars reduction (Hui et al., 2019)	
	Demographics (Age, Education, Income, Gender) (Dogterom et al., 2018; Tran et al., 2019)	Profit model (Qu & Xiong, 2020)			
	Consumption habits (e.g., Using smartphone, Travel frequency) (Muller, 2019)	Car purchase and Maintenance cost			
	Familiarity with the car sharing concept (Gao et al., 2017)	Safety (Qu & Xiong, 2020)			
	Trust for shared platform (Muller, 2019; Tran et al., 2019)	Market competition			
	Average travel distance	A Sound Management System (e.g., service, cleaning, and tidying) (Gao & Chen, 2019)			
		Availability and Parking convenience (Gao & Chen, 2019; Li et al., 2018)			
		Car type, Charging facilities, service stations (Li et al., 2018; Zhang et al., 2018)			
		Platform reputation (Dogterom et al., 2018)			

Figure 14 Main Impact Factors for Shared Cars (Hu & Creutzig, 2022).

The growth and development of car sharing businesses are influenced by a variety of factors, including the recharge mileage of electric vehicles (EVs) that they are able to provide, the profit model, the level of safety, the car maintenance and purchase costs, the intensity of competition on the market, the availability of a sound management system, such as timely cleaning of cars, the charging facilities as well as service stations, and the platform's existing reputation in the marketplace (Hu & Creutzig, 2022). The government's oversight and promotion will also have a significant impact on the future development and growth of car sharing.

	Consumer	Company	Government	Environmental benefit	Others
Bike sharing	Cost of using unit	Digital technology	Subsidy	Emission reduction (Yang et al., 2019b; Zhang & Mi, 2018)	Temperature, Precipitation and Air quality (Campbell et al., 2016)
	Transportation cost (Yang et al., 2019b)	Smartphones	Supervision and incentives (Yu-Shi et al., 2019)	Pollution reduction (Qiu & He, 2018)	
	Demographics (Age, Education, Income, Gender) (Chen et al., 2019)	Profit model (Yang et al., 2019a)		Built environment (e.g., Population density, Road length and density, Urban traffic accessibility) (D. Liu et al., 2019; Zhang et al., 2017)	
	Consumption habits (e.g., Using smartphone, Travel frequency) (Fan et al., 2019; Si et al., 2020)	Riding safety (Gao et al., 2019; Y. Y. Guo et al., 2019)			
	Perceived usefulness (Shao & Liang, 2019; L. Y. Sun et al., 2019)	The convenience of picking up and parking (Shi et al., 2018)			
	Perceived ease-of-use (Ma et al., 2018; X. W. Ma et al., 2019; Shao & Liang, 2019)	Bicycle availability (Xin et al., 2018)			
	The contribution to users' health (Huang et al., 2020)	Supply quantity of bike sharing (Chen et al., 2017)			
	Average travel distance (Du & Cheng, 2018)	Management (e.g., service, cleaning and tidying)			
	Using comfortable capability (Y. Y. Guo et al., 2017)				

Figure 15 Main Impact Factors for Shared Bikes (Hu & Creutzig, 2022).

Regarding bike sharing in China, as depicted in the preceding figure, consumers' decisions regarding whether or not to use shared bikes are heavily influenced by a number of influential factors, including cost, educational level, income level, gender, age, consumption habits, travel frequency, perceived usefulness, perceived ease of use, contribution to health, level of comfort, as well as average travel distance and time (Hu & Creutzig, 2022). Three years ago, China's bike-sharing industry was growing, and start-ups overflowed with vibrant two-wheelers to line city streets. In 2019, the bubble broke, leaving behind a massive bike cemetery and a wave of bankruptcies. As people avoid using buses and subways out of fear of contracting the virus, the COVID-19 epidemic is also igniting a new excitement for cycling in China. Sharing economy businesses are now offering services that are more intelligent as a result of their previous blunders. Customers in China choose companies that offer shared bicycles for a variety of reasons, including convenience for returning, packing, and picking up bikes; riding safety; availability of bicycles; supply quantity; level of service provided; and supply quantity; in addition to the level of service provided.

Since the coronavirus outbreak began, Chinese commuters have utilized shared bikes more often for longer trips. According to statistics from bike-sharing firms, there were twice as many

journeys longer than 3 kilometers in February and March as there were in the same two months last year. This was a departure from customary use, in which individuals would board shared bikes for short trips, such the so-called "first mile" between their front door and the next subway or train station. People continued beyond the first mile and rode their bikes the whole way because they wanted to ride in open spaces and reduce their chance of contracting an illness. Electric bikes and scooters are becoming increasingly popular as a result, which makes long distance travel more convenient. E-bikes and e-scooters are more likely to be shared since they are more costly than traditional bikes, particularly by young and mobile persons who may only remain in a city for about a year before exploring educational or employment prospects elsewhere. People may get unrestricted access to sharing sites for as cheap as 200 yuan (less than $30) each month. A brand-new e-scooter, on the other hand, would cost several thousand yuan.

Compare to car sharing, electric bikes and scooters were previously a relatively underappreciated trend in China, in part because they first appeared in lesser-known places with less accessible public transportation. But even before COVID-19, their usage in certain cities significantly outpaced that of regular bikes. In China in 2019, traditional bikes were used for roughly 300 million trips daily, according to statistics gathered by the bike-sharing business Hellobike. In that year, 700 million rides per day, or more than twice as many trips, were taken on electric bikes and scooters. In Nanning, a secondary city in Guangxi Province, electric vehicle travel accounted for more than 34% of all travel that year, outpacing both private automobiles and public transit. That tendency has reached large cities due to changes in lifestyle brought on by the pandemic, and sharing platforms have taken notice. The Chinese firm Meituan, which controls the bike-sharing business Mobike, said in May 2020 that it will release a significant number of e-bikes into the roads in the second quarter. It declared that more may be added if necessary. Additionally, Didi' Qingju Bicycle has established e-bike sharing business expansion as a top target for 2020.

Newly published research findings by Hu & Creutzig (2022) indicate that temperature, air quality, and precipitation are also significant factors that influence consumers' decisions to use or not use shared bicycles in China.

2.5.3 Living and sustainable transportation from bicycle to car sharing

Lower-level regulatory techniques are microscopic and particular, while higher-level regulatory techniques are macroscopic and universal. While bike sharing has had a successful run over the last ten years, scooter sharing's explosive growth in popularity and the rising number of operators have captured everyone's attention.

1) The most crucial element at the initial level is the equilibrium between transportation demand and supply. On the one hand, arguments on environmentally friendly and efficient transportation will be pointless if there is a supply-demand imbalance. On the other hand, if supply and demand for transportation were to balance out passively, the market would become chaotic. Instead, regulatory regulations should be implemented to control transportation demand. While transportation demand, its spatial-temporal distribution, and the features of traffic distance are influenced by urban patterns and land use types, transportation supply is primarily dictated by transportation infrastructure, such as road utilities. The overall demand may be decreased, and demand characteristics can alter as a result of reasonable urban designs and land use patterns.

2) The second level of transportation is the structural adjustment, or the distribution of various forms of transportation. Public transportation uses less road resources and emits far fewer exhaust emissions than private transportation, even when transit capacity is equal.

When there is a fixed demand for transportation, encouraging slow traffic in short distances, reducing the number of motor vehicles, and boosting public transit may significantly cut down on overall exhaust emissions. The most efficient approach to accomplish green transportation is via the modification of the transportation system since the capacity for boosting supply is generally restricted in many major cities.

The latter two tiers include the optimization of road network architecture and scientific transportation regulatory systems (advanced regulatory methods like traffic control and traffic guiding). By reducing undesired traffic conditions (such idle speed, low speed, and stop-and-go), this activity helps to realize smooth and orderly transportation while also efficiently

reducing vehicle emissions. These techniques have only a limited impact on green transportation since they can only improve traffic conditions given the current transportation supply and demand. Nevertheless, they are helpful due to their inexpensive price and quick results.

The implementation of green transportation and the change in development modes of transportation are critically dependent on the regulatory level of transportation systems. Transportation administrators should choose a few levels as the beginning point and propose strategies to accomplish objectives based on the phases of urban growth, urban shape, urban economic level, and demographic structure. For instance, it is difficult to expand the supply of roads in many large cities since they are already saturated. In order to achieve the growth of transportation that is green and healthy, management and structure of transportation should be modified. The idea of green transportation should be included from the beginning of development in certain small cities, meantime. From top to bottom, these regulatory layers exhibit unipolarity. Lower level approaches are challenging to use to higher level problems because the upper level methods have a significant impact on them while the lower level methods have a weak reaction to them. The essential and efficient approaches to build green transportation are, therefore, higher level solutions. From a management standpoint, these regulatory thresholds provide workable ways to encourage the advancement of transportation in a sustainable and effective manner.

Early entries such as Car2Go, BMW ReachNow, Lime Pods, Bolloré's Electric BlueCar initiative, and General Motors' Maven had some early success but have mostly left the market in favor of more sustainable enterprises. Car sharing has been something of a roller coaster ride. Whether vehicle sharing operators can develop a viable business model that satisfies the requirements of the urban commuter of today, it will be interesting to watch if it gains the same level of popularity as scooter and bike sharing.

2.6 Current Challenges and Limitations of Car Sharing in China

On the basis of a review of a number of existing research findings, China's car sharing model faces a slew of challenges and limitations that impede its development. These challenges can be summed up as follows.

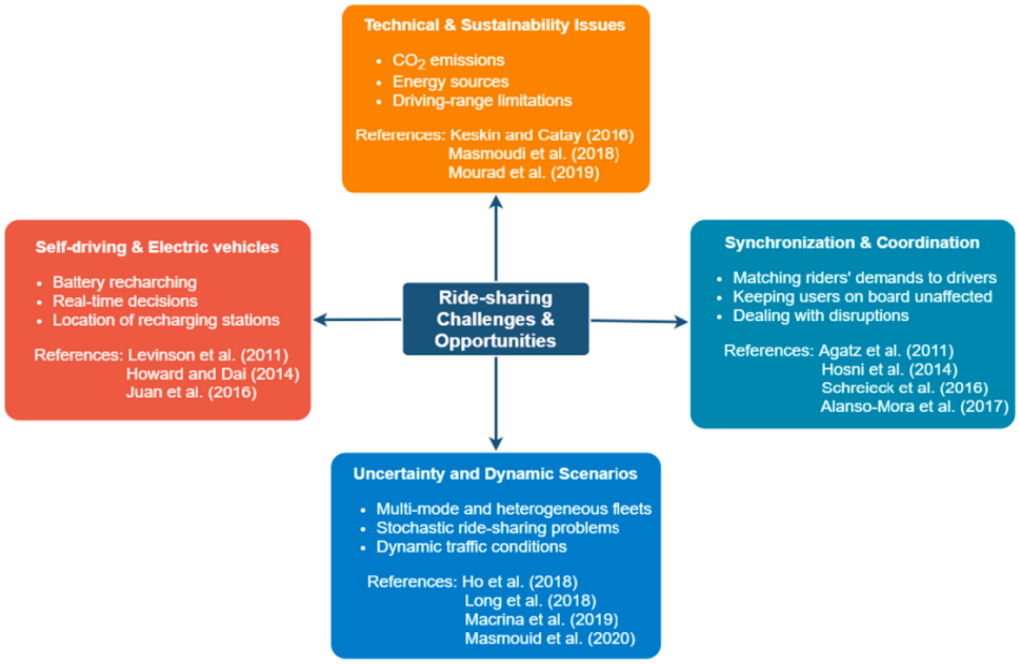


Figure 16 Challenges confronting Car Sharing Model Summarized by Martins et al., (2021).

As shown in Figure 16, Martins et al. (2021) have posed a number of challenges for the car sharing model. Common challenges for car sharing models adopted in China include battery recharging difficulty, limited location and difficulty in planning the locations of recharging stations, matching rider demand, and dynamic traffic conditions. In addition, a large proportion of shared vehicles suffer from a high level of human-caused damages due to unsupervised operations and significant supervision challenges. This adversely affected the profitability of these car sharing companies by incurring high maintenance costs and making it difficult to identify vehicles in need of immediate repair.

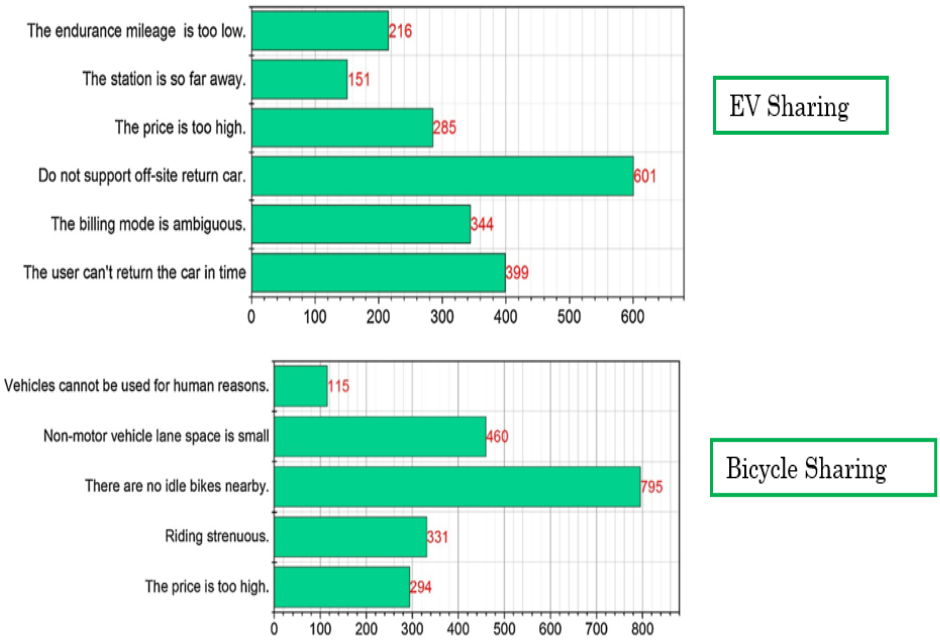


Figure 17 The Challenges Users Confront Summarized by Martins et al., (2021).

