Working Paper in Economics No. 726

Value of commuting time saving in Beijing: a stated preference study

Hang Yin

Department of Economics, March 2018

ISSN 1403-2473 (Print)
ISSN 1403-2465 (Online)

UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Value of commuting time saving in Beijing: a stated preference study

Hang Yin

Abstract

We estimate the value of travel time savings with a discrete choice model using data from choice experiments on both car drivers and public transport users in Beijing. We find that, compared with public transport users, car drivers would be willing to pay more to save one hour during their commute; crowding inside the bus and subway carriage is very important for public transport users; the value of time saving is higher in the morning than in the evening; and the marginal willingness to pay for commuting time savings varies according to gender, income, education, and time flexibility. Moreover, we compare results from a model addressing attribute non-attendance and a standard model. The results from the model addressing non-attendance are more plausible, with higher consistency in estimated parameters and lower standard deviations.

Key words: Value of commuting time, attribute non-attendance, preference heterogeneity

JEL classification: C25, R41

1 Introduction

As one of the most populous cities in the world, Beijing is heavily burdened with a seriously congested road network, especially during rush hours. According to the Beijing Transport Report, the number of registered vehicles was 5.59 million at the end of 2014. Every day, people in the central city make about 28.5 million trips, of which 57.1% are commuting trips and 31.5% are made by car[1]. The public transport system has been expanded and upgraded over a couple of decades and it covers a vast majority of the city area. However, as the population and number of vehicles increase rapidly, congestion is still a growing problem. All commuters, both car drivers and public transport users, have to endure the inefficiency of low speed and long travel times. The average travel time for one trip by car is about 45 minutes and with public transport is 60 to 75 minutes. The congestion becomes significantly worse during rush hours and at city center (Beijing Municipal Commission of Transport, 2015).

Since 2007, a series of regulations have been introduced to improve traffic conditions. For example, driving is restricted according to the last digit of the license plate number; new car plates are allocated through a lottery; the ticket price of bus and subway has been reduced;[2] and the parking fee at the downtown center has increased. However, the congestion remains severe. Hence, as a possible solution based on positive experiences in other cities such as Singapore, congestion charges have received increasing attention, both on mass media and the internet.

Before introducing a new policy or making any change in an existing policy, it is important to know about people's preferences and to predict the policy effect as accurately as possible. When we talk about congestion charges and any other transport policies, one fundamental concept about commuters' preference is the value of travel time saving (VTTS). It refers to the benefits that commuters get from time savings, and it

[1] In 2014, the average number of trips every day in the central city area (i.e., within the sixth ring road) is 28.54 million, including 8.99 million by car, 8.17 million by bus, 5.55 million by subway, 3.59 million by bicycle, 2.24 million by taxi, and other modes (Beijing Municipal Commission of Transport, 2015). Beijing has a system of ring roads, with the second ring road enclosing the city center, the third farther out, etc. There is no first ring road.

[2] However, the ticket price for the bus and subway increased at the end of 2014.

can be measured in terms of the amount of money that they would be willing to pay for shorter travel time. This is also the basis for the valuation of a transport policy, and for a cost-benefit analysis of any transport project (Beesley, 1965; DeSerpa, 1971; Mackie et al., 2001; Hensher, 2001). In this study, we aim to estimate the marginal willingness-to-pay (MWTP) for commuting time saving in Beijing using data from a choice experiment. Compared with other studies, we focus only on commuters and their commuting trips to the downtown center, and both car drivers and public transport users are included in our sample. Because a congestion charge scheme is the regulatory policy most likely to be introduced, we focus on this. In the choice experiment section, we describe the congestion charge scenario and public transport improvements to the respondents before they answer the choice questions.

The VTTS has been estimated in numerous studies, in different countries, and in different contexts. Previous studies have showed that VTTS varies with trip purpose, trip length, travel mode, size of travel time saving, and trip and traveler characteristics such as income level (see, e.g., Beesley, 1965; Calfee and Winston, 1998; Mackie et al., 2001; Börjesson and Eliasson, 2014; Lam and Small, 2001; Borger and Fosgerau, 2008; Hess et al., 2005). Moreover, the VTTS is potentially time-dependent throughout the day; thus, the conventional linear model may not be a very plausible estimation strategy (Tseng and Verhoef, 2008).

In addition to observable factors, previous research shows that the VTTS varies also with unobservable characteristics of respondents, such as time and risk preferences. For example, in a setting of road pricing, Li and Hensher (2012) included reliability into the utility function to correct the underestimated value of travel time, because evidence suggested that risk preferences also play a role. A similar concern presented in Börjesson and Eliasson (2014) is that "if travel time is unreliable, it is possible that respondents do not consider travel time savings that lie within the normal variation of the travel time". Thus, in a study with the purpose of estimating the value of travel time, we should take both observable and unobservable characteristics into account.

The value of time is often estimated using stated preference methods, including choice experiments. In a choice experiment, the "good" (for instance, the commuting trip in this study) is described by several attributes with different levels, and the respondents have to select the preferred alternative from a series of choice situations. The implicit assumption is that respondents make tradeoffs with consideration of all attributes.

However, what we observe in the experiment is their choices, but not how they make the decisions. Since the late 1990s, researchers have noticed that respondents may make their decisions using different heuristics; for example, someone may focus solely on some attributes, but totally ignore others. This is called "attribute non-attendance (ANA)." The inference one draws could be biased if, for example, a particular attribute is largely ignored by some respondents, unless that non-attendance means the attribute is unimportant to the respondent. Non-attendance is found in stated preference studies in various contexts such as transport, health care, and agriculture. For example, Hensher et al. (2005) found that car commuters do not consider each and every attribute; thus, estimates that assume that all attributes are duly processed lead to significantly different WTP, compared to a model assuming one or more attributes are ignored. Hole (2011) also found, in a choice experiment about health care, that patients use various heuristic strategies when making decisions, and noted that preference heterogeneity is partly driven by attribute non-attendance; he also found that a model accounting for attribute non-attendance gives a slightly better fit and produces considerably lower WTP than a standard mixed logit model.

