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Business Risk Management for Bike-sharing in China

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Abstract

Dockless bike-sharing, as an innovative industry in China, is developing rapidly. The new technology brings the bike users convenience, while the bike-sharing companies face a number of potential business risks may lead to financial loss. The purpose of this project is to assess these risks, understand the users' perceived risks, and examine an optimized product plus possible risk management strategies to reduce risks.

Stakeholder analysis helps bike-sharing companies better understand importance and expectations of each stakeholder. The results indicate that the main business risks are accidents, congestion, users' information disclosure, insecure deposits, theft, and vandalism. The users' perceived risks are relatively balanced, which means users have no clear perceptions of business risks as of present. The result of a Multi-Criteria Decision Analysis shows that one designed option is the optimized product under the criteria of cost, profit risk, and safety, namely the product with high-level-safety for companies and users alike. Furthermore, this report advises a number of possible risk management strategies. Enhancing management for both bike-sharing companies and governments, preparing proper arrangement after the occurrence of risks, and considering communication and cooperation among all stakeholders during the management process.

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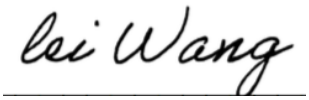
Preface

This report is written as a master's thesis of 30 ECTS points on the 4th semester for the master's program Risk & Safety Management at Aalborg University, Campus Esbjerg. The report is written during the period of 1st September 2017 to 10th January 2018.

The rapid development of dockless bike-sharing in China is an interesting trend, that has been discussed extensively in the media. The ascribed business risks regarding safety and product upgrading has caught the author's attention and given motivation to analyse possible risks leading to financial loss. Furthermore, the aim of the project is to figure out potential solutions for reducing relevant risks.

The author would especially like to thank the supervisors of this project, Anders Schmidt Kristensen and Dewan Ahsan for giving inspiration and feedback throughout the process. Furthermore, a big thank you to the interviewee Zhang Yuhuan, Professor at Tianjin University of Technology, for giving inspirations in the early stage on relevant risks and his advices for enhancing management. Lastly, I would like to thank all respondents for donating their time filling out the research's questionnaire.



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Acronyms

QR	Quick Response
MAU	Monthly Active Users
GPS	Global Position System
MCDA	Multi-Criteria Decision Analysis
NGO	Non-Governmental Organization
UNEP	UN Environment Programme
WHO	World Health Organization
WWF	World Wildlife Fund
WRI	World Resources Institute
SD	Standard Deviations
SE	Standard Errors
SIM	Subscriber Identity Module
CEO	Chief Executive Officer

Contents

1 Introduction

1.1 Background of the Bike-sharing Industry in China

China was called “the kingdom of bicycles” in 1980s. For example in Beijing, there were more than 60% of all commuters riding bike every day. However, the number had dropped to less than 12% by 2014 due to an increasing number of roads, a permanent population growth and with urban area development [1] [2].

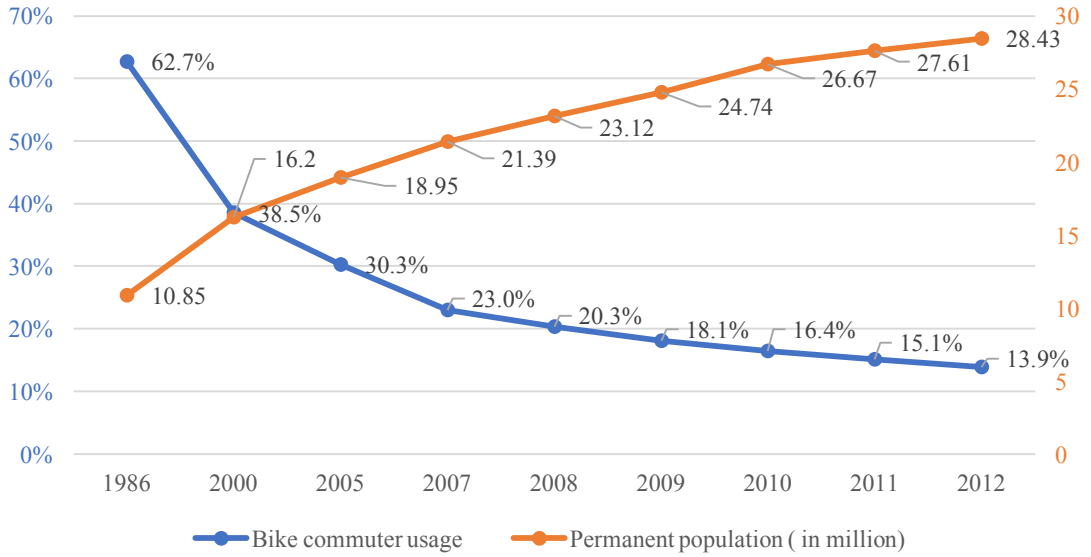

Figure 1. Usage of Bike by Commuters and Permanent Population in Beijing [3] [4]

Beijing Transportation Research Centre has reported the bike usage of commuters in Beijing from 1986 to 2012, as shown in Fig. 1. In 1986, 62.7% of all commuters chose biking, and since then, the number has been decreasing year by year. Biking decreased to 13.9% in 2012, because at this point most bikes were replaced with private cars and/or public transit [3]. The second vertical axis (the orange axis, Fig.1) represents the growth of the permanent population in Beijing [4].

Today, green energy and low-carbon growth has become a hot topic in China due to increasingly serious environmental problems. In order to achieve low-carbon development and help reach China's national target for reducing the high energy and carbon intensity of its economy, the Chinese government encourages people to choose various means of public transportation, such as walking or cycling, instead of driving private cars [5]. The shared services are becoming more and more popular in China too, with examples such as shared-cars, napping pods, and goods such as basketballs and umbrellas and so on. Thus, it is an opportunity for the bike-sharing industry, and its popularity seems inevitable.

1.2 Bike-sharing Industry

This bike-sharing system is made for the short-term bike use through an automated system in the cities [6]. These bikes can be picked up at one bike station, used for a period of time, and then returned at another station, which provides bike-sharing users with a low-cost, environmentally friendly and healthy choice of transportation [7]. Bike-sharing began in Europe in 1965 and it became a viable form of transportation in the middle of the 2000s, thanks to modern information technology [8]. Public bike-sharing exists all over the world now, but in most cities, they are not profitable. They mainly rely on governmental subsidies or "public capital" of enterprise to operate.

Let's go back to the initial idea of why people choose biking? Because bikes are suitable for travelling distances in no more than 30 minutes or within 5 kilometres, which

approximately equals the distance between the subway station and home, or the distance connecting different public transportations for most commuters [9].

1.3 Bike-sharing Industry in China

In the past decade, many cities have been placing public bikes with hubs in China, in order to increase the usage of bikes and achieve low-carbon development. The Chinese government believes that these public bicycles are more convenient and flexible for short distance transportation. However, surveys show that 64% users think the system is not ideal, and there are many problems. For instance, each user must apply for a special card and each card only works for the city in which the user is applying. In addition, it is not always easy to find a hub nor very tourist friendly [1].

This short distance is called “the last kilometre of the trip”. Chinese bike-sharing companies believe they could meet the demand of “the last kilometre of the trip” and solve the mentioned problems by launching an upgraded bike-sharing system. The innovating part of the new Chinese bike-sharing system is that they are “dockless”, which means they do not have the so-called hubs for retrieval and delivery. This has been realized through the Internet Technology and the Internet of Things. Based on the dockless characteristic, the bike-sharing companies initially place their bikes at one public bicycle parking area which is close to densely-populated areas or subways. Users do not need to worry about returning the bike - it can be placed anywhere as long as it’s legal. Since 2016, dockless bike-sharing transportation means has become one of the best choices for commuters travelling from the metro/bus stops to their destinations.

Additionally, the policies restricting the usage of private cars in cities with high traffic pressure and traffic congestion problems have motivated more and more people to consider bike-sharing. Mobile payment technology makes the bike-sharing system smarter, simpler, and more accessible for all types of users. Now, the phrase "bike-sharing" means "dockless bike-sharing" in China, due to these new-model shared-bikes launched by the bike-sharing companies.

User Scale

As shown by the State Information Centre of China, the accumulative total size of existing shared-bikes in China was about 16 million in July 2017, and the number of domestic users has achieved 106 million [10]. If the total number of users is insufficient to explain how many people use bike-sharing, let's look at the number of active users, which is more precise.

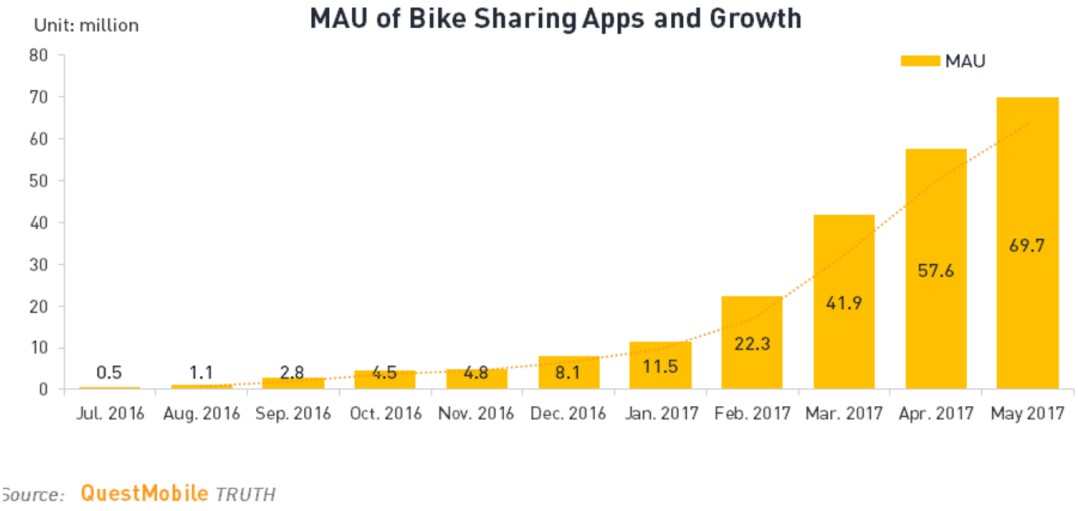

Figure 2. Number of Monthly Active Users of Bike-sharing Apps [11]

Figure 2 shows the growth of active monthly users of bike-sharing from July 2016 to May 2017. There were 540,000 users in July 2016, and this number has been continuously increasing. It achieved almost 70 million MAU in the bike-sharing market in May 2017, and this number is still growing to this day [11].

Purpose of Using Bike-sharing

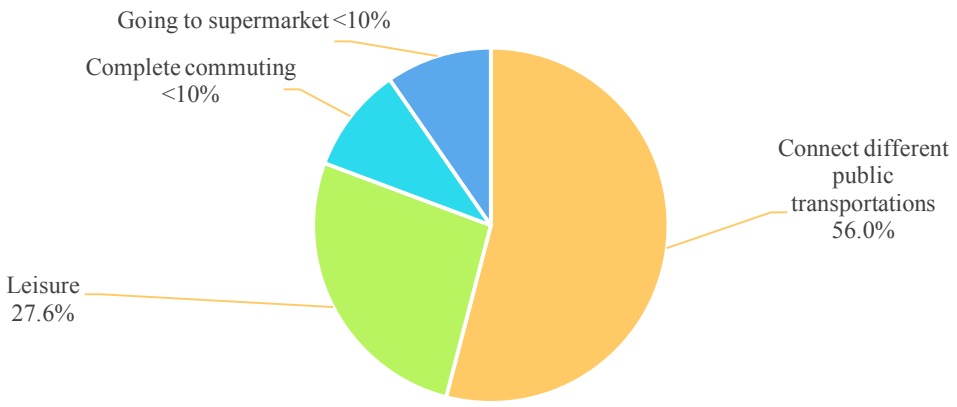

Figure 3. Purpose of Using Bike-sharing [12]

The Jiefang Daily Social Survey Centre and KuRunData China Online made an online research in the first season of 2017 with its sample size being 1,000 people. As shown in the research results, 56% of the interviewees chose shared-bike for connecting different public transportations, as this purpose can't be satisfied by using private bikes. Additionally, 27.6% of interviewees chose bike-sharing for leisure, while less than 10% of commuters chose bike-sharing for total commuting or going to the supermarket, as shown in Fig. 3 [12]. It seems that bike-sharing plays an important role in solving "the last kilometre of the trip". More than half of the users take the shared-bikes to commute,

which means that a large number of shared-bikes are used during rush hour, effectively relieving traffic pressure.

1.4 Characteristics of Dockless Bike-Sharing

Besides the public bike-sharing with hubs, there are two main types of shared-bikes in the Chinese market, namely bikes with GPS-based intelligent locks and bikes with mechanical locks. There are two representative companies using these types of locks, and they occupy the biggest market share in China, namely Ofo and Mobike. In April 2017, Mobike occupied 56.56% of the market share, and Ofo 29.77% [13]. This report uses Ofo and Mobike as two examples to explain the characteristics of China's bike-sharing trend.

1.4.1 Mobike

Figure 4. 'Classic' and 'Lite' Models of Mobike [14]

Mobike has applied for 29 patents between 2016 and January 26th of 2017, including 12 inventions, 12 utility models and 5 appearance designs. These patents are distributed in three major parts, namely the new type of a no chain-drive transmission device, an easy-open intelligent lock, and a real-time positioning anti-theft system [15]. Mobike has their own manufacturers and strategy partners, including Foxconn Technology Group, which effectively supports their production [16]. As shown in Fig. 4, the first product launched by Mobike is 'Classic', an independently researched and developed product. With a smartphone, people can easily find a bike closest to them. The "bicycle management system and control method and apparatus" is the core technologies of Mobike. It provides a bicycle management system comprising a mobile communication device, a cloud end, a bicycle and an operation policy centre [17].

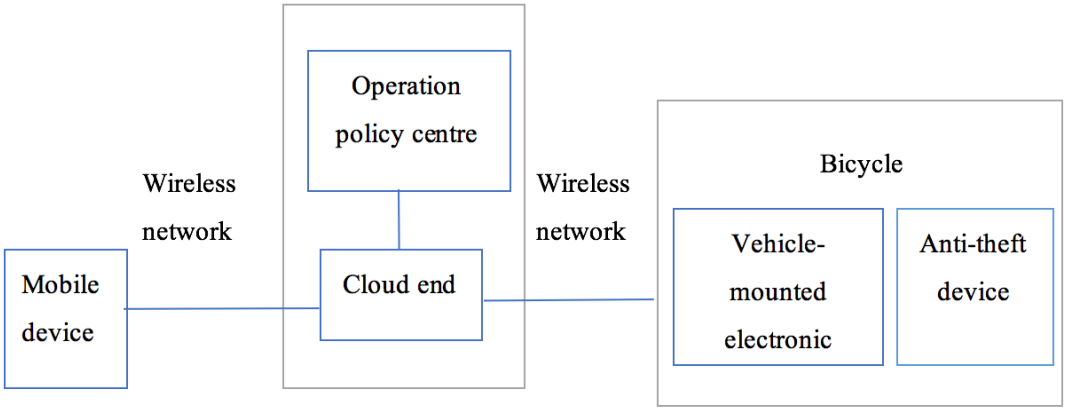

Figure 5. Bicycle Management System, Control Method and Apparatus

This system works as shown in Fig. 5, that is, the cloud end establishes communication with the mobile device and bicycle via a wireless network. The operation policy centre provides a bicycle management policy to the cloud end, in order for the mobile device to control the bicycle via the cloud end. The bicycle periodically reports status

information to the cloud end. For example, if a Mobike hasn't been used for three days, the bike itself will report the status, and the company can send someone to check whether the bike needs maintenance or if the location is too distant to reach [17].

The intelligent lock is the core component of their shared-bikes. It contains a lithium battery so as to support the GPS positioning module, an independent SIM card and a communication module [18]. For charging lithium batteries, Mobike 'Classic' uses a back hub with dynamo. Moreover, the intelligent lock is wirelessly connected to the Internet, satellite positioning systems, databases, mobile payment systems, as well as a central management platform through data collection and applications of artificial intelligence [15].

Although it is a high-technology product, the truth is - it's still a bike. Hence, it needs to fulfil the requirements of frequent and high-strength usage. For this reason, Mobike has applied an aluminum frame, non-spoke wheels, enclosed shaft-drive and solid tyres to enhance durability. Conversely, these applications make Mobike 'Classic' heavier than an ordinary bike. After twelve times of product improvements, the new model Mobike 'Lite' was launched, which was announced by the CEO of Mobike, Wang Xiaofeng [19]. Mobike 'Lite' uses a solar battery charging board and a chain-drive transmission device, which gives it a lighter weight and higher comfort level.

As mentioned by Hu Weiwei, founder of Mobike, in one interview, since Mobike is the first mover in this market, there was no any other similar product for reference at the beginning, the design and invention could be thoughtless or over considered, which

must be tested in the market. [16]. In a word, the main idea of Mobike is to create a product with lower maintenance costs and good usability with a higher safety level.

How to Use Mobike?

First, users download and install a Mobike App on their smartphone. Second, users register an account and pay the deposit, EUR 38.3 (RMB 299). Then, the distribution of bikes will be displayed on the smartphone. Users can make a 15-minute appointment or find a bike directly and scan the QR code on the bike. The Mobike will then be remotely unlocked by the system and automatically begin billing. When users reach their destination and lock the bike, the billing will automatically stop and they don't need to do anything else.

1.4.2 Ofo

Figure 6. Ofo 1.0 (left) and 3.0 (right) [20]

Ofo started their business on a number of Chinese universities in 2014 without using any intelligent components. The initial idea was to make it convenient for students on campuses. Ofo has more than ten different models on the market, but its main technical differences with others are the locks and tyres. As shown in Fig. 6, Ofo uses chain-

drive; Ofo 1.0 uses pneumatic tyres and touch-tone mechanical locks, while Ofo 3.0 uses solid tyres and rotary type mechanical locks [21]. Except the solid tyres in edition 3.0, Ofo bikes are basically the same as regular bikes. Even if Ofo bikes provide users with a better comfort level at the beginning, a high damage-rate gives users a bad experience in the long run. In addition, increasing maintenance costs encroach upon their revenue.

Benefiting from their early entrepreneurship on campuses, the company keeps moving ahead with their occupied market share and a large amount of obtained financing. Of course, Ofo is aware of the future of bike-sharing with high-technological contents. Consequently, they have started developing new products to compete with Mobike.

How to Use Ofo?

Similar to Mobike, users download and install Ofo App on their smartphone at first. Second, they register an account and pay deposit, EUR 25.5 (RMB 199). Then, they just need to find a bike and scan the QR code or input the bike number (ID), and then the App will provide a code to unlock the bike. The last thing is, that the users must lock the bike after use and pay the rent through their smartphones manually. Otherwise, the App will keep charging. One thing which needs to be mentioned, is that many users found out some bikes couldn't work after unlocking, and the bike cannot report its status information by itself.

2 Problem Formulation

Thanks to the new low-carbon trend and new business model, bikes have been brought back to China. Mobike founder Hu Weiwei claims that bike density is a key factor in competition, following accessibility and convenience of the shared-bikes [22]. Therefore, it is not difficult to understand why most sharing companies focus on placing a large number of new products in big cities in order to enhance product awareness and gain more users. However, market share based on population density shouldn't be the most important factor for bike-sharing to achieve success in the industry. According to the "Copenhagenize Index" (index of the world's most comprehensive inventory and highest ranking of bicycle-friendly cities), there are a total of 14 parameters to evaluate and rank bicycle-friendly cities, such as bicycle infrastructure, bike share programmes, perception of safety, politics, and social acceptance [23] [24].

As mentioned, the cumulated number of share-bikes is more than 16 million in China, but many problems have been revealed regarding the sustainability of business growth and the current profitable operation. For example, service prices among different brands or models don't differ greatly due to the fierce competition. The bikes are approximately charged with EUR 0.13 (RMB 1.0) per hour. The fact is, that there are huge cost differences in production regarding to high-technological components. The cost of an Ofo bike is about EUR 38.4 (RMB 300), but it cost EUR 256 – 384 (RMB 2,000 - 3,000) for a Mobike 'Classic' [21]. Meanwhile, many complaints about the products' durability and discussions related to maintenance and potential safety issues

has appeared amongst the Chinese population. Vandalism and theft have also become serious issues. This is why Ofo was forced to increase their deposit from EUR 12.7 to 25.5 (RMB 99 to 199) on 20th June 2017. The Chinese government subsequently started to intervene the industry operation, such as restricting the quantity of shared-bikes in many cities, maintenance locations, and age limits for users [25]. Therefore, it is important to recognize and reduce business risks when bike-sharing companies consider promoting the industry development and achieve economic benefits, in order to ensure the benign growth of the bike-sharing industry.