Additionally, as shown in Figure 7-8 above, a survey conducted by Sun et al. with 1,029 participants revealed a variety of additional obstacles and limitations, which are outlined as follows:

- The limited range of the EV, particularly in metropolitan cities such as Beijing, where daily single travel distances can vary from 30 to 50 kilometres.
- Stations are limited and scattered.
- Ambiguous billing mode.
- Car return difficulty.
- Confined space for non-motor vehicle lane space.
- A high percentage of existing bicycles are in use.
- The bicycles are difficult to ride.
- Exorbitant rental charges.

2.7 The barriers facing car sharing

There have been discussions in the past about the possible social, economic, and environmental advantages of car sharing. Before they can provide their full range of services, car sharing businesses must solve a number of obstacles. Due to the potential contributions that car sharing can make to the common good, there is a case to be made for public authorities to support companies that share vehicles, particularly in the initial phases of those companies' development.

There is virtually little study on the obstacles faced by individual car sharing consumers. Nawangpalupi and Demirbilek examined the obstacles that car sharing consumers in Sydney, Australia face. The authors discovered that the accessibility of car sharing cars was the leading complaint of service users. This was followed by parking problems, administrative complexities (such as improper billing and booking issues), the condition of the car-sharing vehicles (such as cleanliness and damage), and the irritation caused to other customers (such as returning the vehicle late). Minor obstacles were difficulty with customer support, price and insurance regulations that were unclear, prohibitions on moving dogs, and troublesome scheduling times. Another study evaluated the obstacles potential car share customers face in Beijing, China, and discovered that the largest concerns with vehicle sharing are connected to liability in the event of car theft or an automobile accident, as well as the safety devices of the automobiles.

In addition, Nawangpalupi and Demirbilek investigated the reasons why members used car-sharing services. According to the authors, participants were largely driven by practicality (such as seldom needing a vehicle and having easy access to car share cars), cost effectiveness (the financial benefits of car sharing), and environmental concern (the impact of car ownership on the environment). The authors advise introducing car-sharing solutions that reduce the drawbacks of individual automobile ownership, such as parking places devoted to car-sharing vehicles. Those that have problems finding parking for their own automobiles may find this useful. Similarly, Martin and Shaheen established that securing a parking space is one of the

most difficult obstacles for drivers in Beijing; thus, guaranteed parking spaces for car-sharing vehicles would be a significant benefit of utilizing the program.

Globally, car sharing operators have incurred substantial start-up expenses. When car sharing vehicles are utilised frequently, the service becomes economically viable. Few car sharing systems are self-sufficient in terms of user fees; the majority rely on government and private-sector support. As a component of public financing, for instance, start-up incentives and guaranteed usage of the program by central or local government agencies have been provided. Permitting car sharing in new developments rather than the construction of private parking lots can assist developers in the process of finding solutions to parking problems in planned developments.

Most car sharing businesses in other countries require access to on-street parking spaces in order to function. Obtaining access to on-street parking is challenging for car sharing companies. Commonly, local authorities own and manage on-street car parks. Local governments may be fragmented, susceptible to legislative changes, under pressure to meet a range of objectives (such as parking for residents or shops), have no obligation to assist car sharing firms, and may react more cautiously than the private industry. Free or inexpensive car parking is essential for the proliferation of vehicle sharing. The cost of insurance has proven to be a significant barrier for car sharing companies in other countries. According to Shaheen and Cohen, insurance is no longer considered prohibitively costly in the majority of global markets.

2.8 Summary

Multiple studies have found that car sharing has potential advantages, such as reducing automobile ownership and usage, which can decrease traffic, parking demand, and greenhouse gas (GHG) emissions. Additionally, a number of studies have been undertaken on the features of car share clients and communities. Significantly, car sharing appears to be effective in small cities due to the correlation between high population density and parking shortages, car-less and single-car families, and the accessibility of other means of transportation. Car sharing is an

essential component of a sustainable system of transportation since it fulfils the gap left by other forms of transportation's limited load capacity, rigid schedules, and high costs. The service provides an alternative to both not having a vehicle and owning one. Several studies have also highlighted the close association between car sharing and contemporary technologies, as well as the rising significance of technology to the business's future. Several studies show the obstacles faced by car sharing businesses and how they could be solved with government aid. The tremendous public benefits that car sharing can provide demonstrate that this support is warranted. Car sharing has a developing corpus of worldwide literature, but very little has been written about it in China. By examining car sharing in China, this thesis adds to the literature in various ways as well. Therefore, considering the situation in different cities and multi-factors in China, it’s quite difficult to promote car sharing due to the low utilization rates & intentional damages, and the uptake of car sharing, and country situation difference between China and other countries like access to on-street parking is challenging for car sharing companies. All factors make car sharing in China more challenging.

Chapter 3. Research Methodology

3.1 Research Paradigm

Pragmatism is the study's philosophical outlook. The foundation of pragmatism is not a singular philosophical stance on reality. Conversely, pragmatism acknowledges that research occurs in a social, historical, and political context, and that it ought to be organised according to what works best and the study's desired objectives. (Creswell, 2014b; Creswell & Clark, 2011). Typically, the research questions that require the most data analysis and data collection are the most important ones. This permits the application of various approaches to answer them (Creswell, 2014b; Creswell & Clark, 2011). The study of the pragmatic worldview focuses on the various philosophical questions that arise. This worldview is typically more receptive to diverse forms of data collection and analysis (Creswell, 2014b; Creswell & Clark, 2011). This research collected qualitative and quantitative data utilising a pragmatic worldview. This has enabled the study to collect data with greater nuance, and are able to have a more in-depth understanding of the research issue.

3.2 Research Approach

This research used a convergent technique in which quantitative and qualitative information were gathered concurrently and incorporated into the analysis of the overall findings. A convergent design seeks to collect a variety of complementary data in order to better understand the complementary components of the research problem.

The quantitative data were used to investigate the relationship between a variety of Chinese residents' characteristics, including sociodemographic, automobile ownership rates, and travel preferences, and their propensity to utilise car sharing. Qualitative data were utilised to study the potential advantages of extending vehicle sharing in China, in addition to how car sharing promotes a compact lifestyle and sustainable mobility practices, from the perspectives of a number of stakeholders. Furthermore, the challenges that vehicle sharing faces and strategies

for overcoming them are analysed from the perspectives of Chinese residents and a variety of stakeholders.

3.3 Research Methods

Quantitative information was collected from an online survey by using closed-ended questions. The qualitative data was gathered through an online survey with open-ended questions. This section describes the selection of each study technique, its implementation, and the analysis of each data set.

This study was granted ethics approval by the Auckland University of Technology Ethics Committee. [1]

3.3.1 Online Survey

3.3.1.1 Rationale

This research surveyed Chinese citizens on their desire for vehicle sharing, as well as their location, principal modes of transportation, and views toward automotive ownership. In surveying, a sampling of a population is analyzed in order to give a quantitative description of trends, attitudes, or views. This strategy was chosen as it provides a quick, cost-effective, and simplistic approach to reaching a large audience.

As stated earlier, car sharing in China remains in its early developmental phase, with just a handful of automobiles accessible in each city. Instead of examining current car sharing customers, it was believed that asking the general population of Chinese residents regarding their interest in car sharing would provide more information. It would have been impossible to obtain such a large sample size if the survey had been limited to existing car sharing customers. In addition, polling the entire Chinese resident population allowed for a more comprehensive examination of those who are enthusiastic about car sharing as well as those who are opposed

to it. In the coming segment, we are going to delve deeper into the survey recruitment process as well as the results.

The biases introduced by limiting respondents to those with internet access and basic computer skills are among the disadvantages of online surveys (Fowler, 2014).

3.3.1.2 Survey Design

There were both closed and open-ended questions in the survey [2]. Closed-type questions rely primarily on multiple-choice questions, whereas open-type questions depend solely on fill-in-the-blank questions. Open-ended questions are used to collect supporting data. The survey was designed and administered using survey software powered by WJX. WJX is an online crowdsourcing service in mainland China that delivers services similar to Amazon Mechanical Turk. The poll, which was intended to be confidential and anonymous, was hosted by WJX. [3]

3.3.1.3 Survey Questions

Following a comprehensive review of the relevant literature, the survey questions were developed. First, the objective of the survey was to collect information on the residence, travel, and automobile ownership characteristics of Chinese individuals, as well as their perceptions and opinions regarding their preferred mode of transportation, car ownership, and car sharing. Specifically, pointed survey will be designed to investigated the point of view of Chinese people and their opinions on the car sharing, their worries and expectations. Further, some interview will conducted to deeply to understand their feeling and their concern according to their own experiences and their views acquired from their friends, online or from other social media. Then, their suggestions will be collected. Following the survey design method and matrix, basic conclusion can be obtained to guide this research on the car sharing issues and facing problems people concern. To allow for comparability with census data, extra demographic inquiries were included.

Given that it was believed that a large number of survey respondents had never heard of vehicle sharing before completing the survey, a description of my research study was presented prior to the car sharing queries. Whereas many respondents had heard of or used car sharing, many of those who responded to the question had never heard of or used car sharing. Consequently, these findings should be regarded as preliminary.

Before agreeing to participate, participants indicated that they had read and understood the online Participant Consent form. Only those who resided in China were permitted to answer the first question. Those who indicated they did not reside in China were redirected to a survey conclusion page. All the survey will be collected, all the interviews will be recorded to draw our conclusions.

3.3.1.4 Recruitment Method

The survey was carried out using a nonprobability sampling technique known as the snowball method. It has the advantages of being economical and swift. Which is essential for this study. This is an exploratory research, given there has been minimal research on vehicle sharing in China, and it is doubtful that such information could be obtained in any other way owing to time and expense restrictions. Additional work will be necessary to corroborate the study's conclusions in China's broader environment. As non-probability samples are not selected at random, they may not accurately represent the population. Nonetheless, they may be compatible with studies conducted elsewhere (Fricker, 2011; Sue & Ritter, 2012). The first step of the snowball method is to identify people who meet the participation criteria. Thereafter, those participants are invited to recommend additional participants to interview for the survey. As a result of the study's objective to examine car sharing in China, a variety of mechanisms were employed. Each one of them is detailed as follows.

Forum: those who are curious about innovative notions are active on online forums such as Zhihu, where they share their own opinions and perspectives on car sharing. Their participation in this investigation can assist the author in collecting additional points of view.

Social Media: a series of targeted social media posts, primarily on WeChat. This will be multifaceted in nature, with individual posts made by the primary applicant that will appear in the feeds of their contacts. In order to be eligible for participation in the survey, respondents had to be at least 18 years old and residents of China.

By enabling self-selection and the disproportionate representation of certain demographic groups, the snowball approach may distort answers (Fowler, 2014; Sue & Ritter, 2012). The benefit of the snowball approach is that it enables the survey to address a broad range of individuals at cost effectively. The snowball approach offers the advantages of being quick and inexpensive, which is a need for this research. This is a relatively exploratory study, since only little research has been conducted on vehicle sharing in China, and it is unlikely that such information could be acquired in any other manner due to cost and time constraints. Additional research will be necessary to corroborate the study's conclusions in China's broader environment. Nonetheless, they may be compatible with studies conducted elsewhere.

3.3.1.5 Responses

Participants were given a full month to respond to the survey, which started on March 8, 2022, and ended on April 8, 2022. In total, 2087 responses were received in the survey. Online advertisement is recorded [4] due to the snowballing recruitment method utilised and responses are anonymous. This indicates that the number of people who have viewed the advertisement online cannot be determined, and that the advertisement can be forwarded and shared online. Correspondingly, I do not track such data. Therefore, I am unable to calculate the survey response rate. [5] Participants who were unable to answer more than 50% of the survey questions were eliminated from the dataset for a more comprehensive analysis. There were 2,087 valid replies remained after that, which were included in the analyse.

3.3.1.6 Survey Data Analysis

Based on whether the responses were closed-ended or open-ended, the results of the online survey were divided into two groups. Microsoft Excel and SPSS were utilised for data preparation and analysis. The analysis eliminated missing data pairwise.

First and foremost, responses to closed-ended queries were re-coded as necessary, for instance when a respondent listed a particular response under the "other" category. The sample was then analyzed to determine the demographic features of the participants and to determine if it was representative of China. In the frequency chart, the gender, age range, wealth, and highest level of education of the sample are compared to the findings of China's seventh population census, which took place in 2020.

3.4 Data Collection Limitations

The fundamental limitations of the data gathering methods used in this research have been outlined. The decision to conduct the survey online was made as it is a quick and economical way to reach a sizable population, though it may restrict the pool of participants to those with internet access and rudimentary computer knowledge. The sample size was 2,087 due to the snowball recruitment strategy, which prompted respondents to forward the survey link to their friends. This strengthens the credibility of the results and conclusions. This strategy, however, results in participant self-selection, which may lead to bias against certain demographic groups.