Therefore, attribute non-attendance (ANA) has rather recently been considered in a number of stated preference studies. In a choice experiment about toll roads, Hensher and Rose (2009) found that a number of respondents are not fully attentive to attributes of free flow time, running cost and toll cost, and therefore the WTP is statistically significantly higher when taking this inattention into account, compared with the standard model. In a healthcare project in Ghana, Lagarde (2013) found that a majority of respondents have considered only one or two attributes, and that the goodness-of-fit was improved when taking ANA into account by using a latent class model. Scarpa et al. (2009) found, in a landscape valuation study, that the model fit improved in ANA models. However, in a study about Swedish environmental quality, Carlsson et al. (2010) used a follow-up question about attribute attendance after the choice tasks, and found that respondents had less concern about the attributes that they claimed to ignore; in other words, they did not totally ignore these attributes, but felt that they were not important. Hole et al. (2013) also compared inferred versus stated attribute attendance, and affirmed that a model allowing for attribute non-attendance and preference heterogeneity has higher goodness of fit; they suggested caution in incorrectly classifying the respondents with weak preference into “non-attenders”.

However, observed “ignoring” and “weakly attending” may – but does not necessarily – result in a biased estimate of MWTP. This depends on two different motivations of non-attendance: the attribute is not important for some respondents, or the attribute is important but not considered when some respondents answer the choice questions. In the first case, the conventional estimation is unbiased. In the other case, the marginal utility could be underestimated or overestimated. There are several practical reasons for the latter case, such as an impatient respondent or a too-complicated choice task; see, e.g., Hole, 2011; Hensher et al., 2005.

Therefore, apart from estimating VTTS of commuting trips, we also investigate the role of ANA for these estimates. This is done by estimating the probability of non-attendance using a latent class model (LCM). Apart from investigating the effect on WTP estimates and model fit, we also investigate whether addressing ANA improves the consistency of the estimates. We do this by utilizing the fact that we estimate the preferences for two cost attributes: fuel cost and congestion cost.

The remaining sections are organized as follows: Section 2 explains the survey, sampling, questionnaires and choice experiment design; Section 3 presents empirical models; Section 4 shows descriptive statistics; Section 5 presents and discusses estimation results; and the conclusion and main ideas are summarized in Section 6.

2 Survey and sampling

2.1 Survey and sampling method

Two generic choice experiments were conducted in 2014, one for car owners and one for commuters who use only public transport, including buses and the subway. Eligible respondents for the car experiment include commuters who drive every work day and also commuters who have access to a car in their household, even though they may not frequently drive it for commuting trips.

The rush hours in Beijing are from 7:00 to 9:00 a.m., and 5:00 to 7:00 pm, and the area within the third ring road is usually mostly congested. Therefore, the eligible respondents in our study are commuters who have to get across the third ring road, from any of the directions.[3] A screening question was asked to find eligible respondents before the survey. It reads "Is there any adult at least 18 years old in your household who has to commute across the third ring road during rush hours every day?" The face-to-face interview was carried out if the eligible household member was available for the survey. If there was more than one eligible commuter in the same household, one of them was randomly chosen as the respondent.

The sample was collected in both residential areas and business districts. We used a stratified sampling method with consideration of household location and income level. As a result, our sample includes 11 out of 35 residential areas[4] and 2 out of 5 business areas located inside the third ring road. The number of completed surveys in each area was decided based on population size.

Prior to the main survey, we had a focus group discussion with nine persons and four pilot surveys using paper questionnaires. In total, 80 commuters, both car owners and public transport users, were interviewed at the pilot stage. Based on the data from the pilots, we got useful information about commuting trips during rush hours, differences between car driving and public transport, and commuters' attitudes toward traffic conditions and existing policies. Moreover, we revised the attribute levels and improved the choice experiment design after each pilot.

A computer-assisted personal interviewing (CAPI) technique was employed in the main survey. It allows us to generate individualized choice situations easily and quickly. There

[3] The purpose of commuting trips includes going to work, going to school, and taking family members to work or school and/or picking them up. Some respondents have retired but were still eligible because they commute in order to take their grandchildren/other household members to school and/or pick them up during rush hours.

[4] The property price varies from 10,000 to 58,000 yuan per m^2.

were 24 experienced enumerators hired from a research firm, and they attended a training session before the survey started. The training session focused on both explaining questions in the survey and on the skills of working with the CAPI system, which was installed in a laptop. The main survey lasted for three months, from May to July in 2014.

2.2 Questionnaires and experiment design

The questionnaire had in total seven sections. It started with a socio-economics section focusing on individual and household information. Information about respondents' work was collected in this section, as well as questions on the number of work days per week and punctuality requirements at work.

The second section was about commuting trips. Respondents answered questions about commuting distance, departure, and destination address. They were also asked to state their departure and arrival time, average time spent on the way, time spent with severe congestion, probability of having severe congestion, and the frequency of driving to work. We asked all respondents to describe their commuting trips by both car and public transport. Morning and evening trips were described separately.

The third section was customized for respondents from a household with and without a car. For car owners, it was about car ownership and car use, such as brand, car age, price at purchase, and miles per year. For public transport users, it was about their willingness and preference for a car purchase.

