

## **Individuals' Attitudes of Acceptance to Carsharing Mode: A Web-Based Survey in China**

Yun Wang<sup>1</sup>, Xuedong Yan<sup>2\*</sup>, Yu Zhou<sup>3</sup>, Qingwan Xue<sup>4</sup>

1. **Yun Wang, Ph.D.** MOE Key Laboratory for Urban Transportation Complex System Theory and Technology, School of Traffic and Transportation, Beijing Jiaotong University, Beijing 100044, China. Tel: 152-1057-6691, E-mail: 13114248@bjtu.edu.cn.

2. **Xuedong Yan, Ph.D. (Corresponding Author)**, Professor, MOE Key Laboratory for Urban Transportation Complex System Theory and Technology, School of Traffic and Transportation, Beijing Jiaotong University, Beijing 100044, China. Tel: 158-1007-4718, E-mail: xdyan@bjtu.edu.cn.

3. **Yu Zhou, Ph.D.**, State Key Lab of Rail Traffic Control and Safety, Beijing Jiaotong University, Beijing 100044, China. Tel: 152-1057-5587, E-mail: 14114231@bjtu.edu.cn.

4. **Qingwan Xue, Ph.D.**, MOE Key Laboratory for Urban Transportation Complex System Theory and Technology, School of Traffic and Transportation, Beijing Jiaotong University, Beijing 100044, China. Tel: 155-1295-6999, E-mail: 14114258@bjtu.edu.cn.

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## **ABSTRACT**

In this study, individuals' attitudes of acceptance to carsharing were measured from three aspects, namely: carsharing mode choice behavior, highest acceptable price for using carsharing, and willingness to forgo car purchases. The data were collected by a web-based survey. The hierarchical tree-based regression (HTBR) method was applied to explore the effects of potential influencing factors, and some interesting findings were obtained: participants knowing carsharing were more likely to use carsharing, pay higher price and forgo car purchases; the most competitive trip purpose and trip distance for choosing carsharing were respectively running errands and 11- 20 km; most of participants (47.1%) were willing to pay 1-2 Yuan per minute for using carsharing; when car purchase restrain policy (CPRP) was carried out in a city or the urban public transport service level (UPTSL) was high, participants were more willing to give up buying new cars. Based on above findings, corresponding policies were proposed to provide guidance for successful establishment of carsharing.

## **KEYWORDS**

Carsharing; Private car ownership; Sustainable transportation; Hierarchical tree-based regression

## 1. INTRODUCTION

The exorbitance of automobile usage and its negative impacts on the energy and environment have been a major global issue and obtained growing concerns. Ahmad and Oliveira (1) pointed that about 23% of energy-related CO<sub>2</sub> emissions were emitted by transportation sector. Moreover, the emissions from private vehicles accounted for nearly half of the whole transportation sector. Therefore, numerous countries are gradually involved in the efforts to relieve CO<sub>2</sub> emissions and have proved that by formulating reasonably policies for a more sustainable transportation system, emissions from the transportation sector can be reduced (2).

Promoting alternative fuel vehicles, such as hybrid and electric vehicles, offers an efficient pathway to reduce CO<sub>2</sub> emissions from private vehicles. As an innovative and sustainable transportation mode, carsharing, i.e., a mode where individuals can rent cars for a short time period, has been proved to have an obvious effect on the private vehicle reduction (3). The carsharing has prominent advantages over the private car in the following three aspects: Firstly, the emergence of carsharing makes remarkable contributions to CO<sub>2</sub> emission reduction since the vehicles involved are electric vehicles. Meanwhile, it offers an opportunity to introduce electric vehicles to a broader consumer base. Chen and Kockelman (4) found that in North America, approximately 51% of carsharing members' average individual transportation energy use and CO<sub>2</sub> emissions could be reduced. Secondly, as a beneficial complement to the urban public transport, carsharing mode can provide users with more flexible and comfort service. By using carsharing, people can arrive at their destination without transfer in the urban public transport system. Thirdly, using carsharing is less expensive to enjoy a high-quality trip, while users can gain the benefits of a private vehicle without paying the cost of ownership.

The carsharing originated in Europe between the 1940s and 1980s, and become popularized in the early 1990s. For nearly 20 years, the knowledge and advanced operation technologies of carsharing have spread throughout Europe and expanded to five continents, including Europe, North America, South America, Asia and Australia (5). Exploring and understanding of individuals' attitudes to carsharing is the basic support for making carsharing development planning, policies and strategies. Comprehensive studies been carried in many developed counties (USA, Australia, Switzerland, Germany, and Korea et. al) on the issue of improving individuals' willingness to postpone private cars and participant in the carsharing (6-12).

However, previous findings in above developed countries significantly underrepresent the carsharing development prospect in China. The stage of private car development in China is quite different from that in development countries. As one of the world's largest automobile markets, China has been in a period of rapid urban motorization development, with the private vehicle ownership increasing from 6 million in 2000 to 123 million in 2014 (13). Inversely, the vehicle fleet in developed countries increases steadily at a low speed, or even diminishes in size. For example, in 2009, the number of private

1 privates of America reduced (14). Moreover, the low-quality transport service and  
2 inadequate supply of urban public transport have caused that urban mobility in China is  
3 increasingly reliant on private vehicles. But compared with developed countries, China has  
4 obvious disadvantages in terms of either the road facility density or the urban public  
5 transport service level. It might be more difficult for Chinese people to postpone private  
6 cars due to the continuing growth of motorization and car dependency. Thus, exploration of  
7 individuals' attitudes to carsharing mode can reveal fundamental and valuable information  
8 about the potential of private car reduction and carsharing promotion.

9 This study aims to explore individuals' attitudes of acceptance to carsharing  
10 including the following three aspects: individuals' carsharing mode choice behavior under  
11 given trip purposes and distances, which is critical for planners to reasonably distribute  
12 carsharing infrastructures and vehicles; individuals' acceptable price for using carsharing,  
13 which is vital for operators to accurately fix the price; and individuals' willingness to  
14 participant in carsharing and postpone buying new cars, which is the basic information for  
15 environmental protection departments to estimate the contribution of carsharing to the CO<sub>2</sub>  
16 emission reduction. To obtain the required data above, a web-based survey was conducted.  
17 Moreover, the method of Hierarchical Tree-based Regression (HTBR) was used to  
18 characterize the differences in individuals' attitudes to carsharing between different groups  
19 based on individual and external factors. Given the above, this study would contribute to  
20 providing a better understanding of the carsharing development direction in China, and  
21 make preliminary recommendations for carsharing planning and operation so as to improve  
22 its acceptance.

## 23 24 **2. LITERATURE REVIEW**

### 25 26 **2.1 Influencing Factors on Carsharing Mode Choice Behaviors**

27 Some potential factors have been considered to explore their influences on individuals'  
28 carsharing mode choice behaviors. Factors can be generally divided into two categories.  
29 One is individual characteristics (15-16), such as gender, profession, income, children in  
30 the household, car ownership, etc. The other one is the external factors including the  
31 quality of carsharing vehicles, the level of carsharing service, and the using costs, etc (11).