3.5 Summary

Using a pragmatic quantitative and qualitative method approach, this study collected quantitative and qualitative information on car sharing in China. Statistical analysis of numerous crucial factors, such as attitudes towards automobile ownership, travel habits, and interest in vehicle sharing, was made possible by information from an online survey of Chinese

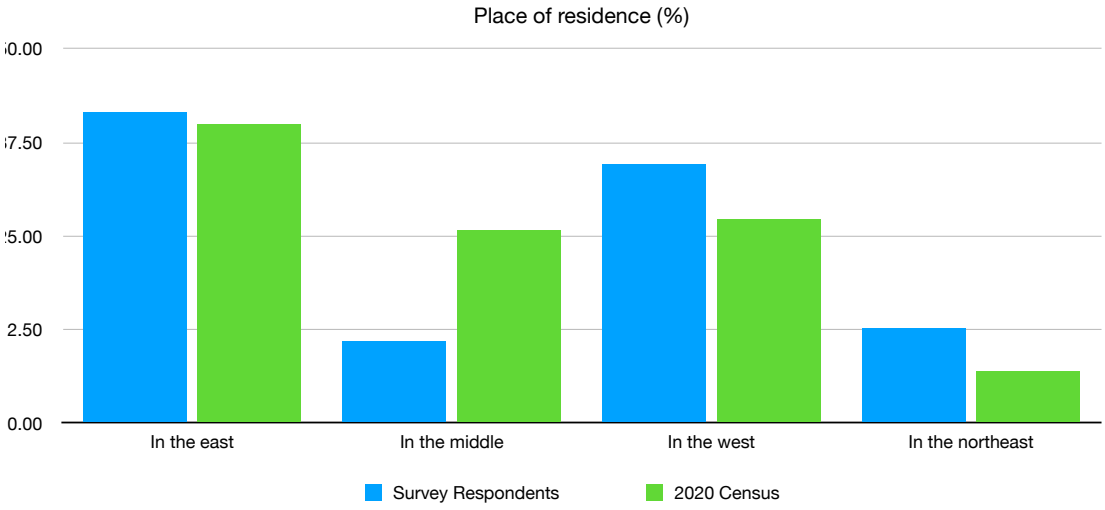
participants. The advantages of car sharing, its potential contribution to compact living and sustainable transportation, and its obstacles in China were analysed.

Chapter 4. Findings and Discussion

4.1 Introduction

The purpose of this Chapter is to present the most important discoveries made throughout the course of this dissertation, taking into account both the quantitative and qualitative research. In order to precisely address the central research question, which is "How to develop sustainable car sharing in China?"

4.2 Survey Characteristics



Place of residence (%)

	Survey Respondents	2020 Census
In the east	41.64	39.93
In the middle	11.02	25.83
In the west	34.74	27.12
In the northeast	12.60	6.98

Figure 18 Place of Residence of the survey sample (n=2087) compared with 2020 census data for China.

Figure 18 summarizes and classifies the cities according to the residence cities filled in by the interviewees. The categorisation of cities into four regions allows for a more accurate comparison with China's population census data (2020). Since there are no participants from

Hong Kong, Macao, or Taiwan in the data, no comparisons can be made among these locations. To demonstrate the multi-disciplinary characteristics of this research, we designed this survey for different region of China from the east, middle, west and northeast areas. Different areas have different culture, economic development level, development standard is also different. As ewe known, middle and east has more developed cities and car sharing will be more welcome in this regions. Also, different gender will also affect our results. Therefore, we designed all genders in this survey, due to their affection on car driving is different, man will more interested in driving than woman, while car sharing maybe show different because car sharing will be more convenient and cost-friendly. Moreover, age difference will also be considered, in which, 18-35, 36-50, 51-64. 65+, totally five levels will be classified as different level and the survey results will be considered differently.

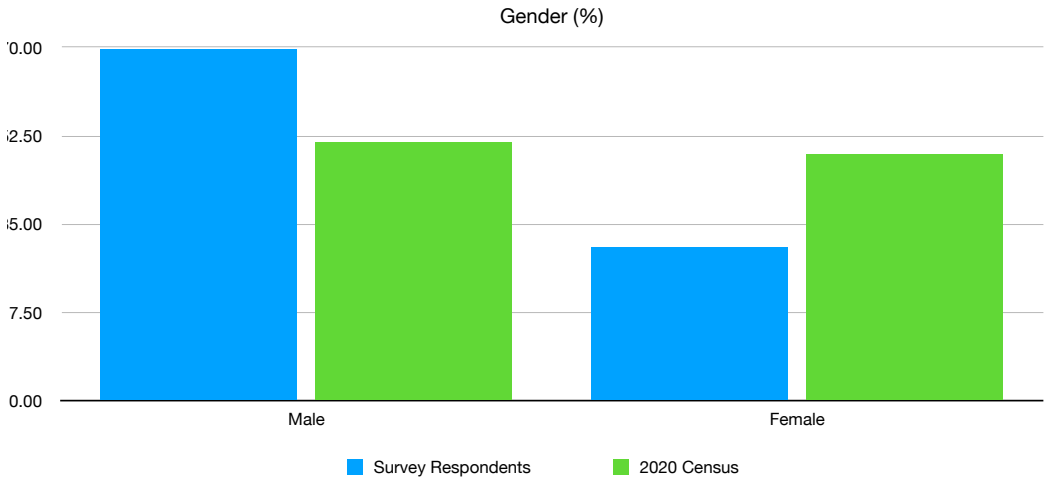
Northeast	Liaoning province, Jilin Province, Heilongjiang Province
Eastern	Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan
Central	Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan
Western	Inner Mongolia Autonomous Region, Guangxi Zhuang Autonomous Region, Chongqing Municipality, Sichuan, Guizhou, Yunnan, Tibet Autonomous Region, Shaanxi, Gansu, Qinghai, Ningxia Hui Autonomous Region, Xinjiang Uygur Autonomous Region

Figure 19 Source of information.

The essential demographic information pertaining to the 2,087 participants has been outlined in Figure 19 above. When compared to the survey for the 2020 Census, the distribution of the participants is relatively in line with the results of the 2020 Census, with the highest participating rate being in the eastern regions of China. With Hangzhou, Suzhou, Ningbo, and Shanghai ranked first, second, third, and fourth, respectively, in terms of the number of shared bikes in China, this corresponds significantly with the research results discussed in section 2.5.2. These four cities are all typical Eastern Chinese cities with relatively high GDP strengths. More

importantly, the number of shared bikes in China in 2016 reached 66,500, compared to 55,680 in Wei Fang, the city with the second-most shared bikes in China, with 16% more in total in Hangzhou.

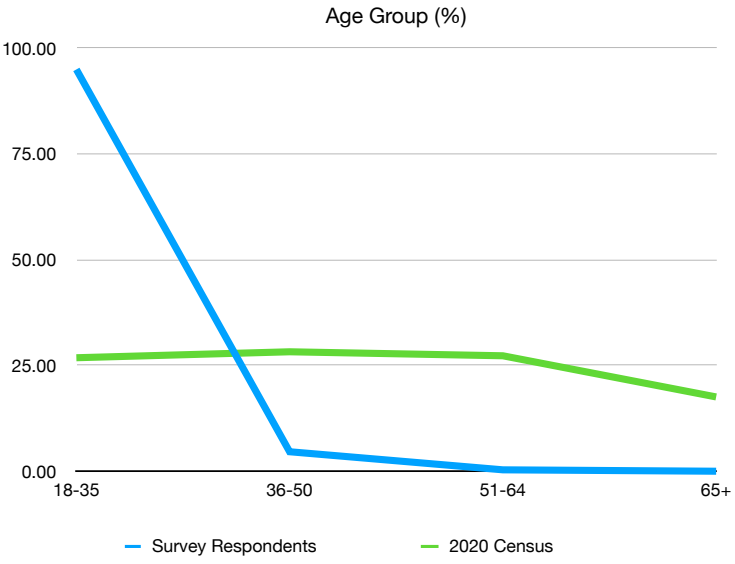
The results of the 2020 Census in China showed that the percentage of residents in Western China had increased more in 2022 compared to the results revealed in 2020, indicating that, shared mobility has become more prevalent throughout China's less developed regions.



Gender (%)

	Survey Respondents	2020 Census
Male	69.67	51.24
Female	30.28	48.76

Figure 20 Gender of the survey sample (n=2087) compared with 2020 census data for China.



Age Group (%)

	Survey Respondents	2020 Census
18-35	94.92	26.85
36-50	4.65	28.25
51-64	0.38	27.31
65+	0.05	17.59

Figure 20 Gender of the survey sample (n=2087) compared with 2020 census data for China.

Figures 20 and 21 compare selected sociodemographic data from the sample with the latest China census data to better understand the characteristics of respondents. These data demonstrate that the research sample is not typical of the Chinese resident population. This is likely owing to the constraints of the self-selected sample strategy we discussed before.

As reflected on Figure 21, the age distribution of the sample indicates that there is a significant bias against those aged 18 to 35 and that those aged 65 and older are underrepresented.

The statistical technique utilised is the Kruskal-Wallis test. This study aims to investigate the factors that affect the level of interest in shared cars. The dependent variable in discrete outcome modelling is comprised of categorical variables. There are three prerequisites for applying ANOVA techniques: all populations must have a normal distribution, all populations must have equal standard deviations, and samples must be drawn independently. These are the inspection procedures:

1) List all the observations $N = \sum_{i=1}^{m} n_i$ of each sample in an increasing order.

2) The value of Ri (i=1, ⋯, m) represents the sum of the ni observations of the i-th sample, X1, ⋯, Xni's rank in this permutation.

3) Calculation statistic.

4) To a control for a given significance level p, a significance correlation exists if this value was> 0.05.

4.3 Research question

Originally, we designed several questions on the survey on the topic “How to develop sustainable car sharing in China?” Where, multi-disciplinary independent research will be considered in this survey. Different region of China, specifically different cities will be investigated. Moreover, gender differences and age differences will also be considered in this

survey to further study the car sharing potential and the sustainable development of car sharing in China.

Specifically, according to the economy development difference of different regions, we designed different questions and same questions corresponding to different people in different region. For instance, in Shanghai, and Beijing, it's quite difficult to acquire a licence plate due to lots of people working in these two cities as the merging cities and super cities in China. Therefore, even they can afford a car but they cannot apply for a licence plate, which makes it meaningless to drive cars in these cities. Also, play as huge and super cities in China, branding No.1 and No.2, cities are very large in size and often public commuting sessions cost a lot of time on the road. This in turn makes everyday travel very difficult. This is also the difference in geography, and we have to take it into account. In other cities, although modernization is very high, they still cannot compare with Beijing and Shanghai. It is not difficult to buy a car and apply for a license in these cities. Therefore, the questionnaires for the two cities are different.

Moreover, gender differences are also very pronounced. In modern society, the proportion of male drivers is much higher than that of females, so the gender factor should also be taken into consideration. At the same time, boys and girls also have different preferences for car sharing, which is closely related to the occupations and social status of men and women in society. Therefore, different questionnaires are designed here for men and women. This is more scientific and more in line with the requirements of diversification.

Finally, the age factor was also taken into consideration. Because vehicles are relatively valuable items, young people often do not have the strength and money to own a vehicle, because young people do not have enough savings to realize their car purchase plan when they are in school or when they find a job. However, middle-aged men or women over 35 already have a certain financial strength and can include buying a car in their annual list. The elderly may need more than one vehicle at home due to further accumulation of wealth. For example, when working, you need a more commercial car or Multi-Purpose Vehicle (MPV). But in leisure time, the vehicles that accompany the family need to be lighter or more practical and

safer. When satisfying your own driving pleasure, you may need a performance car as your preferred vehicle. At this time, the age gap is reflected. At the same time, the elderly may consider giving up the plan of buying a car and driving. As their bodies age, their ability and desire to drive will decrease.

4.3.1 Explore ways of encouraging car sharing in China

There is a scarcity of international research on the challenges that individual car sharing consumers confront. In order to gain a more thorough insight of automobile sharing in China, participants to a survey were asked both closed- and open-ended inquiries about their concerns with vehicle sharing. We inquired from the participants what would motivate them to use the service. The responses are outlined in this section.

The study began by addressing the question, "How do I hear about car sharing? The results (Figure.21) indicate that as many as 98.56% of participants learned about car sharing services through commercial channels. It is evident that commercial advertising can encourage consumers to use car sharing services to some extent.

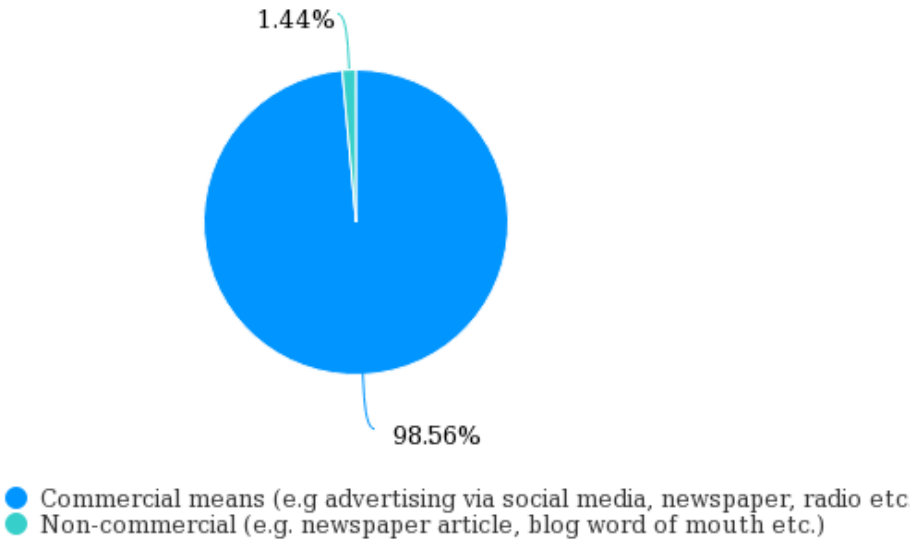


Figure 21 The sample "How do I hear about car sharing?".

Analysis of urban crowd travel data

Residents travel for the following reasons, which can be grouped into the following categories:

Working, attending school, shopping, daily affairs, recreation, conducting business, and returning home.

Activity processes are characterised by a travel chain (a chain of activities that begins with the first travel purpose and ends with returning home).

The most common travel chain includes:

(1) Working — returning home

(2) Working — shopping — returning home

(3) Working — daily affairs — returning home

(4) Working — recreation — returning home

Travel for work and education (including the equivalent return journey) is also referred to as commuting or subsistence travel, and when coupled with travel to and from employment and school, commuting accounts for about 80% of all travel. Commuter travel belongs to the category of rigid travel, which is characterised by time constraints and obvious peak phenomena. This type of travel, recognised as flexible or life travel, is less constrained by time and accounts for approximately 20% of all travels (Xu, 2007).