Then, before the choice experiment, we asked their opinions about the effectiveness of existing transport policies, such as driving day restrictions, low-priced public transport, the lottery for new vehicle plate allocation, a fuel tax, and increased parking fees. Respondents rated each policy on a scale from 1 to 10, where 1 indicates "not helpful to reduce congestion at all" and 10 indicates "very helpful in solving the congestion problem". A cheap talk script[5] was read to all respondents before they started the choice experiment section.

[5] "Before making your choices, we would like you to consider how the changes will affect you, for example in terms of increased costs. Previous studies of this kind have shown that some people tend to overstate that they are willing to change their behavior very easily, while others tend to overstate that they

In the choice experiment section, we first described the general setting of the experiment. To a car owner, we explained the definition of the congestion charge scheme and how it works to reduce traffic congestion. We also described our assumptions about the implementation of a congestion charge in Beijing, especially payment of for driving into the area within the third ring road during morning and evening rush hours. To a public transport user, instead of a congestion charge, we described a scenario about improvement in public transportation. We suggested how the bus and subway network might change and how respondents would benefit from the improvement in traffic conditions.

We use efficient design theory to generate the choice experiments. With this method, the orthogonality is relaxed and the asymptotic standard errors of the parameter estimates are minimized. Using one of the statistical criteria, D-error, the D_p-optimal design method shares the advantage of efficiency and utility balance with efficient design methods using other criterion terms, such as A-error and S-error. Prior parameter values of all attributes were taken from focus groups and four pilot surveys. More details about the choice experiment section are provided below in Sections 2.2.1 and 2.2.2.

In the last section after the choice experiment, there were questions about the possible policy effectiveness of the congestion charge. As in our questions about existing policies, respondents were asked to rate the proposed congestion charge on a scale from 1 to 10, where 1 means "totally useless to solve the problem with congestion" and 10 means "very helpful to Beijing transportation".

2.2.1 More about the choice experiment for car commuters.

The car commuters' choice experiment was designed for respondents from households with at least one car. After the socio-economic questions, we introduced the congestion charge scheme to respondents. A congestion charge scheme has received a lot of attention in Beijing, but it has not been implemented yet; thus, many citizens are not very familiar

---

are very unwilling to change their behavior. Furthermore, in this part of the survey, we want you to consider how you would change your behavior if the policy were implemented, but not your opinion about whether it should be implemented. For example, please make your choices under the assumption that subway ticket price is increased, instead of thinking a higher ticket price is good or bad."

with it. In the survey, congestion charge was described as a potential future scenario, and the charging price was included as one of the attributes in the choice experiment. We described specifically that private cars would have to pay for entering the third ring road during morning and evening rush hours on working days. In this scenario, a smaller traffic flow is one of the expectations because the cost of driving to work is increased. Public transport could be improved by using revenue collected from the charge.

The choice experiment included 12 choice questions. In each question, respondents were required to choose between two generic commuting alternatives with four attributes describing the trips. Information about the individual commuting trips was collected prior to the experiment, and the current situation was listed in each choice question as a reference. Morning and evening commuting time were used as separate attributes, based on the results from pilots showing that people have different preferences for commuting time in the morning and evening. The levels of both these two attributes were based upon individual current levels to make them realistic. The congestion charge (yuan) was included as one of the monetary attributes and the levels were set from 10 to 25 yuan (1 yuan=0.16 USD in January 2018). The fuel cost of one commuting day (i.e., the cost for commuting trips in both morning and evening) was used as the cost attribute, and its levels were also based upon each respondent's current situation.

2.2.2 More about the choice experiment for public transport users

In the public transport experiment, the public transport users are those who do not have any cars in their households. We described the ongoing expansion of the subway network, and a potential future scenario of public transport improvements from which they would benefit. For example, the network might expand and be easier to reach; the frequency could be increased and better scheduled; the ride on buses and the subway might be more comfortable with fewer people; and more advanced buses and subway carriages could become available with more financial support.

There were 12 generic choice questions with two commuting alternatives, and alternatives were also described with four attributes. The levels of morning and evening commuting time were based upon the individual situation. The ticket cost for one day was used as the monetary attribute, and the levels were set from 4 to 10 yuan per day. Also, the degree of crowding in public transport was included as one of the attributes, because it turned out to be of great concern in the pilot surveys and focus group. It was described via the probability of severe crowding, and pictures were used to make it easy to distinguish between "severe" versus "general" crowding.

Table 1. Attributes and levels in car and public transport experiments

Attributes	Levels		Interpretation
	Long	Short	
1: Generic experiment to car commuters			
Morning time	6,9,12,15	4,6,8,10	minutes less than current commuting time
Evening time	6,9,12,15	4,6,8,10	minutes less than current commuting time
Congestion charge	10,15,20,25	10,15,20,25	fixed number
Fuel cost	-6,0,8,18	-5,0,5,10	yuan less or more than current level
2: Generic experiment to public transport commuters			
Morning time	6,9,12,15	4,6,8,10	minutes less than current commuting time
Evening time	6,9,12,15	4,6,8,10	minutes less than current commuting time
Crowding	0	0	6 out of 10 days are very crowded, otherwise crowded
	1	1	8 out of 10 days are very crowded, otherwise crowded
	2	2	always very crowded (today)
Ticket cost	4,6,8,10	4,6,8,10	yuan/day

Attributes and levels are shown in Table 1. In both experiments, commuters whose current morning commute time was greater than 45 minutes were assigned to the sub-group of long commuting time; otherwise, they were placed in the short commuting time sub-group. The levels of time and fuel cost were different for the two sub-groups, given that people who spend 90 minutes per trip are unlikely to trade off between time and cost in the same way as those whose travel time was only 20 minutes.