The business risks for bike-sharing companies include capital chain rupture caused by investors' disinvestment, tough operation resulting from unpopular products, an increase in maintenance and operation costs, and even theft, vandalism, compensation for incidents etc. From the second half of 2017, a number of small sharing companies went bankrupt one after another. In June, Wu Kong Bike became the first bike-sharing company to close after only five months of operation due to capital chain rupture and low-quality products. They were followed by Ding Ding and Ku Qi, as a result, many of their customers have experienced a difficult deposit-refunding process [26].

2.1 Research Question

Since the previous sections highlighted the present status of the bike-sharing industry, an issue of business risks appears, being the uncertainty of sustainable development and profitable product. In order to analyse and suggest possible solutions to this issue, it requires a main question and some sub-questions regarding possible business risks as

well as how to reduce these risks by using risk management approaches. The main question is formulated as the following:

What are the major business risks and how to reduce these risks for bike-sharing industry in China?

To answer this question, it is important to understand who are the related stakeholders, and how they may impact the bike-sharing business. In addition, one must understand and evaluate these risks. Thus, the following sub-questions are proposed:

Which parties could be the key stakeholders in this research?

Which risks could lead to financial loss for the bike-sharing industry?

How do the users perceive these risks?

Which types of shared-bikes could be optimized as the renovated product?

How to reduce the risks related to the business?

2.2 Delimitation

In this report, traffic incidents and congestion in this report will not include the occurrence of risks that cannot be distinguished between regular bikes and dockless shared-bikes. The analysis is only based on bike-sharing related business risks that could lead to financial loss, and all risks will be oriented from the companies' point of view. Besides the risks discussed in this report, there are many other success factors for

the bike-sharing business that will not be included in this report. These include quality of public transportation, weather and other technical factors [27].

There are four main consequences for each event in risk analysis, namely financial loss, human injury, psychological trauma, and environmental consequences. This research only focuses on financial loss. In order to differentiate from “economic financial”, the risks for financial loss due to non-profitable products or any other property losses will be called “business risks”, while any financial discussion in the technical aspect is excluded.

The dockless bike-sharing industry is moving forward at the start-up stage. For obvious reasons, this report cannot include various uncertainties causing potential risks in the future.

2.3 Methodology

This project includes both qualitative and quantitative analyses. First, a stakeholder analysis was utilized to identify the key players of this research. Second, information was collected through an online interview with Zhang Yuhuan, the professor from Tianjin University of Technology, which gave inspiration for risk identification. In combination with the information gathered through online secondary research, a coarse analysis was performed to identify the risks. Third, primary research was used to collect data about users’ risk perception and preferences, and this was done through a questionnaire with a sample size of 350. The statistical data from this questionnaire was

used to indicate the perceived risks of users, and to make a Multi-Criteria Decision Analysis (MCDA) so as to optimize products for decision making. Also, a sensitivity analysis for the results of MCDA was made to test the results. Finally follows recommendations to reduce the risks in question. The entire of the report follows the risk management process based on the standard DS/ISO 31000 [28].

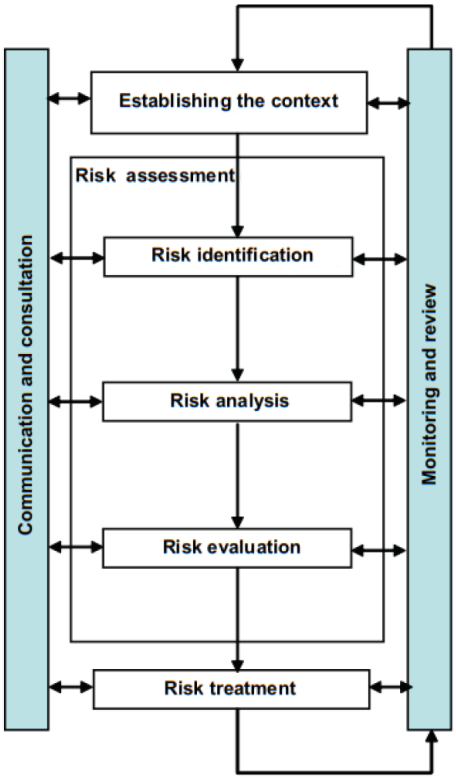

Figure 7. Risk Management Process [28]

The risk management process starts by establishing the context followed by a risk assessment. A risk assessment includes risk identification, risk analysis, and risk evaluation. After obtaining the results of the risk assessment, a risk treatment must be decided. Communication and consultation between different stakeholders run throughout the whole process. If deviations are observed by monitoring and reviewing

the process, the cycle may be re-started, which will ensure that the risk management process and the chosen decisions are appropriate [28].

2.3.1 Theories

Stakeholder Analysis

Since the American professor R. Edward Freeman, in 1984 defined a stakeholder as an individual or group who influence and/or is influenced by the achievements of an organization, stakeholder analysis has become essential for strategical propositions of management [29] [30]. This report identified all relevant stakeholders based on Freeman's theories, and then used salient stakeholder analysis to point out all key players.

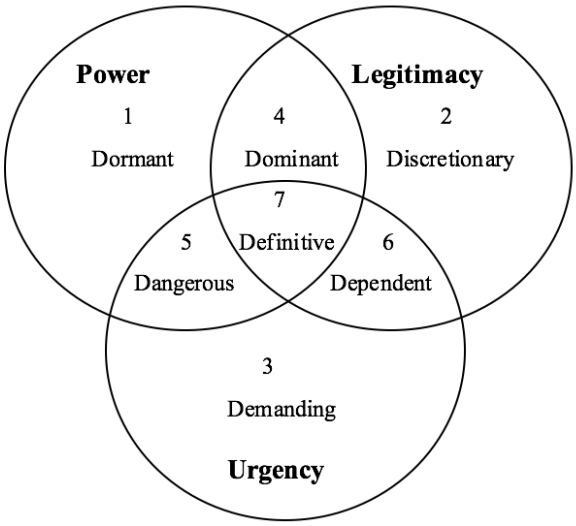

Figure 8. Stakeholders' Typology [30]

As stated by the professors Ronald K. Mitchell and Donna J. Wood, in 1997, there are three attributes to identify stakeholders' types, namely power, legitimacy and urgency [30]. As shown in Fig.8, the low salience stakeholders (latent) are only presented by

one attribute in area 1, 2, and 3; the moderately salient stakeholders (expectant) are presented by two attributes in area 4, 5, and 6; the high salient stakeholders (definitive) are presented by all three attributes in area 7 [30].

Coarse Risk Analysis

Coarse risks analysis is a very common method for establishing a crude risk picture, which normally covers the entire or partial bow-tie diagram [31]. It is often performed by dividing analysed subjects into sub-elements, and using tables to display all information about risks, their causes and possible consequences.

Reliability and Factor Analysis in Questionnaire Analysis

To evaluate the questionnaire, this report used IBM SPSS Statistics 23 (SPSS), a programme designed for statistical analysis such as the reliability check and content validity analysis. Before calculating the results of specific perceived risks, the reliability of the corresponding questions must be tested. The coefficient "Cronbach's Alpha" is normally used to reveal the internal consistency. After adding data to the SPSS, choose option - "Reliability Analysis" with internal option "Intraclass correlation coefficient". If the calculated value of "Cronbach's Alpha" is high, it means the internal consistency is high. It's normally accepted when $\alpha >= 0.7$ [32].

To verify the content validity, factor analysis is normally used to investigate the dimensionality of the scale construction. In such applications, the items that make up each dimension are specified in advance [33]. The purpose of factor analysis is also to

reduce the number of questions. In this research, after adding data into SPSS, choose "Factor Analysis" with internal options "Dimension Reduction" and "KMO and Bartlett's test of sphericity". "The Kaiser-Meyer-Olkin Measure of Sampling Adequacy" varies between 0 and 1, normally 0.5 as minimum and the larger the better. Result of "The Extraction of Communalities" shows whether all values are well represented, and normally they are well represented if there is no particularly low value. Result of "Total variance explained" shows the number of major factors. Result of "The cumulative %" in "Rotation sums of squared loadings" indicates the percentage of variance accounted for by the current and all the above factors. These elements mentioned are used to complete the factor analysis in this research.

MCDA

Multi-Criteria Decision Analysis has been selected for product optimization, because the volume and nature of available data used to support this analysis may vary, and there are many different criteria to different options. In addition, different analytical skills or inherent subjectivity of the people supporting these decisions may vary [34]. Thus, the MCDA approach can be used to deal with the difficulties confronting decision-makers, when they attempt to handle large amounts of complex information in a consistent way, by combining different analytical skills [34]. Another advantage is, that the choices of criteria, weights and scores can be changed if there is any inappropriate in the future such as the change of the trend and new technologies.

There are 7 detailed steps in MCDA analysis:

"1. Establish the decision context

2. Identify the options to be appraised

3. Identify objectives and criteria

4. Scoring and weighting

5. Combine the weights and scores for each option to derive an overall value.

6. Examine the results

7. Sensitivity analysis [34]*"*

Bow-tie Diagram

The bow-tie diagram is able to visualize risk events, clearly showing the threats leading to the occurrence of event, the resulting consequences, and the barriers which should be prevented and recovered from. The entire bow-tie diagram is shown in Fig. 9, where the barriers in the left side of the diagram work as prevention and the barriers in the right side work as recovery.

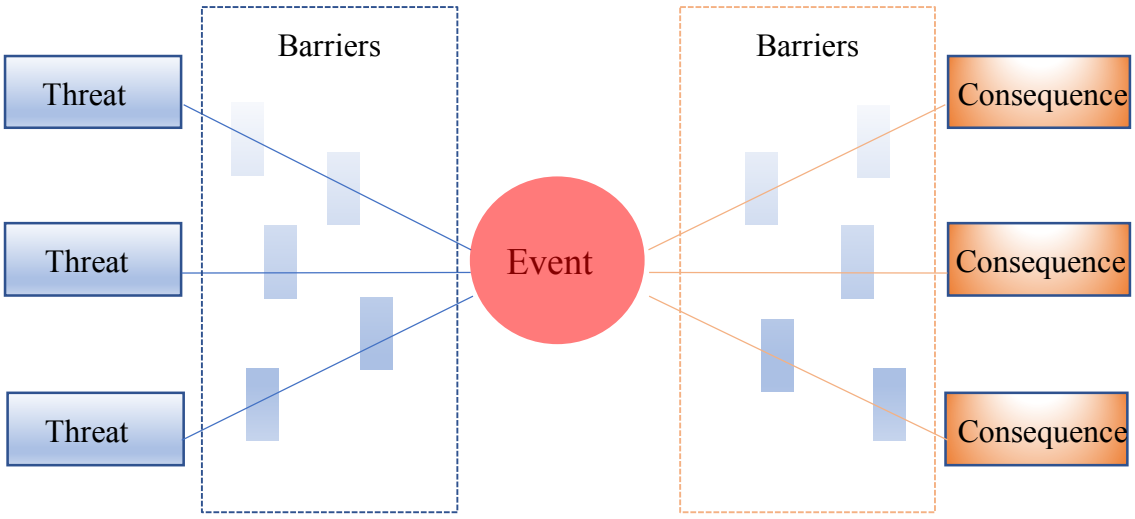

Figure 9. Bow-tie Diagram [31]

2.3.2 Questionnaire

In order to understand the users' perception of bike-sharing, propose measures and provide necessary information for MCDA, this report has carried out a questionnaire survey involving both potential and existing users of bike-sharing.

There are three types of research methods available for performing questionnaires, exploratory, descriptive, and causal [35]. Only one question in the present survey used the exploratory method, that is, the final open-ended question. This open-ended question aimed to further understand the respondents' opinions towards bike-sharing, even if the answers might not provide any statistical data, it provided the author with richer quality information and offered inspirations for related problems [35]. The remaining questions used the descriptive method. Used this kind of method aim to understand the respondents' opinions and their attitudes towards a given subject by pre-set questions, and the results of this type of questions can generally be converted to statistical data. In other words, the questionnaire was mostly formed by multiple choice questions, and only the last question provided a blank space where the respondents were free to write down additional opinions.

Sample and Data Collection

This survey was conducted between November 1st and November 17th of 2017. It focuses on three areas, namely the usage of bike-sharing, risk related questions and personal information.

Generally speaking, larger sample sizes result in less errors, but the fact is that it's difficult to implement a research with a large sample size in a limited period of time. There are 23 provinces and 4 municipalities directly under the central government in China. Therefore, due to the large number of bike-sharing users, the survey was sent out online. Social media was used to spread the questionnaire around the country. Tencent Questionnaire is often used as a platform to make self-administered questionnaires, where a link is created and shared online. Tencent Questionnaire belongs to one of the most famous Chinese Internet companies Tencent, which provides platforms for both social media and research. It can easily and correctly collect data and then transfer the data to an Excel document. Respondents are free to answer this survey via smartphone and computer.

This survey was designed in Chinese, and there was a 10-person-participating pre-test before the large-scaled survey was carried out. After the pre-test, the wording was changed to be more user friendly, simpler, and more understandable according to advice from the test subjects. When all data was collected, the questions were translated to English for the purpose of this report (Appendix 1).

Structure of the Questionnaire

Most of the questions followed a Likert Rating Scale from 1 to 5, the results provided useful data to estimate the level of information. For example, when it comes to questions about importance of a certain, the answer provided 5 options, from very unimportant to very important.

The structure of the questionnaire was divided into 4 stages:

1. Question 1-6: usage of bike-sharing and user attitude. This stage of the study tells us how often they use bike-sharing service, their purposes, the experience of bike-sharing and their attitudes.

2. Questions 7-8: this stage is expected to collect users' preferences for shared-bike components, which supports scoring and weighting criteria in the MCDA section.

3. Question 9-18: this stage focuses on risk perception. These questions are made for gathering the risks perceptions of bike-sharing users, which includes 6 dimensions of risks. Perceived risks of bike-sharing in all dimensions are calculated by the formula:

   $$\text{Overall Perceived Risk} = (\text{Probability}_1 \times \text{Consequences}_1) + (\text{Probability}_2 \times \text{Consequences}_2) + \ldots + (\text{Probability}_6 \times \text{Consequences}_6)$$

   Each perceived risk must be calculated by multiplication of the probability of a risk and the consequence connected to the occurring of this event, and the sum of the 6 dimensions of risks is the overall perceived risk. The calculation approach is made by Hoa Le Dang, et al. (Li, Dang, Nuberg, & Bruwer, 2014), based on a study on farmers' perceived risks of climate changes and influencing factors [36].

4. Question 18-23: the stage is concerning the respondents' personal information, including the regions where they are living, gender, age, education level and occupation. In the end is the open-ended question providing a blank space for

additional opinions.

2.4 Outline

This report consists of seven chapters. The first chapter is introduction, which provides background knowledge of the industry and two representative companies and their major products. The second chapter describes the formulated problems, namely the main research question and supporting sub-questions, as well as an explanation of the methodology used in this research.

Risk assessment in the shape of stakeholder analysis begins in chapter 3. Initially, this chapter identifies the primary and secondary stakeholders. Secondly, it analyses the salient stakeholders and their expectations, which provides the consideration for the following chapter, risk analysis. In chapter 4, risk analysis is used to identify possible business risks leading to financial loss, which is later applied in the questionnaire for collecting data about the users' perceived risks as well as preferences. In chapter 5, MCDA is applied to provide overall scores of all designed options, which can help the decision maker select the optimized product according to the present status of the industry.

The risk treatment starts with possible strategies for risk management, and a number of suggestions are proposed for risk reduction based on three parts; prevention, recovery, communication and cooperation.

In the final chapter, conclusion, the research questions are answered.

3 Stakeholder Analysis

3.1 Stakeholder Identification

The main purpose of this project is to analyse and evaluate business risks and through risk management gain sustainable profit growth for bike-sharing companies. The project's stakeholder analysis contains identification and understanding of each stakeholder's expectations and impacts, which can be used as a steppingstone for further analysis.

Figure 10. Primary and Secondary Stakeholders

Primary stakeholders of bike-sharing companies are users, suppliers, investors and employees. Secondary stakeholders of bike-sharing companies are governments, local communities, public, insurance companies, strategic partners, competitors and the media, as shown in Fig. 10.

Many stakeholders are involved since the development of this industry has influenced their benefits and baselines, for example local communities are involved by disordered bikes, ordinary bike companies are influenced due to decreased number of customers. Bike-sharing companies' development generally depends on their primary stakeholders, but the government plays a very important role in this emerging industry. As stated by Hu Weiwei, the slogan of Mobike is "cycling changes cities". It's well known that a bicycle-friendly city should have bike lanes, fresh air and other conditions. However, each of us can contribute to the future to make the "bicycle-friendly city" become a reality or just wait for the circumstances being changed [16]. The fact is, cycling conditions are changed by this new business, and governments pay much attention to this industry trying to provide better cycling conditions for the public and users. It can be concluded by a number of existing new policies, new bike lanes, new bike parking places, and issued industry guidance [25] [37]. Chinese governments keep supporting this new industry in order to promote its development, regulate and even limit its development to reach the purposes of economic growth, keeping the balance of market growth and maintain social order [25] [37] [38]. The *Guidance on Encouraging and Regulating the Development of Internet Rental Bicycles* was issued in August 2017 [39]. This guidance includes encouraging the development of policies, standardizing the user deposit, network information security, and creating a good environment for the industry development. For example, restriction on placing new shared-bikes in some cities, bike-sharing companies should strengthen the regulation of users' deposit security, and shared-bikes must not be rented to children under 12 years old, etc.

Local communities are involved in the bike-sharing process passively. Some randomly placed shared-bikes bring them additional work. Objections in local communities mainly stems from this additional work and consideration of potential safety risks. As a solution, one of the communities in Shanghai utilizes "third party management assistance" as a pilot to solve this conflict, but the community must pay the resulting costs [40]. Individuals from public can be the users of shared-bikes, meanwhile they can also be protester. Voices from the public revealed that randomly placed shared-bikes caused problems for car parking, slowed down walking speed, and pedestrians have to pay more attention to road circumstances [41]. Therefore, standardization of bike-sharing management is a serious task for both sharing companies and the government, and it will somehow drive the public awareness about bike-sharing. The media always plays a catalytic agent role in a society. They share the advantages of bike-sharing with the public, but also lay out disadvantages and risks. Today's society is more concerned and aware of risks than in earlier days, due to a higher level of communication through the media as well as new ways of evaluating and identifying risks [42] [43]. Therefore, although the media is a neutral stakeholder they could potentially threat the future development of bike-sharing. As one method for risk treatment, both users and bike-sharing companies can transfer risks to insurance companies, as the new guidance of bike-sharing issued by Beijing's government, is advising sharing companies to purchase insurance for their users [44]. Strategic partners could be NGOs and other industries. An example is the World Cycling Day, sponsored by Mobike and supported by environmentally and socially responsible organizations,

such as UN-Habitat, UNEP (UN Environment Programme), WHO (World Health Organization), WWF (World Wildlife Fund) and WRI (World Resources Institute) [45]. Another example is 'Mobike Hunters', which is a group of volunteers who approve of Mobike's mission and vision, supervises and report users with bad behaviour, and help move improperly-parked bikes in their spare time [46]. Another important strategic partner for bike-sharing companies is Zhima Credit, a credit-scoring service from Alibaba Group and affiliated with the technology company Ant Financial, Zhima Credit attributes scores to the biggest third-party payment platform in China, Alipay [47]. Some bike-sharing companies allow certain users with higher scores from Zhima Credit to obtain free-of-charge deposit service or only pay partial deposit for their cycling, which is very popular among the bike-sharing users.

To summarize, many stakeholders are defined above by Freeman's suggestion, but the scope is too broad. As stated by Mitchell et al (1997), the stakeholders' narrow group is consistent with only those directly related with the company's economic interests, and this is appropriate for analysing the business risks in this project [30] [48]. So, the four primary stakeholders together with governments are defined as the five key stakeholders of sharing companies' economic interests.

3.2 Salient Stakeholders

Stakeholders are classified based on the previously mentioned key stakeholders, namely users, suppliers, investors, employees and governments.