32 Since the emergence of carsharing, numerous surveys have been conducted to  
33 investigate the characteristics of participants' demographic distribution. Cervero (15)  
34 conducted a survey of City CarShare, a carsharing organization in San Francisco, and he  
35 found that the members were relatively young while 67% of them were between age 20 and  
36 40. Additionally, the members generally had moderate incomes, and approximately 75% of  
37 them were from zero-car households. Fairly similar results were obtained by Martin and  
38 Shaheen (16). Through analyzing the data from several North American carsharing  
39 organizations, they found that 84% of carsharing members were well-educated, with at  
40 least a bachelor's degree, and 43% of them had incomes less than \$60,000. Moreover, the  
41 results revealed that 62% of members reported that they were zero-vehicle households

1 before joining carsharing. A web-based survey was conducted among participants of Seoul  
2 electric vehicle sharing programs (10). Results showed that age and income significantly  
3 influenced the sharing behaviors. Specifically, participants with higher income were found  
4 to be less likely to change their sharing behaviors. Contrary to the findings in previous  
5 studies that young people were more likely to participant in carsharing, they found that  
6 older people showed higher willingness to continuously participate. From above studies, it  
7 could be summarized that individuals with high education level and moderate income and  
8 not having a car might be more likely to participant in carsharing.

9 Except for individuals' personal attributes, some external factors were also found to  
10 have significant impact on individuals' attitudes to participant in carsharing. The results of  
11 an investigation conducted in Europe showed that residents would not like to use  
12 carsharing if organizations provided poor services, bad vehicles and inconvenient ways to  
13 rental spots, and fixed a high price (11). According to the data from Car Sharing Portland  
14 (CSP), Katzev (17) found that the distance to the nearest vehicle station and length of  
15 membership were the two most important predictors of carsharing usage. Individuals living  
16 closed to vehicle stations tended to have higher using frequency. Moreover, the longer  
17 individuals joined membership in CSP, the fewer times they would be likely to use,  
18 especially among those having personal vehicles. Short-term and long-term predictions on  
19 carsharing usage were carried out respectively using the indicators of weather and  
20 socio-demographic data from the booking data of two carsharing systems in Munich (12).  
21 The results indicated that the weather had no impacts, but the age structure of a city had  
22 distinct influences on the success of carsharing. Findings in previous studies have great  
23 significations to estimate the potential carsharing acceptable degree among different  
24 individual groups in China.

## 25 26 **2.2 Impacts on the Environmental Improvements and Private Car Ownership**

27 The impact of carsharing operations on the environmental improvements has been  
28 examined by a considerable body of existing studies. By investigating 11 carsharing  
29 organizations in North America, Martin and Shaheen (16) estimated that the annual CO<sub>2</sub>  
30 emission reduction at the household level, and the results showed that 0.58 tons of CO<sub>2</sub>  
31 could be reduced by each person, which was roughly equal to 11–16% of the average  
32 American household's transport-related CO<sub>2</sub> emissions (18). A stated preference survey  
33 was conducted among carsharing members in Ulm, Germany by Finkhorn and Muller (19).  
34 They estimated a reduction of 0.15–0.31 tons of CO<sub>2</sub> emissions per member per year,  
35 considering the reduced vehicle ownership and vehicle-kilometer traveled (VKT) at the  
36 same time.

37 As a vital factor influencing the CO<sub>2</sub> emissions, the vehicle ownership has been a  
38 research hotspot. In the research field of carshairing, reducing the number of private  
39 vehicles by promoting carsharing is widely recognized as the most effective way to realize  
40 environment sustainability. Extensive studies have paid continuous attention to the impact  
41 of carsharing on reducing the private vehicle ownership. Eighteen months after the

1 Short-Term Auto Rental (STAR) program was established in San Francisco in the early  
2 1980s, Walb and Loudon (20) found that 17% of the members sold their vehicles, and 43%  
3 of them would be willing to forgo a vehicle purchase. Katzev (17) studied the early  
4 adopters of Car Sharing Portland (CSP), and found that after joining CSP, 26% of them  
5 sold their personal vehicles and 53% give up vehicle purchases. Considering most of  
6 previous studies focused on a specific carsharing organization, Transit Cooperative  
7 Research Program (TCRP) summarized 31 former studies about carsharing, and pointed  
8 out that 21% of respondents would give up vehicles and 34% reported forgoing vehicle  
9 purchases (3). In view of the rapid spread of carsharing in the world, Shaeen and Cohen (5)  
10 made a systematic comparison of carsharing between Europe and North America based on  
11 the previous 44 studies. The results revealed that each carsharing vehicle could contribute  
12 to the reduction of 4-10 private vehicles in Europe, and 6-23 vehicles in North America.  
13 Moreover, among those joining carsharing, the proportions of participants selling private  
14 vehicles were 15.6%-34% in Europe, and 11%-29% in North America. Above findings  
15 suggest that carsharing has a significant impact on reducing the number of private vehicles.  
16 Regina (7) compared the individuals' attitudes to private vehicle ownership not only  
17 between members and non-members, but also between urban and suburban area in the San  
18 Francisco. The results suggested that urban carsharing members owned fewer vehicles than  
19 others, and they were more likely to choose environment friendly vehicle. Nevertheless,  
20 there are still no previous studies on individuals' willingness to participant in carsharing  
21 instead of giving up buying new cars in China.

22 Based on the above literature review, we can know that a growing body of studies  
23 have been carried out worldwide. But, there is no relevant study focus on individuals'  
24 attitudes to carsharing in China. What makes things more complicated is that due to  
25 different development backgrounds of carsharing, some specific factors which is quite  
26 important in China have never been analyzed in previous studies, such as car purchase  
27 restriction policy, awareness of carsharing and so on. As thus, this study makes a new  
28 attempt about the issue by conducting a survey taking various potential influencing factors  
29 into consideration, developing hierarchical tree-based regression models to estimate  
30 individuals' attitudes to carsharing and explore the relationships between variables, and  
31 providing practical strategies for establishing and promoting carsharing system in China.

### 32 **3. METHOD**

#### 33 **3.1 Survey and data**

34  
35 To collect the information about influencing factors on individuals' acceptance of  
36 carsharing in China, a questionnaire-based survey was conducted on a professional online  
37 survey platform. Of the 845 participants completing the survey, there were 826 valid  
38 responses that could be used to analyze participants' attitudes' to carsharing in China, after  
39 filtering the incomplete, incorrect and inaccurate data.