Table 2-1 and Table 2-2 are two examples, for car drivers and public transport users respectively, of the choice questions in the interviews. Screenshots of CAPI are shown in the Appendix.

Table 2-1. An example of choice questions in car experiment, for long commute group

	Status Quo	**Alternative 1**	**Alternative 2**
Morning commuting time by car without severe congestion	60 minutes	45 minutes	54 minutes
Evening commuting time by car without severe congestion	70 minutes	64 minutes	55 minutes
Daily congestion charge	0 yuan	20 yuan	20 yuan
Daily commuting cost (Fuel)	20 yuan	38 yuan	38 yuan
Your Choice		◯ Alternative 1	◯ Alternative 2

Table 2-2. An example of choice questions in public transport experiment, for long commute group

	Status Quo	**Alternative 1**	**Alternative 2**
Morning commuting time by bus without severe congestion	50 minutes	41 minutes	35 minutes
Evening commuting time by bus without severe congestion	55 minutes	40 minutes	49 minutes
Crowding in public transport	Always severely crowded (Pic. B)	Always severely crowded （Pic.B）	6 out of 10 trips are severely crowded (Pic.B), otherwise crowded (Pic. A)
Daily commuting cost (Ticket)	2 yuan	4 yuan	10 yuan
Your Choice		◯ Alternative 1	◯ Alternative 2

3. Econometric model

When analyzing the responses, we defined the utility of commuter *n* choosing alternative *i* as

$$U_{in} = V(X_{in}, Z_n; \beta) + \varepsilon_{in} \text{ ,} \tag{1}$$

where $V(X_{in}, Z_n; \beta)$ captures the observable components, and the error term ε_{in} captures all unobservable preferences. X_{in} denotes the vector of k attributes relevant in the choice experiment, and describes the "good", which is the commuting trip in our case. Z_n is a set of socio-economic characteristics of respondents. β is the parameter vector.

The assumption is that, in each choice situation, respondents compare all attributes in all the alternatives and choose the alternative that maximizes their utility. The probability that respondent *n* chooses alternative *i* instead of *j* implies

$$P_{in} = P\left(U_{in} > U_{jn}\right), ij \qquad (2)$$

$$P_{in} = P\left(\varepsilon_{jn} - \varepsilon_{in} < V(X_{in}, Z_n; \beta) - V\left(X_{jn}, Z_n; \beta\right)\right), i \neq j \qquad (3)$$

We can estimate this model by specifying the distribution of ε_{in} and the functional form of $V(X_{in}, Z_n; \beta)$. In a simple case without any socio-economic variables, the functional form in the car and public transport experiment could be written as follows, respectively:

$$V_n^{car} = \beta_1 T\_morning_n + \beta_2 T\_evening_n + \beta_3 Charge + \beta_4 FuelCost_n \qquad (4)$$

$$V_n^{pt} = \beta_1 T\_morning_n + \beta_2 T\_evening_n + \beta_3 Crowding + \beta_4 TicketCost \qquad (5)$$

where β_1, β_2, β_3 and β_4 are parameters to be estimated. Note that the subscript *n* is omitted for *Charge* in (4) and *Crowding* and *TicketCost* in (5), because these are attributes with the same levels for all respondents. The values for marginal willingness-to-pay (MWTP) are calculated as coefficient ratios between non-monetary attributes and the cost attributes: fuel cost and congestion charge for car and ticket price for public transport.

In the widely used multinomial logit model (MNL), the error term ε_{in} is assumed to be independently and identically distributed (IID), and this restrictive assumption makes the estimated probability P_{in} independent from irrelevant alternatives (IIA), which is not the case in many empirical studies. Therefore, we mainly focus on the random parameter logit model (RPL). With the RPL model, we relax both the IIA and homogeneity assumptions and allow for preference heterogeneity in some attributes. The parameter β_k for attribute *k* is called random because it has two components: the mean β_{ik}, which is the same for all respondents, and the heterogeneity term η_{ikn}, which produces variation. We assume that all non-monetary attributes (*T_morning, T_evening, Crowding*) have random parameters and that their η_{in} are normally distributed.

We furthermore investigate attribute non-attendance (ANA). As discussed in Section 1, respondents may, consciously or subconsciously, weakly consider one attribute, even if they claim to ignore it (Carlsson et al., 2010; Hole et al., 2013)[6]. We employ a latent class model (LCM) to identify the probability of not considering each attribute (see Scarpa et al., 2009; Scarpa et al., 2012; Lagarde, 2013). The intuition is that respondents may have attended to different attributes, and thus we can categorize them into several classes: within each class, one attribute is not attended to while all the others are. When the attribute is attended to, we assume at this stage that the preferences are the same across all respondents. For example, in our case, people in one class may not attend to fuel cost, while in another class they might not attend to morning commuting time. This is done by restricting the corresponding coefficient to zero.

Technically, we estimate a five-class LCM where one of the attributes is ignored in four of the classes. From the LCM, we get π_{nc}, which are the probabilities of respondent *n* belonging to the class *c*. These are the probability of considering all four attributes (π_{n1}) and the probability of ignoring each attribute (π_{n2}, π_{n3}, π_{n4}, and π_{n5}). In the next step, which is a RPL model, we use the result from LCM to consider attribute non-attendance by recoding the attribute levels by multiplying a weight factor ω_{nc}, defined as

$\omega_{nc} = 1,$ if *c*=1

$\omega_{nc} = 1 - \pi_{nc},$ if *c*>1

The weight ω_{nc} indicates the extent to which the respondent has considered the attribute.