Therefore, the majority of users utilise car sharing services as an alternative to commuting, and easier access to car sharing services has become a crucial factor in promoting car sharing.

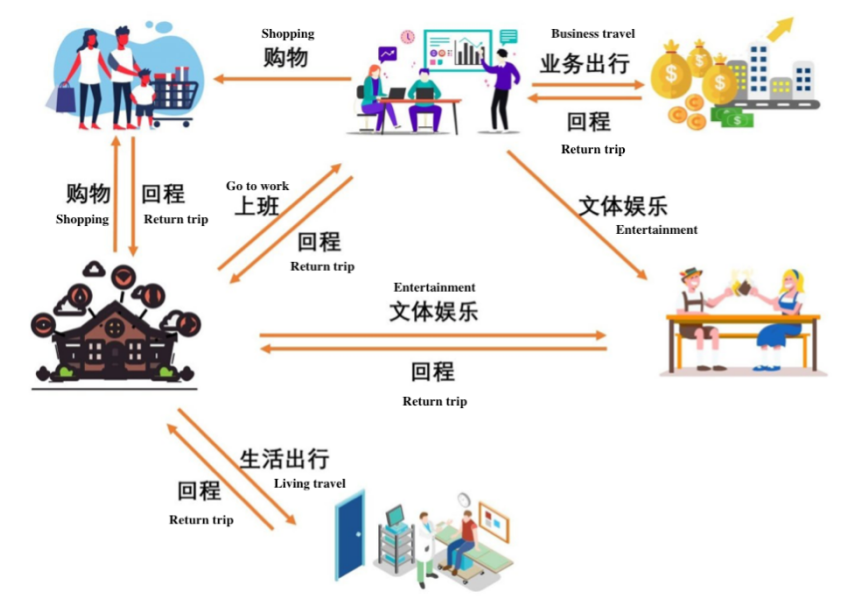


Figure 22 Schematic diagram of travel chain for each travel purpose

The samples have been subjected to reliability analysis. Figure 24 depicts the findings of Cronbach's α coefficient, including Cronbach's α coefficient value, standardised Cronbach's α coefficient value, the number of item and sample that are employed to quantify the data dependability. The model's Cronbach α coefficient is 0.972, denoting an outstanding questionnaire reliability.

Output result 1: Cronbach's alpha coefficient table

Cronbach's alpha coefficient	Standardize Cronbach's alpha coefficient	Number of items	Number of samples
0.972	0.980	18	2087

Figure 23 Cronbach's α coefficient results of sample reliability analysis.

In light of the fact that the value of the Cronbach's α coefficient is 0.972, which is both a very high and reliable value, the analysis for the data shown in Figures 20 and 21 that involve the demographic descriptive information of the participants can be assured to be of high quality.

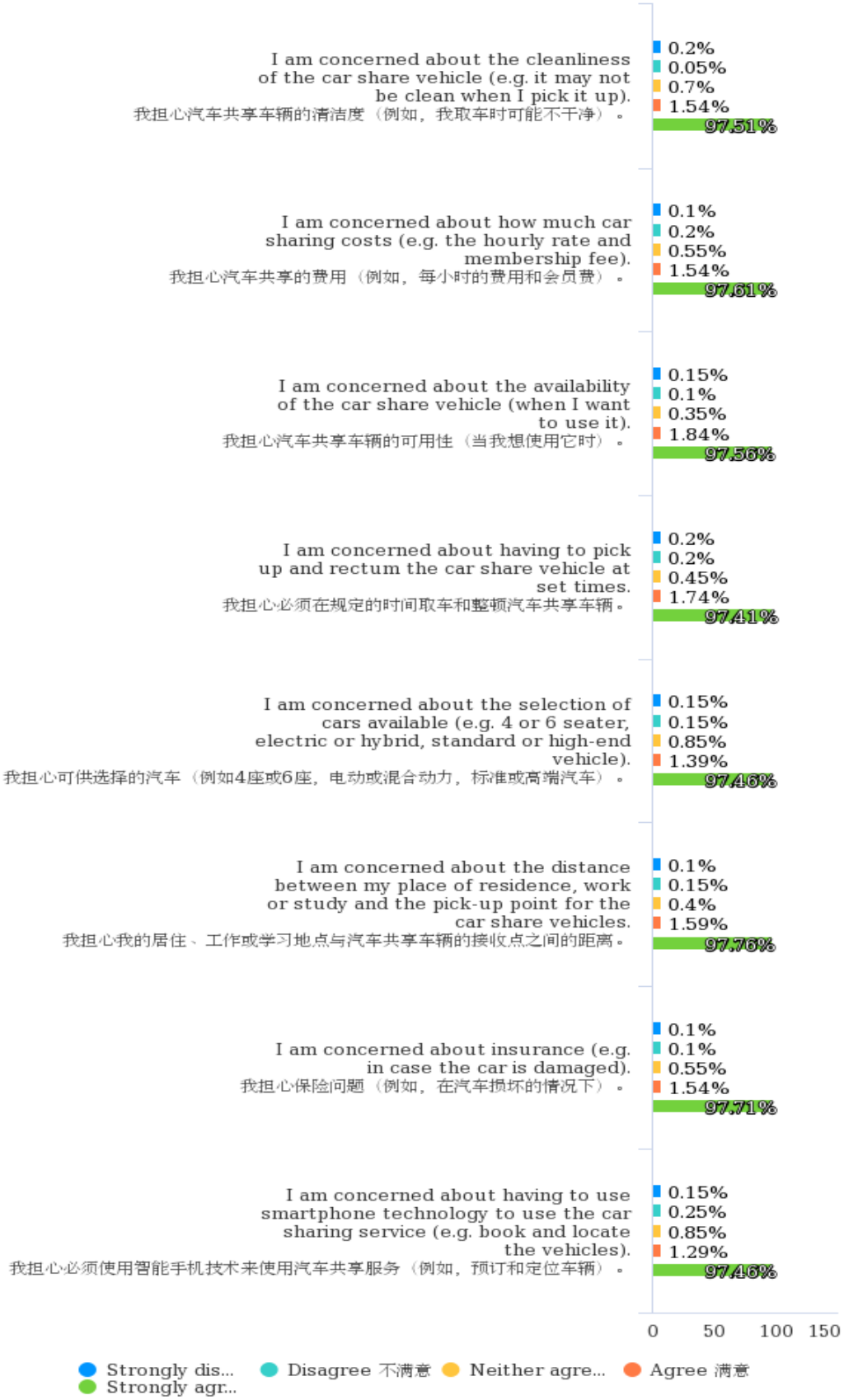


Figure 24 The sample on a series of concerns about the use of car sharing.

Figure 25 illustrates the degree to which participants concur with a variety of issues regarding automobile sharing. The statement "I am concerned about the distance between my residential location, employment, or education and the pick-up site for car sharing cars" obtained the greatest degree of agreement, with 97.7% strongly agreeing and 1.59% agreeing. This was followed by "I worry about insurance" (97.7% strongly agree, 1.54% agree).

However, "I am concerned about having to pick up and return the car share vehicle at designated times" and "I am concerned about having to use smartphone technology to use the car sharing service" had the highest proportion of respondents who disagreed; 4% of respondents said they did not agree. It was followed by "I am concerned about how much it costs to share a car" and "I am concerned about the selection of available cars," with 0.3% disagreeing.

According to the poll findings, individuals in China have a number of challenges with vehicle sharing, and practicality, affordability, and environmental concerns are the primary motivations for car sharing.

The two main issues with vehicle sharing that respondents were worried about were availability and cost. The majority of respondents were also concerned about the need to return car share cars at specific times, the proximity of the vehicles to their homes, the cleanliness of the cars, and the insurance coverage. In addition, respondents expressed worries over vehicle security and maintenance, sharing with others, different operational challenges, and the environmental effect of car sharing if it encourages individuals to drive.

	How would you describe your place of residence?	What is the main transport method?	What is the main reason you used or are using car sharing?	Car sharing would be a more environmentally friendly alternative to car ownership.	I'm concerned about the cleanliness of the car sharing.
Kruskal-Wallis	63.551	217.551	78.780	1336.867	1291.930
df	2	2	2	2	2
p-value	.000	*.000*	.000	.000	.000

Figure 25 How interested are you in using car sharing?

The question now is, what factors influence Volkswagen's interest in the launch of a car sharing programme? The author conducted a questionnaire survey on this issue, researched the factors that may influence the launch of shared cars, and selected the five representative factors shown in the table for analysis and exploration.

First, one of the most significant factors that determined whether the residents were interested in using shared cars was the floor height of their residence. As depicted in the image below, the higher the height, the more willing they are to use shared cars, whereas single-family cars and people living in rural areas are not interested. According to the findings of this research, the presence of high-rise housing denotes the presence of a significant number of residents and residents. When compared with residential buildings on the ground floor, spacious villas, the countryside, and other locations, the supply of parking space in high-rise residences is limited; as a result, residents of these types of buildings are more likely to utilise shared cars. In a similar vein, this collection of data serves as a timely reminder that the high demand for parking spots is one of the primary factors that drive people to opt for the more affordable and convenient option of parking shared cars. In order to realise the purpose and social value of shared cars, the quantity and location of the cars must be taken into account during their actual operation.

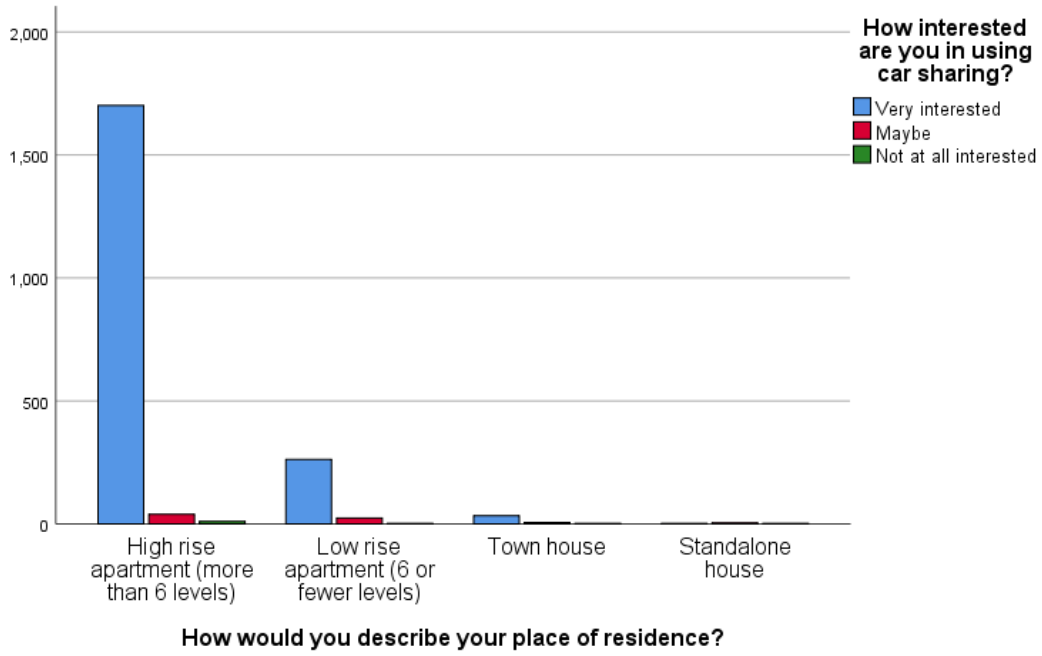


Figure 26 Place of residence connected to interested degree.

Second, the residents' primary modes of transportation correlate strongly with their interest in shared cars. As shown in the graph below, motorists are the most enthusiastic about the introduction of shared cars, followed by residents who rely on public transportation and car-less taxi riders. This is also due to the impact of the accompanying concerns with shared cars, as was discussed earlier in Chapter 2. It is difficult to give up the convenience of driving, and car sharing is one solution that can help alleviate this problem to a large extent; however, motorists face a number of challenges, the most significant of which are parking and vehicle maintenance. As a result, in the actual operation process, the pertinent businesses and departments had the best insights for how to maximise customer needs after rigorous consideration.

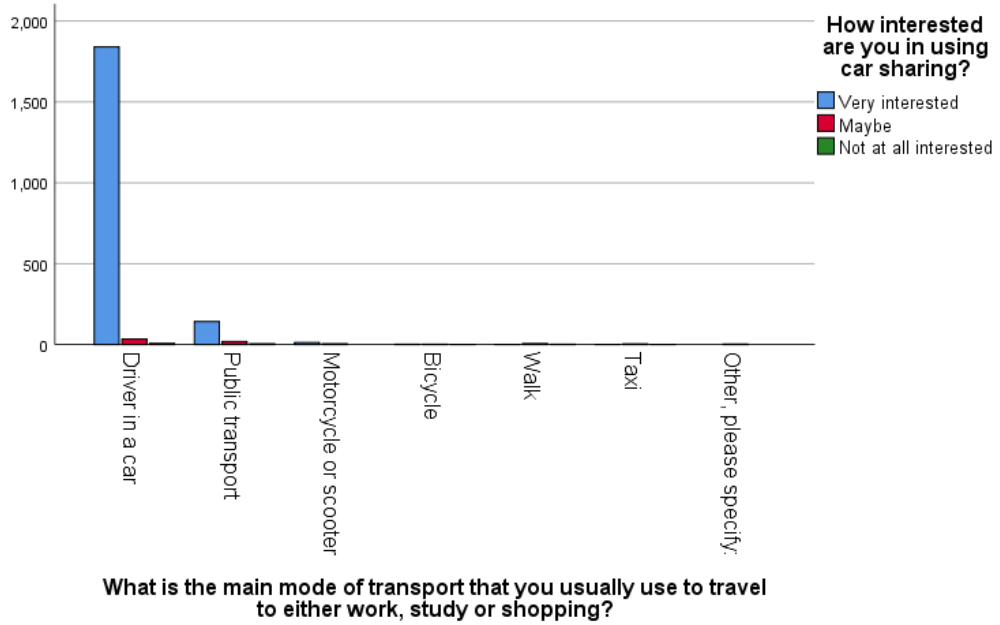


Figure 27 Main mode of transport&Interested degree.