40 In the survey, participants were asked about their (a) demographic information, such

as gender, age, profession, education level, personal income, children in the household and vehicle ownership; (b) awareness of carsharing and lowest acceptable price of carsharing vehicles; (c) living cities' car-purchase restriction policy (CPRP) and urban public transport service level (UPTSL); (d) carsharing mode choice patterns under different trip purposes and trip distances; (e) highest acceptable price of using carsharing; (f) attitudes to forgoing a vehicle purchase and participating in carsharing.

Table 1 is relevant statistical information about valid collected responses. Participants' education level was divided into three different categories according to their highest school record, namely: low-education participants who had never been to a university; middle-education participants who were studying for or had obtained a bachelor's degree; and high-education participants who were studying for or had obtained a graduate degree. Similarly, personal income level was also divided into three categories, namely: low-income participants with less than 5 thousand Yuan per month; middle-income participants with income between 5 thousand and 10 thousand Yuan per month; and high-income participants with more than 10 thousand Yuan per month.

**TABLE 1 Independent Variables Used in the Study**

Independent variables	Description/levels	Summary statistics	
		N	%
Car purchase restriction policy (CPRP)	Have	546	33.9
	Not have	280	66.1
Urban public transport service level (UPTSL)	Low	363	43.9
	Medium	133	16.1
	High	330	40
Gender	Male	420	50.8
	Female	406	49.2
Age	<20	52	6.3
	21-30	472	57.1
	31-40	233	28.2
	41-50	53	6.4
	Above 50	16	1.9
Profession	Office worker	523	63.3
	Non-office worker	303	36.7
Education level	Low-education	110	13.3
	Middle-education	612	74.1
	High-education	104	12.6
Personal income (¥)	Low-income	405	49.0
	Middle-income	296	34.8
	High-income	125	15.1
Children in the household	None	375	45.4
	Yes	451	54.6

Car ownership	Having a car	514	62.2
	Not having a car	312	37.8
Awareness of carsharing	Know about it	429	51.9
	Haven't heard	397	48.1
Price of carsharing vehicles	Below 100 thousand Yuan	336	40.7
	Among 100 to 200 thousand Yuan	319	38.6
	Among 200 to 300 thousand Yuan	138	16.7
	Above 300 thousand Yuan	33	4.0
Trip purpose	Commute	826	16.7
	Shopping	826	16.7
	Go to a doctor	826	16.7
	Visit relatives and friends	826	16.7
	Run errands	826	16.7
	Ferry children	826	16.7
Trip distance	Trip distance less than 3 km	826	16.7
	Trip distance between 4 and 10 km	826	16.7
	Trip distance between 11 and 20 km	826	16.7
	Trip distance between 21 and 30 km	826	16.7
	Trip distance between 31 and 40 km	826	16.7
	Trip distance more than 40 km	826	16.7

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### 3.2 Hierarchical Tree-based Regression (HTBR) method

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Hierarchical Tree-based Regression (HTBR) is a flexible non-parametric statistical method for dealing with prediction and classification problems (21), which has been widely applied for research in travel behavior in recent years. Compared with parametric statistical methods, HTBR has several advantages. Firstly, most parametric statistical methods need to propose model assumptions and pre-define potential relationships between dependent and independent variables, whereas HTBR does not require variables being selected in advance as well as a specified assumption of function form. Thus, HTBR can effectively avoid unreasonable assumptions that may lead to erroneous estimation (22). Secondly, by using a stepwise method, HTBR can straightforwardly yield predictions for dependent variables and identify subgroups of target variable following the optimal splitting rules (23). Thirdly, both continuous variables and nominal variables can be dealt with by HTBR, so relationships between various variables can be explored efficiently and the results can be illustrated visually.

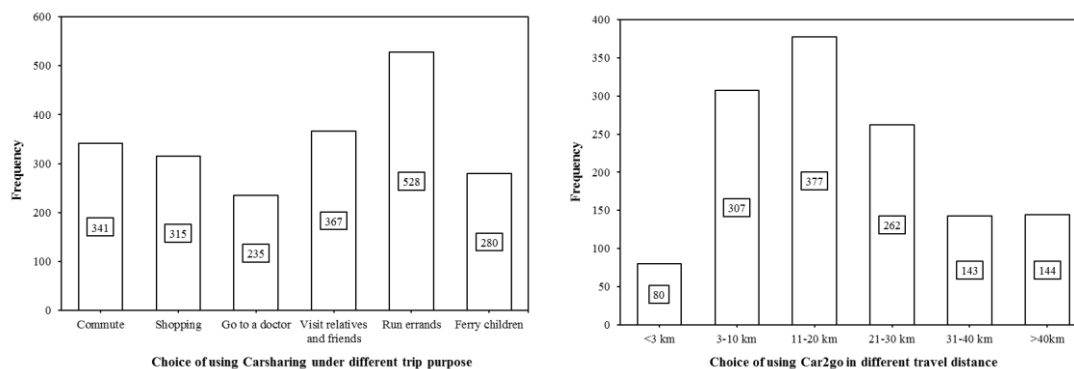
In this study, there were three dependent variables, including participants' carsharing mode choice, highest acceptable price for using carsharing, and willingness to forgo car purchases. Moreover, independent variables were multi-categorical nominal variables. Therefore, HTBR method is quite suited for exploring the influencing relationships between independent and dependent variables.



**4. DESCRIPTIVE ANALYSES**

**4.1 Carsharing Mode Choice under Different Trip Purposes and Trip Distances**

Figure 1 shows the distribution of participants' carsharing mode choices under different trip purposes and different trip distances. From Figure 1(a), it could be found that among the six trip purposes, running errands occupied the highest choosing proportion of carsharing mode, followed by visiting friends and relatives, commuting, shopping, drop-off and pick-up of children, and finally go to a doctor. Specifically, participants' choosing rate ranges from a minimum of 28.5% to a maximum of 64%. From Figure 1(b), 377 participants showed willingness to use carsharing mode when the trip distance was 11- 20 km, accounting for the highest proportion, 46%. The results revealed that other relatively competitive trip distance intervals of carsharing mode included 3-10 km and 21-30 km, the choice rate of which were both higher than 30%. When the trip distance was within the other three intervals, including <3 km, 31-40 km and >40 km, the carsharing mode was not attractive to participants.



(a) Trip purposes

(b) trip distances

**FIGURE 1 Participants' carsharing mode choices under different trip purposes and trip distances.**

**4.2 Highest Acceptable Price for Using Carsharing**

Results obviously revealed that 389 participants (47.1%) could accept the price between 1 and 2 Yuan per minute. 211 participants (25.5%) insisted that only when the price was less than 1 Yuan per minute, they would consider to use carsharing. 187 participants (22.6%) could accept the price between 2 and 3 Yuan per minute, while only 39 participants (4.7%) would be willing to pay more than 3 Yuan per minute.

Specially, Table 2 lists the statistical information of participants' highest acceptable price based on different categories of independent variables. From Table 2, the following general characteristics of participants' acceptable price can be identified.

- Compared with females, more males could accept relatively higher trip cost. Specifically, when the price was more than 2 Yuan, 32% of male could accept, but only 23% female could accept.