Note that both *Charge* and *FuelCost* are included in (4). Thus, in each choice task for car commuters, there are two monetary attributes that are measured in the same unit: yuan per trip. We should therefore expect similar parameter magnitudes if people have consistent preferences for money. Thus, the size of the coefficient ratio $\gamma = \frac{\beta_3}{\beta_4}$ indicates

[6] Following the method in Carlsson et al. (2010), we tested stated attendance using data from the follow-up questions. We assumed the attribute is completely ignored if the respondent stated that he or she “did not attend to” that attribute. We included an interaction term of attribute levels and the dummy of non-attendance into the ANA model. As a result, the parameters of interaction terms were not statistically significant, which indicated that attributes were actually (weakly) considered.

preference consistency when it is close to 1, and vice versa. Moreover, it is informative about the fitness of the ANA model.

4 Respondent characteristics

A total of 1370 commuters, 622 car owners and 748 public transport users completed the survey. However, some observations have to be dropped in the empirical analysis due to either unrealistically short commuting time or missing commuting distance[7]. As a result, the total number of qualified observations used in this study is 1347: 605 for car and 742 for public transport (Table 2).

Table 2. Sample sizes of both car and public transport experiment

	Long time (T>45min)	Short time (T≤45min)	Total
1: Car experiment	248	357	605
2: Public transport experiment	377	365	742

The key variables used in the empirical analysis are summarized in Table 3. The average commuting time in the morning is less than that in the evening, for both car commuters and public transport users. With severe congestion, the commuting time could be more than one hour. Because of the policy of low-priced public transport, commuting cost is much lower with public transportation.[8] About 40% of respondents stated that arriving late to work is not accepted without penalty[9]. This is one of the main reasons why we believe it is important to separate between commuting time in the morning and in the evening.

Table 3. Descriptive statistics of key variables in the sample

	Long time		Short time	
	Mean	SD	Mean	SD

[7] There are 17 observations in the car sample and 6 observations in the public transport sample that were dropped. The reasons include (1) reported commuting time is too short and/or commuting cost was too low, thus we got zero or a negative level in the choice experiment that followed, and/or (2) respondents couldn't provide information about distance and/or household location.
[8] Since 28 December, 2014, the low-priced public transport policy was ended and the ticket prices of buses and subway have increased and been charged according to distance.
[9] About 98% of the respondents have a job.

1: Car experiment					
Commuting time in the morning by car	minutes	59.96	14.50	31.78	7.20
Commuting time in the evening by car	minutes	65.20	18.57	37.27	10.69
Commuting time when serious congestion	minutes	81.60	30.38	51.44	19.47
Commuting cost by car	yuan per day	36.52	28.97	24.04	11.63
Age	years	35.41	9.80	36.69	10.66
Gender	1=female	0.42		0.49	
Education	1=university	0.38		0.39	
Individual income in year 2013	10000 yuan	7.67	7.69	7.66	5.81
Have children	1=yes	0.41		0.43	
Late to work	1=not allowed	0.39		0.45	
2:Public transport experiment					
Commuting time in the morning by public transport	minutes	63.14	20.00	33.77	7.00
Commuting time in the evening by public transport	minutes	65.46	19.54	37.31	9.47
Commuting time when serious congestion	minutes	71.94	26.57	45.74	15.82
Commuting cost by public transport	yuan per day	3.44	1.84	2.58	1.73
Age	years	35.03	10.33	34.12	11.42
Gender	1=female	0.57		0.55	
Education	1=university	0.29		0.28	
Individual income in year 2013	10000 yuan	5.74	3.00	5.49	3.12
Have children	1=yes	0.31		0.26	
Late to work	1=not allowed	0.40		0.43	

5 Empirical analysis

5.1 Multinomial logit model results

We begin with estimating a simple multinomial logit (MNL) model, where we only include the attributes in the experiment. We estimate separate models for long and short travel time commuters, as defined above, because a likelihood ratio test can reject the hypothesis of equal parameters between the two groups, while correcting for a potential difference in scale parameters using the grid search procedure suggested by Swait and Louviere (1993).[10]

The results of the multinomial logit models are presented in Table 4. The MWTP for the time attributes are multiplied by 60; thus, the interpretation is how much the commuters would be willing to pay for a one-hour reduction in travel time. For the car experiment, we estimate MWTP using both fuel cost and congestion charge as the marginal utility of money.

In the car experiment, all attribute coefficients are, as expected, negative and statistically significant at the 1% level. In the long travel time group, the MWTP for travel time reduction is higher for mornings than for evenings. When using the coefficient of the fuel cost as the denominator, the MWTP for a reduction in travel time in the mornings is 44 yuan per hour, while for the evening it is around 15 yuan. The difference is about 29 yuan and it is statistically significant at the 1% level. The MWTP values using congestion charge as the denominator are higher because subjects are less sensitive to changes in the congestion charge. Thus, the VTTS is higher when the congestion charge, instead of fuel cost, is used as the cost coefficient. In the short travel time group, the difference between morning and evening time is similar to the long travel time group. The MWTP values for morning time are higher than the MWTPs for evening time. Again, the MWTP values based on congestion charge are higher than those calculated with fuel cost.

The MWTP for the congestion charge, i.e., the coefficient ratio of the two monetary attributes – congestion charge and fuel cost – should be one if commuters only care about their own private cost of the two policies, because both are expressed in yuan per trip. However, they could be different if, for example, respondents use the experiment as a way of expressing an attitude toward a certain policy, or if respondents do not believe the information that is presented to them. The MWTP values for the congestion charge are smaller than 1 in both the long and short group, 0.65 yuan and 0.74 yuan respectively,

[10] The hypotheses of equal parameters and equal scale factor are rejected because the chi-square statistics are greater than the critical value at the 95% level with 5 degree of freedom (11.07). The chi-square statistic is 32.75 in the car experiment and 45.91 in the public transport experiment.

and both are statistically significantly different from 1 at the 1% level. Thus, commuters are less sensitive to an increase in the congestion charge than to an increase in fuel cost.