Third, there is a significant relationship between the reasons for using shared cars and the level of interest in launching shared cars. The proportions of cost, convenience, and environmental protection are depicted in the figure below, with cost dominating by a significant margin. Car sharing has the advantage of only requiring payment of the cost of use, as opposed to insurance, gasoline, and other maintenance costs. This reduces the economic pressure and living expenses of residents, which is one of the primary economic benefits of car sharing.

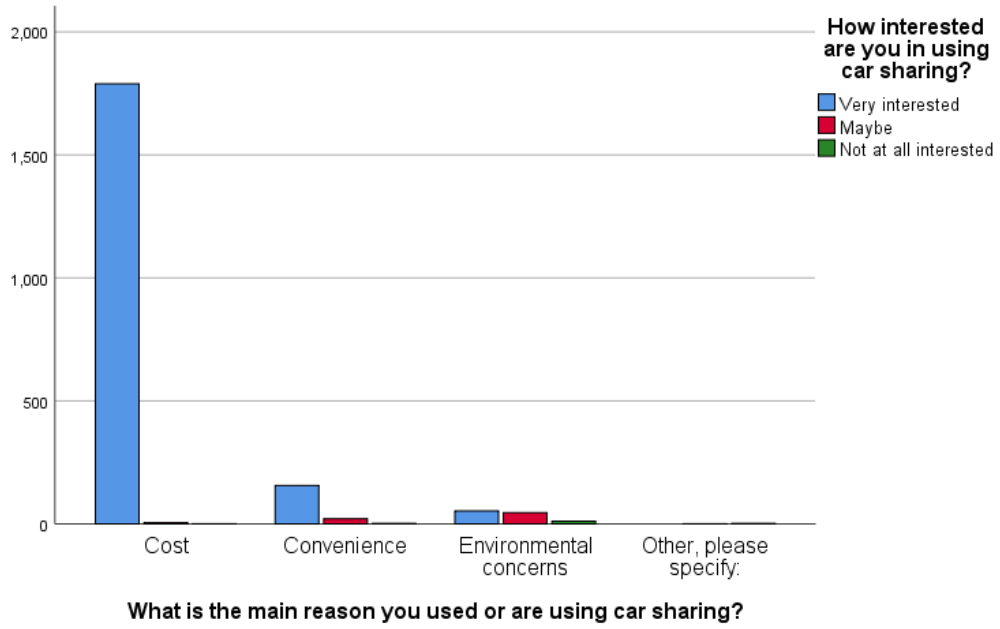


Figure 28 Main using reason&Interested degree.

The environmental friendliness of car sharing is a significant factor in whether residents are interested in it. As depicted in the figure below, a sizeable proportion of individuals who agree that car sharing is a more eco-friendly mode of transportation will also be interested in car sharing delivery. The superstructure is established by the so-called economic foundation. In the present era of abundant material resources, the spiritual world of residents, such as environmental awareness, is also enriched. It is impossible to ignore both the convenience cars provide for humans and conversely, the damage they cause to the environment, just as it is impossible to ignore the effects of greenhouse gas and exhaust pollution mentioned in the literature review chapter. Sharing cars can reduce greenhouse gas emissions and factories related to automobile manufacturing, thereby reducing water pollution, air pollution, and light pollution, making it an equally environmentally friendly mode of transportation as sharing bikes. In addition, it encourages investors to encourage the shared car manufacturing industry to develop more environmentally friendly new energy sources to realise its environmental benefits.

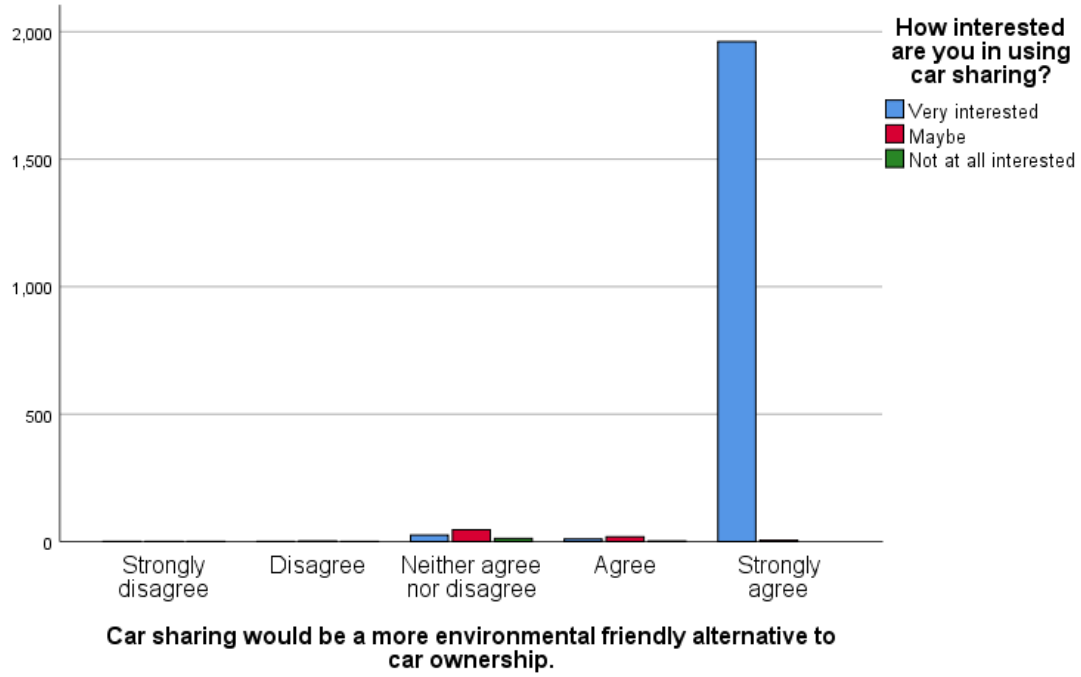


Figure 30 Environmentally friendly&Interest degree.

Finally, the interior hygiene of the shared vehicle has an effect on its delivery density. As depicted in Figure 31, the participants who are most concerned with the hygiene of the vehicle are also the most interested in car sharing. The benefits of car sharing to society and the environment as a whole are desirable, but there are also individual risks that cannot be ignored. The greatest advantage of private cars over shared cars is that they are highly private, highly personalised, and relatively guaranteed in terms of sanitation and hygiene. Due to the sharing and high circulation of shared cars, the question of whether their interiors can be kept clean is a significant issue. In contrast, the solution to this problem, in addition to the early formulation of a sound supervision and management system, should also be adjusted in response to changes in the actual situation. In order to fundamentally resolve this issue, it is essential to ensure that the minimum qualification of users exceeds a certain benchmark.

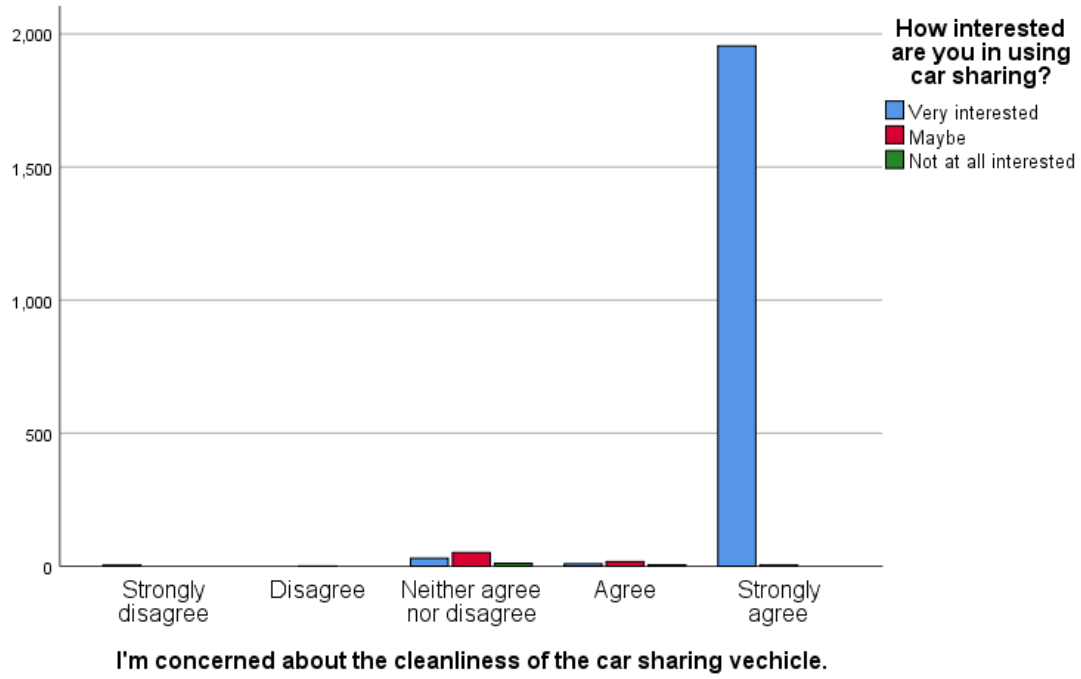


Figure 31 Cleanliness&Interest degree.

4.4 Discussion

Few studies have been conducted on the concerns of car sharing among the general public. However, based on the available literature, the concerns raised in this study are comparable to those raised in other countries. For instance, Nawangpalupi and Demirbilek (2008) discovered that the most common complaint among car sharing customers was the lack of availability. Liability in the event of a car share vehicle theft or accident, as well as the safety features of car share vehicles, posed the greatest concern regarding car sharing in Beijing, China (Shaheen & Martin, 2010).

Many respondents indicated that they are likely to utilise car sharing if it were less expensive than owning a car or if there were more restrictions on car ownership. Many respondents indicated that they would be more likely to utilise the service if it was simple to use and adaptable, as well as highly available and in the vicinity. The use of electric vehicles and the potential for car sharing to reduce emissions were also significant factors. According to the findings of Nawangpalupi and Demirbilek (2008), vehicle share users in Sydney were primarily

motivated by practicality, economic efficiency, and environmental concerns. According to the authors, car sharing can attract customers by eliminating many disadvantages of private car ownership. Car sharing, for instance, could attract individuals with limited access to parking for private vehicles if there are designated parking spaces for car share vehicles (Nawangpalupi & Demirbilek, 2008). Likewise, car parking is one of the most challenging elements of driving in Beijing; therefore, offering guaranteed parking spots for car sharing cars would be a huge advantage of using the service (Shaheen & Martin, 2010). Those respondents who did not have access to parking at their place of work or education were more interested in car sharing. Those poll respondents who regarded parking easy at their home location were less interested in car sharing. The findings of the survey indicated that car sharing is more effective in locations with a higher population density since residents already have good access to facilities and transportation options, automobile ownership is more costly and inconvenient, and parking space is limited as well. Density is essential for constructing a car sharing network since it allows a network of automobiles to be placed within easy access of a large number of users.

In general, the survey results reveal a number of concerns regarding car sharing. By offering a low-cost, convenient, and environmentally friendly substitute for car ownership, many of these problems may be mitigated. Automobile sharing has the potential to alleviate many of the disadvantages of car ownership, such as the need for dedicated parking places.

Families that want to avoid purchasing a second automobile may explore car sharing. Automobile sharing may also attract environmentally conscious individuals seeking a more sustainable option for car ownership. Participants also hypothesised that consumers of car sharing services are "clever" or have a "millennial mindset".

It can encourage public transportation, walking, and cycling while improving public health. Instead of purchasing a vehicle, individuals and businesses can make significant financial savings while simultaneously expanding their range of available transportation options by participating in car sharing programmes. Car sharing can save individuals money and expand their transportation options by offering a substitute to car ownership. Additionally, car sharing may be an effective approach to addressing sustainability.

The survey findings are crucial for determining whether car sharing can be a practical substitute for ownership of a vehicle and whether it can be used in conjunction with other modes of transportation such as biking or walking. There was a substantial association between participants' willingness in car sharing and their primary mode of transportation to work or school, food shopping, and leisure activities.

This paper also emphasized that car sharing is supplementary to other forms of transportation, despite the fact that they compete with one another. Automobile sharing serves as a potential substitute to car ownership for those whose driving demands are met by other means the majority of the time.

Those who mostly use active or public transport are far more inclined to be excited about vehicle sharing than those who primarily drive. Car sharing is more convenient than owning a car for those who are interested, it would increase their transportation options, and it is regarded as an environmentally responsible alternative to car ownership. The participants believe that modes of transportation such as public transportation, walking, and cycling help support vehicle sharing as they enable travellers to reduce their reliance on private vehicles.

Automobile sharing was thought to fill a transport network gap by offering a viable alternative to car ownership. In addition to promoting public transit, walking, and cycling, it may also compete with them.

According to the results of the survey, modern technology may play a significant role in promoting car sharing in China. Technological innovations include the most up-to-date electric vehicle (EV) technology and operating technologies such as computerized reservation systems, invoicing, and vehicle access.

As stated above, car sharing is capable of facilitating the public adoption of modern technologies. Globally, car sharing companies are increasingly utilising modern technology. It has been discovered that the inclusion of electric vehicles in car share fleets, as well as the usage of smartphone technology to locate and book car share vehicles, are likely to entice those who are most interested in car sharing. In 2015, EVs were incorporated into car sharing

programmes in more than half of the countries that offer car sharing. (Shaheen & Chan, 2015). As EV technology advances and prices decline, EVs will become more common in car-sharing fleets. Modern operational technology, such as computerised booking, are important to make vehicle sharing convenient and running the network. Modern technologies, it is clear, will play a critical role in the success of car sharing in China.

This research demonstrates how current technology and automobile sharing are inextricably linked. Globally, car sharing companies have incorporated modern technology to manage their networks and enhance the convenience of their services (Shaheen & Cohen, 2013). In China's car sharing operations, modern technology appears to play an increasingly significant role. The benefits of car sharing are autonomous and do not include electric vehicles.