Stakeholder	Stakeholder Category	Area	Sub-Classification	Feature	Power	Legitimacy	Urgency
Suppliers / **Employees**	Low Salience	2	Discretionary	No pressure to engage this stakeholder		X	
Users	Moderate	4	Dominant	Matter to sharing companies	X	X	
Investors / **Governments**	High Salience	7	Definitive	Dominant can move into definitive category	X	X	X

Table 1. Stakeholder Classification Based on Power, Legitimacy and Urgency [30] [49]

Employees and suppliers are discretionary stakeholders who only hold legitimate attributes. It is not hard to engage suppliers and employees, since bike-sharing companies always have power to choose which suppliers they prefer and which employees they wish to hire. So, these two stakeholders are neither powerful nor urgent, as they have low impacts on sharing companies. Users can be treated as dominant stakeholders, because they are a powerful and legitimate group who can make the bike-sharing companies profitable. Investors and governments are definitive stakeholders, because withdrawal of investors easily make the company vulnerable to bankrupted, while new policies can suddenly create barriers for the companies. Therefore, they are powerful and legitimate, and their expectations are urgent as well.

3.3 Strategies for Managing Salient Stakeholders

A profitable business with low risk is investors' main expectation. Investors invest huge funds to get market share, which is not their final purpose. They wish to create value and make the industry continue being profitable. Obtaining more users will indirectly

achieve investor expectations, while the users' expectations will become urgent. Stakeholders' impact is variable rather than constant in the different stages of development, as well as any expectant stakeholder can become a definitive stakeholder by acquiring the missing attribute [30]. Let us take a look at the typical bankrupt case mentioned in chapter 2, Wu Kong Bike. Why did the investors lose confidence in the company's development? Customer satisfaction and potential profit growth are the key factors [26]. In the start-up stage of a new industry, users always expect and receive much of managers' attention than many other industries. If satisfying user requirements are expected to be urgent, then users can move into a definitive category by acquiring the missing attribute.

Governments pay close attention to this industry because they need taxable, low-risk and socially-valuable products. The mission and vision of bike-sharing is clear and specific, green, environmental protection, energy saving and emission reduction, so the cooperation between sharing companies and governments should be positive and close.

4 Risk Analysis

It is important to know what threats can lead to business risks and how users perceive these threats in the bike-sharing industry. Firstly, this chapter uses coarse risk analysis as a framework to show the existing and potential risks for the business. Secondly, meeting the expectations of investors and governments will satisfy the low risk business by considering the results of stakeholder analysis. Therefore, an optimized product analysis is necessary to meet the expectations of the key stakeholders. The questionnaire aims to collect the data about perceived risks of users, and provides information for Multi-Criteria Decision Analysis (MCDA) from the bike-sharing companies' point of view.

4.1 Risk Identification

Using a backward-inference approach to deduce related risks and threats for business risks means utilizing the possible consequences from the right side to deduce the left side of the bow-tie diagram. The news in mass media and social media shows many events or near-miss events such as accidents, congestion, theft and vandalism. Some governmental departments also pointed out many potential risks. For example, Guo Jianrong, Secretary General of Shanghai Bicycle Industry Association said, 1.5 million shared-bikes is far beyond the capacity of the city based on their estimated demands, and generally 500,000 bikes in total can meet the demands without causing chaos [50]. This means that every 50 people will share one bike [50].

Sub-element	Risks/Causes			Comments
	Dimension	Undesirable event	Causes	
Shared-bikes in service	Traffic accidents	Riding damaged bikes	Damages are not repaired	Can result in serious injury, and then trigger big financial loss due to lawsuit
			Leak of maintenance/recycle	
		Collision	Illegal riding	
			Insufficient bike lane	
	Congestion	Congestion in the public places	Illegal parking	Can result in huge compensations for serious incidents, e.g. congestion occurs on the blind pass, evacuation pass, emergency road etc.
		Bikes crowded on the road	Massive bikes	
			Insufficient parking place	
Users	Users' information disclosure	Users' information disclosure	Forgery and alterations of QR code	Can result in users' financial loss, companies may need to compensate users
			Network bugs and/or management weakness	
	Insecure deposits	Deposit getting misappropriated	Unsupervised deposit	Can result in compensation and/or lawsuit, and even lose the trust of users
			Network bugs and/or management weakness	
Theft, vandalism	Theft	Bikes being stolen	Without anti-theft system	Can result in huge financial loss due to costs of replacing new bikes
			Without alarm system	
			Without GPS positioning system	
	Vandalism	Bikes being vandalized	Without anti-theft system	Can result in huge financial loss due to costs of replacing new bikes and repair
			Without alarm system	
			Without GPS positioning system	

Table 2. Coarse Risk Analysis towards Financial Loss in Bike-sharing Industry [31]

Professor Zhang indicated many problems regarding the bike-sharing market. For instance, the number of shared-bikes exceeds the city's capacity, illegal parking, unreasonable design, theft and vandalism, and management defects (Appendix 9). Therefore, the risks could be identified by the online secondary research and the interview with the professor. The possible events are mainly found in three areas,

namely shared-bikes in service, users, theft and vandalism. The events occurring in service process could be traffic accidents and congestion; the events for users could be information disclosure and insecure deposits; the events for theft and vandalism are self-explanatory. As for these risks and their causes leading to financial loss, details are shown in Table 2. Herein, the six risks are used as pre-set factors for forming the partial questionnaire.

The expectations of the definitive stakeholders should be considered, and the possible risks are identified in risk identification so as to reduce the related risks and satisfy the expectations of investors and users. Additionally, product optimization is also the most direct and controllable parts to support bike-sharing companies in meeting the expectations of the key players. Therefore, understanding risk perception and providing useful information for further solutions is the main goals of this chapter.

4.2 Respondent Statistics of Questionnaire

The questionnaire is attached in appendix 1, while the detailed results of said questionnaire are stated in appendix 2.

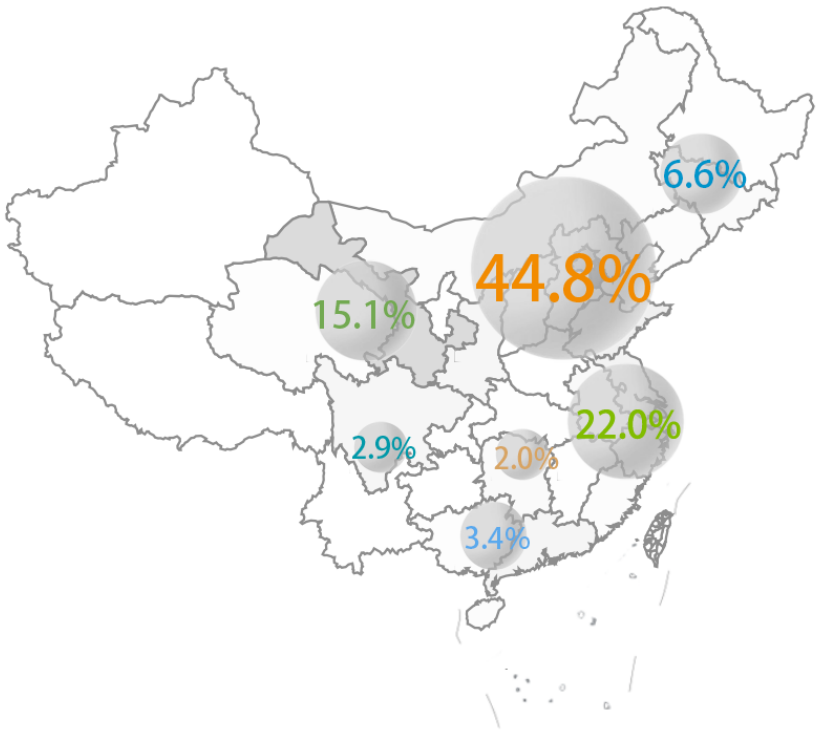

Figure 11. Probabilities of Respondent Numbers in Different Regions

The Tencent Questionnaire indicates that more than 95% of all respondents answered the survey via smartphone. There are 1,267 people who read or opened this survey, among which 350 are valid, indicating a 27.6% response rate. The respondents covered the most densely-populated areas, including 16 provinces and 4 municipalities directly under the central government. The probabilities of the respondents' number in each region are display in Fig. 11. The larger the bubble, the more respondents. The final open-ended question gave a total of 84 answers.

Besides their locations, respondents covered all age groups, different education levels, and both employed and unemployed people.

	Respondents				
Gender	Female: 54.6%	Male: 45.4%			
Age	21-30: 35.7%	31-40: 32%	40+: 30%		
Education	Bachelor: 49.4%	Master: 11.7%	Academy: 20.9%	Others: 18%	
Job	Have job: 63.7%	Freelancer: 13.7%	Student: 9.1%	Retired: 11.7%	No job: 1.7%

Table 3. Respondents' Background

As shown in Table 3, 54.6% of the respondents are female, while 45.4% are male, which gave a balanced gender grouping. Most respondents are young or middle aged; 35.7% of all respondents are found in the age group between 21 and 30 years old, and 32% are between 31 and 40 years old. There are not only younger people, but also seniors or teenagers, which constitutes more than 30% of all respondents. Almost 50% of all respondents have bachelor degrees as their highest education level, 11.7% have obtained master's degrees, 20.9% with academic experience. 63.7% of all respondents are employed while 1.7% unemployed. Finally, 13.7% of all respondents are freelancers, the student group makes up 9.1% and retired group 11.7%.

4.3 Results of Usage and Attitude

The detailed results are displayed in appendix 2.

4.3.1 Main Purpose - Solving "the last kilometre of the trip" Problem

The answers to question 1 show that more than 90% of all respondents have experience with bike-sharing, while 43% of all respondents use shared-bikes often or very often. In the results of question 2, we learn that the top three purposes of using bike-sharing are connection between public transportations (57.8%), use shared-bike whilst walking to saving time (48%) and leisure (35.2%). These results reveal that the most common purpose is connection between public transportations, which is a result similar to the early online research made by Jiefang Daily Social Survey Centre and KuRunData China Online (56%), as shown in chapter 1.2. In addition, it means that bike-sharing companies have been solving "the last kilometre of the trip" problem well. Besides, some people chose complete commuting, so the commuters are the main target group for bike-sharing.

4.3.2 The More Users, the More Acceptable of Drawbacks

Even if most people consider the bike-sharing service convenient or very convenient (86%), there are a small number of people who believe bike-sharing brings inconvenience at the same time or even hold the belief that the inconvenience clearly outweighs any possible benefit (4%).

	R (Cross result/Sum of each frequency)				
	Never	Seldom	Sometimes	Often	Very often
Very inconvenient	**6.5%**	**2.0%**	**2.4%**	**1.1%**	**0.0%**
Inconvenient	12.9%	1.0%	1.2%	1.1%	0.0%
Neither convenient nor inconvenient	35.5%	14.3%	8.5%	2.1%	2.3%
Convenient	32.3%	67.3%	56.1%	40.0%	22.7%
Very convenient	**12.9%**	**15.3%**	**31.7%**	**55.8%**	**75.0%**

Table 4. The Cross Result and Sum of Each Frequency Number Ratio

By using cross-analysis for question 1 and 3, the author found that the more frequently users choose bike-sharing, the more convenient they feel. This also means that people using bike-sharing frequently will be more prone to accept drawbacks, since the product has a direct benefit to them, shown by the bold rows in two extreme levels of convenience in Table 4. The calculation of the ratios is displayed in appendix 3. It seems to be an obvious result, but it verifies the chosen approach for risk management, which is maximally satisfy the expectations of users as well as maximally mitigate the risks confronting ordinary people.

4.3.3 People are not Willing to Pay More Deposit

In the results of question 4, only 23.2% of all respondents are willing to pay deposit of more than EUR 12.9 (RMB 101), 34.9% are willing to pay less than EUR 12.8 (RMB 100), and 42% prefer to use free-of-charge service via Zhima Credit. This result is not only dependant on the amount of money, but also due to the fact that users might consider a deposit to be a risk. This outcome was inferred by the open-ended question

as well. 8 out of 84 text answers mentioned the deposit risk directly, even if there are already several questions related to deposit issues in previous questions.

Another point in relation to deposits is found in the differences between public bikes and dockless shared-bikes. Users must pay more than one deposit if they want to use different brands of dockless shared-bikes. However, for bike-sharing companies, the amount of deposit is estimated according to the production costs and risk consideration from their own viewpoint. As mentioned before, the production costs vary from EUR 38.5 to 385 (RMB 300 to 3,000) per bike in different companies. The fact is users will never stand in the companies' position to think about the risk. For them, the less deposit is needed, the safer it is.

4.3.4 More Than 60% Respondents Think Their Cities have Sufficient Shared-bikes

The results of question 5 show that more than 64% of all respondents believe there are sufficient, or even too many, shared-bikes in their cities. In the result of the open-ended question, some comments focused on an imbalance between the number of shared-bikes in different cities and areas. It seems as if there are too many shared-bikes in big cities, but an insufficient number of bikes in small cities, and it is even difficult for users to find a shared-bike during rush hour in some places. Here two problems are exposed; marketing positioning and management defects. Certainly, targeting big cities in start-up stages is the right strategy, but most of bike-sharing companies rushed to big cities in swarms, which might have led to fierce competition too. Besides, bike-sharing

companies can be easily be affected by new policies. In addition, management defects may lead to bad customer experience and reduction of revenue.

4.3.5 Most People Think They Can Get Their Deposit Back

Looking at the results of question 6, we discover that only 6.8% of all respondents have negative perceptions of getting their deposit back after using bike-sharing. This is a not a large number, and it may to some extent be caused by bad experience in deposit refund or previously-mentioned news from mass media. 42% of all respondents believe they can get their deposit back, and more than 27% are quite sure about it. The remaining 24% of chose somewhere in between, which means they are not very sure about their answers. Conclusively, most respondents do not think there is serious risks to the deposit, even though some news reported incidents where users couldn't get their deposit back after the bankruptcy of bike-sharing companies.

4.4 Results of Specific Perceived Risks

Question 9 to 17 include questions about perceived probabilities and consequences for the six dimensions of the risks, as stated in Table 2. The 350 valid responses were inserted into an Excel sheet for calculating perceived risks.

4.4.1 Result of Reliability and Factor Analysis

The original results are shown in appendix 4.

Before calculating the specific perceived risks, the reliability of this part of questionnaire must be tested. The reliability analysis in SPSS is used to analyse the coefficient of reliability for these 21 sub-questions in question 9 - 17. The result of "Cronbach's Alpha" is equal to 0.898, which is relatively high in these questions (it's normally accepted when $\alpha >= 0.7$) [32].

Factor analysis is used to investigate the dimensionality of the scale construction in this research. The outcome of "Kaiser-Meyer-Olkin Measure of Sampling Adequacy" is 0.867, which is a good result. The "Bartlett's Test of Sphericity" is significant and very close to 0. The "Extraction of Communalities" shows that all values are well represented, because there is no particularly low value in this case. "Total variance explained" shows there are 6 factors, as requested. The cumulative "Rotation sums of squared loadings" is equal to 71.385%, which means that those 6 factors together account for 71.385% of the total variances.

4.4.2 Results of Perceived Risks

The representatives of each dimension are shown below:

- Questions 9 and 10 focus on the probability of congestion, by asking whether parking places are sufficient, and what do they think about illegal parking in their cities.

- Questions 11, 12 and 13 focus on the probability of accidents by asking the respondents whether the dedicated bike lanes are sufficient, how many cyclists do not obey the traffic regulations, and the maintenance of shared-bikes.

- Question 14 concerns the probability of deposit misappropriation by asking each potential reason of deposit misappropriation, including unsupervised deposit management, network bugs and/or management defects of sharing companies.

- Question 15 concentrates on the probability of users' information disclosure by asking about each potential reason for users' information disclosure, including false QR codes, network bugs and/or management defects of sharing companies.

- Question 16 is asking the probability of theft and vandalism.

- The six sub-questions in question 17 focus on the severity of consequences for all above risks.

The calculation is obtained by finding the sum of the six specific perceived risks. The specific perceived risk is equal to the multiplication of perceived probability and severity in each dimension. Each specific perceived probability or severity is obtained by getting the average results of all oriented sub-questions/questions in each dimension.

There are 5 options for each question/sub-question, the highest probability or severity being 5, and the lowest 1, based on the 5 Likert Rating Scale. Thus, each specific perceived risk ranges from 1 to 25 in this case. The calculation as follows: the minimum risk is equal to the multiplication of two minimum numbers of probability (1) and

severity (1). Similarly, the maximum risk is equal to the multiplication of two maximum numbers of probability (5) and severity (5). Since there are six dimensions in total, the overall specific risk ranges from 6 to 150 theoretically. This approach to calculate the perceived risks refers to the study made by Hoa Le Dang, et al. as mentioned [36].

Dimensions	Perceived probability			Perceived severity			Specific perceived risks		
	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE
Accidents	3.621	0.549	0.029	3.014	1.082	0.058	11.028	4.658	0.249
Congestions	3.726	0.666	0.036	2.854	1.102	0.059	10.790	4.984	0.264
Misappropriation of deposit	3.282	0.964	0.052	3.074	1.115	0.060	10.596	5.786	0.309
Users' information disclosure	3.389	1.017	0.054	3.197	1.211	0.065	11.425	6.422	0.343
Theft	2.849	1.077	0.058	3.337	1.092	0.058	9.811	5.623	0.301
Vandalism	2.977	1.070	0.057	3.529	1.091	0.058	10.874	5.972	0.319
Overall perceived risk							64.524		

Table 5. Means, Standard Deviations (SD) and Standard Errors (SE) of Specific Perceived Risks

As shown in Table 5, “Accidents” and “Users’ information disclosure” receives greatest attention with their mean values at 11.028 and 11.425 respectively. Users seem to perceive risks which might influence themselves to be at higher levels. “Congestions”, “Vandalism” and “Misappropriation of deposit” receives lower risks with their mean values at 10.790, 10.874 and 10.596 respectively. “Theft” receives the lowest risk with the mean value at 9.811. Overall, all perceived risks in the six dimensions are relatively balanced. This is also to say that many people may not have a clear perception of business risks. In other words, there hasn’t been any deeply-rooted negative risk perception yet, and the development of risk perception could provide uncertainties in the future.

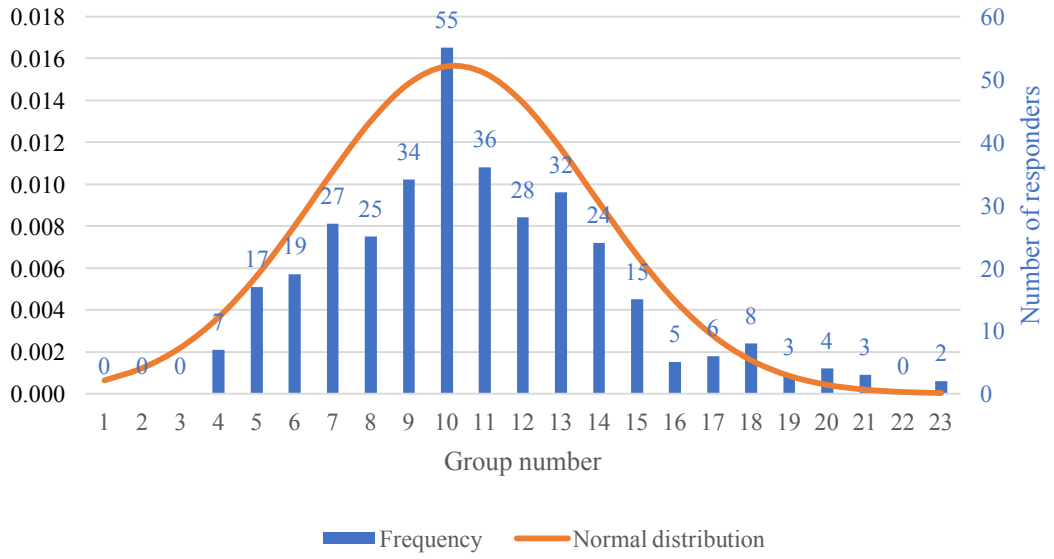

Figure 12. Normal Distribution Curve and Frequency Histogram

The frequency histogram and the normal distribution curve are shown in Fig.12, with the mean value at 64.524 and standard deviation at 25.507 (calculation process is displayed in appendix 5). Herein the secondary vertical axis (the blue axis, Fig.12) represents the frequency of how many calculated "perceived risks" are found in the corresponding group. The statistics show that the most frequently perceived risks are located in group 10 (perceived risk from 56 to 63, see appendix 5) on the x-axis in Fig. 12, which means most of the respondents (55) perceived risks in the range of 56 - 63. It seems the statistic result is merely a little lower than the calculated mean value of the overall perceived risk (64.524). Nevertheless, there are no existing studies about the risk of dockless bike-sharing, meaning that the calculated risks value cannot be defined as high or low. Additionally, the perceived risks in the questionnaire do not express the probabilities or severities of those risks occurrences in reality, but only a study for understanding the risk perceptions of people.