- 1 ● 31% of non-office workers thought that the price should be smaller than 1 Yuan,  
 2 while the percentage of office workers (23%) was a little lower. Inversely, 34% of  
 3 office workers showed acceptance of the price higher than 2 Yuan, while that of  
 4 non-office workers was 22%. The results revealed that office workers were willing  
 5 to pay more for using carsharing than non-office workers.
- 6 ● With the increase of income, the percentage of accepting high price (>2 Yuan)  
 7 would also increase, respectively 18% for low-income, 33% for middle-income,  
 8 48% for high-income.
- 9 ● Participants having private cars were found to be more willing to accept high price  
 10 than those not having cars. Particularly, the accepting percentage of each price  
 11 interval for participants having private cars was 48% for 1-2 Yuan, 27% for 2-3  
 12 Yuan, and 5% for >3 Yuan, which were all higher than percentages of participants  
 13 not having a private
- 14 ● Results showed that participants knowing carsharing could accept higher price.  
 15 Specifically, 30% of participants knowing carsharing could accept the price  
 16 between 2-3 Yuan, which was 16% higher than those not knowing carsharing.
- 17 ● When participants could accept the price of carsharing vehicles less than 100  
 18 thousand, only 14% of them were willing to pay more than 2 Yuan. But, with the  
 19 price of carsharing vehicles increasing to 200 thousand, more than 50% of  
 20 participants could accept the price more than 2 Yuan. It indicated that participants  
 21 would be willing to pay more when hoping carsharing vehicles to be expensive.

22 **Table 2 Statistical Information of Participants' Highest Acceptable Price Based on**  
 23 **Different Categories of Independent Variables**

Independent variables	<1 Yuan		1-2 Yuan		2-3 Yuan		>3 Yuan	
	N	%	N	%	N	%	N	%
<i>By CPRP</i>								
Have	126	23	264	48	133	25	23	4
Not have	85	30	125	45	54	19	16	6
<i>By UPTSL</i>								
Low	102	28	165	46	79	22	17	5
Medium	38	29	59	44	28	21	8	6
High	71	22	165	50	80	24	14	4
<i>By gender</i>								
Male	98	23	189	45	108	26	25	6
Female	113	28	200	50	79	20	14	3
<i>By age</i>								
<20	15	29	22	42	11	21	4	8
21-30	121	26	233	29	99	21	19	4
31-40	51	22	106	46	54	28	12	5
41-50	16	30	23	43	12	22	2	4

>50	8	50	5	31	1	6	2	13
<i>By profession</i>								
Non-office worker	93	31	142	47	57	19	11	3
Office worker	118	23	247	47	130	25	28	5
<i>By monthly income ( ¥)</i>								
Low-income	141	35	195	48	55	14	14	4
Middle-income	58	20	141	48	82	28	15	5
High-income	12	10	53	42	50	40	10	8
<i>By education level</i>								
Low-education	35	32	53	48	15	14	7	6
Middle-education	152	25	283	46	149	24	28	5
High-education	24	23	53	51	23	22	4	4
<i>By child</i>								
No	116	31	180	48	63	17	16	4
Yes	95	21	209	46	124	27	23	5
<i>By car ownership</i>								
Having a car	101	20	245	48	141	27	27	5
Not having a car	110	35	144	46	46	15	12	4
<i>By awareness of carsharing</i>								
Know about it	67	16	211	49	130	30	21	5
Haven't heard	144	36	178	45	57	14	18	5
<i>By price of the carsharing vehicle</i>								
Below 100 thousand	135	40	154	46	35	10	12	4
Among 100 to 200 thousand	66	21	166	52	73	23	14	4
Among 200 to 300 thousand	8	6	57	41	63	46	10	7
Above 300 thousand Yuan	2	6	12	36	16	49	3	9

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### 2 4.3 Willingness to Forgo Car Purchases

3 To measure the influence of carsharing on the private car reduction, participants were asked  
 4 whether they were willing to give up buying new cars if the carsharing service could satisfy  
 5 their travel demand. Results showed that 513 (62.1%) participants were willing to forgo car  
 6 purchases, which was obvious more than participants not willing to quit buying a new car.

7 Table 3 displays the statistical information of participants' willingness to forgo car  
 8 purchases based on different categories of independent variables. From Table 3, we can  
 9 identify the following general characteristics:

- 10 ● When living in a city without CPRP, 55% of participants were inclined to give up  
 11 buying a new car. The proportion would increase to 66% among participants living  
 12 in a city having CPRP. The results revealed that CPRP could provide a meaningful  
 13 pathway to reduce the private car ownership and promote the carsharing.
- 14 ● Only 5% of participants with low satisfaction on UPTSL would be willing to using  
 15 carsharing instead of buying a car. Conversely, when having high satisfaction,

more participants (37%) showed interests in forgoing car purchases. It indicated that with the increase of participants' satisfaction on UPTSL, their willingness to forgoing buying cars would dramatically increase.

- Results showed that males were more insistent to buying cars. The proportion of male participants accepting to forgoing car purchases was 59 %, while that of female was 65 %.
- A clear relationship between participants' attitudes to giving up buying cars and their income level was that the former increased with the latter. Particularly, the willing proportion of participants from the low-income group was 58%, while that of participants from the high-income group was 68%.
- 75% of participants having cars were willing to forgoing car purchases, which was obviously more than those not having cars (44%). It indicated that carsharing had a positive impact on reducing the number of cars in the household.
- Participants knowing carsharing would be more likely to accept forgoing car purchases (75%) than those not knowing carsharing (48%). Thus, carsharing organizations should pay more attentions to widely advertise carsharing.

**Table 3 Participants' Willingness to Forgo Car Purchases Based on Different Categories of Independent Variables**

Independent variables	Willing to forgo car purchases		Not willing to forgo car purchases	
	N	%	N	%
<i>By CPRP</i>				
Have	359	66	187	34
Not have	154	55	126	45
<i>By UPTSL</i>				
Low	134	37	229	63
Medium	64	48	69	52
High	315	95	15	5
<i>By gender</i>				
Male	256	61	164	39
Female	257	63	149	37
<i>By age</i>				
<20	21	40	31	60
21-30	280	59	192	41
31-40	163	70	70	30
41-50	38	72	15	28
>50	11	69	5	31
<i>By profession</i>				
Non-office worker	167	55	136	45
Office worker	346	66	177	34
<i>By monthly income ( ¥)</i>				
Low-income	234	58	171	42

Middle-income	194	66	102	34
High-income	85	68	40	32
<i>By education level</i>				
Low-education	66	60	44	40
Middle-education	390	64	222	36
High-education	57	55	47	45
<i>By child</i>				
No	194	52	181	48
Yes	319	71	132	29
<i>By car ownership</i>				
Having a car	340	66	174	34
Not having a car	173	55	139	45
<i>By awareness of carsharing</i>				
Know about it	324	76	105	24
Haven't heard	189	47	208	53
<i>By price of the carsharing vehicle</i>				
Below 100 thousand	190	56	146	44
Among 100 to 200 thousand	207	65	112	35
Among 200 to 300 thousand	95	69	43	31
Above 300 thousand Yuan	21	64	12	36