For public transport commuters, most attribute coefficients are statistically significant at the 1% level with the expected negative signs. The exception is the evening time attribute for the long travel time group, where the coefficient is positive and statistically significant. This is an indication of a problem with this experiment, and we will return to this later on when we investigate decision heuristics. For the short travel time group, the MWTP for travel time reduction is slightly higher for mornings (5.8 yuan per day) than for evenings (5.6 yuan per day), but the difference is not statistically significant according to a double-sided t-test (p-value = 0.91). Public transport commuters have a much lower value of time than car commuters, and the difference is between 3 to 8 times. This is perhaps expected because public transport users have much lower commuting cost and lower income. The MWTP for reducing crowding shows how much the commuters would be willing to pay for a unit change in the crowding attribute, which is 2 out of 10 days with severe crowding. Commuters who travel a shorter time with public transport have higher MWTP for fewer days of severe crowding than those who travel longer trips (MWTPs are 0.78 yuan and 0.32 yuan respectively). One explanation is that, in the short travel time group, there are respondents who have self-selected to live close to their work places because they strongly dislike crowding and thus have very high MWTP for a less crowded trip. However, we don't have many details to investigate whether this is true.

Table 4. Multinomial logit model (MNL) estimation results for both car and public experiment, MWTP calculated and standard errors are in parenthesis

	Car experiment						Public transport experiment			
	Long time			Short time			Long time		Short time	
	Coef.	MWTP with cost	MWTP with charge	Coef.	MWTP with cost	MWTP with charge	Coef.	MWTP	Coef.	MWTP
Time morning	-0.114***	44.22***	68.46***	-0.131***	36.65***	49.42***	-0.012	1.69	-0.051***	5.82***
	(0.009)	(2.27)	(4.01)	(0.010)	(2.12)	(2.92)	(0.009)	(1.15)	(0.011)	(1.25)
Time afternoon	-0.037***	14.39***	22.28***	-0.088***	24.64***	33.23***	0.029***	-3.95***	-0.049***	5.62***
	(0.008)	(2.57)	(3.99)	(0.009)	(2.15)	(2.97)	(0.008)	(1.17)	(0.011)	(1.23)
Crowding							-0.137***	0.32***	-0.410***	0.78***
							(0.037)	(0.08)	(0.033)	(0.05)
Charge	-0.100***	0.65***		-0.159***	0.74***					
	(0.007)	(0.02)		(0.007)	(0.01)					
Cost	-0.154***			-0.214***			-0.433***		-0.522***	
	(0.009)			(0.009)			(0.015)		(0.015)	
No. of obs.	248			357			377		365	
R^2	0.11			0.14			0.38		0.39	

*Note: * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

5.2 Attribute non-attendance

As described in Section 3, we employ a latent class model to identify the likelihood that an attribute is not attended to. For both experiments, we estimate an LCM model with five classes. In one class, all attributes are attended to. In four of the classes, one of the attributes is not attended to, but the others are. The average probabilities of each class are reported in Table 5. For the car experiment, the probability of attending to all attributes is over 50%. The only two attributes that have a positive probability of not being attended to are the two cost attributes: the congestion charge and the fuel cost. For the public transport experiment, the picture is very different. The likelihood that the two time attributes are ignored is substantial in the long travel time group, while in the short travel time group the crowding attribute is very likely to be ignored. (The full results of the latent class models are presented in the appendix)

Table 5. Probabilities of ignoring attributes, results from LCM model

	Car experiment		Public transport experiment	
	Long time	Short time	Long time	Short time
Consider all attributes	0.566***	0.618***	0	0
Ignoring morning time	0	0	0.591	0
Ignoring evening time	0	0	0.225	0.345***
Ignoring congestion charge	0.366***	0.329***		
Ignoring crowding			0	0.562***
Ignoring fuel/ticket cost	0.068***	0.053***	0.184***	0.093***
No. obs.	248	357	377	365
McFadden Pseudo R^2	0.15	0.20	0.49	0.52

*Note: * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

These class probabilities remain much the same when we include socio-economic variables in the LCM model, and the socio-economic variables in the class selection model are mostly not statistically significant. The results are available on request.

5.3 Preferences with and without ANA

We now move to the next step, where we use the information about ANA from the LCM models. As described in Section 3, we recode attribute levels using individual class probabilities estimated in the LCM. Then, we estimate a RPL model using the recoded attribute levels (hereinafter, ANA model), and compare the result with the original RPL model using original data (hereinafter, RPL model). All models are estimated with 1000 Halton draws. Tables 6 and 7 present the estimated coefficients and MWTP for the car experiment.