4.5 Result for Users' Choices

Ultimately, the results of user preference must be calculated before suggesting product optimization in the next chapter. This section uses the answers of question 7 and 8 in the questionnaire. Detailed results of questions 7 and 8 are shown in appendix 2.

There are 350 valid respondents in total, and approximately 37% of them "never" use or only "seldom" use bike-sharing. For the purpose of precise positioning, analysis in this section only involves those who use bike-sharing more often, that is, those who responded "Sometimes", "Often", or "Very often" in question 1. In total, 221 respondents are found in this section.

4.5.1 Experience Preferences

Dimensions	Mean	SD	SE
Intelligent technologies content	3.484	1.178	0.079
Comfort	4.267	0.980	0.066
Quality	4.308	0.984	0.066
Convenience	4.321	0.968	0.065
Better appearance and condition	3.493	0.975	0.066

Table 6. Means, Standard Deviations (SD) and Standard Errors (SE) of Experience Preference

In Table 6, the results show that "Convenience", "Quality" and "Comfort" obtain the higher levels of experience preferences with the mean values at 4.321, 4.308 and 4.267 respectively. "Better appearance and condition" and "Intelligent technologies content" obtain smaller results, namely 3.493 and 3.484.

4.5.2 Functional Users' Preferences

Dimensions	Mean	SD	SE
GPS positioning system	3.842	1.201	0.081
GPS navigation	3.448	1.273	0.086
Quick unlock	4.253	1.009	0.068
Support USB charging for phone/tablet	3.199	1.299	0.087
Adjustable seat	4.253	1.044	0.070
Anti-theft system	3.774	1.284	0.086
Vibration sensors report destruction/tracking and alarm	3.914	1.193	0.080
Free or deducted deposit by using Zhima Credit	3.910	1.184	0.080
Support riding insurance	4.000	1.144	0.077
Instant deposit refund	4.140	1.117	0.075

Table 7. Means, Standard Deviations (SD) and Standard Errors (SE) of Functions Preference

In the functional preferences dimensions, the "Quick unlock" and "Adjustable seat" functions received the highest levels of attention with both mean values at 4.253. "Instant deposit refund" and "Support riding insurance" received lower levels of attention with the mean values at 4.14 and 4 respectively. "Vibration sensors report destruction/tracking and alarm", "Free or deducted deposit by using Zhima Credit", and "GPS positioning system" received much lower levels of attention with the mean values at 3.914, 3.91 and 3.842 respectively. "Anti-theft system", "GPS navigation", and "Support USB charging" received the lowest levels of attention with the mean values at 3.774, 3.448 and 3.119 respectively.

4.6 Limitation of the Questionnaire

There are some regional differences in this industry, such as population density and quantity of shared-bikes in each city, which means the rating results are relatively subjective. In addition, local governmental policies are not exactly the same in different cities.

Because of the survey's characteristics, a disadvantage is shown during this research process. A scholastic survey is not a short questionnaire. The design for this research has an answer time of more or less 5 minutes. The durations of respondence show that most of the younger people could finish the questionnaire within 4 or 5 minutes. However, feedback from some senior people indicate that even if they preferred to answer it by mobile platform since it is more popular and simple, but it was not that easy to operate via a small screen on a smartphone since some of them have never done a survey on smartphone. That's why some of them spent more than 9 minutes to finish this survey.

Once respondents couldn't finish it within minutes or they were in a hurry to do something else, they would give up in the middle of the answering process. For similar reasons, some respondents lacked the patience to read all the questions carefully and completely. What's worse, some respondents chose the first option as their answers for all questions after they had finished the first few questions. Ultimately, the author had to remove these invalid answers.

5 Multi-Criteria Decision Analysis

As an innovative product, dockless shared-bikes may be considered as an advanced development of traditional shared-bikes. It might be developed through requirements analysis, functional analysis and design, prototype development, and then are launched to the market with testing [51]. Considering the different models with different components and functions at present, the dockless bike-sharing is assumed to be in the testing phase, which can be deduced by its various functions and frequentative changes in the two years since lauching. Most of the identified risks, accidents, congestions, risk deposit, theft and vandalism can be minimized by selecting an optimized product. Thus, an optimized product can be assumed to be one of the main requirements for gaining low-risk business.

5.1 Identifying the Options to be Appraised

As described in the stakeholder analysis part, the definitive stakeholders are governments and investors. Both of them apply great importance to the opinions of users, so the options must focus on the interests and expectations of these stakeholders.

Making optimal options for bike-sharing companies, low risk products and profitable considerations are necessary for its sustainable development. Considering the stakeholders' different expectations, five options are identified (see detailed information in appendix 6).

Option 1: considered conditions similar to Mobike 'Classic', which is a

relatively safe product for bike-sharing companies with some considerations of bike usage.

Option 2: considered conditions similar to Mobike 'Lite', lower production cost than Mobike 'Classic', and contain many intelligent components.

Option 3: considered conditions similar to Ofo 1.0, with very low production cost and very low durability, but a potentially high maintenance rate in the future.

Option 4: designed as a high-safety-level product for bike-sharing companies.

Option 5: designed as a high-safety-level product for both users and bike-sharing companies.

5.2 Identifying the Criteria

As shown in Fig.13, there are two crucial factors when it comes to cost, namely production cost and maintenance cost. Profit risks based on user preferences are divided into experience preference and functional preference. In this case, the research set the user-based profit risks in relation to the industry characteristics, that is, the user is one of the most important factors for business success. It means whoever wins the users will ultimately succeed in the market, and an optimized product can retain users at the competitive market rather than adopting the high-bike-density strategy. Safety is important not only to users but also to companies in this case, which is also based on the industry characteristics. A successful bike-sharing process heavily depends on the

continuous usage of shared-bikes, but theft and vandalism will cause trouble for the bike usage and lead to an increase in costs.

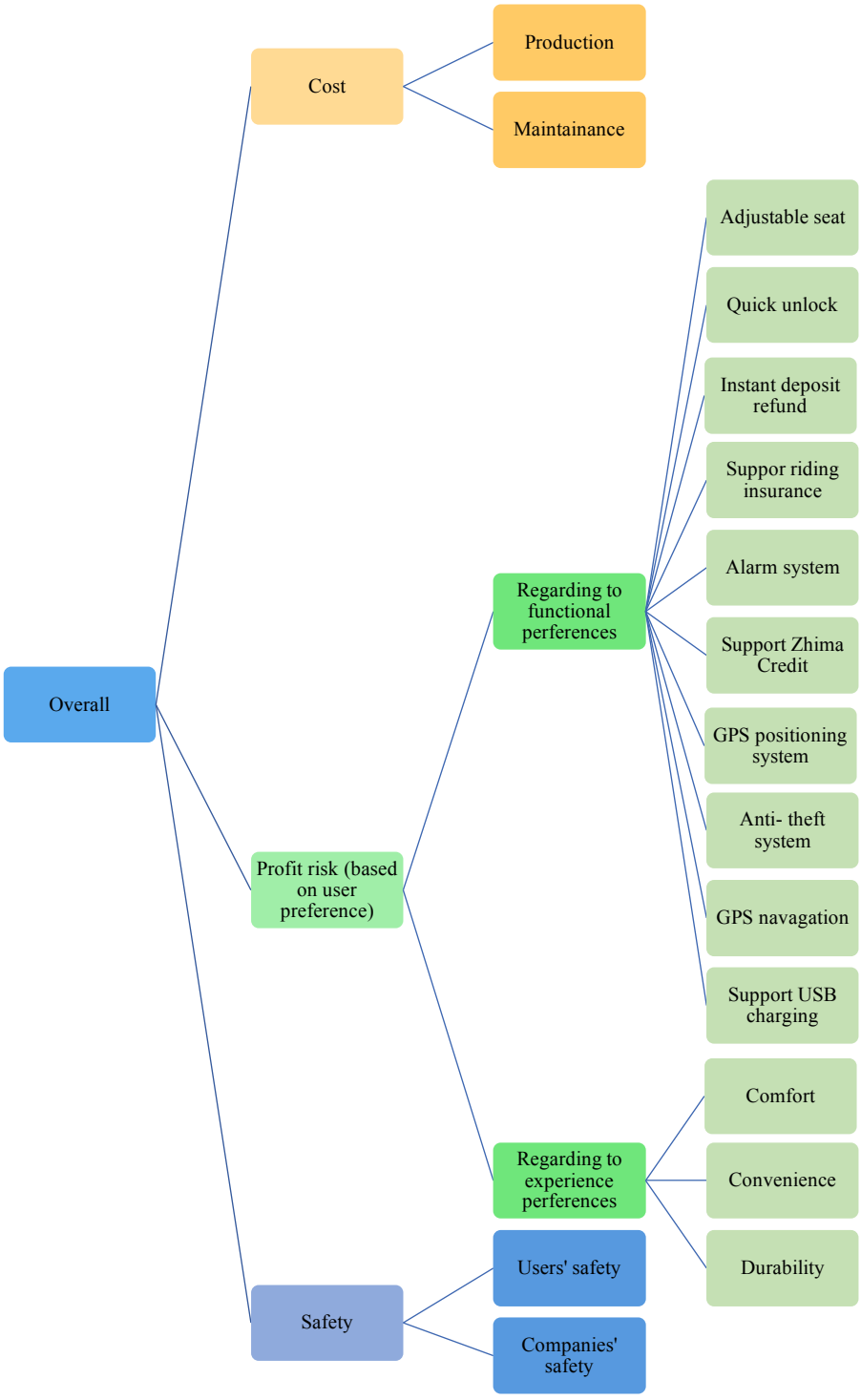

Figure 13. Criteria for MCDA

In experience preference, only the top 3 out of all 5 factors in Table 6 are considered, because these three factors received almost the same high risk scores. In functional preference, the mean values for the ten sub-criteria are used to weight the scores.

5.2.1 Performance Matrix for Functional Preferences

	GPS positioning	GPS navigation	Quick unlock	Adjustable seat	Anti-theft system	Alarm system	Zhima Credit	Support insurance	Instant deposit refund	Support USB charging
Option 1	Yes	No	Yes	No	Yes	Yes	No	No	No	No
Option 2	Yes	No	Yes	Yes	Yes	Yes	No	No	No	Yes
Option 3	No	No	No	Yes	No	No	Yes	Yes	No	No
Option 4	Yes	No	Yes	Yes	Yes	Yes	No	No	No	No
Option 5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No

Table 8. Sub-Criteria for Profit Risk towards Users' Preferences

Table 8 shows the differences between these 5 options. The functions for option 1, 2 and 3 are based on secondary research online, as previously mentioned. Option 4 is designed to obtain functions safe for bike-sharing companies. Option 5 is designed to contain functions which are safe for both users and bike-sharing companies.

The lower the cost of a bike frame is, the lower the durability and higher maintenance cost. The more intelligent components are applied, the higher convenient level and lower comfort level, because many intelligent components increase the total weight of the bike (Appendix 6).

5.2.2 Performance Matrix for User Experiences

Option	Comfort	Convenience	Durability
1	Low	High	Very high
2	High	Very high	High
3	Medium	Low	Low
4	High	Very high	High
5	High	High	Very high

Table 9. Scoring the Options for Profit Risk towards User Experiences

In Table 9, user experience is assigned with a 5-point (very low, low, medium, high, and very high) scale. The information of each option is referring to its production costs, frame materials, obtained components and online research.

5.2.3 Performance Matrix for Cost and Risks

	Production cost	Maintenance cost	Users' safety	Companies' safety
Option 1	High	Low	Medium	High
Option 2	Medium	Medium	Medium	High
Option 3	Low	Very high	Medium	Medium
Option 4	Medium	Medium	Low	Very high
Option 5	Very high	Very low	Very high	Very high

Table 10. Scoring the Options for Costs and Risks

In Table 10, scoring production and maintenance cost is based on the secondary research and the correlation between production and maintenance costs (Appendix 7). Users' safety is evaluated by both product cost and add-on services, such as supporting riding insurance and instant deposit refund. Conversely, company safety is evaluated by cost and safety related components such as anti-theft and alarm systems.

5.3 Evaluation of Overall Scores by Scoring and Weighting

When scoring the criteria for all options, the consistency must be checked. For example, a higher comfort level means higher score in evaluation, while a high score in cost means low cost. This section employs a 0 to 100 point scale, with the most preferred option assigned to the score of 100, and the least preferred a score 0 [34].

5.3.1 Calculation for Functional Preferences Scores

Functions	Mean	Weight
Adjustable seat	4.253	0.11
Quick unlock	4.253	0.11
Instant deposit refund	4.140	0.11
Support riding insurance	4.000	0.1
Vibration sensors report destruction/tracking and alarm (Alarm system)	3.914	0.1
Free or deducted deposit by using Zhima Credit	3.910	0.1
GPS positioning system	3.842	0.1
Anti-theft system	3.774	0.1
GPS navigation	3.448	0.9
Support USB charging for phone/tablet	3.199	0.8
Sum	38.733	1

Table 11. Calculation of Weight for Functions Preferences

Table 11 displays the mean values of functional preferences, and the calculated weights for following calculation. The result of each weight is equal to each mean value divided the sum of all mean values.

	GPS positioning	GPS navigation	Quick unlock	Adjustable seat	Anti-theft system	Alarm system	Zhima Credit	Support insurance	Instant deposit refund	Support USB charging	Scores
Option 1	100	0	100	0	100	100	0	0	0	0	**42**
Option 2	100	0	100	100	100	100	0	0	0	100	**60**
Option 3	0	0	0	100	0	0	100	100	0	0	**30**
Option 4	100	0	100	100	0	100	100	100	100	0	**71**
Option 5	100	100	100	100	100	100	100	100	100	0	**92**
Weight	11%	11%	11%	10%	10%	10%	10%	10%	9%	8%	

Table 12. Calculation of Total Scores for Functional Preferences

The total scores for options in functional preferences are laid out in the above Table 12. According to the results of functional preferences in chapter 4.5.2, assigning 100 to the criteria includes the corresponding function, and 0 to the criteria excluding the corresponding function. Once the scores and weights are set, the total scores for all options in the functional preferences can be calculated. The result indicated that option 5 gains the highest score in functional preferences, since it contains most functions.

5.3.2 Calculation for User Experience Scores

5-point scales can be transferred to 0-to-100 point scales. 100 means very high, 75 high, 50 medium, 25 low, and 0 very low.

Option	Comfort	Convenience	Durability	Score
1	25	75	100	**67**
2	75	100	75	**83**
3	50	25	25	**33**
4	75	75	75	**75**
5	75	75	100	**83**

Table 13. Calculation of Total Scores for User Experiences

Based on the results of user experiences in chapter 4.5.1, this section only took account of the top three factors with similar mean values. Additionally, the calculation assumed

comfort, convenience and durability with same weight, based on their similar mean values.

5.3.3 Calculation for Costs and Risks Scores

	Cost		Safety	
	Production cost	**Maintenance cost**	**Users' safety**	**Companies' safety**
Option 1	25	75	50	75
Option 2	50	50	50	75
Option 3	75	0	50	50
Option 4	50	50	25	100
Option 5	0	100	100	100

Table 14. Calculation of Costs and Safety

By using the same method, the scores for cost and safety are shown in Table 14. In the following step these scores must be combined with weight.

5.3.4 Calculation for Overall Value

	Cost 30%		Safety 40%		Profit risk 30%		Total score
	Production cost	**Maintenance cost**	**Users' safety**	**Companies' safety**	**Functional preferences**	**Users experiences**	
Option 1	25	75	50	75	42	67	**56**
Option 2	50	50	50	75	60	83	**61**
Option 3	75	0	50	50	30	33	**41**
Option 4	50	50	25	100	71	75	**62**
Option 5	0	100	100	100	92	83	**81**
Weight	15%	15%	20%	20%	15%	15%	

Table 15. Overall Scores of All Product Options

Users' safety issues could trigger extra cost, and so does company safety, such as financial loss by theft or vandalism. Cost, profit risk and safety are almost equally important based on the key stakeholders' expectations. Therefore, it's assumed that

safety gains a slightly higher weight, which is 40%, while cost and profit risk gains 30% weight each. The result in Table 15 tells us that option 5 is on the top of the list with the highest score, 81. This means that the benefits from option 5 are better than the other options.

5.4 Examining the Results

Examining the results aims at indicating how much the winner (option 5) beats the competitors. Then, this section moves down a level in the calculation of total scores and displayed the options in a two-dimensional plot to show the main trade-offs [34]. If profit risks and benefits constitute the next level down, a relative value-for-profit risk picture is made. To show the benefits as being separated from the profit risk, this section sets the weight on profit risk as zero.

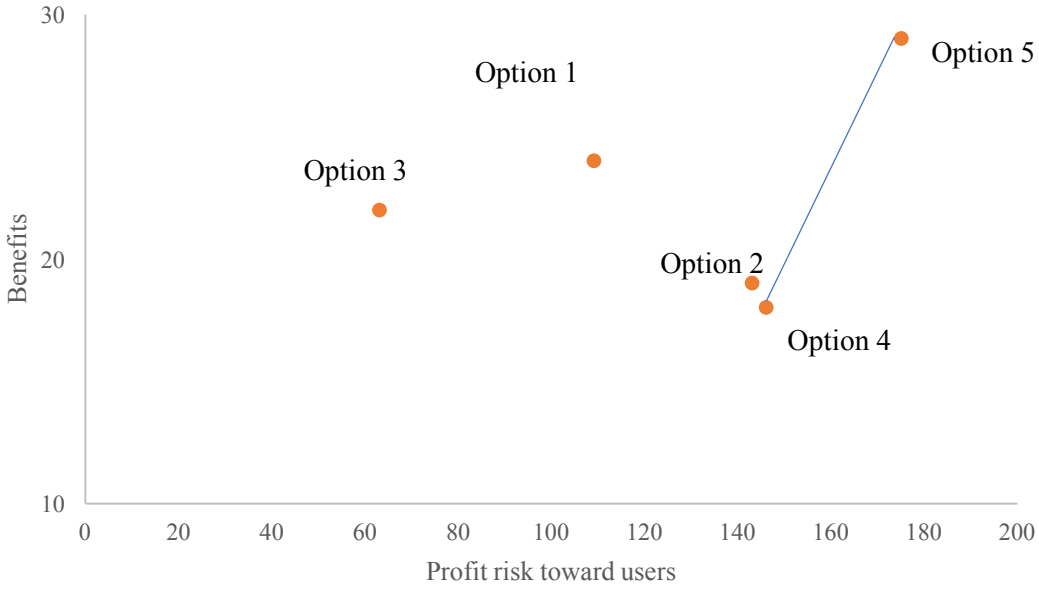

Figure 14. Benefits vs. Profit Risk for Shared-bike

After recalculating the benefits, benefit versus profit risk is shown in Fig. 14. Compared to option 4 (a high-level safety product for bike-sharing companies), option 5 (a high-level safety product for both users and bike-sharing companies) provides more benefits. This also indicates that option 5 can gain lower risks in "Profit Risk" by considering "Users' preferences", and then gain larger benefits. Ultimately, option 5 is still the winner.

5.5 Sensitivity Analysis

Conducting a sensitivity analysis aims to test how sensitive the given result is, by changing inputs such as preferences or weights, and how this change affects the overall ordering of the options [34]. The previous result shows that option 5, as the winner, has the highest production cost with a total score of 81. Offering products with very high production costs is a hard decision making process for bike-sharing companies in practice. The reasons are also obvious since saving costs and occupying larger market shares are their main purposes in the start-up stage, instead of considering operation maintenance costs in the future. A good example of is Ofo who gain the second large market share even though there are many complaints about the quality of their bikes. Hence, testing the sensitivity of maintenance cost and total cost can provide further information for decision making.

5.5.1 Changing Weight on Maintenance Cost

Fig. 15 shows how the overall ordering is affected if the weight on maintenance costs is changed, but the weight on total cost is still 30%.