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## 5. HTBR MODELING RESULTS

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### 5.1 HTBR Model #1 and Model #2–Predicting Participants' Carsharing Mode Choice

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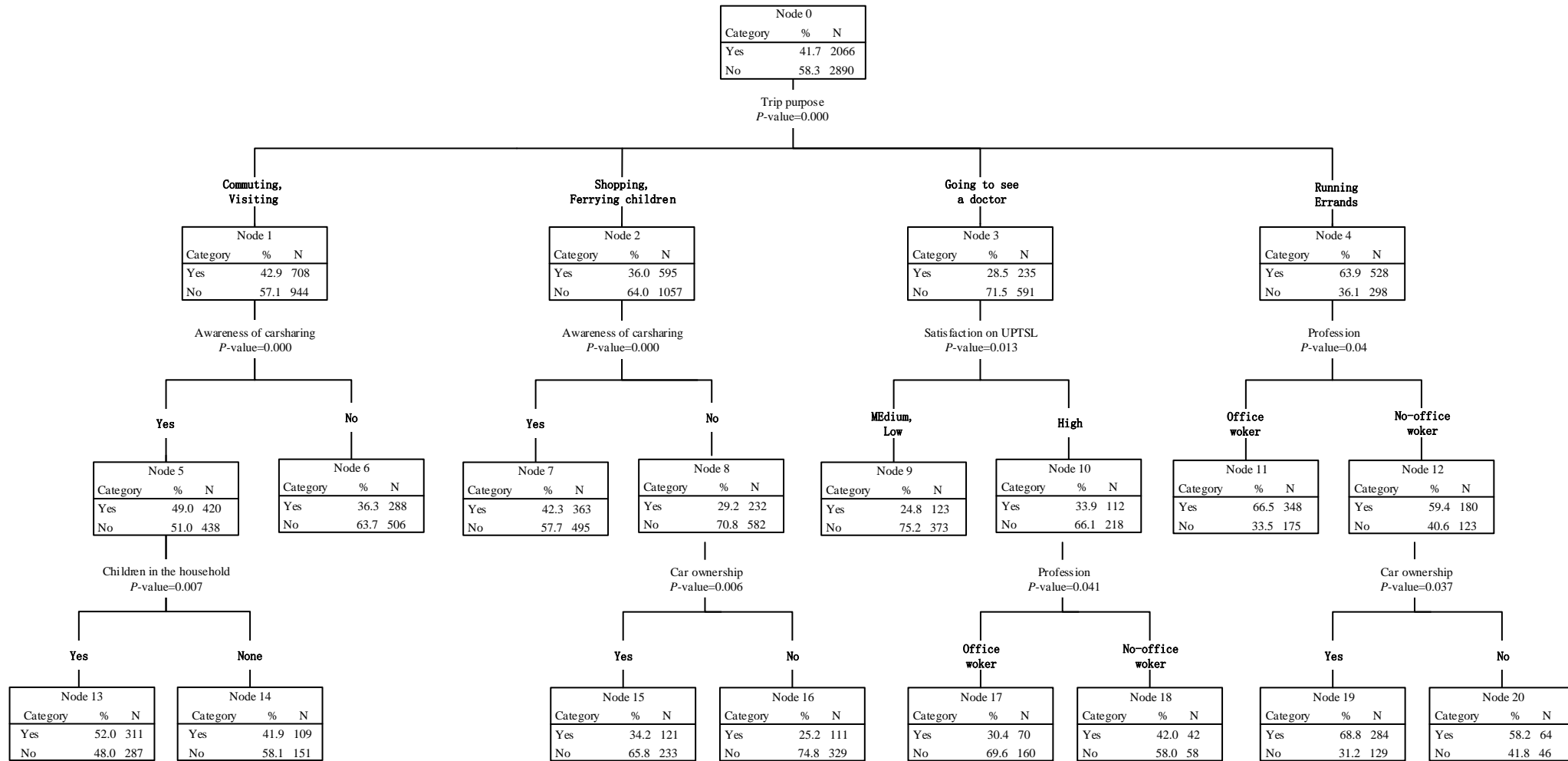
The results of Model #1 and Model #2 are respectively displayed in Figure 2 and Figure 3. The final tree structures for participants' carsharing mode choice under different trip purposes and different trip distances respectively involves six splitting variables (trip purpose, awareness of carsharing, UPTSL, profession, children in household, and car ownership), and six splitting variables (trip distance, children in household, awareness of carsharing, car ownership, profession, and CPRP). As shown in Figure 2, the tree could be classified as follows.

*In the first level:* the purposes of commuting and visiting were classified into the same subgroup, while shopping and ferrying children were in the same subgroup. The

1 results meant that participants tended to make the same choice of whether to use carsharing  
2 mode under purposes in the same subgroups. Moreover, the proportion of participants  
3 choosing carsharing mode when running errands was the highest (63.9%), followed by  
4 commuting and visiting (42.9%), shopping and ferrying children (36.0%), and finally going  
5 to a doctor (28.5%).

6 *In the second level:* when commuting, visiting, shopping or ferrying children,  
7 participants' awareness of carsharing was the most important influencing factor for  
8 carsharing mode choice, while participants' satisfaction on UPTSL was the most important  
9 when going to a doctor, and profession was the most important when running errands.  
10 From Node 5 to Node 8, it could be found that participants knowing carsharing were more  
11 likely to use it compared with those not knowing carsharing. When going to a doctor,  
12 participants with high satisfaction on UPTSL would be more willing to use carsharing.  
13 When running errands, 66.5% of office workers chose to use carsharing, which was 7.1%  
14 higher than the choosing proportion of non-office workers.

15 *In the third level:* when commuting and visiting, children in the household  
16 significantly influenced the choice behavior of participants knowing carsharing:  
17 participants having children were more likely to use carsharing; when shopping and  
18 ferrying children, the choice behavior of participants not knowing carsharing was  
19 influenced by the car ownership: participants having cars were more likely to use  
20 carsharing. The same conclusion could be addressed when analyzing the choice behavior of  
21 office workers when running errands; when going to a doctor, participants' profession was  
22 the key factor influencing the choice behavior of participants with high satisfaction on  
23 UPTSL: the proportion of non-office workers choosing carsharing (42.0%) was much  
24 higher than that of office workers (30.4%).