The findings of the survey show that car sharing companies in China are making progress in attracting new clients. Among survey respondents, the availability of electric vehicles and smartphone technologies was positively correlated with their interest in and likelihood of using a car-sharing service. Car sharing and modern technology are inextricably linked. In other words, the respondents to the survey who are most interested in car sharing would be motivated by modern technologies to participate in car sharing. It is more likely that respondents who are not interested in car sharing at all will be dissuaded by the incorporation of modern technologies. Those who were most concerned about the environmental effect of automobile ownership were also more likely to utilise car sharing if the service utilised electric cars. Because of consumers' concern for the environment, this is crucial information before signing up for a vehicle sharing program.

As technology advances and costs decrease, the majority of stakeholders believe that all car sharing companies will eventually adopt EVs. However, many interviewees expressed concerns about deploying EV technology at this time as it might pose a risk or complicate service quality. Moreover, without adding EVs to car sharing fleets, car sharing offers a number of compelling benefits. Surprisingly, a number of participants expressed a desire for driverless technology to be added to car sharing services, thereby increasing their interest in car sharing services. Today,

car sharing services have gradually permeated society. It has greatly influenced people's way of travel, way of life and even way of thinking.

Now, as a result of the fast growth of the information era, science and technology have been thoroughly incorporated into modern society. The advancement of driverless car technology is unstoppable. Driverless cars will gradually integrate into people's daily lives in the coming decades, changing their traditional daily travel mode and routines. The future market for autonomous vehicles has enormous growth potential, and autonomous vehicles will also progress toward commercialization and scale.

The majority of respondents believed that current technology, for instance, the online booking, was essential for the management of car sharing networks, rendering the service convenient, and enhancing the vehicles safety. According to the opinions of stakeholders, it was evident that modern technology plays a crucial role in the success of car sharing in China increasingly. The benefits of its social, economic, and environmental can be an effective instrument for discussing sustainability, and it may temper China's car culture. This is a benefit discovered by this research that has gotten less attention in the literature and is particularly pertinent to China. By altering perceptions of automobile ownership, car sharing might help China transition away from private car dependence and toward sustainable mobility practices.

This research found that the people who are most interested in using car sharing in China have similar features to car share members in other countries. This thesis has discovered a significant advantage that car sharing can provide in China, most of which are like those found elsewhere. car sharing maybe most critically, can reduce car ownership and usage, hence reducing traffic congestion, parking demand, and greenhouse gas (GHG) emissions in China. Car sharing has numerous social, economic, and environmental advantages. It can help China's compact and sustainable transportation patterns. Car sharing providers in China must overcome a series of obstacles, particularly those related to parking and financing, to become widely used.

There is a case for both the central and local governments to encourage vehicle share companies, in particular, in the early phases of the development, because of the public good benefits that car sharing can give. Significant effort has already been devoted in China to tackle the barriers

to car sharing, but additional support for the practise might allow China to fully benefit from its advantages.

This thesis demonstrates how car sharing can benefit people in China by providing a convenient alternative to owning a car and so improving their transportation options. Some journeys need the use of a car, and taxis or auto rentals are not always appropriate. Car sharing bridges a major gap in the transportation system.

Car sharing can also help to increase the use of alternate modes of transportation, broaden the transportation options available to Chinese citizens, and improve access for low-income households. Furthermore, car sharing has the potential to improve public health, save individuals and businesses money, and encourage the adoption of current technologies. Furthermore, the government may encourage car sharing by guaranteeing that the expenditure of private automobile ownership can reflect all social expenses and eliminating driving incentives.

This research has shed light on the challenges that car sharing faces in China, as well as how these challenges might be overcome. Car sharing raised a range of concerns among survey respondents, including the accessibility of shared car and the expense. Car share participants are generally motivated by practicality, affordability, and environmental concerns. By providing allocated parking places for car share vehicles, the potential of automobile sharing to circumvent many of the drawbacks and expenses of private ownership might be advantageous..

Access to car parks is crucial for providers, and economic aid may support them grow and become self-sufficient. Car sharing is further hindered by a lack of public awareness and China's car culture. Local and central governments may aid car share firms by offering low-cost or free parking as well as financial endorsement based on the demonstrable public good advantages of car sharing.

The international literature highlighted funding vehicle sharing as a significant hurdle, particularly for new market participants (Barth & Shaheen, 2002; Bleischwitz et al., 2009; Enoch & Taylor, 2006; Litman, 2000). Relatively few car sharing programs are wholly financed

by user fees and rely on government and private investors for funding (Barth & Shaheen, 2002; Shaheen et al., 2004). The government has provided start-up incentives, guaranteed usage by government organizations, and subsidised parking access. The Low Emission Vehicle Contestable Fund has offered car sharing companies in China a source of financing. However, this funding is oriented toward programs that promote the use of electric vehicles. Car share operators might be backed by financing that is tailored to their services and recognises the variety of public good advantages that car sharing provides, irrespective of whether their vehicle fleets incorporate EVs.

Local authorities might possibly assist car share operators by highlighting the social, economic, and environmental advantages of automobile sharing to the general public. Several respondents advised that local and federal governments raise the cost of automobile ownership to represent its full societal expenses and eliminate incentives for travelling, including free parking, in order to influence China's car culture. As noted previously, one potential advantage of vehicle sharing is its capacity to fight automobile culture by offering an alternative to car ownership. However, the possibility of vehicle sharing to aid the nation's shift to more sustainable transportation patterns warrants additional investigation.

Chapter 5. Conclusion

5.1 Limitations and future research

The national economy and the way of life of the populace both greatly benefit from the sustainable growth of urban transportation. Given its special qualities, socioeconomic and environmental systems are exerting significant pressure on the development of transportation networks. On the one hand, the transportation system must become more efficient in order to fulfill the socioeconomic system's daily growing need for the movement of people and goods. To satisfy the demands of an ecologically conscious society, it should instead cut resource usage and emissions. The management of transportation that is focused on sustainable development is severely hampered by these two apparently incompatible criteria. Urban transportation networks seem to be under conflicting strain from socioeconomic and environmental systems. This research offers a remedy for this problem that is based on the source of all complicated transportation operations, i.e., person behavior.

This thesis makes the case that, from the standpoint of "system emergence," we must place significance on the instruction of citizens' mobility habits if we are to build a sustainable transportation system. In this paper, we provide a paradigm for hierarchical analysis that breaks down the management of transportation networks into four tiers, from the macro to the micro levels. A number of topics relating to various transportation-related behaviors, such as purchase behaviors toward NEVs (new energy vehicle), choosing behaviors toward green travel modes, and behavioral responses against TDM (transport design manual) rules, are examined from top to bottom of the framework. Finally, based on the study findings, practical managerial lessons are gleaned that may help transportation administrators establish and enhance sustainable traffic management strategies.

However, this research contains a number of flaws. Given the absence of consideration for and attention to new travel modes and services, such as bicycle sharing and customized buses, and the fact that this study primarily focuses on conventional forms of transportation, it is not sufficiently comprehensive. Transport services are crucial for the development of sustainable urban transportation systems and should get enough academic attention.

Overall, the survey's findings indicated that some Chinese citizens were interested in carsharing, but that this interest was also influenced by a number of important variables. A common combination of characteristics shared by carsharing members throughout the world is that interest in carsharing increased with educational attainment and decreased with age. At the same time, as family income increased, carsharing interest decreased. Travel patterns and intentions for purchasing vehicles were two other factors that sparked interest in carsharing. Carsharing enthusiasm was more prevalent among those who mostly used the subway for shopping as opposed to those who primarily utilized taxis.

Additionally, a tiny percentage (11%) of families with automobiles said they would be prepared to give them up if carsharing was made accessible. The carsharing idea was better appreciated by those who intended to buy a car soon (within 1 to 3 years). These findings, together with the more general macroeconomic conditions mentioned previously, did not clearly show that carsharing would be adopted in major Chinese cities if it were made accessible. Instead, the findings supported the idea that neighborhood carsharing would encounter a number of difficulties in achieving a large consumer base and the fast membership expansion seen in the US. In China, the cab is a significantly more significant part of urban mobility than it is in U.S. transportation systems. A population with little driving expertise may access automobility through taxis. It is not immediately clear that much driving expertise is even required given the abundance of taxis and the quickly expanding public transportation systems.

Additionally, land usage and parking expenses are high in Chinese cities, thus the economics are typically against a business strategy that requires the deployment of many cars throughout a major city. This research seeks to address a significant deficiency in the existing body of knowledge regarding car sharing by concentrating on the situation in China. Consequently, this thesis investigates a variety of car sharing-related aspects, such as the perceived benefits of the service and the obstacles it faces in China. This has resulted in numerous discoveries regarding car sharing challenges and laid the groundwork for future research in the field. To delve deeper into each of the topics discussed in this thesis, additional research is required.

The existing and prospective conditions for car sharing in China played a role in the decision of the author to focus primarily on the Chinese market. With both local and central government support, car sharing in China is anticipated to grow substantially over the coming years. As a consequence, China may stand to gain from further research into city car sharing. Owing to the confinements of time and costs, it was appropriate for a master's thesis to focus solely on car sharing in China. Future studies may examine car sharing in China's major cities to determine how it varies depending on the circumstance.

Car sharing is still in its infancy in China, with only a handful of vehicles available. Rather than focusing on current car share customers, it was believed that a survey of the general public regarding their travel habits and attitudes towards car sharing would yield more information. As a result, the survey sample size was rather substantial. If the survey had been limited to current vehicle sharing customers in China, it is doubtful that a similar size of the sample would have been collected.

In addition, evaluating the whole Chinese demographic offered a more thorough view of automobile sharing's potential, allowing for a more thorough examination of both supporters and opponents of the service. As car sharing gains popularity in China, it would be beneficial to conduct research on current users. It would be beneficial to understand how vehicle sharing users alter their travel preferences prior to and after joining, in addition to the effect on greenhouse gas (GHG) emissions.

In the methodology chapter, the limitations of this study's data gathering technique were briefly mentioned. A digital survey was adopted as it represents a swift and cost-effective way to contact a large number of individuals; nonetheless, participation may be limited to those with internet connectivity and basic computer skills. The sample size was 2,087 individuals as a function of the snowball recruiting method, which encouraged individuals to forward the survey link to their contacts. This strengthens the credibility of the results and conclusions.

This strategy, however, resulted in participant self-selection, giving rise to biases against specific demographic groupings. Few details regarding businesses that employ automobile sharing are known, which is a lacuna in both Chinese and international literature. More studies

in this area may, for instance, shed light on the health and safety advantages of car sharing, which provides companies with safer automobiles than they would otherwise use. The study highlights the renewed understanding of car ownership by Chinese residents as the most significant barrier to car sharing in China. On the other hand, vehicle sharing may bring major shift to the predominance of privately owned automobile market in China and facilitate the shift to more sustainable travel practices. In the future, additional investigation may be conducted into this association.

A densely populated urban area. Finally, despite relatively low rates of automobile ownership, traffic on Chinese metropolitan roadways is very crowded. How long China's current infrastructure can support further expansion is a question. For these and other reasons, China's potential neighborhood carsharing model may vary significantly from that of Europe and North America. Carsharing in China would probably result in more people getting into privately owned automobiles, despite the fact that it was initially intended to get people out of them.

But these challenges may be solved by using certain neighborhood model designs. In parking garages open to inhabitants of big apartment complexes, carsharing vehicles may be used more often. The only people who could utilize vehicles in this "restricted" or "semi-open" neighborhood type were those who had access to the building. China is in a unique stage of its economic growth when cities are being built quickly and carsharing is commonplace. In the past, it has been advantageous (or disadvantageous, in certain situations) for new cities to develop around the dominant modes of transportation, and carsharing may be better established in China via integration with new infrastructure. Carsharing might eliminate the necessity for personal automobiles in this situation. However, unlike other places, the decreased requirement in China can manifest itself in fewer initial car purchases rather than more vehicles that are subsequently disposed of. The business model that evolves in developed Chinese cities may provide greater value via shared-mobility services, such as ridesharing, rather than shared automobiles. As a result, it is likely that carsharing in some form will develop in China. However, it is unclear if emulating the neighborhood model, which is popular in North America and Europe, would be the best course of action. Instead, given its unique position as a sizable but still-emerging economy, China may need to create a special kind of carsharing that meets

the rising demand for vehicle ownership and mobility while also enhancing the limitations of the country's current transportation infrastructure.

List of References

Acheampong, R. A., & Siiba, A. (2020). Modelling the determinants of car-sharing adoption intentions among young adults: the role of attitude, perceived benefits, travel expectations and socio-demographic factors. *Transportation*, *47*(5), 2557-2580.

Anonymous. (2017). The Ministry of Transport and the Ministry of Housing and Urban-Rural Development jointly issued the Guiding Opinions on Promoting the Healthy Development of Small and Micro Bus Rental. *Chinese business community*, (9), 94-94.

Baptista, P., Melo, S., & Rolim, C. (2014). Energy, environmental and mobility impacts of car-sharing systems. Empirical results from Lisbon, Portugal. *Procedia-Social and Behavioral Sciences*, *111*, 28-37.

Barth, M., & Shaheen, S. A. (2002). Shared-use vehicle systems: Framework for classifying carsharing, station cars, and combined approaches. *Transportation Research Record*, *1791*(1), 105-112.

Beijing Government. (2015). Beijing traffic management bureau: circular of the people's Government of Beijing municipality on limiting traffic control measures during the daily peak hours of work. http://jtw.beijing.gov.cn/xxgk/flfg/zcfg/201912/t20191231_1547502.html

Bleischwitz, R., Bahn-Walkowiak, B., Irrek, W., Schepelmann, P., Schmidt-Bleek, F., Giljum, S., ... Pratt, N. (2009). Eco-innovation-putting the EU on the path to a resource and energy efficient economy. Wuppertal Spezial, Wuppertal Institut für Klima, Umwelt und Energie. http://www.econstor.eu/handle/10419/59278

Britton, E. (1999). Carsharing 2000: a hammer for sustainable development. *Journal of world transport policy and practice*, *5*(3), 351. http://www.eco-logica.co.uk/pdf/wtpp05.3.pdf

Burkhardt, J., & Millard-Ball, A. (2006). Who is attracted to car-sharing*? Transportation Research Record: Journal of the Transportation Research Board, 1986*(1), 98-105.