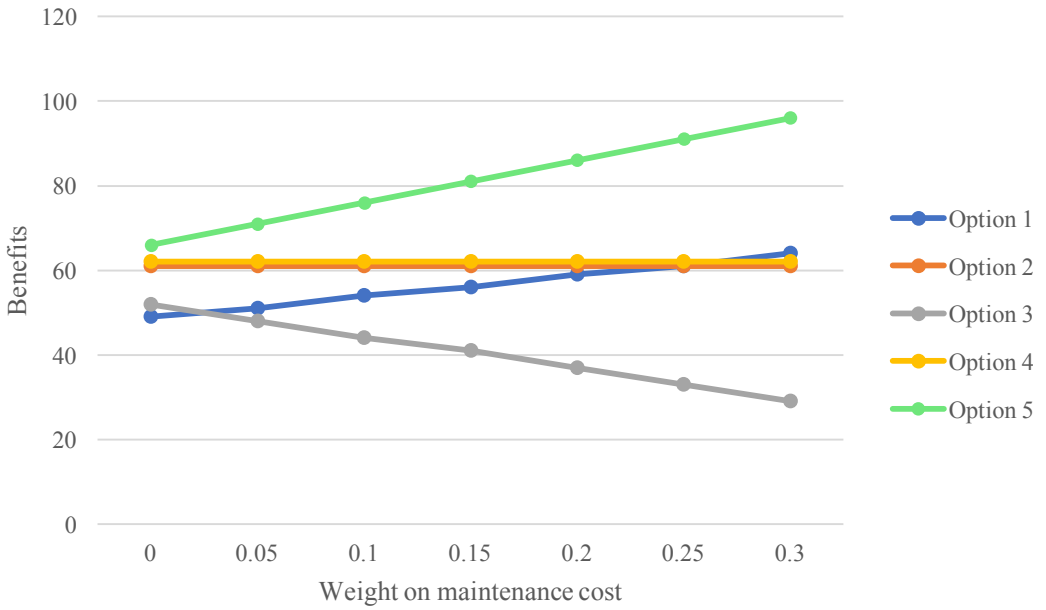

Figure 15. Weight on Maintenance Cost vs. Benefits

The sensitivity analysis above shows that option 2 and 4 are not sensitive when weight on maintenance cost is changed, because the given points on their production and maintenance costs are same. Benefits of option 1 and 5 increases with the weight on maintenance cost, but option 3 is just the opposite. This means the benefits of all options seems relatively similar without considering the maintenance cost, but they will be affected by operation. For option 3, the longer the products have been in the market, the more maintenance cost will be needed, and less benefits will be created. Therefore, the option 5 is still the winner when the weight on maintenance cost is changed.

5.5.2 Changing Weight on Total Cost

Fig. 16 shows how the overall ordering is affected if the weight on total cost is changed.

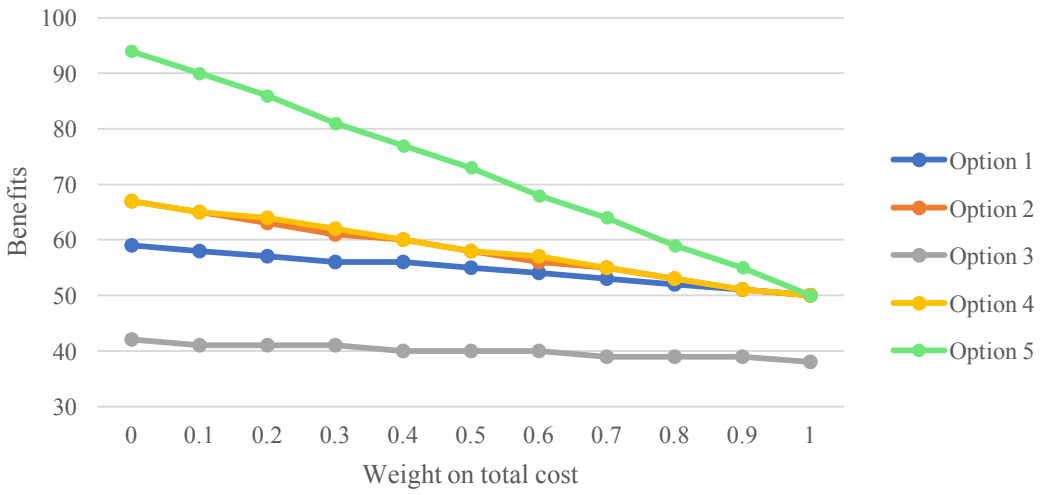

Figure 16. Weight on Cost vs. Benefits

The sensitivity analysis graph (Fig. 16) shows that option 5 is the most sensitive option, which means the less weight on cost, the more benefits on option 5. It may create a hard decision process for bike-sharing companies if they do not prefer a higher-cost product. However, in combination with previous sensitive analyses, option 5 is the optimized option with strong supports when considering a long-term business.

On the other hand, the options in the MCDA are designed by the present status and considerations. Further options can be designed and applied in the MCDA, because an advantage of MCDA is its flexibility for operation. The new options may be based on other considerations or technologies. Hence, this research can be used as a template.

6 Possible Strategies

Bike-sharing companies will face different problems that might also lead to business risk regardless of the choice of optimized product, as mentioned in risk identification. Therefore, how to reduce and avoid identified risks is very important for bike-sharing companies. This chapter focuses on possible strategies for minimizing these risks, which means establishing barriers as prevention in the left side of the bow-tie diagram, and barriers as recovery in the right side.

There are four types of strategies to treat risks, namely avoiding the risks, reducing the risks, transferring risks to other parties, and accepting the risks. The coarse risk analysis toward financial loss in Table 2 covers selected parts of the bow-tie diagram, i.e. initiating events and possible threats. This chapter recommends possible strategies to treat risks based on these identified risks.

6.1 Prevention

Prevention strategies are the barriers to avoid or mitigate the risks before the actual occurrence of events (on the left side of the bow-tie diagram). This section considers both companies and governments in discussing strategies to avoid and mitigate business risks in the bike-sharing industry.

6.1.1 Operational Management

Preventing the above mentioned risks relies heavily on the management of enterprises and governments. Timely maintenance of shared-bikes can prevent traffic accident to a large extent, and this is based on the service team of bike-sharing companies. As professor Zhang mentioned in the interview, *"strengthening routine maintenance and inspection can increase the safety levels of users"*. The bike-sharing companies must increase the number of service personnel while increasing the number of shared-bikes. Furthermore, timely maintenance and cleaning up of faulty bikes can increase the number of available shared-bikes.

At present, there is no system prompt to safety notice in the bike-sharing Apps and no warning signs on the shared-bikes themselves. Therefore, this report recommends prompting safety information in obvious places. For example, users should be informed of the anti-theft system prior to usage and possible consequences, such as any improper behaviour will be reported automatically, compensation, or something to do with the permanent credit history.

High-efficiency maintenance can be achieved by using GPS positioning system, which means the faulty bikes can report their present status and location, thus reducing the time of maintenance personnel arriving at the designated location. For example, the service personnel might find it difficult to locate bikes without a GPS positioning system. Using intelligent technology to increase the safety level is recommended in this

report, since the results of MCDA in the previous chapter indicated that intelligent components can increase the safety level for both bike-sharing companies and users.

Mutual supervision can efficiently supervise the users' behaviours, such as illegal riding, theft and vandalism. Mobike encourages users to report faulty bikes, such as those with broken pedals or missing bells, as well as report - with evidences - whoever violates the regulations, steals or vandalizes bikes. Once one user's behaviour is deemed improper, this user's Mobike Score will drop. The Mobike Score affects users' fares and use of the system, as shown in appendix 8. As Mobike indicated in one talk show, this works very well, but those "bad users" who have gained a very low score might turn to other brands [19]. This strategy may reduce risks for the entire bike-sharing industry, if similar systems can be promoted to all bike-sharing companies. However, it proves very difficult for some bike-sharing companies who do not have these intelligent components, including Ofo.

6.1.2 Governmental Supervision and Management

Supervision is one of the top topics regarding bike-sharing in Chinese social media, especially after the bankruptcy of a number of bike-sharing companies. On the basis of the issued guidance, the direction of future policies is clear. As a long-term strategy, some changes regarding this guidance may cause increased costs or a reduced number of active users in the short run, such as adding GPS positioning components and/or promoting a credit system for the entire industry.

Governmental management is also very important for the reduction of related accidents. People should be instructed about how to reduce their own safety risks, and tighter traffic regulation should be issued so as to reduce the risks of illegal riding. Another issue is infrastructure. As the questionnaire result shows, most people find bike lanes to be insufficient in their cities. A reason for this is that mixed traffic is amongst the main forms of the Chinese traffic [52]. Here, mixed traffic means pedestrian, non-motor vehicle and motor vehicle sharing the same lane, such as some level II and III roads (main road and minor road) [53]. At present, more and more cities are planning to construct bike lanes to relieve the contradiction. For example, Beijing plans to construct a "cycle superhighway" with references to Denmark and Holland [54]. This report recommends the "Copenhagenize Index" as a measure tool for future bike related considerations. The total 14 parameters for ranking bicycle-friendly cities should be considered in China as well [24].

Along with the renaissance of biking in China, planning more urban parking places for bikes becomes more and more urgent. Controlling the total number of shared-bikes has been already been implemented in some cities, such as Beijing, Tianjin, Shanghai, Hangzhou, and Shenzhen.

At present, regularly sorting out disordered bikes is a main solution for local communities and bike-sharing companies, however public are not very satisfied. Using manual labour regularly sorting out disordered bikes is inefficient, and costs for both

bike-sharing companies and governments are great. The standard cost is about 50 personnel for every 10,000 shared-bikes [55].

Therefore, an advanced strategy is needed for reducing the probability of illegal parking, which is virtual fencing technology. Virtual fencing technology uses coordinates, wireless technologies and sensors to control the locations of shared-bikes without actual fencing and/or manual labour. This means that shared-bikes must be parked in designated areas, otherwise the cycling journey cannot be stopped, and the system will keep charging the users [55]. However, there are some technical issues that must be solved before a large-scale implementation of virtual fencing, such as clearing the respective responsibilities, balancing management between bike-sharing companies and governments, considering the add-on costs and maintenance issues for existing shared-bikes in the market.

Prior to the finalization of this research, districts in a few cities have already started to test the virtual fencing technology. “GPS based virtual fencing” is tested in Tongzhou district, Beijing; for non-GPS based bikes, “blue-tooth device fixed at parking places, and blue-tooth label fixed on the bikes” are being tested in Chaoyang district, Beijing; “blue-tooth device fixed on the share-bikes, blue-tooth label fixed at parking places” are being tested in Shanghai and Guangzhou. There is another approach which has just finished internal testing and verification, “using blue-tooth based on smart phone and reading blue-tooth label ID at parking places”. This approach intends to cooperate with the Transport and Communications Committee in Chengdu next year [55].

6.2 Recovery

Recovery strategies are barriers to mitigate the financial loss after the occurrence of the events on the right side of bow-tie diagram.

Dockless bike-sharing is an Internet related product, so that considering social media as a secondary risk in relation to occurrence of mentioned events is necessary in a world that's changing really quickly. Herein social media can be considered to be an uncertainty, which means it could either be a risk or an opportunity. That's because social media can work as free advertising, signal trends and future directions, and even build reputation or recover the reputation after the occurrence of risks. Therefore, after the events occur, the bike-sharing companies must show proper initiatives and enthusiasm through social media, which may win the public trust, support and even more users. Conversely, it could deteriorate the situation and even ruin the corporate reputation, if companies attempt to distort or cover up facts. For bike-sharing companies, social media is more important than in many other traditional industries, which is why it is necessary to suggest training of staff and development of a social media policy. Maybe a special department should be established to manage updates and posts in social media, and deal with users' complaints carefully. As an alternative, outsourcing social media related work to a professional company working with social media risk management is also a possible strategy.

Besides active cooperation after the occurrence of events, transferring risks to third party would also reduce the risk level for bike-sharing companies. As the issued

guidance mentioned, purchasing riding insurance for users can transfer some financial risks to insurance companies.

6.3 Communication and Cooperation

Even though bike-sharing companies are closely cooperating with governments, they can also pose a hindrance for one another. Governmental risk management policies could create uncertainty for the industry development, and unbridled development could create trouble for the governments as well. In addition, the balance between different stakeholders is very important, which is why bike-sharing companies shouldn't solely focus on the key players. It is very important that keeping in regular contact with different stakeholders and considering sustainable development for developing appropriate strategies, effective risk management and risk communication during the operational process. For example, in an interview made by National Business Daily, only seven out of ten interviewees had heard about virtual fencing in one virtual fencing testing area, and none of them noticed they were standing right in the virtual fencing areas [56]. Good communication and cooperation will instruct users about proper use of this new technology before and/or during the implementation. Similar to the credit system, governments and bike-sharing companies ought to promote the new system during the virtual fencing testing process, such as post on social media or hold campaigns, as well as educating people about how and why should we use it, and how it helps improve the environment and reduce risks of possible congestion and accidents.

7 Conclusion

This report has demonstrated that the risk assessment regarding business risks include the involved stakeholders, users' risk perception, product optimization, but also the possible strategies to reduce these risks for bike-sharing industry in China. Many stakeholders are involved in the bike-sharing industry, but some are defined as key players due to their economic influence. In this research, investors and governments are defined as definitive stakeholders, while users are defined as moderate stakeholders. The suggested strategy to manage salient stakeholders is to satisfy the expectations of the definitive stakeholders.

The findings of the research have established that the main business risks that may lead to financial loss for bike-sharing companies are traffic accidents, congestion, users' information disclosure, insecure deposits, theft, and vandalism.

The results of the questionnaire indicated that the users' perceived risks are relatively similar in six risks. The findings further emphasize the degree of the users' experience preferences and functional preferences, which are used to determine the optimized product. Choosing the right product is very important to reduce business risks and satisfy users and further satisfy the definitive stakeholders. The result of product optimization shows option 5 is the optimized product based on the criteria of cost, profit risk, and safety. Here, option 5 is designed to be a high-safety-level product for both

users and bike-sharing companies, including many components and functions, which give the product very high production costs.

The findings also show that the sustainable development shouldn't only focuses on the cost and bike density. The previous chapter discussed possible strategies to reduce these risks. For bike-sharing companies, strengthening maintenance, cleaning up the faulty bikes, informing users prior to usage, and mutual supervision of the shared-bikes can prevent the occurrence of risks. Governments have already begun construction of new bike lanes, testing new technology in some areas, namely virtual fencing technology. However, to some extent there is inefficient communication and cooperation between bike-sharing companies and governments. For example, high efficient risk management relies on the technologies applied to the shared-bikes. Additionally, bike-sharing companies should attach importance to recovery strategies. Proper and timely responses with initiatives and enthusiasm must reach public after the occurrence of events, especially via social media platforms. Dealing with users' complaints, updates and posts on social media are very important for such an Internet related industry. Companies should either choose to establish an internet department for this purpose or outsource the social media risk management.

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Appendix

Appendix 1. Questionnaire

Survey: China's Dockless Bike-sharing

I hope you can take a few minutes to answer this survey. Thank you so much for the support!

---

1. **How often do you usually use bike-sharing?**
   - ☐ Never
   - ☐ Seldom
   - ☐ Sometimes
   - ☐ Often
   - ☐ Very often

2. **Please choose appropriate options for using bike-sharing (multiple answer):**
   - ☐ Connecting between public transportations (e.g. from metro stop to bus stop, stop to home/workplace)
   - ☐ Leisure
   - ☐ When noticing/whilst walking/to save time
   - ☐ Touring
   - ☐ Complete commuting, from A to B
   - ☐ Shopping/going to the supermarket
   - ☐ Others

3. **Is bike-sharing convenient in your life?**
   - ☐ Very inconvenient
   - ☐ Inconvenient
   - ☐ Neither convenient nor inconvenient
   - ☐ Convenient
   - ☐ Very convenient

4. The amount of money you are willing to pay for shared-bike deposit (in CNY):

- ☐ Free-of-charge by using Zhima Credit
- ☐ 0-100
- ☐ 101-200
- ☐ 201-300
- ☐ 301-400
- ☐ 401-500
- ☐ 501+

5. Quantity of shared-bikes in your city:

- ☐ Very insufficient
- ☐ Insufficient
- ☐ Neither insufficient nor sufficient
- ☐ Sufficient
- ☐ Exceed

6. Do you think you can get back the deposit after using bike-sharing?

- ☐ Very impossible
- ☐ Impossible
- ☐ Somewhere in between
- ☐ Possible
- ☐ Very possible

7. Please indicate possible reasons for choosing shared-bike:

1-Very unimportant, 2-Unimportant, 3-Medium, 4-Important, 5-Very important

Intelligent technologies content	☐ ☐ ☐ ☐ ☐
Comfort	☐ ☐ ☐ ☐ ☐
Quality	☐ ☐ ☐ ☐ ☐
Convenience	☐ ☐ ☐ ☐ ☐
Better appearance and condition	☐ ☐ ☐ ☐ ☐

8. Please indicate the degree of importance in the following functions:

1-Very unimportant, 2-Unimportant, 3-Medium, 4-Important, 5-Very important

GPS positioning system*	☐ ☐ ☐ ☐ ☐
GPS navigation*	☐ ☐ ☐ ☐ ☐
Quick unlock	☐ ☐ ☐ ☐ ☐
Support USB charging for phone/tablet	☐ ☐ ☐ ☐ ☐
Adjustable seat	☐ ☐ ☐ ☐ ☐
Anti-theft system	☐ ☐ ☐ ☐ ☐
Vibration sensors report destruction/tracking and alarm	☐ ☐ ☐ ☐ ☐
Free or deducted deposit by using Zhima Credit	☐ ☐ ☐ ☐ ☐
Support riding insurance	☐ ☐ ☐ ☐ ☐
Instant deposit refund	☐ ☐ ☐ ☐ ☐

** GPS positioning system is convenient for finding available bikes, maintenance and recycle management;*

**GPS navigation system is convenient for guide users to destination*

9. Parking places for bike-sharing in your city are:

- ☐ 1-Exceed
- ☐ 2-Sufficient
- ☐ 3-Neither insufficient nor exceed
- ☐ 4-Insufficient
- ☐ 5-Very insufficient

10. Please indicate the parking situation for bike-sharing in your city:

- ☐ 1-Very less illegal parking
- ☐ 2-Less illegal parking
- ☐ 3-A few illegal parking
- ☐ 4-Many illegal parking
- ☐ 5-Very much illegal parking

11. The quantity of dedicated bike lanes in your city:

- ☐ 1-Exceed
- ☐ 2-Sufficient
- ☐ 3-Neither insufficient nor exceed
- ☐ 4-Insufficient
- ☐ 5-Very insufficient

12. How many cyclists do not obey the traffic regulations?

- ☐ 1-Very little
- ☐ 2-Little
- ☐ 3-Some
- ☐ 4-Many
- ☐ 5-A lot

13. Lack of maintenance is

- ☐ 1-Very rare
- ☐ 2-Rare
- ☐ 3-Neither common or rare
- ☐ 4-Common
- ☐ 5-Very common

14. Please indicate the probability of reasons for deposit misappropriation:

1-Very low, 2-Low, 3-Medium, 4-High, 5-Very high

Due to unsupervised deposit getting misappropriated (e.g. Users can't get deposit back after bankruptcy)	☐ ☐ ☐ ☐ ☐
Due to network bugs in sharing companies	☐ ☐ ☐ ☐ ☐
Due to management defects in sharing companies	☐ ☐ ☐ ☐ ☐
Both network bugs and management defects	☐ ☐ ☐ ☐ ☐

15. Please indicate the probability of reasons for users' information disclosure:

1-Very low, 2-Low, 3-Medium, 4-High, 5-Very high

Due to falsifying of the QR code on the shared-bike	☐ ☐ ☐ ☐ ☐
Due to network bugs in sharing companies	☐ ☐ ☐ ☐ ☐
Due to management defects in sharing companies	☐ ☐ ☐ ☐ ☐
Both network bugs and management defects	☐ ☐ ☐ ☐ ☐

16. For the below behaviours, please indicate appropriate options:

1-Very rare, 2-Rare, 3-Neither common or rare, 4-Common, 5-Very common

Vandalism is	☐ ☐ ☐ ☐ ☐
Theft is	☐ ☐ ☐ ☐ ☐

17. The severity of financial loss <u>for sharing companies</u> in the below situations (such as bike damage, incident compensation etc.)