**FIGURE 2 HTBR Model #1-Predicting predicting participants' carsharing mode choice under different purposes.**

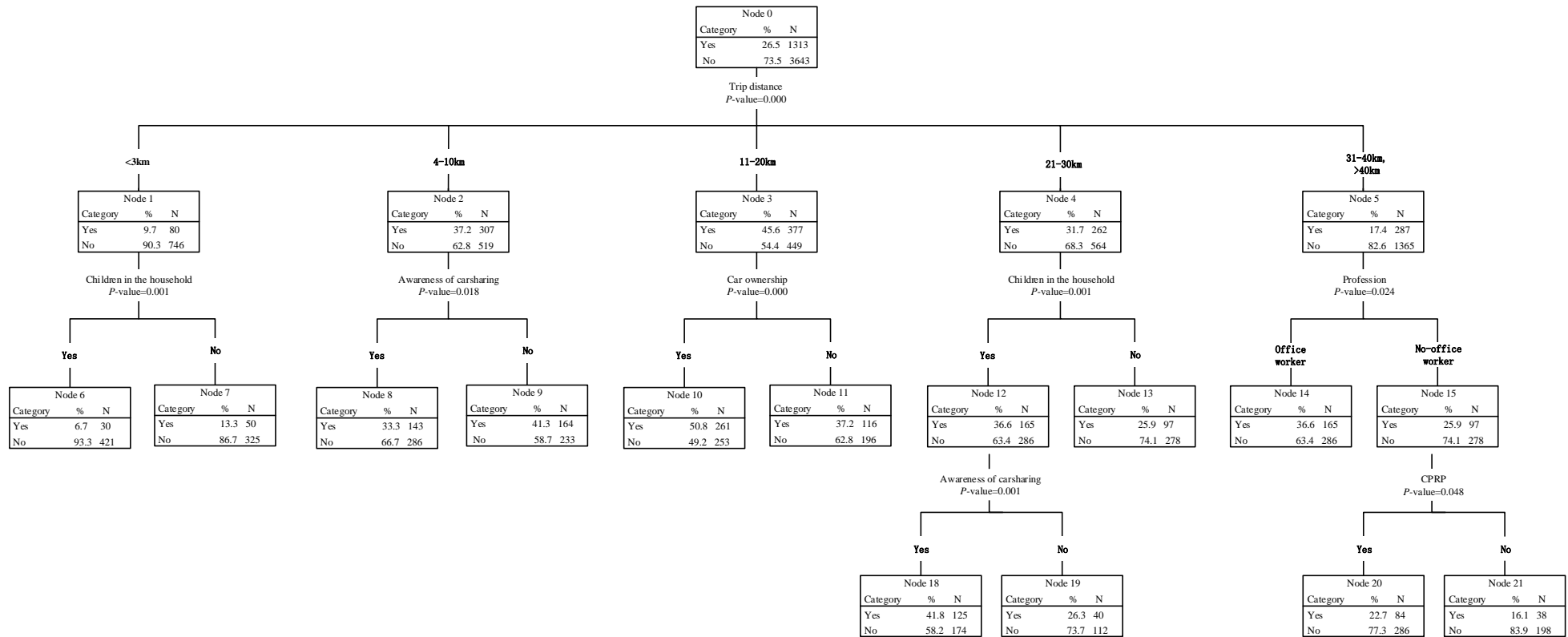
1 As shown in Figure 3, the tree could be classified as follows.

2 *In the first level:* the distance intervals of 31-40km and >40km were classified into  
3 the same subgroup, which meant that participants' choice behavior characteristics was  
4 similar when the trip distance was over 30km. Moreover, the results revealed that  
5 participants were not willing to use carsharing mode when their trip distance was shorter  
6 than 3km or longer than 30km.

7 *In the second level:* For trip distance <3km and 21-30km, children in the household  
8 was the most important classification factor for participants' choice, while participants'  
9 awareness of carsharing mode, car ownership and profession were the most important for  
10 trip distance 4-10km, 11-20km and >30km, respectively. Specifically, for trip distance  
11 <3km, participants not having children were more likely to use carsharing. Inversely, when  
12 the trip distance increased to 21-30km, 36.6% of participants having children were willing  
13 to use carsharing, which was 10.7% higher than those not having children. For trip distance  
14 4-10km, it was found that some participants would still not willing to use carsharing even  
15 though they were aware of it. For trip distance 11-20km, 49.2 % of participants having cars  
16 accepted to use carsharing, which was much higher than participants not having cars, and  
17 37.2%. For trip distance >30km, 36.6% of office workers chose to use carsharing, which  
18 was 10.7% higher than that of non-office workers.

19 *In the third level:* when trip distance was between 21km to 30km, the choice  
20 behavior of participants having children was significantly influenced by their awareness of  
21 carsharing: 41.8% of participants knowing carsharing chose to use the mode while only  
22 26.3% of participants not knowing carsharing were willing to use. When trip distance was  
23 over 30km, CPRP had an obvious impact on the choice behavior of non-office workers:  
24 participants living in a city having CPRP were more likely to use carsharing.





**FIGURE 3 HTBR Model #2-Predicting predicting participants' carsharing mode choice under different distances.**

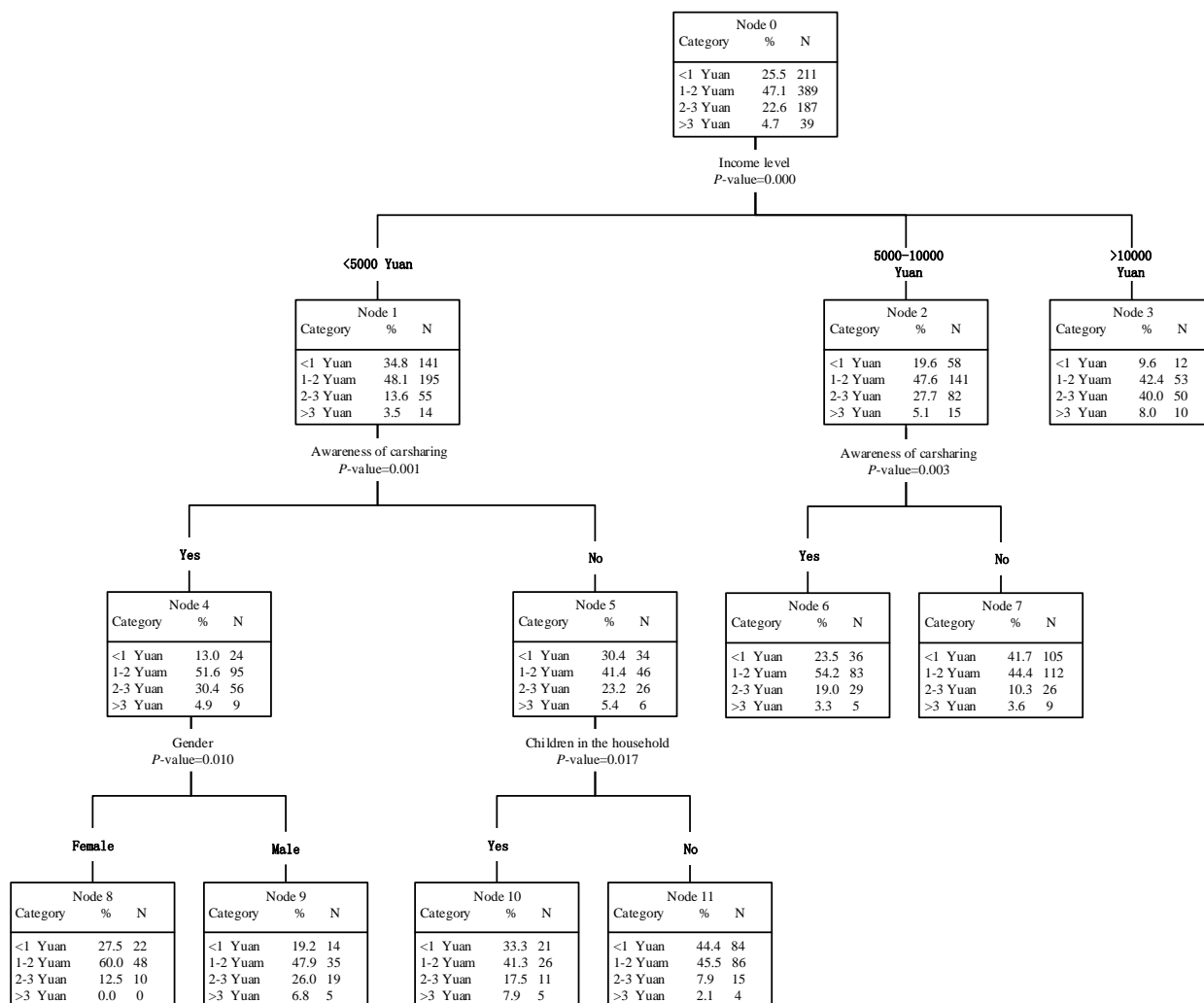
## 5.2 HTBR Model #3-Predicting Participants' Highest Acceptable Price for Using Carsharing