Cairns, S., & Harmer, C. (2012). *The emission impacts of car clubs in London* (No. PPR591). https://trid.trb.org/view.aspx?id=1136673

China Daily. (2013). Report says on the list of the World's top 10 air pollution cities, seven of them are in China-*China Daily website* http://www.chinadaily.com.cn/hqcj/zxqxb/2013-01-15/content_8032310.html [accessed15.06.08].

China National Statistical Yearbook. (2018). National Private Automobile Ownership in China 1985-2018. http://www.stats.gov.cn/tjsj/ndsj/2018/indexch.htm.

Creswell, J. W. (2014a). *A concise introduction to mixed methods research*. SAGE publications.

Creswell, J. W. (2014b). *Research design: qualitative, quantitative, and mixed method approaches (4th Edition). Sage Publications*.

Creswell, J. W., & Clark, V. L. P. (2011). *Designing and conducting mixed methods research (2nd Edition)*. SAGE Publications.

Dowling, R., & Kent, J. (2015). Practice and public–private partnerships in sustainable transport governance: The case of car sharing in Sydney, Australia. *Transport policy*, *40*, 58-64.

Early, L., Howden-Chapman, P., & Russell, M. L. (Eds.). (2015). *Drivers of urban change*. Steele Roberts Aotearoa.

Edited by the National Bureau of Statistics. (2018). *China Statistical Yearbook-2018. China Statistics Press.*

Enoch, M. P., & Taylor, J. (2006). A worldwide review of support mechanisms for car clubs. *Transport Policy*, *13*(5), 434-443.

Firnkorn, J., & Müller, M. (2011). What will be the environmental effects of new free-floating car-sharing systems? The case of car2go in Ulm. *Ecological economics*, *70*(8), 1519-1528.

Firnkorn, J., & Müller, M. (2015). Free-floating electric carsharing-fleets in smart cities: The dawning of a post-private car era in urban environments?. *Environmental Science & Policy*, *45*, 30-40. doi: 10.1016/j.envsci.2014.09.005

Fishman, E. (2019). *The Sharing Economy and the Relevance for Transport*. Academic Press.

Floater, G., Rode, P., Robert, A., Kennedy, C., Hoornweg, D., Slavcheva, R., & Godfrey, N. (2014). Cities and the New Climate Economy: the transformative role of global urban growth. http://lsecities.net/publications/reports/the-new-climate-economy- report/?/

Fowler, F. J. (2014). *Survey research methods (5th ed.). SAGE Publications*.

Fricker, R. D. (2008). Sampling methods for web and e-mail surveys. *The SAGE handbook of online research methods. London: SAGE Publications Ltd*.

Guo, Y., Zhou, J., Wu, Y., & Li, Z. (2017). Identifying the factors affecting bike-sharing usage and degree of satisfaction in Ningbo, China. *PloS one*, *12*(9), e0185100.

Hu, J. W., & Creutzig, F. (2022). A systematic review on shared mobility in China. *International Journal of Sustainable Transportation*, *16*(4), 374-389.

Hui, Y., Wang, Y., Sun, Q., & Tang, L. (2019). The impact of car-sharing on the willingness to postpone a car purchase: a case study in Hangzhou, China. *Journal of Advanced Transportation*, *2019*.

IPCC. (2014). Climate Change 2014: Mitigation of Climate Change - Chapter 12 *Human Settlements, Infrastructure and Spatial Planning. Potsdam: IPCC - Working Group III*. http://pure.iiasa.ac.at/11114/

Katzev, R. (2003). Car sharing: A new approach to urban transportation problems. *Analyses of social issues and public policy*, *3*(1), 65-86.

Kelly, P., Kahlmeier, S., Götschi, T., Orsini, N., Richards, J., Roberts, N., ... & Foster, C. (2014). Systematic review and meta-analysis of reduction in all-cause mortality from walking and cycling and shape of dose response relationship. *International journal of behavioral nutrition and physical activity*, *11*(1), 1-15. https://search-proquest-com.helicon.vuw.ac.nz/docview/1635675409/abstract/A0747E06FFB24996 PQ/1

Kent, J. L. (2014). Carsharing as active transport: What are the potential health benefits?. *Journal of Transport & Health*, *1*(1), 54-62.

Kent, J. L., & Dowling, R. (2013). Puncturing automobility? Carsharing practices. *Journal of Transport Geography*, *32*, 86-92.

Kim, J., Rasouli, S., & Timmermans, H. (2017). Satisfaction and uncertainty in car-sharing decisions: An integration of hybrid choice and random regret-based models. *Transportation Research Part A: Policy and Practice*, *95*, 13-33. https://doi.org/10.1016/j.tra.2016.11.005

Le Vine, S., Zolfaghari, A., & Polak, J. (2014). Carsharing: evolution, challenges and opportunities. *Scientific advisory group report*, *22*, 218-229. http://www.carsharing.org/research/ICL/SAG_Report_Car_Sharing.pdf

Liao, F., Molin, E., Timmermans, H., & van Wee, B. (2020). Carsharing: the impact of system characteristics on its potential to replace private car trips and reduce car ownership. *Transportation*, *47*(2), 935-970. doi: 10.1007/s11116-018-9929-9

Litman, T. (1999). Carsharing benefits to consumers and society. *World Transport Policy & Practice, 5*(3). https://trid.trb.org/view.aspx?id=1162177

Litman, T. (2000). Evaluating carsharing benefits. *Transportation Research Record*, *1702*(1), 31-35.

Litman, T. (2002). Evaluating transportation equity. World Transport Policy & Practice, 8(2), 50–65.

Litman, T. (2017). Smart congestion relief: comprehensive evaluation of traffic congestion costs and congestion reduction strategies. http://www.vtpi.org/cong_relief.pdf

Loose, W. (2010). The State of European Car-Sharing, Project Momo Final Report D 2.4 Work Package 2. http://carsharing.de/images/stories/pdf_dateien/wp2_report__englisch_fina l_2.pdf

Martin, E. W., & Shaheen, S. A. (2011). Greenhouse gas emission impacts of carsharing in North America. *IEEE Transactions on intelligent transportation systems*, *12*(4), 1074-1086. http://tsrc.berkeley.edu/sites/default/files/Greenhouse%20Gas%20Emission%20Impacts%20of%20Carsharing%20in%20North%20America%20%28final%20report%29.pdf

Martin, E. W., & Shaheen, S. A. (2011). Greenhouse gas emission impacts of carsharing in North America. *IEEE Transactions on intelligent transportation systems*, *12*(4), 1074-1086. doi: 10.1109/tits.2011.2158539

Martin, E. W., & Shaheen, S. (2011a). The impact of carsharing on household vehicle ownership. *Access Magazine*, *1*(38), 22-27. http://escholarship.org/uc/item/7w58646d.pdf

Martin, E. W., & Shaheen, S. (2011b). The impact of carsharing on public transit and non-motorized travel: an exploration of North American carsharing survey data. *Energies*, *4*(11), 2094-2114. doi: 10.3390/en4112094

Martin, E. W., Shaheen, S. A., & Lidicker, J. (2010). Impact of carsharing on household vehicle holdings: Results from North American shared-use vehicle survey. *Transportation research record*, *2143*(1), 150-158.

Martins, L. D. C., de la Torre, R., Corlu, C. G., Juan, A. A., & Masmoudi, M. A. (2021). Optimizing ride-sharing operations in smart sustainable cities: Challenges and the need for agile algorithms. *Computers & Industrial Engineering*, *153*, 107080.

Millard-Ball, A. (2005). *Car-sharing: Where and how it succeeds* (Vol. 60). Transportation Research Board.

Münzel, K., Boon, W., Frenken, K., & Vaskelainen, T. (2018). Carsharing business models in Germany: characteristics, success and future prospects. *Information Systems and e-Business Management*, *16*(2), 271-291. https://doi.org/10.1007/s10257-017-0355-x

Münzel, K., Boon, W., Frenken, K., Blomme, J., & van der Linden, D. (2020). Explaining carsharing supply across Western European cities. *International Journal of Sustainable Transportation*, *14*(4), 243-254. doi: 10.1080/15568318.2018.1542756

Nawangpalupi, C., & Demirbilek, O. R. (2008). Investigation of the drivers and the barriers for travel behaviour changes. *The International Journal of Environmental, Cultural, Economic and Social Sustainability*, *4*(4).

Nijland, H., & van Meerkerk, J. (2017). Mobility and environmental impacts of car sharing in the Netherlands. *Environmental Innovation and Societal Transitions*, *23*, 84-91. https://doi.org/10.1016/j.eist.2017.02.001

Pangbo. (2022, January 11). 395 million vehicles, 481 million people! The Ministry of Public Security released national motor vehicle and driver data in 2021.

Perboli, G., Ferrero, F., Musso, S., & Vesco, A. (2018). Business models and tariff simulation in car-sharing services. *Transportation Research Part A: Policy and Practice*, *115*, 32-48. doi: 10.1016/j.tra.2017.09.011

Perri, J. (2021, September 14). The U.S. Rideshare Industry: Uber vs. Lyft. *Bloomberg Second Measure*. https://secondmeasure.com/datapoints/rideshare-industry-overview/

Porter M. E. (1980). Competitive strategy; techniques for analyzing industries and competitors. 1980; *New York, Free Press*

PricewaterhouseCoopers (2017). It's time to share cars: the current situation and trend of shared cars in China. https://www.strategyand.pwc.com/cn/zh/reports/2017/development-trends-of-car-sharing-market-in-china-cn.pdf

Rabbitt, N., & Ghosh, B. (2013). A study of feasibility and potential benefits of organised car sharing in Ireland. *Transportation Research Part D: Transport and Environment*, *25*, 49-58.

Rabbitt, N., & Ghosh, B. (2016). Economic and environmental impacts of organised Car Sharing Services: A case study of Ireland. *Research in Transportation Economics*, *57*, 3-12.

Racioppi, F., Dora, C., & Rutter, H. (2005). Urban settings and opportunities for healthy lifestyles: rediscovering walking and cycling and understanding their health benefits. *Built environment*, *31*(4), 302-314.

Rode, P., Floater, G., Thomopoulos, N., Docherty, J., Schwinger, P., Mahendra, A., & Fang, W. (2017). Accessibility in cities: transport and urban form. *Disrupting mobility*, 239-273. http://eprints.lse.ac.uk/60477/

Sai, Q., Bi, J., Xie, D., & Guan, W. (2019). Identifying and predicting the expenditure level characteristics of car-sharing users based on the empirical data. *Sustainability*, *11*(23), 6689.

Shaheen, S. A., & Chan, N. D. (2015). Evolution of e-mobility in carsharing business models. In *Electric Vehicle Business Models* (pp. 169-178). Springer, Cham. http;//link.springer.com/chapter/10.1007/978-3-319-12244-1_10

Shaheen, S. A., Chan, N. D., & Micheaux, H. (2015). One-way carsharing's evolution and operator perspectives from the Americas. *Transportation*, *42*(3), 519-536.

Shaheen, S. A., & Cohen, A. P. (2007). Growth in worldwide carsharing: An international comparison. *Transportation Research Record*, *1992*(1), 81-89.

Shaheen, S. A., & Cohen, A. P. (2013). Carsharing and personal vehicle services: worldwide market developments and emerging trends. *International journal of sustainable transportation*, *7*(1), 5-34. https://doi.org/10.1080/15568318.2012.660103

Shaheen, S. A., & Cohen, A. (2016). Innovative mobility carsharing outlook: Winter 20.16. Transportation Sustainability Research Center, UC Berkeley. http://innovativemobility.org/wp-content/uploads/2016/02/Innovative-MobilityIndustr_Outlook_World- 2016-Final.pdf

Shaheen, S. A., & Martin, E. (2010). Demand for carsharing systems in Beijing, China: an exploratory study. *International Journal of Sustainable Transportation*, *4*(1), 41-55.

Shaheen, S. A., Schwartz, A., & Wipyewski, K. (2004). Policy considerations for carsharing and station cars: Monitoring growth, trends, and overall impacts. *Transportation Research Record*, *1887*(1), 128-136.

Shuai, Ling., Shoufeng, Ma., & Ning, Jia (2022). Sustainable urban transportation development in China: A behavioral perspective. Frontiers of Engineering Management, 9(1), 16-30.

Steininger, K., Vogl, C., & Zettl, R. (1996). Car-sharing organizations: The size of the market segment and revealed change in mobility behavior. *Transport Policy*, *3*(4), 177-185.

Stillwater, T., Mokhtarian, P. L., & Shaheen, S. (2008). Carsharing and the built environment: A GIS-based study of one US operator. Institute of Transportation Studies. http://escholarship.org/uc/item/2wj7q6cm

Sue, V. M., & Ritter, L. A. (2012). *Conducting online surveys (2nd ed.)*. SAGE Publications.

Sun, L., Wang, S., Liu, S., Yao, L., Luo, W., & Shukla, A. (2018). A completive research on the feasibility and adaptation of shared transportation in mega-cities–A case study in Beijing. *Applied Energy*, *230*, 1014-1033.

The Chinese Central Government's Official Web Portal http://www.gov.cn/xinwen/2022-01/11/content_5667669.htm

The New Climate Economy. (2014). Better growth better climate: the new climate economy report. *The New Climate Economy.* https://www.unilever.com/Images/better-growth-better-climate-new-climate-economy-global-report-september-2014_tcm244-425167_en.pdf

Wang, N., Liu, Q., Guo, J., & Fang, T. (2021). A user-based adaptive joint relocation model combining electric car-sharing and bicycle-sharing. *Transportmetrica B: transport dynamics*, 1-24.