1-Very light, 2-Light, 3-Medium, 4-Serious, 5-Very serious

Traffic accidents compensation	☐ ☐ ☐ ☐ ☐
Lawsuit or compensation due to congestion in public transportation or public places	☐ ☐ ☐ ☐ ☐
Financial loss by misappropriation of deposit (lawsuit)	☐ ☐ ☐ ☐ ☐
Compensate users' loss due to information disclosure	☐ ☐ ☐ ☐ ☐
Loss caused by theft	☐ ☐ ☐ ☐ ☐
Loss caused by vandalism	☐ ☐ ☐ ☐ ☐

18. Which Chinese region do you live in?

- ☐ Northeast region
- ☐ Northern region
- ☐ Eastern region
- ☐ Central region
- ☐ Central southern region
- ☐ Northwest region
- ☐ Southwest region

19. Gender:

- ☐ Male
- ☐ Female

20. Age:

- ☐ Under 20
- ☐ 21-30
- ☐ 31-40
- ☐ 41-50
- ☐ 51-60
- ☐ 61+

21. Your highest education level:

- ☐ Junior school
- ☐ High school
- ☐ Academy
- ☐ Bachelor
- ☐ Master
- ☐ Ph.D.
- ☐ Others

22. Your occupation:

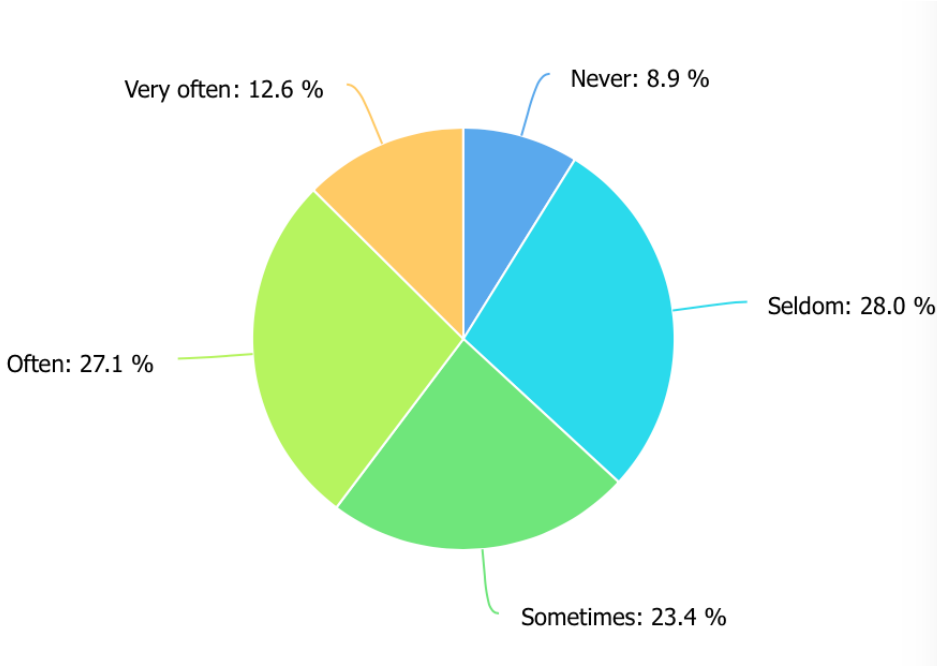
- ☐ I have a job
- ☐ I am a freelancer
- ☐ I am a student
- ☐ I am retired
- ☐ I don't have a job

23. If you like, please write any additional opinions or advice for bike-sharing related to safety and risk problems.

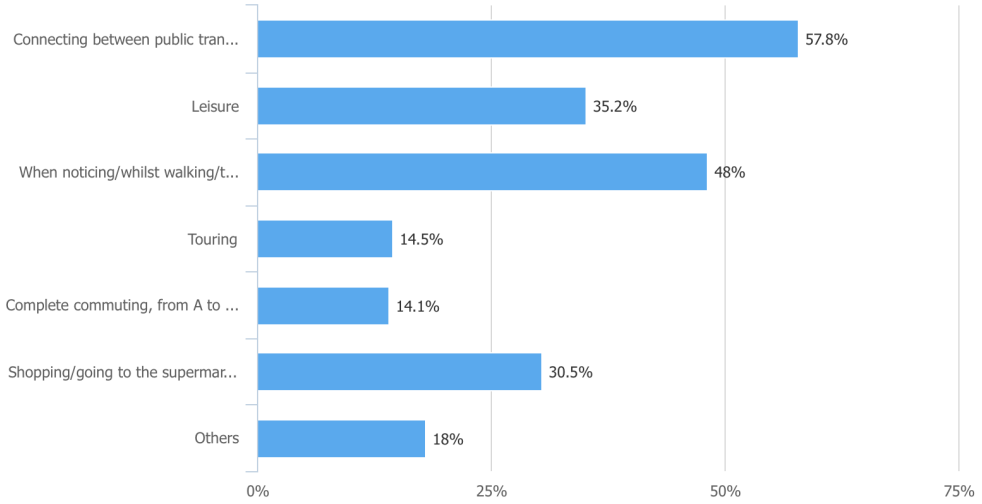
_____

Appendix 2. Questionnaire Results

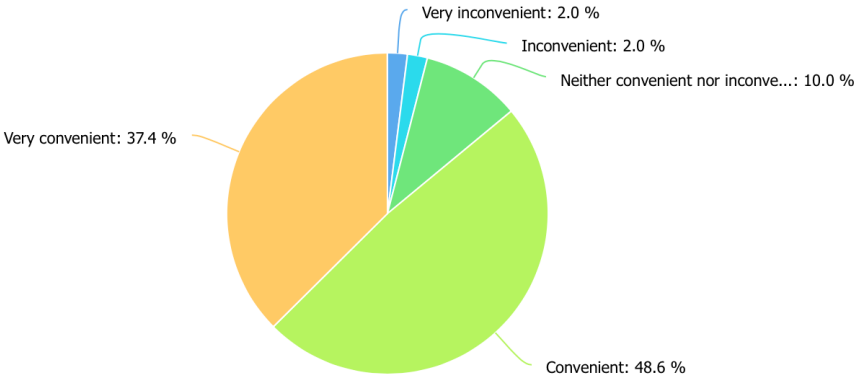
1. How often do you usually use bike-sharing?



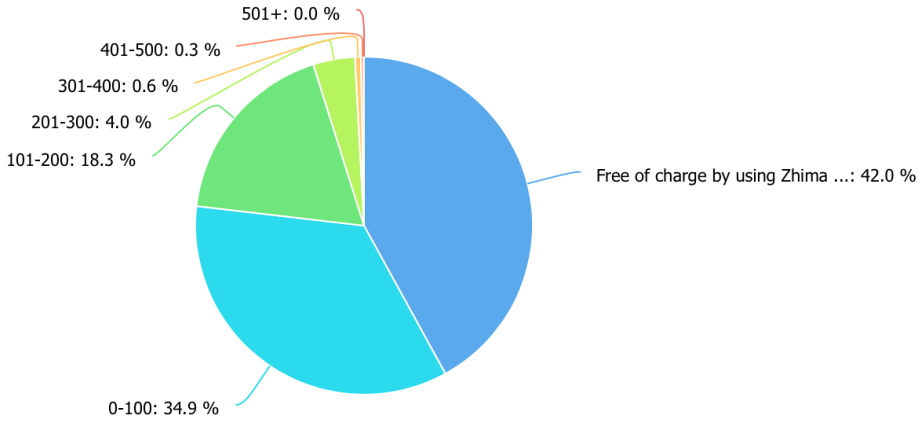
2. Please choose appropriate options for using bike-sharing (multiple answer):



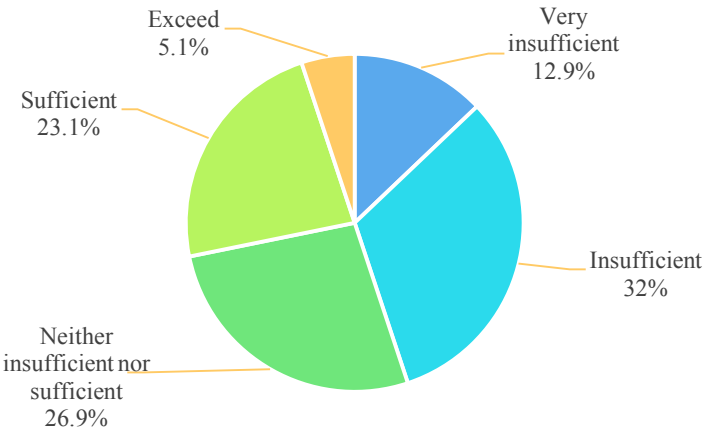
3. Is bike-sharing convenient in your life?



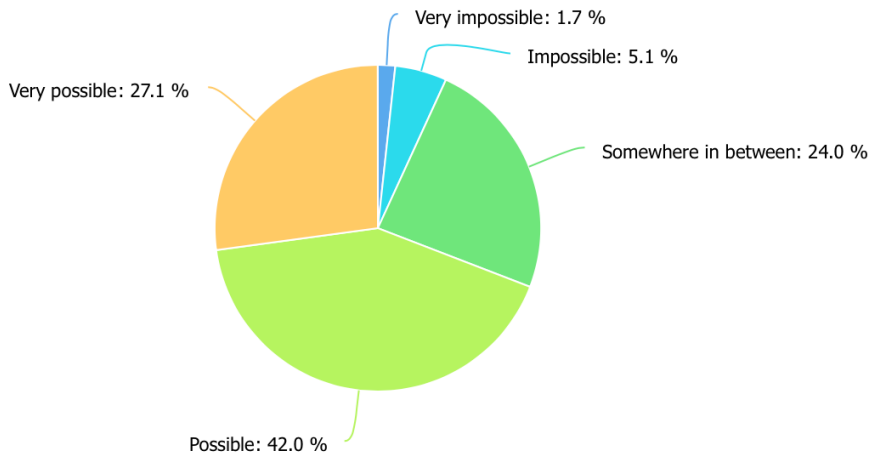
4. The amount of money you are willing to pay for shared-bike deposit (in CNY):



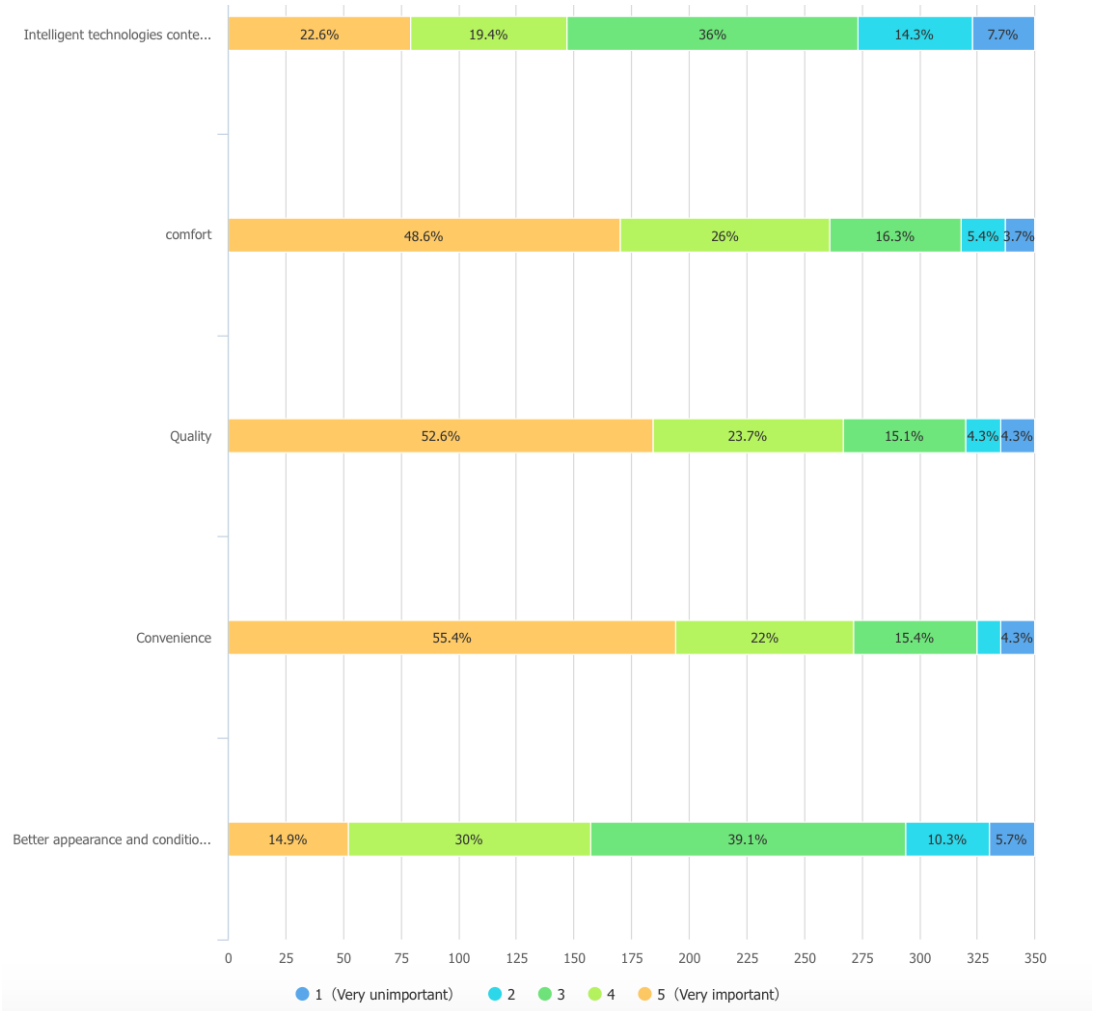
5. Quantity of shared-bikes in your city:



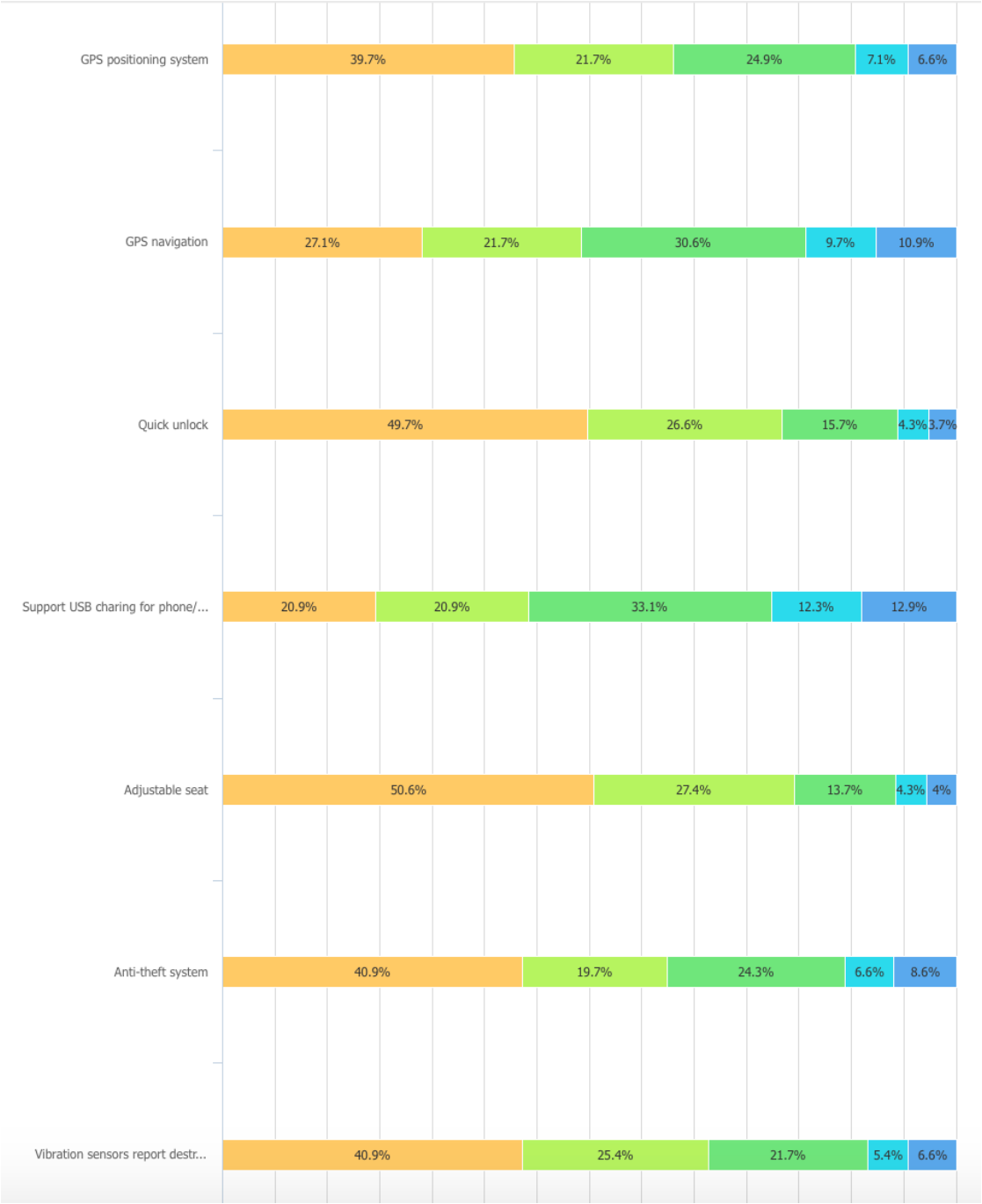
6. Do you think you can get back the deposit after using bike-sharing?

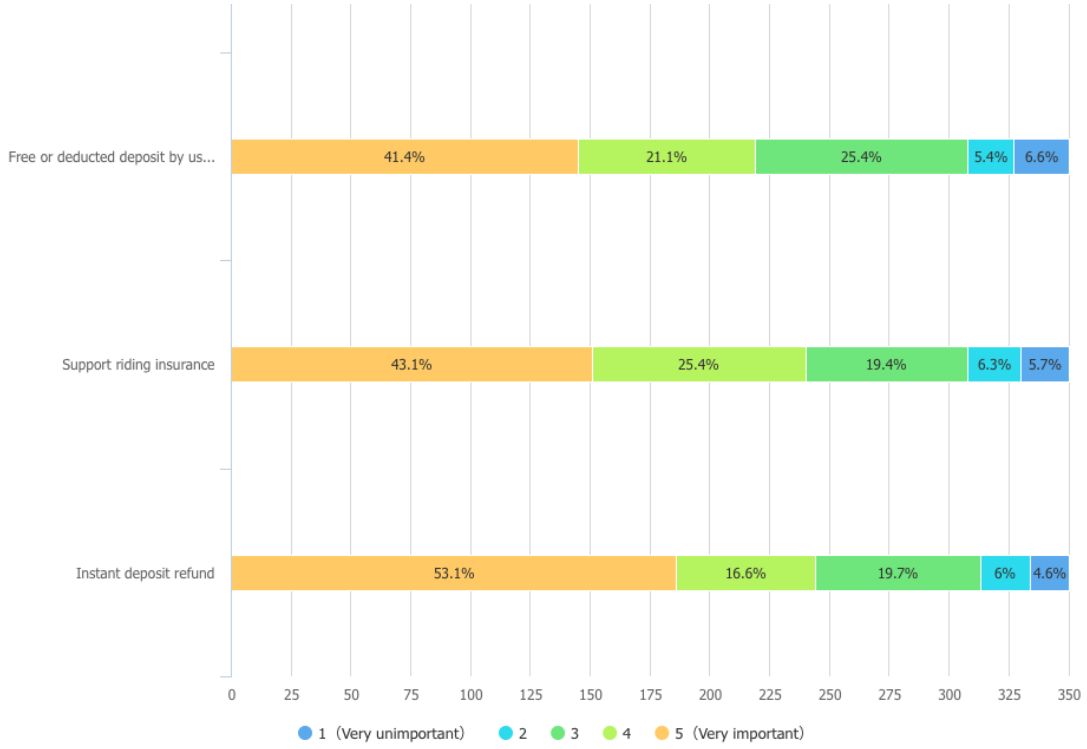


7. Please indicate possible reasons for choosing shared-bike:

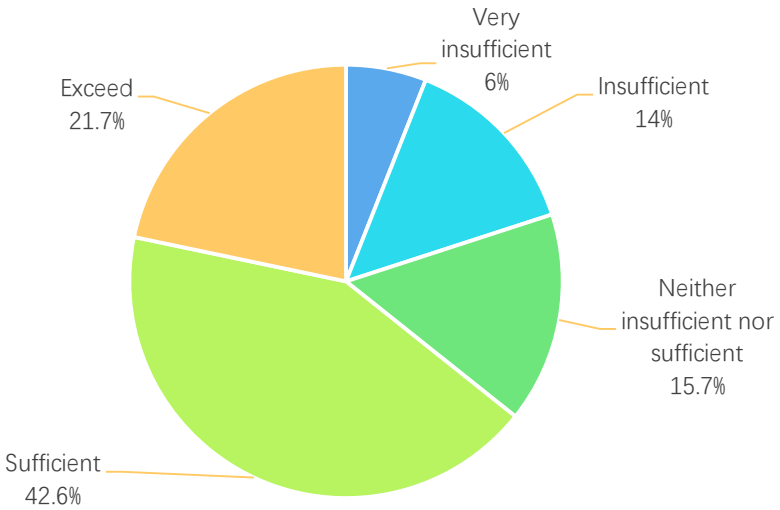


8. Please indicate the degree of importance in the following functions:

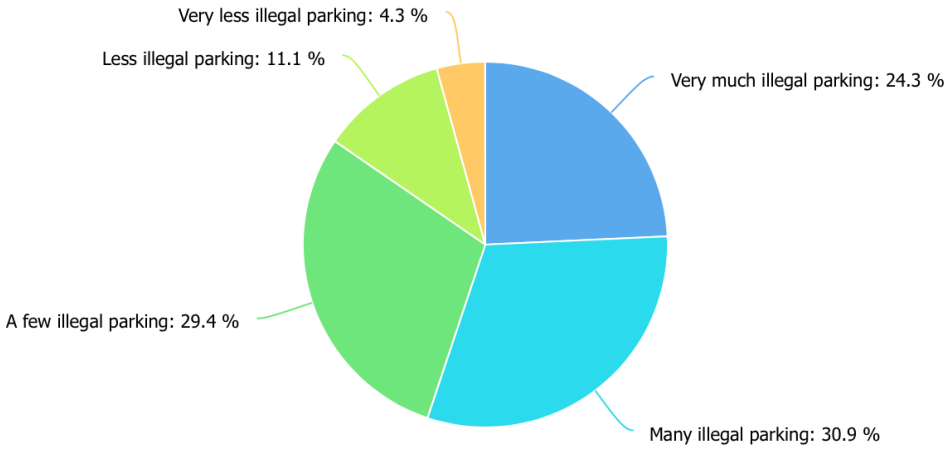




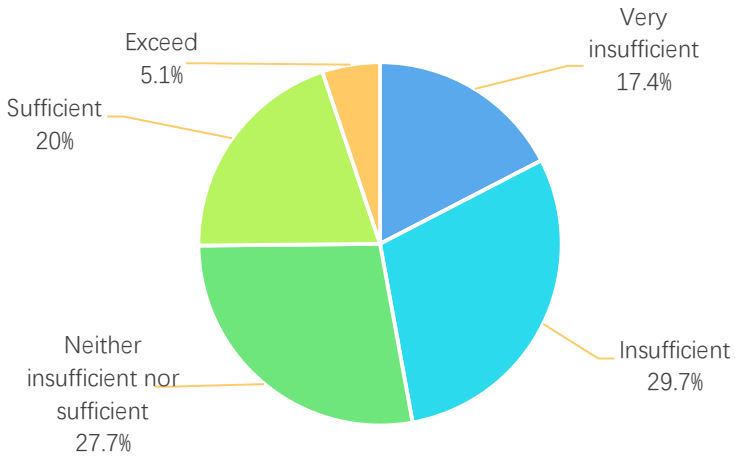
9. Parking places for bike-sharing in your city are:



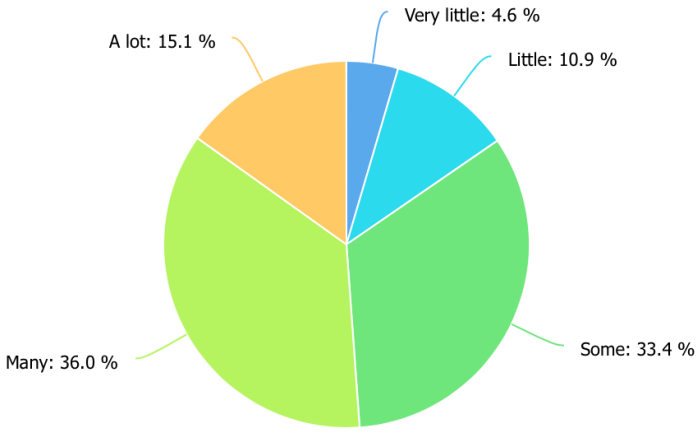
10. Please indicate the parking situation for bike-sharing in your city:



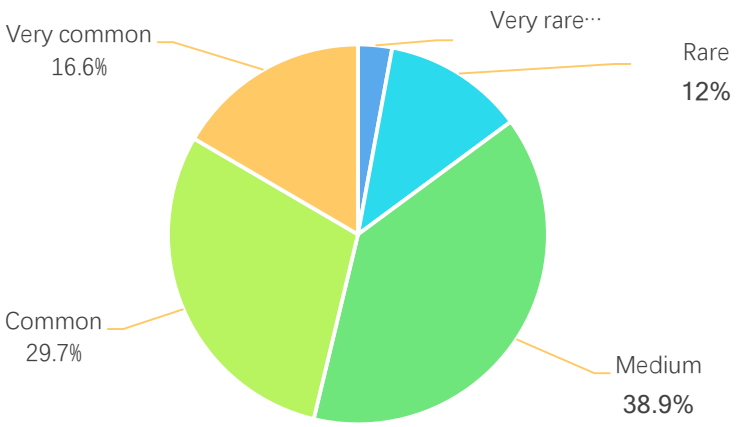
11. The quantity of dedicated bike lanes in your city:



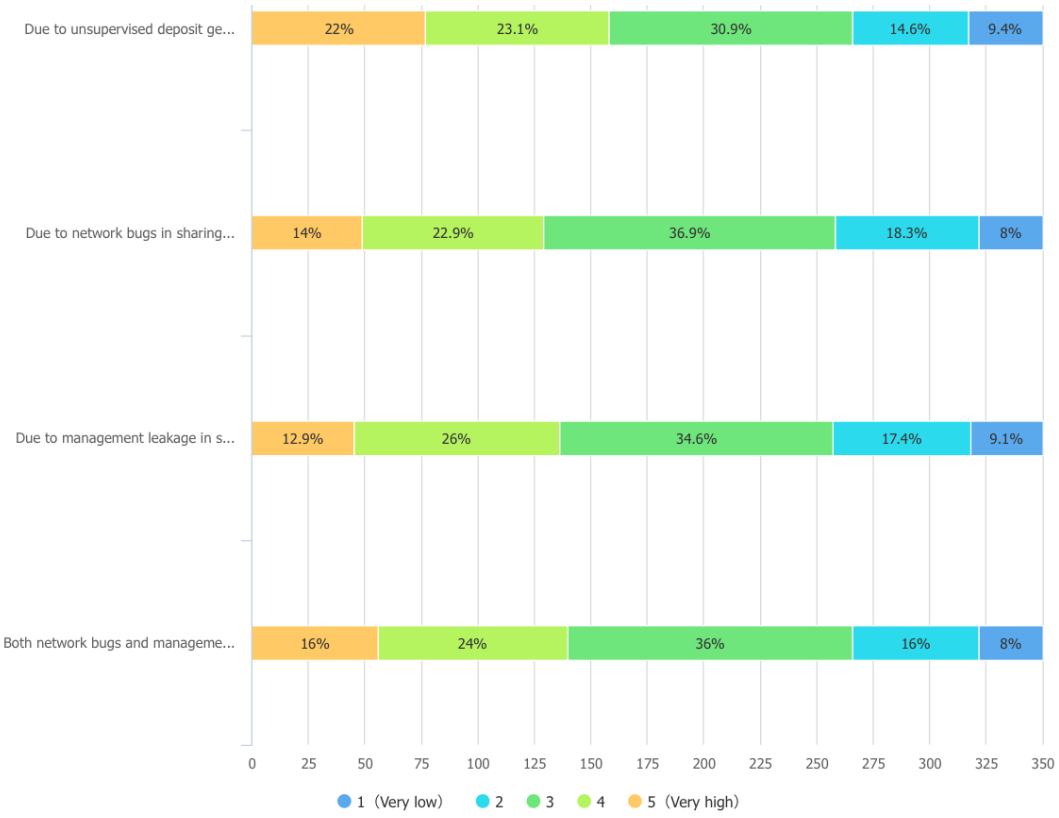
12. How many cyclists do not obey the traffic regulations?



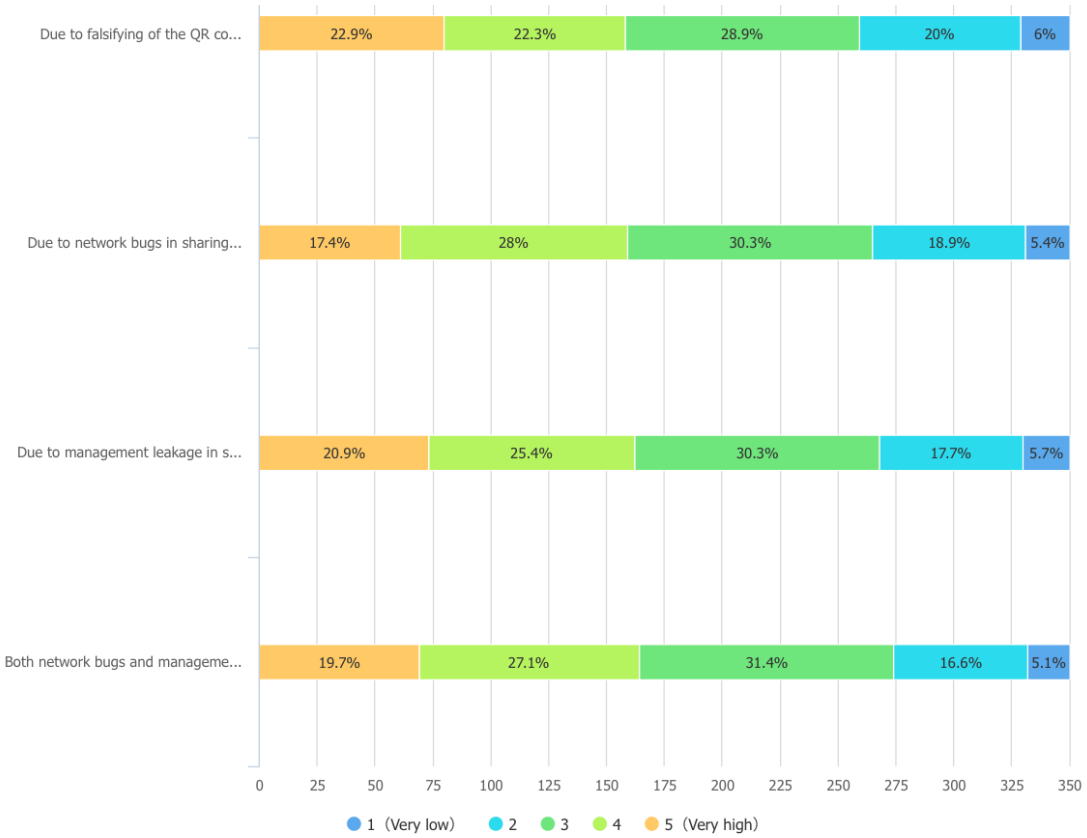
13. Lack of maintenance is:



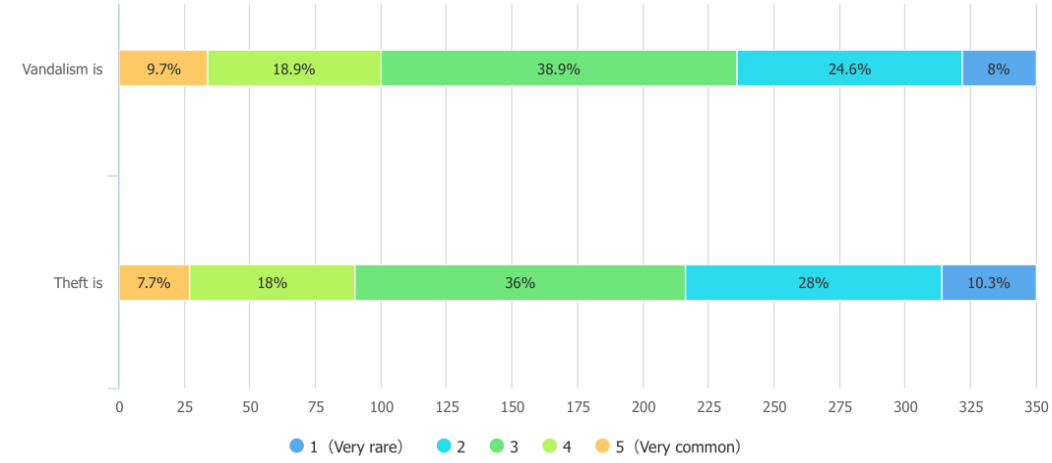
14. Please indicate the probability of reasons for deposit misappropriation:



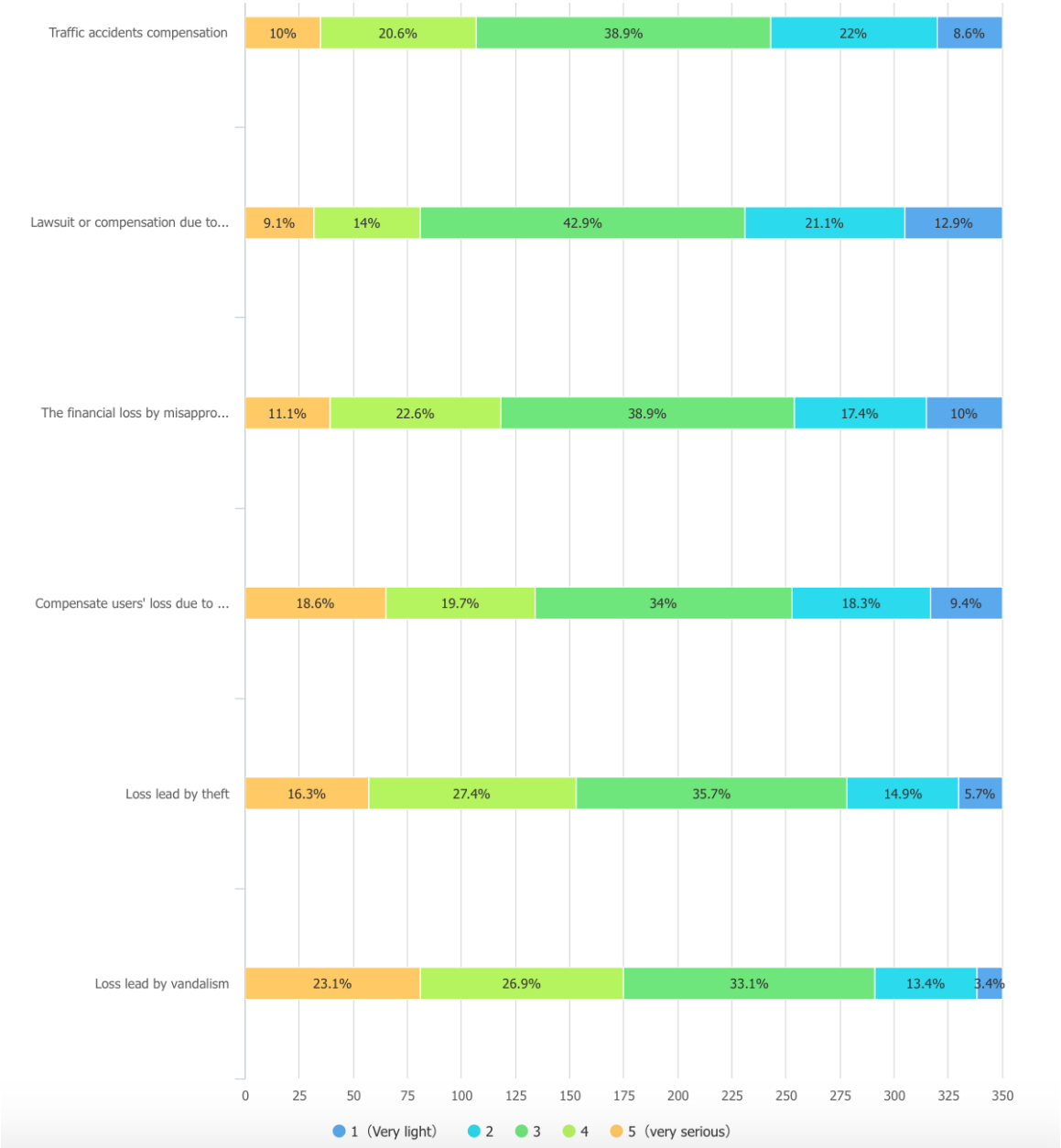
15. Please indicate the probability of reasons for users' information disclosure:



16. For the below behaviours, please indicate appropriate options:



17. The severity of financial loss <u>for sharing companies</u> in the below situations (such as bike damage, incident compensation etc.)



18. Which Chinese region do you live in?

Northeast region – 6.6% (23 respondents)

Northern region – 48.0% (168 respondents)

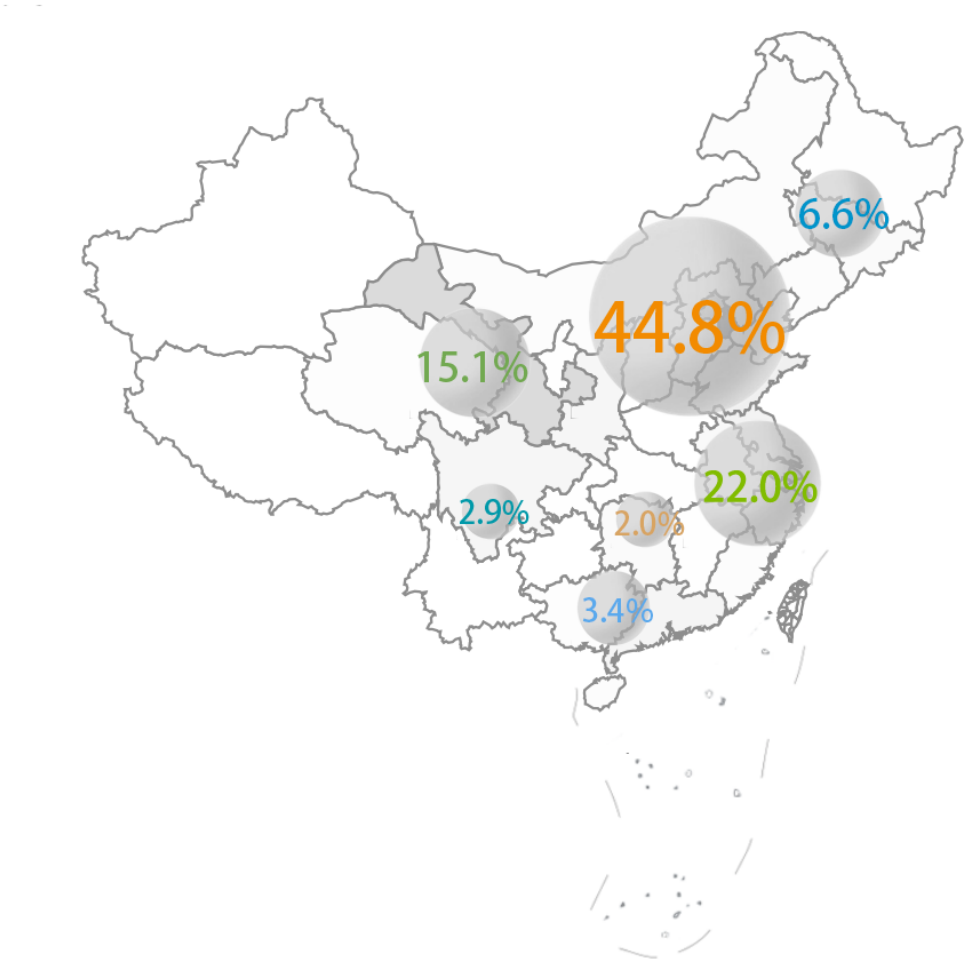
Eastern region – 22.0% (77 respondents)

Central region – 2.0% (7 respondents)

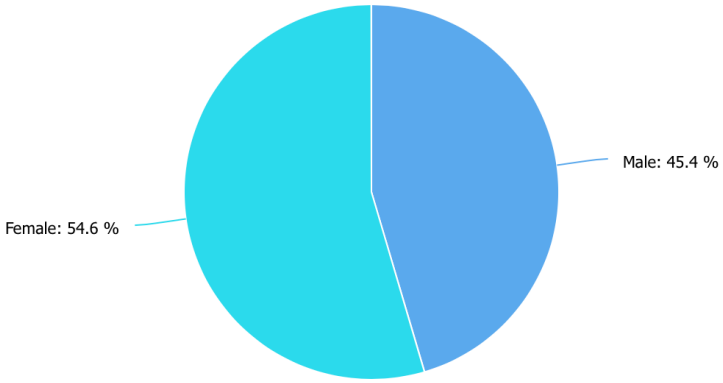
Central southern region – 3.4% (12 respondents)

Northwest region – 15.1% (53 respondents)