Table 6. Estimated coefficients from RPL for car experiment,
comparing RPL model without and with ANA

	Long time		Short time	
	RPL	RPL with ANA	RPL	RPL with ANA
Random parameters in utility functions				
Morning time	-0.115***	-0.157***	-0.131***	-0.136***
	(0.010)	(0.011)	(0.011)	(0.014)
Evening time	-0.036***	-0.056***	-0.088***	-0.078***
	(0.008)	(0.009)	(0.009)	(0.011)
Nonrandom parameters in utility functions				
Congestion charge	-0.100***	-0.217***	-0.160***	-0.288***
	(0.007)	(0.009)	(0.007)	(0.010)
Fuel cost	-0.155***	-0.225***	-0.215***	-0.270***
	(0.009)	(0.009)	(0.009)	(0.009)
Standard deviation of random parameters				
Morning time	0.033**	0.072***	0.055***	0.178***
	(0.014)	(0.012)	(0.017)	(0.015)
Evening time	0.037***	0.066***	0.72583D-04	0.063***
	(0.013)	(0.012)	(0.014)	(0.022)
N.obs	248	248	357	357
McFadden Pseudo-R^2	0.12	0.28	0.15	0.33

*Note: * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

Table 7. Estimated MWTPs for car experiment, comparing RPL models without and with ANA

	RPL				RPL with ANA			
	MWTP with fuel cost	SD	MWTP with congestion charge	SD	MWTP with fuel cost	SD	MWTP with congestion charge	SD
Long commuting time group								
Morning time	44.21***	12.83**	68.75***	19.96**	41.88***	19.30***	43.59***	20.08***
	(2.44)	(5.67)	(4.27)	(8.82)	(2.23)	(3.44)	(2.55)	(3.60)
Evening time	13.97***	14.26***	21.72***	22.17***	15.00***	17.53***	15.61***	18.25***
	(2.77)	(5.16)	(4.32)	(8.02)	(2.20)	(3.41)	(2.37)	(3.56)
Congestion charge	0.64***				0.96***			
	(0.02)				(0.03)			
Short commuting time group								
Morning time	36.41***	15.45***	48.93***	20.76***	30.26***	39.62***	28.31***	37.06***
	(2.29)	(4.59)	(3.13)	(6.13)	(3.01)	(3.19)	(2.84)	(2.86)
Evening time	24.40***	0.02	32.79***	0.03	17.37***	13.93***	16.25***	13.03***
	(2.16)	(3.90)	(2.98)	(5.24)	(2.24)	(4.82)	(2.17)	(4.48)
Congestion charge	0.74***				1.07***			
	(0.01)				(0.02)			

*Note: The MWTPs for commuting times are in Yuan/Hour. The MWTP for congestion charge is in Yuan. * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

For the long travel time group, when we use fuel cost in the calculation, the MWTP values are very similar in the two models. They are 44 and 42 yuan for morning time, and about 14 and 15 yuan for evening time; the differences are not statistically significant according to t-tests. But when we use a congestion charge in the calculation, the MWTP for morning time in the ANA model is much lower (44 yuan) than in the RPL (69 yuan), and the difference is significant at the 1% level. The MWTP for evening time is also lower in the ANA model than in the RPL model (16 yuan and 22 yuan respectively), but the difference is not statistically significant. For the short travel time group, we found similar but stronger patterns. Whether we calculate based on fuel cost or congestion charge, the MWTP values for commuting time are statistically significantly[11] lower in the ANA model than in the RPL model.

The major reason for the difference between the model with and without ANA is the MWTP for the congestion charge and fuel cost. In both long and short commuting time groups, the MWTP values in the ANA model (0.96 in the long group and 1.07 in the short group) are much closer to 1 than in the RPL model (0.64 in the long group and 0.74 in the short group) and the differences are statistically significant at the 1% level. This implies that the estimates from the ANA models are more internally consistent. As a consequence, in this model there is no difference in MWTP values calculated with fuel cost or congestion charge. In the long group, MWTP is about 43 yuan for morning time and 15 yuan for evening time; while in the short group it is about 30 yuan for morning time and 17 yuan for evening time.

[11] According to the t-tests, when calculate with fuel cost, the difference between MWTP values for morning time (30 yuan in ANA model and 36 yuan in RPL model) is significant at the 10% level; and the differences between the two models for the three other MWTP values (17 yuan and 24 yuan for evening time; when calculate with congestion charge, 28 yuan and 49 yuan for morning time, 16 yuan and 33 yuan for evening time) are significant at 1% level.

Table 8. Estimated coefficients from RPL for public transport experiment, comparing RPL models without and with ANA

	Long group		Short group	
	RPL	RPL with ANA	RPL	RPL with ANA
Random parameters in utility functions				
Morning time	-0.014	-0.173***	-0.103***	-0.125***
	(0.012)	(0.028)	(0.015)	(0.021)
Evening time	0.037***	-0.005	-0.057***	-0.192***
	(0.010)	(0.013)	(0.013)	(0.026)
Crowding	-0.178***	-0.406***	-0.416***	-1.848***
	(0.042)	(0.058)	(0.060)	(0.099)
Nonrandom parameters in utility functions				
Ticket cost	-0.522***	-1.061***	-0.633***	-1.082***
	(0.022)	(0.044)	(0.022)	(0.042)
Standard deviation of random parameters				
Morning time	0.137***	0.218***	0.095***	0.172***
	(0.012)	(0.032)	(0.025)	(0.027)
Evening time	0.071***	0.033	0.045	0.147***
	(0.015)	(0.039)	(0.042)	(0.033)
Crowding	0.297***	0.532***	0.865***	0.678***
	(0.061)	(0.075)	(0.056)	(0.081)
N.obs	377	377	365	365
McFadden Pseudo-R^2	0.39	0.57	0.45	0.65

*Note: * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

Table 9. MWTP from RPL for public transport experiment, comparing RPL model without and with ANA