Wappelhorst, S., Dobrzinski, J., Graff, A., Steiner, J., & Hinkeldein, D. (2016). Flexible carsharing—Potential for the diffusion of electric mobility. In *Markets and Policy*

Measures in the Evolution of Electric Mobility (pp. 67-84). Springer, Cham. http://link.springer.com/chapter/10.1007/978-3-319- 24229-3_5

White, L. E. (2022, June 10). *17 benefits of car sharing - Save time, money, and help the environment*. Sustainable Business Toolkit. https://www.sustainablebusinesstoolkit.com/environmental-benefits-of-car-sharing/

Xu, Y., Ji, X., & Jin, Z. (2021). What travel scenarios are the opportunities of car sharing?. *Plos one*, *16*(12), e0260605. https://doi.org/10.1371/journal.pone.0260605

Xuchu, X. (2007). Urban Road and Traffic Planning. *China Construction Industry Press*.

Zhang Xiaoming. (2001). Shared car - a brand - brand - new consumption model. *World Automobile*, (7), 21-22.

Zhou, X. (2013). The Analysis of Cost Structure of Car Sharing. https://pdf.hanspub.org/OJTT20130200000_92487604.pdf

Appendix A: Ethics approval letter

Auckland University of Technology Ethics Committee (AUTEC)

Auckland University of Technology
D-88, Private Bag 92006, Auckland 1142, NZ
T: +64 9 921 9999 ext. 8316
E: ethics@aut.ac.nz
www.aut.ac.nz/researchethics

7 March 2022

Sangeeta Karmokar
Faculty of Design and Creative Technologies

Dear Sangeeta

Re Ethics Application: **22/37 Sustainable Development of Car Sharing in China**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 7 March 2025.

Standard Conditions of Approval

1. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC in this application.
2. A progress report is due annually on the anniversary of the approval date, using the EA2 form.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using the EA3 form.
4. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form.
5. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.
6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.
7. It is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard and that all the dates on the documents are updated.
8. AUTEC grants ethical approval only. You are responsible for obtaining management approval for access for your research from any institution or organisation at which your research is being conducted and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

Please quote the application number and title on all future correspondence related to this project.

For any enquiries please contact ethics@aut.ac.nz. The forms mentioned above are available online through http://www.aut.ac.nz/research/researchethics

(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat
Auckland University of Technology Ethics Committee

Cc: htp3674@autuni.ac.nz; andrew.connor@aut.ac.nz

Appendix B: Online survey

Online survey - Sustainable Development of Car Sharing in China

Participant consent
Thank you for your interest in this research project. Please read the following information before deciding whether to take part in the survey.

Who am I?
My name is Yichao Chen, and I am a master's student in the Creative technologies at Auckland University of Technology, New Zealand. This survey is being conducted as part of my thesis.

What is the aim of this project?
My thesis will explore the role car sharing could play in supporting high-density living and low-carbon transport patterns in China, as well as determine the barriers facing car sharing in China and how they might be overcome. The goal of this research is to add to the literature by looking at automobile sharing in China. Its goal is to determine if vehicle sharing has potential advantages in China, particularly in terms of supporting compact living and sustainable transportation patterns in the core city. Examining the relevance of high density, alternate means of transportation, and current technology for the success of car sharing in China is part of this. This study further adds to the literature by looking at the obstacles to automobile sharing in China and how they could be solved. This research contributes to the sustainable development of car sharing in China by exploring car sharing in China.

How can you help?
If you agree to take part, you will fill out a 10 to 15 minute survey that consists of demographic questions. questions about how you travel, your access to vehicles and parking your perceptions of car ownership and driving and questions about car sharing. You are not required to answer every question if you do not wish to. You may withdraw your participation at any time while taking the survey; however, once you submit your survey it will be impossible to withdraw.

What will happen to the information you give?
All of the information you provide is anonymous and confidential. Access to the collected data will be restricted to me and will be stored in a password-protected file for up to six years, after which it will be erased.

What will the project produce?
The data will be reported in my master's thesis, which will be submitted for marking to the School of Future Environments, Auckland University of Technology. A copy of this thesis will be publicly available through the Auckland University of Technology library, The information may also feature in academic. industry or local government publications and/or be presented at academic or professional conferences.

If you have any questions or problems, who can you contact?
If you have any questions regarding this study. please email me at htp3674@autuni.ac.nz, or you can email my supervisor Dr. Sangeeta Karmokar at sangeeta.karmokar@aut.ac.nz and Associate Professor Andy Connor at andrew.connor@aut.ac.nz

Ethics committee Information
If you have any concerns about the ethical conduct of this research, you may contact the Auckland University of Technology Ethics Committee Secretariat: Executive Secretary. Email ethics@aut.ac.nz or telephone +64 9 921 9999 extn:6038.

Thanks and kind regards,
Yichao Chen

I confirm that I am 18 years of age or older, and have read and understood the information provided and wish to continue with the survey.

Note: Questions will be viewed by respondents according to their answers. Therefore, not every question will be viewed by all participants.

Introduction
It should take you approximately 10 to 15 minutes to complete this survey, which is divided into three sections:
1 Section one includes a range of demographic questions
2 Section two includes questions about how you travel, your access to vehicles and parking, and your perceptions of car ownership and driving
3 Section three includes questions about car sharing

Thank you for taking the time to complete this survey.

Please remember that your responses are confidential and anonymous.

Section 1. demographic questions
Q1. Which city in China do you live in?

Q2. How would you describe your place of residence?
High rise apartment (more than 6 levels)
Low rise apartment (6 or fewer levels)
Town house
Standalone house

Q3. Please indicate your gender:
Male
Female

Other

Q4. Please indicate your age:
18 - 35
36 - 50
51 - 64
65 +

Section 2. Transport patterns, access to vehicles and parking, perceptions of car ownership and driving Transport patterns

Q5. What is the main mode of transport that you usually use to travel to either work, study or shopping?
Car
Public transport
Motorcycle or scooter
Bicycle
Walk
Taxi
Other, please specify:

If Public transport, Motorcycle or scooter, Bicycle, Walk, Taxi, Other is selected, the participant is directed to question 9.

Access to parking
Q6. Do you have access to car parking at your place of residence?
Free off-street parking
Free on-street parking
Paid off-street parking
Paid on-street parking
No access to parking

Q7. Do you have access to car parking at your place of work or study?
Free off-street parking
Free on-street parking
Paid off-street parking
Paid on-street parking
No access to parking

Perception of car ownership and driving
Q8. Please indicate to what extent you agree or disagree with each of these statements:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
It is important for me to own my own vehicle.					
I prefer driving as opposed to public transport, walking or cycling.					
I do not have an alternative to driving (e.g. public transport is too far away; I have to travel with heavy work equipment).					
It is very important to me what make/model of vehicle I drive.					
I am concerned with the negative impact car ownership has on the environment.					

Section 3. Car sharing

Familiarity with car sharing
Q9. Have you used car sharing before?
Yes
No

If no is selected, the participant is directed to question 18.

Q10. How did you hear about car sharing?
Commercial means (e.g. advertising via social media, newspaper, radio etc.)
Non-commercial (e.g. newspaper article, blog word of mouth etc.)

Q11. Where have you used car sharing?
In China
Overseas

Q12. What is the main reason you used or are using car sharing?
Cost
Convenience
Environmental concerns
Other, please specify:

Perceptions of car sharing
Q13. Car share vehicles can generally be rented by the hour or for the day. If you were to use car sharing services which of the following types of trips do you think you would do via car sharing? Please select all that apply.
Commuting to work or study
Food shopping
Regular recreational/leisure activities (e.g. weekly sports game, visiting friends/family)
Occasional recreational/leisure activities (e.g. daytrips)
Holiday travel
Other. please specify:

Q14. Car share vehicles are generally located in a number of convenient locations around the city, such as CBD and transit hubs, how far do you think you would be happy to walk from your place of residence, work or study to the car share vehicle pick up/return point?
Less than a 2 or 3 minute walk
Less than a 5 minute walk
5 to 10 minute walk
10 to 15 minute walk
15 to 20 minute walk

More than a 20 minute walk

Q15. Please indicate to what extent you agree or disagree with each of these statements:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Car sharing would be more convenient than owning my own car or buying a car.					
Car sharing would improve my transport options, giving me greater accessibility to amenities.					
Car sharing would be more affordable than owning my own car or buying a car.					
If car sharing used electric vehicles, I would be more likely to use the service.					
Car sharing would be a more environmentally friendly alternative to car ownership.					

Q16. Please indicate to what extent you agree or disagree with each of these statements:

	Strongly disagree	Disagree	Neither agree nor	Agree	Strongly agree

			disagree		
I am concerned about the cleanliness of the car share vehicle (e.g. it may not be clean when I pick it up).					
I am concerned about how much car sharing costs (e.g. the hourly rate and membership fee).					
I am concerned about the availability of the car share vehicle (when I want to use it).					
I am concerned about having to pick up and rectum the car share vehicle at set times.					
I am concerned about the					

selection of cars available (e.g. 4 or 6 seater, electric or hybrid, standard or high-end vehicle).					
I am concerned about the distance between my place of residence, work or study and the pick-up point for the car share vehicles.					
I am concerned about insurance (e.g. in case the car is damaged).					
I am concerned about having to use smartphone technology to use the car sharing service (e.g. book and locate the vehicles).					

Q17. Are there any other concerns you have about car sharing? Please specify:

Q18. How interested are you in using car sharing?
Very interested
Maybe
Not at all interested

Q19. What if anything would encourage you to use car sharing services? Please specify:

Q20. Do you have any other comments regarding car sharing?

End of survey
Thank you for taking the time to complete this survey. Your answers and opinions are highly valued.

Appendix C: Participant Information Sheet

Participant Information Sheet

Date Information Sheet Produced:

20/01/2022

Project Title

Sustainable Development of Car Sharing in China

An Invitation

My name is Yichao Chen, and I am a master's student in the Creative technologies at Auckland University of Technology, New Zealand. This survey is being conducted as part of my thesis.

What is the purpose of this research?

My thesis will explore the role car sharing could play in supporting high-density living and low-carbon transport patterns in China, as well as determine the barriers facing car sharing in China and how they might be overcome. The goal of this research is to add to the literature by looking at automobile sharing in China. Its goal is to determine if vehicle sharing has potential advantages in China, particularly in terms of supporting compact living and sustainable transportation patterns in the core city. Examining the relevance of high density, alternate means of transportation, and current technology for the success of car sharing in China is part of this. This study further adds to the literature by looking at the obstacles to automobile sharing in China and how they could be solved. This research contributes to the sustainable development of car sharing in China by exploring car sharing in China.

How was I identified and why am I being invited to participate in this research?

As its aim is to study car sharing in China, a number of different mechanisms will be used. Each of them is listed here.

Forum: Many people who are interested in new things are active in the online forum, and you have your own unique opinions and views on car sharing. Inviting you to participate can make my investigation hear different voices. Such as Zhihu.

Social Media: A series of targeted posts on social media, specifically WeChat. This will be multi-faceted in nature with individual posts made by the primary applicant that will appear in the feeds of their contacts.

How do I agree to participate in this research?

When you complete this research survey and submit it, I will automatically assume that you have agreed to participate in this research survey.

What will happen in this research?

If you agree to take part, you will fill out a 10 to 15 minutes survey that consists of demographic questions. questions about how you travel, your access to vehicles and parking your perceptions of car ownership and driving and questions about car sharing. You are not required to answer every question if you do not wish to. You may withdraw your participation at any time while taking the survey; however, once you submit your survey it will be impossible to withdraw. Completing the survey indicates consent to participate in the study.

What are the discomforts and risks?

This research will take a little of your time and will also ask for your views and opinions on the sustainable development of car sharing in China.

How will these discomforts and risks be alleviated?

You are not required to answer every question if you do not wish to. You may withdraw your participation at any time while taking the survey.

AUT Student Counselling and Mental Health is able to offer three free sessions of confidential counselling support for adult participants in an AUT research project. These sessions are only available for issues that have arisen directly as a result of participation in the research and are not for other general counselling needs. To access these services, you will need to:

- drop into our centre at WB203 City Campus, email counselling@aut.ac.nz or call 921 9998.
- let the receptionist know that you are a research participant, and provide the title of my research and my name and contact details as given in this Information Sheet.

You can find out more information about AUT counsellors and counselling on https://www.aut.ac.nz/student-life/student-support/counselling-and-mental-health

What are the benefits?

The data will be reported in my master's thesis, which will be submitted for marking to the School of Future Environments, Auckland University of Technology, New Zealand. A copy of this thesis will be publicly available through the Auckland University of Technology library, The information may also feature in academic. industry or local government publications and/or be presented at academic or professional conferences.

How will my privacy be protected?

All the information you provide is anonymous and confidential. Access to the collected data will be restricted to me and will be stored in a password-protected file for up to six years, after which it will be erased.

What are the costs of participating in this research?

This may take 10 to 15 minutes of your time.

What opportunity do I have to consider this invitation?

The survey is expected to last one month. you can choose to participate at any time during the month.

Will I receive feedback on the results of this research?

Due to the anonymity of the survey, I will provide you with a web site where you can read a summary of the survey results (www.wjx.cn/vj/e0QwtoR.aspx).

What do I do if I have concerns about this research?

If you have any questions regarding this study. please email me at htp3674@autuni.ac.nz, or you can email my supervisor Dr. Sangeeta Karmokar at sangeeta.karmokar@aut.ac.nz and Associate Professor Andy Connor at andrew.connor@aut.ac.nz.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Yichao Chen

htp3674@autuni.ac.nz

Project Supervisor Contact Details:

Dr. Sangeeta Karmokar

sangeeta.karmokar@aut.ac.nz

Associate Professor Andy Connor

andrew.connor@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on *type the date final ethics approval was granted*, AUTEC Reference number *type the reference number*.

Appendix D: Online advertisement