The results of Model #3 are displayed in Figure 4, which are applied for predicting participants' highest acceptable price. The final tree structure involved four splitting variables, including participants' income level, awareness of carsharing, gender and children in the household. As shown in Figure 4, the tree could be classified as follows.

*In the first level:* it was found that participants' income level was the most important influencing factor on participants' highest acceptable price. For income <5000 Yuan, 34.8% of participants could only accept the price lower than 1 Yuan, which was much higher than proportions of participants with income 5000-10000 Yuan (19.6%) and >10000 Yuan (9.6%). Similar trend could also be found for income between 1 Yuan and 2 Yuan. Inversely, for income >10000, 48% of participants could accept the price over 2 Yuan, which was respectively 15.2% and 30.9% higher than the proportions of participants with income <5000 Yuan and 5000-10000 Yuan. The results revealed that with the increase of income, participants would be willing to pay more for using carsharing.

*In the second level:* For income <10000, participants' awareness of carsharing was the most important classification factor for participants' highest acceptable price. Specifically, from Node 4 to Node 7, it could be found that participants knowing the carsharing were more likely to pay higher price for using carsharing than those never hearing about carsharing.

*In the third level:* For income <5000 Yuan, the highest acceptable price of participants knowing carsharing was significantly influenced by gender: 32.8% of males could accept the price over 2 Yuan which was much higher than the proportion of female (12.5%). For income 5000-10000 Yuan, when participants not knowing carsharing, whether having children had an obvious impact on participants' highest acceptable price: if having children, participants tended to accept higher price.



**FIGURE 4 HTBR Model #3-predicting participants' highest acceptable price for using carsharing.**

### 5.3 HTBR Model #4-Predicting Participants' Willingness to Forgo Car Purchases

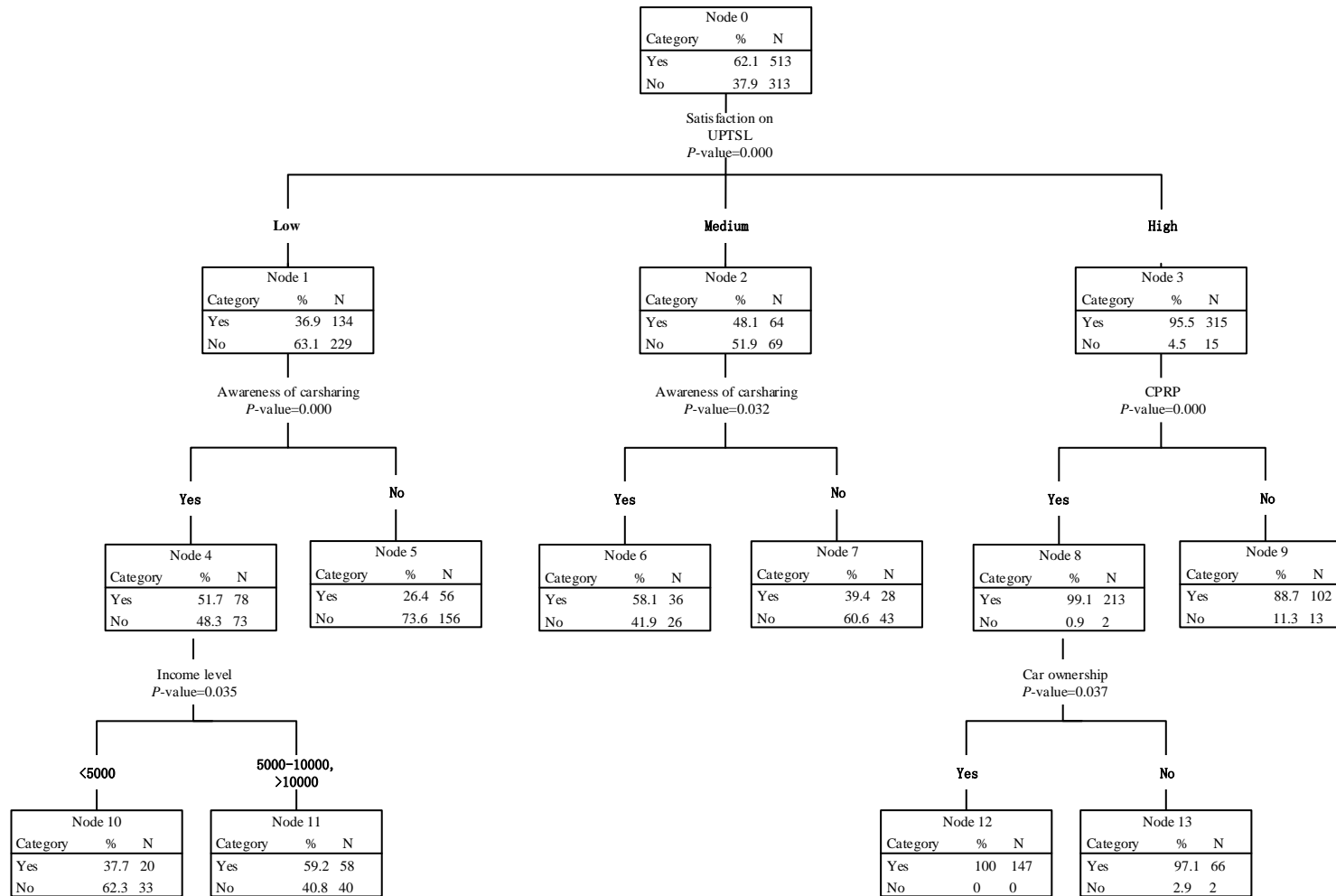
The results of Model #4 are shown in Figure 5. The final tree structure involved five splitting variables, including participants' satisfaction on URTSL, awareness of carsharing, CPRP, income level and car ownership. As shown in Figure 5, the tree could be classified as follows.