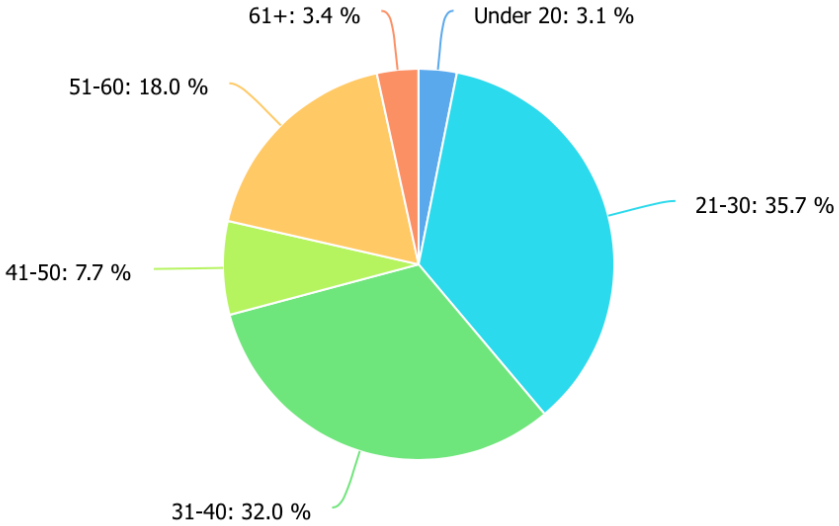
Southwest region – 2.9% (10 respondents)



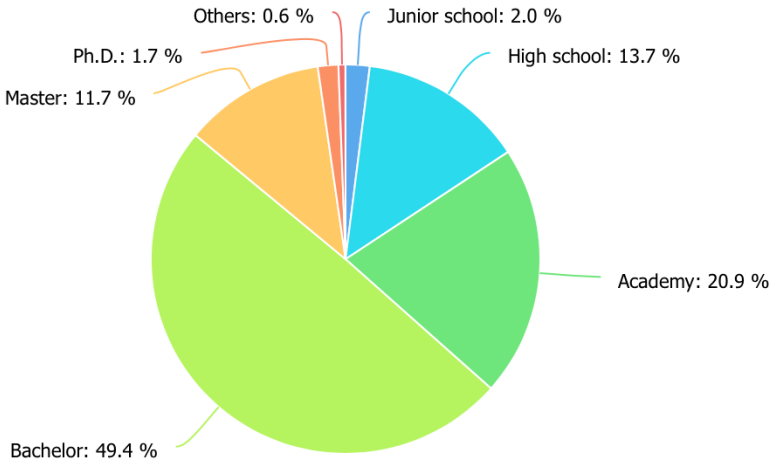
19. Gender



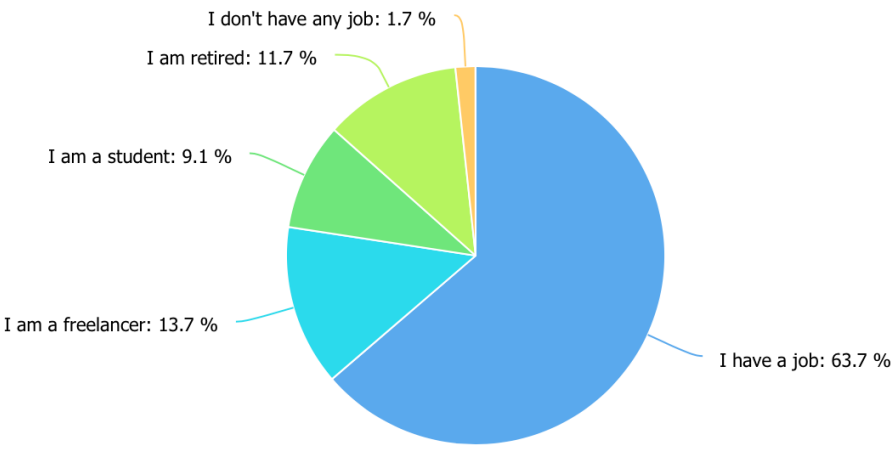
20. Age



21. Your highest education level



22. Your occupation:



Appendix 3. Cross-analysis of Frequency and Convenience Level

	Never	Seldom	Sometimes	Often	Very often
Very inconvenient	2	2	2	1	0
Inconvenient	4	1	1	1	0
Neither convenient nor inconvenient	11	14	7	2	1
Convenient	10	66	46	38	10
Very convenient	4	15	26	53	33
Sum of each frequency	**31**	**98**	**82**	**95**	**44**

	Ratio (Cross results/Sum of each frequency)				
	Never	Seldom	Sometimes	Often	Very often
Very inconvenient	2/31=6.5%	2.0%	2.4%	1.1%	0.0%
Inconvenient	4/31=12.9%	1.0%	1.2%	1.1%	0.0%
Neither convenient nor inconvenient	11/31=35.5%	14.3%	8.5%	2.1%	2.3%
Convenient	10/31=32.3%	67.3%	56.1%	40.0%	22.7%
Very convenient	4/31=12.9%	15.3%	31.7%	55.8%	75.0%

Appendix 4. SPSS Result of Reliability and Factor Analysis

Reliability Statistic

Case Processing Summary

		N	%
Cases	Valid	350	100.0
	Excluded[a]	0	.0
	Total	350	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.898	21

Factor Analysis

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.867
Bartlett's Test of Sphericity	Approx. Chi-Square	4285.940
	df	210
	Sig.	.000

Communalities of Risk Questions:

Communalities		
	Initial	Extraction
11: Accident: The quantity of dedicated bike lanes in your city	1	0.677
12: Accident: How many cyclist do not obey the traffic regulations?	1	0.673
13: Accident: How many bikes are lack of maintenance in your city?	1	0.489
10: Congestion: How many illegal parking of bike-sharing in your city:	1	0.684
9: Congestion: Quantity of parking places for bike-sharing in your city	1	0.577
14.1: Misappropriation of deposit due to unsupervised deposit getting misappropriated	1	0.636
14.2: Misappropriation of deposit due to network bugs in sharing companies	1	0.744
14.3: Misappropriation of deposit due to management defects in sharing companies	1	0.805
14.4: Misappropriation of deposit due to both network bugs and management defects	1	0.822
15.1: Users' information disclosure due to falsifying of the QR code on the shared-bike	1	0.616
15.2: Users' information disclosure due to network bugs in sharing companies	1	0.866
15.3: Users' information disclosure due to management defects in bike-sharing companies	1	0.847
15.4: Users' information disclosure due to both network bugs and management defects	1	0.895
16.2: Probability of theft is	1	0.740
16.1: Probability of vandalism is	1	0.791
17.1: Severity of traffic accidents	1	0.656
17.2: Severity of congestion in public transportation or public places	1	0.679
17.3: Severity of misappropriation of deposit (lawsuit)	1	0.758
17.4: Severity of information disclosure	1	0.660
17.5: Severity of theft	1	0.717
17.6: Severity of vandalism	1	0.658

Extraction Method: Principal Component Analysis.

Total Variance Explained:

Total Variance Explained									
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.518	35.800	35.800	7.518	35.800	35.800	3.575	17.024	17.024
2	1.957	9.319	45.119	1.957	9.319	45.119	3.293	15.682	32.707
3	1.840	8.760	53.879	1.840	8.760	53.879	3.090	14.716	47.422
4	1.294	6.164	60.043	1.294	6.164	60.043	2.264	10.780	58.202
5	1.253	5.969	66.012	1.253	5.969	66.012	1.463	6.969	65.171
6	1.128	5.373	71.385	1.128	5.373	71.385	1.305	6.214	71.385
7	.832	3.960	75.345						
8	.773	3.683	79.028						
9	.674	3.207	82.235						
10	.607	2.888	85.123						
11	.504	2.402	87.526						
12	.472	2.247	89.773						
13	.433	2.060	91.833						
14	.341	1.624	93.457						
15	.294	1.402	94.859						
16	.245	1.168	96.027						
17	.230	1.094	97.121						
18	.195	.928	98.049						
19	.174	.829	98.878						
20	.135	.641	99.519						
21	.101	.481	100.000						

Extraction Method: Principal Component Analysis.

Appendix 5: Frequency and Normal Distribution

Below are the calculated values based on the values of all respondents' perceived risks:

Max	150.000
Min	14.583
Max-min	135.417
Number of groups	19
Distance between groups	7.127
MEAN	64.524
SD	25.507

Calculated frequencies and values for drawing normal distribution curve by Excel:

Number	Group	Frequency	Normal distribution
1	0	0	0.000638
2	7	0	0.001230
3	14	0	0.002199
4	21	7	0.003647
5	28	17	0.005611
6	35	19	0.008004
7	42	27	0.010591
8	49	25	0.012996
9	56	34	0.014791
10	63	55	0.015613
11	70	36	0.015284
12	77	28	0.013877
13	84	32	0.011686
14	91	24	0.009126
15	98	15	0.006610
16	105	5	0.004441
17	112	6	0.002767
18	119	8	0.001599
19	126	3	0.000857
20	133	4	0.000426
21	140	3	0.000196
22	147	0	0.000084
23	154	2	0.000033

Appendix 6: Products Information for All Options

Option 1: conditions similar to Mobike 'Classic'. Relatively safe product for bike-sharing companies with some considerations of bike usage.

Option 2: conditions similar to Mobike 'Lite', lower production cost than Mobike 'Classic', and contain many intelligent components.

Option 3: conditions similar to Ofo 1.0, with very low production cost and very low durability, but maybe very high maintenance rate in the future.

Option 4: a high-safety-level product for bike-sharing companies.

Option 5: a high-safety-level product for both users and bike-sharing companies.

The offered functions are:

	GPS positioning	GPS navigation	Quick unlock	Adjustable seat	Anti-theft system	Alarm system	Zhima Credit	Support insurance	Instant deposit refund	Support USB charging
Option 1	Yes	No	Yes	No	Yes	Yes	No	No	No	No
Option 2	Yes	No	Yes	Yes	Yes	Yes	No	No	No	Yes
Option 3	No	No	No	Yes	No	No	Yes	Yes	No	No
Option 4	Yes	No	Yes	Yes	Yes	Yes	No	No	No	No
Option 5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No

All above characteristics are based on online research of different products in the market. Product information of Mobike and Ofo is shown as following.

Mobike:

Mobike chose aluminium as their frame material. Mobike 'Classic' uses a shaft-drive transmission device, an easy open smart lock, and a real-time positioning anti-theft system [57]. This model has high durability, gives users smart use experience, its vibration sensors can report position and alarm when severe destruction occurs. Mobike 'Lite' has changed to chain-drive in combination with a solar battery charging board instead of using shaft-drive, which provide users with a lighter frame but lower durability. Mobike also improved the solid tyre for 'Lite', which provide users with a more comfortable experience. The production cost of Mobike 'Classic' is about EUR 256 – 385 (RMB 2000 - 3000); using chain-drive together with a solar battery charging board on Mobike 'Lite', which has reduced production cost to approximately EUR 128 (RMB 1000) [21].

The smart lock of Mobike is shown as below:

Figure 17: Smart Lock of Mobike [58]

Ofo:

Same as regular bike, Ofo 1.0 uses regular pneumatic tyre and chain-drive transmission device, with a production cost of approximately EUR 38.5 (RMB 300).

Figure 18: Ofo 1.0 Lock (left) and Ofo 3.0 Lock (right) [18]

Figure 18 shows the locks on the two models. Ofo 1.0 uses a touch-tone mechanical lock, and Ofo 3.0 uses a rotary type mechanical lock. As a shortage, Ofo 1.0 uses a fixed code, which can be remembered after usage. Ofo 3.0 still uses fixed code, but it can be changed after usage manually, meaning that the next user should apply for pin code again. From Ofo's point of view, 3.0 is safer than 1.0, but only if users are willing to change the code after their journey. It is not as safe as Mobike's lock.

Figure 19: Smart Lock for Newest Model of Ofo

As shown in Figure 19, Ofo announced that their newest model has been changed to smart lock since June 2017, because Ofo wanted to improve their weaknesses, such as fixed code, and no accumulation of usage data. However, this new smart lock still doesn't have a GPS module, and it uses a regular lithium battery with approximately 2 years' life time, which means it must be changed after the battery runs out.

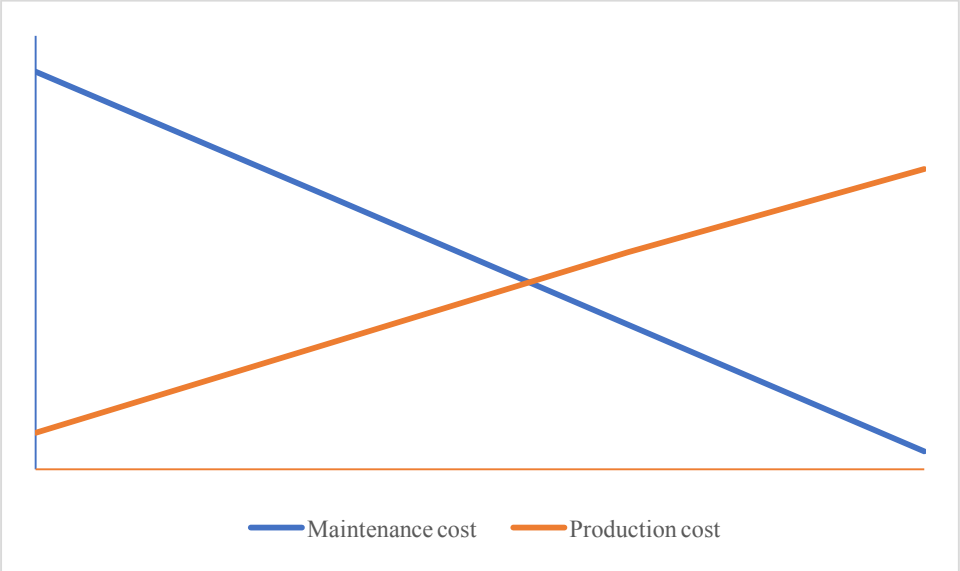
The main differences of the two brands are shown in the table below:

<table>
<tr><th colspan="2">Mobike</th><th colspan="3">Ofo</th></tr>
<tr><th>Classic</th><th>Lite</th><th>1.0</th><th>3.0</th><th>Newest edition</th></tr>
<tr><td>25kg</td><td>17kg</td><td colspan="2">15 kg</td><td></td></tr>
<tr><td>Shaft-drive</td><td>Chain-drive</td><td colspan="3">Chain drive</td></tr>
<tr><td colspan="2">GPS positioning</td><td colspan="3">No GPS module</td></tr>
<tr><td colspan="2">Quick unlock smart lock</td><td>Touch-tone lock</td><td>Rotary type lock</td><td>Smart lock</td></tr>
<tr><td>Solid tyre</td><td>Lighter solid tyre</td><td colspan="2">Pneumatic tyre</td><td>Solid tyre</td></tr>
<tr><td colspan="2">Communication module</td><td colspan="3">No communication module</td></tr>
<tr><td>No adjustable seat</td><td>Adjustable seat</td><td colspan="2">Adjustable seat</td><td></td></tr>
<tr><td>Chargeable Li battery</td><td>Solar battery</td><td colspan="2">No need for battery</td><td>Non-chargeable Li Battery</td></tr>
<tr><td colspan="2">Easier to be found</td><td colspan="2">Difficult to be found</td><td></td></tr>
<tr><td>Approximately EUR 256 – 385</td><td>Approximately EUR 128</td><td colspan="2">Approximately EUR 38.5</td><td></td></tr>
<tr><td>Very low maintenance cost</td><td>Low maintenance cost</td><td colspan="2">Very high maintenance cost</td><td></td></tr>
<tr><td colspan="2">Anti-theft system</td><td colspan="3">No anti-theft system</td></tr>
<tr><td colspan="2">Alarm system</td><td colspan="3">No alarm system</td></tr>
<tr><td>EUR 0.13 per hour</td><td>EUR 0.06 per hour</td><td colspan="3">EUR 0.13 per hour, EUR 0.06 for students</td></tr>
<tr><td colspan="2">Available for 15 min appointment</td><td colspan="3">Not available for appointment</td></tr>
</table>

Table 16: Comparison of Mobike and Ofo [59] [18]

As shown in Table 16, a product with higher technology components means heavier frame, higher cost, but also smarter, stronger, and cheaper for future maintenance. The idea of all 5 options is to choose the typical existing products, as well as products with different safe levels. Thus, Mobike 'Classic' and 'Lite' are both involved, Ofo 1.0 is also involved because there is a large quantity of Ofo 1.0 in the market. Ofo's newest model is excluded is because there is not much available information online. Besides, in the market, other brands developing their products tend to contain intelligent components. Therefore, the other two options are designed with different intelligent components based on the factors of safety for bike-sharing companies and for both companies and users.

Appendix 7: Production and Operation Costs for Bike-sharing [21]



Appendix 8: What is Mobike Score

"To encourage legitimate, standard and proper use of the bikes, Mobike has implemented a "Mobike Score" system

Each user will start with a Mobike Score of 550 by default. The Mobike Score will change based on user behavior

A user's Mobike Score will affect their fares and use of the system. If a user's Mobike Score is between 301-500, they will have to pay double the standard fare for a single trip, and cannot make reservations. If the Mobike Score drops to 300 or lower, the users' fare will be adjusted to 100 times the standard fare. If a user's Mobike Score drops to 0, their Mobike account will be suspended and they will not be able to access any Mobike services

Users who believe their Mobike Score has been deducted incorrectly may submit an appeal by tapping "Appeal" in the top right corner of the Mobike Score records page when their Mobike Score is updated each month.

How can I increase my Mobike Score?

Observing traffic rules, and riding in a safe and orderly manner.

Parking the bike so it is easier for the next user to access it (i.e. within designated bicycle parking areas where available).

Not abusing the bikes; keeping them clean

Supporting the platform by using the bikes regularly

What will cause my Mobike Score to drop?

Riding bikes in an unsafe manner and ignoring traffic rules.

Parking bikes in off-limits areas such as: residential properties, basements, building lobbies and active bike lanes.

Obstructing other people.

Vandalizing bikes, such as installing personal locks or removing the seat.

Other civil violations while using the bikes [60]"

Appendix 9: Online Interview Summary

The interviewee is a professor of Tianjin University of Technology, Zhang Yuhuan. The summary of the interview content as following.

The risks of bike-sharing at present:

In Tianjin, shared-bikes are everywhere, which is solving the citizens' problem of "the last kilometre of the trip". However, it brings a series of problems while providing convenience:

1. Excessive shared-bikes, which is a mismatch with its management level.

2. Casual parking. "Dockless" is the most convenient part for users, which is just

the most inconvenient part for others. People can park shared-bike everywhere, and many of them are parked in illegal areas.

3. Unreasonable design. For example, Mobike Classic is very heavy and uneasy to balance, which is a potential risk for users; some shared-bikes from Ofo are difficult to ride too.

4. Vandalism. Some citizens do not have a clear concept of the legal system. They destroy shared-bikes but have no idea about the possible consequences.

5. Theft, some citizens took shared-bikes home and used their own locks, namely use shared-bikes as their private bikes. This behaviour happened mostly on Ofo, because Ofo applies fixed pin code with mechanical locks.

6. Trivial operation process. For example, the Ofo 3.0 needs users to scan a QR code to get the pin code, and then press the code on the shared-bike to open the lock manually. After the journey, the users must change the code randomly in case the bike get directly used by next person without paying. The last, users must finish their journey on the App to stop charging.

7. Management defects. For example, the occurrence of some accidents with young children under 12, mainly because their parents unlocked the shared-bikes and supported their cycling.

Some advices for enhancing bike-sharing management :

Controlling the quantity of shared-bikes, reorganizing the parking areas, and establishing industry standards. Use a data-base to control the total quantity and distribution. Set up a corresponding team for related management and service. I advise the government to move bike-sharing into the public transport system, build up more bike lanes and parking areas. Use intelligent technology to achieve online manage and display parking status.

Making new policy for bike-sharing industry in order to stop vandalism, illegal parking and so on. Forcing the entire industry implement a real names system, establishing a credit system. Using promotion activities to encourage people to properly use shared-bikes, such as a point system, red envelope and coupon. Punishing people who use shared-bikes improperly or worse. Legal action is very important for sustainable development of the industry. Besides, educate the knowledge about safety among families, schools, and society.

Enhancing off-line maintenance service. Regularly sorting out disordered bikes, enhancing the routine maintenance and inspection, ensure the users' safety. Timely cleaning up the faulty bikes to increase the number of available bikes.

Bike-sharing companies should stop using mechanical locks, and install positioning systems. These measures can reduce risks such as management defects effectively. Enhancing safety education and behaviour supervision, encouraging people to report the illegal behaviour.