*In the first level:* it was found that participants' satisfaction on UPTSL was the most important influencing factor on participants' willingness to give up buying new cars. 95.5 % of participants with high satisfaction considered to give up car purchases if carsharing could satisfy their travel demand, while the proportions of participants with medium and low satisfaction were respectively 48.1% and 36.9%. It indicated that the higher the UPTSL was, the less new private cars would be by introducing carsharing.

*In the second level:* participants' awareness of carsharing were found to be the most important influencing factor on the willingness to forgoing buying new cars of participants

1 with low or medium satisfaction on UPTSL. From Node 4 to Node 7, it was obvious that  
2 participants knowing carsharing were much more willing to forgoing buying new cars.  
3 CPRP was found to be the key factor influencing the willingness to forgoing buying new  
4 cars of participants with high satisfaction. When living in a city having CPRP, 99.1% of  
5 participants were willing to forgoing buying new cars, which was much higher than the  
6 proportion of participants living in a city not having CPRP.

7 *In the third level:* For participants with low satisfaction on UPTSL and knowing  
8 carsharing, income was the most important influencing factor: when income was less than  
9 5000 Yuan, 37.7% of participants were willing to forgoing buying new cars, which was  
10 much lower than that of participants with more than 5000 Yuan income, 59.2%. When  
11 living in a city having CPRP, car ownership had an obvious impact on the willingness to  
12 forgoing buying new cars of participants with high satisfaction on UPTSL: if having cars,  
13 all participants were willing to forgoing buying a new car.



**FIGURE 5 HTBR Model #4-predicting participants' willingness to forgo car purchases.**

## 6. CONCLUSIONS AND POLICY IMPLICATIONS

Using the data collected from an online survey, this study has identified factors that influence individuals' attitudes to carsharing in China, including individuals' carsharing mode choice behavior, highest acceptable price for using carsharing, and willingness to forgo car purchases. Through correlation description analyses and HTBR methods, some important findings have been obtained. Relationships between factors and individuals' attitudes of acceptance to carsharing can provides better insights in the development potential of carsharing in China. As with any new concept, carsharing faces challenges in getting a stronghold as a sustainable urban transport mode. Based on findings in this paper, some challenges were outlined and corresponding policies were proposed to improve individuals' acceptance to carsharing throughout the process of planning, operation and management, which may also be applicable to other countries.

In the planning aspect, carsharing could be considered into urban and traffic development planning documents as an important sustainable strategy, so as to provide strong support for carsharing development from the governments. Besides, planning schemes of carsharing pilot projects in China could be published to guide the implementation of carsharing system, especially for reasonably allocating carsharing vehicles and infrastructures. In this paper, trip purpose and trip distance were found to be the most two important influencing factors of carsharing mode choice behavior. For trip purpose, results showed that most of individuals chose to use carsharing when running errands, followed by visiting friends and relatives, commuting, shopping, ferrying children, and finally going to a doctor. It can be said that the demands of using carsharing in China mainly distribute in office blocks and neighborhoods. Thus, more carsharing vehicles could be planned to be allocated in neighborhoods major employment centers, and central business areas (9). For trip distance, it was found that carsharing was attractive to individuals when their trip distance interval was 3-30 km. As the trip distance was a determinant directly influencing the battery usage of carsharing vehicles, the findings about attractive trip distance interval could provide important basic information for further exploring and quantitatively calculating the optimal layout plan of carsharing infrastructures, such as parking lots, battery-charging stations and so on.

In the operation aspect, carsharing operators should focus on providing high-quality and diversified service to satisfy individuals' different demands. In this paper, it was found that the relatively competitive price range was <2 Yuan. In particular, participants' highest acceptable price for using carsharing was obviously effected by participants' socio-demographic characteristics. The results showed that males were more likely to pay higher price than females and participants with higher-income could accept higher price. Moreover, participants hoping for high-price carsharing vehicle showed more willingness to pay more. Thus, to satisfy the diversified demand, carsharing operators should provide various choices of carsharing vehicles for individuals and reasonably set the price. Vehicles of different price levels can be introduced into the carsharing system, and the using prices

1 can be set accordingly. Moreover, relatively expensive cars can be allocated around the  
2 high-class residence communities, since individuals living there are always with  
3 higher-income.

4 In the management aspect, great efforts should be made to improve individuals'  
5 awareness of carsharing and strengthen the urban management policies to reduce private  
6 cars. As expected, results indicated that individuals knowing carsharing were more likely to  
7 use carsharing, pay higher price and forgo car purchases. Similarly, TCRP (3) found that  
8 only 0.03% of the US urban population joined carsharing in 2004, and the key reason was  
9 the lack of knowledge about carsharing. In this study, approximately half of participants  
10 (48.1%) had never heard about carsharing. It meant that lots of individuals in China did not  
11 understand what carsharing was, how it differed from ridesharing, and how and where it  
12 worked. Thus, to popularize carsharing in China and highlight its advantages in private car  
13 deduction, it is quite urgent to make great efforts to dispel individuals' confusion about this  
14 new concept and increase their awareness. Marketing is considered to be the most effective  
15 way to promote better understanding of carsharing among the public. Specially, marketing  
16 can be carried out by different methods, such as delivering information on websites and in  
17 newsletters, distributing materials at transportation fairs, encouraging media coverage,  
18 issuing press releases, offering links from transportation department website to carsharing  
19 service website, and forming nation-wide organizations to educate policy makers and the  
20 wider public as to the role and benefits of carsharing. The results also showed that variables  
21 related to participants' living city significantly influenced their attitudes to forgo car  
22 purchases. Particularly, when CPRP was carried out in a city or the UPTSL was high,  
23 individuals were more willing to give up buying new cars. Thus, to realize the goals of  
24 private car reduction, great efforts should be made to strengthen the urban management  
25 policies as well as improve the UPTSL. Measures controlling the increase of private cars,  
26 such as CPRP and auto plate auction policy, should continue to be carried out, especially in  
27 metropolis like Beijing, Shanghai, ShenZhen, etc.

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