	RPL	SD	RPL with ANA	SD
Long commuting time group				
Morning time	1.64	15.81***	9.81***	12.32***
	(1.32)	(1.83)	(1.46)	(2.06)
Evening time	-4.26***	8.18***	0.26	1.89
	(1.15)	(1.67)	(0.71)	(2.21)
Crowding	0.34***	0.57***	0.38***	0.50
	(0.08)	(0.13)	(0.05)	(0.08)
Short commuting time group				
Morning time	9.80***	8.97***	6.96***	9.54***
	(1.33)	(2.23)	(1.12)	(1.35)
Evening time	5.36***	4.27	10.65***	8.15***
	(1.20)	(3.92)	(1.40)	(1.70)
Crowding	0.66***	1.37***	1.71***	0.63***
	(0.09)	(0.08)	(0.07)	(0.09)

*Note: * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

Tables 8 and 9 present results for the public transport experiment. For the long travel time group, the results of the two models are very different. In the RPL model, the MWTP for morning time is statistically insignificant, and the MWTP for evening time is significant with a negative sign, which is obviously not plausible. In the ANA model, the MWTP for morning time is about 10 yuan per hour and is statistically significant. The MWTP for evening time is now positive as expected, but much lower and not statistically significantly different from zero. The MWTP for reducing crowding is still significant and quite close to the estimate in the RPL model.

For the short time group, in the RPL model, the MWTP values for morning and evening times are about 10 yuan and 5 yuan, respectively. But in the ANA model, the MWTP is lower in the morning (7 yuan per hour) and higher in the evening (11 yuan per hour). And, the MWTP for less crowding, 1.71 yuan, is much higher than in the RPL model, which is only 0.66 yuan. All the differences in MWTP values between the RPL and ANA models are tested by double-sided t-tests.

Table 10 summarizes the t-test results of the difference between estimated MWTP in RPL and ANA models, for both car and public transport experiments. In the long commuting time group in the car experiment, when using a congestion charge, the MWTP for morning time in the ANA model is lower than in the RPL model, and the difference is statistically significant at the 1% level. In the short group, the MWTP values for morning and evening time, regardless of whether we use fuel cost or congestion charge, are all significantly lower in the ANA model. The MWTP for congestion charge is higher in the ANA model for both the long and short group.

Table 10. Differences between MWTPs from RPL models without and with ANA, results from t-tests, both car and public transport experiments

	Car experiment				Public transport experiment	
	Long time		Short time		Long	Short
	on fuel cost	on charge	on fuel cost	on charge		
Morning time	0.04	0.42***	0.13*	0.42***	3.14***	1.74***
	(0.06)	(0.08)	(0.07)	(0.07)	(0.83)	(0.29)
Evening time	-0.02	0.10	0.16***	0.34***	-0.07	-0.08
	(0.06)	(0.08)	(0.06)	(0.06)	(0.06)	(0.05)
Congestion charge	-0.32***		-0.48***			
	(0.32)		(0.03)			
Crowding					0.58***	1.58***
					(0.10)	(0.08)

*Note: * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

In the public transport experiment, we find similar t-test results for both the long and short time groups. The MWTP for morning time is significantly lower in the ANA model than in the RPL model. But the difference is not significant for evening time. The MWTP for less crowding is also significantly lower in the ANA model.

As a result, car drivers value their morning time as highly as around 40 yuan per hour, with a standard deviation of about 20 yuan. This is roughly equal to or a bit higher than the average wage rate. Meanwhile, car drivers have much lower MWTP for evening time; it is less than half of the wage rate. In the case of public transport users, their values of commuting time savings are significantly lower than car drivers, and are very similar in the morning and the evening, at about 10 yuan per hour and one-third of the wage rate[12].

Given the setting, our estimation is not exactly in line with some previous studies but it is still comparable and plausible. For example, there were three waves of value of time studies in the UK conducted from the early 1970s to 1994, and the estimated VTTS is only 20% to 43% of the wage rate. But these studies were not focused only on commuting trips, and the marginal disutility of longer travel time is probably higher for commuting trips than leisure trips, especially in crowded and congested conditions (Mackie et al., 2001). In Fezzi et al. (2014), the average value of travel time is only 3/4 of the wage rate, but this is for recreational trips to three popular beach sites along the Italian peninsula. Moreover, oppositely with our results, estimated value of travel time savings will be higher when attribute non-attendance is considered (Hensher and Rose, 2009).

5.4 Heterogeneity in VTTS

We investigated individual heterogeneity in MWTP by including a set of socio-economic characteristics in the RPL model, where we take ANA into consideration. There are five dummy variables included in the model: female, university level education, high income level, having one or more children in the household, and a dummy indicating a respondent has flexibility in the time of arrival at work in the morning (see Table 3 in Section 4). The MWTP results are presented in Table 11. In the car experiment, all

[12] According to the Beijing Municipal Human Resources and Social Security Bureau, the average wage rate in 2014 was 6463 yuan per month and thus about 37 yuan per hour.

MWTPs are calculated with only the fuel cost, because, with consideration of ANA, the results are basically the same as if we used the congestion charge instead (See Table 7).

First, using the dummy of *female*, we investigated the differences between male and female. We observe statistically significant heterogeneity only in the long travel time group of the car experiment. On average in this group, a male car commuter would be willing to pay more for both morning and evening travel time saving, compared to a female car commuter. This is also the case for the dummy of *having children*; car commuters in the long travel time group are willing to pay more to save time when they have children in the household.

Second, *income*-related heterogeneity is statistically significant only in the car experiment. This is especially the case in the short group, where a respondent with high individual income has significantly higher MWTP for both morning and evening time saving. This is plausible because, with a short commuting distance and higher individual income, a car commuter is willing to pay more to save time.

Third, *education* has similar effects on preference heterogeneity for both car and public transport commuters. In the long groups, commuters with university level degree have significantly higher MWTP for time savings in morning, but not in the evening, whereas in the short groups the heterogeneity is significant in the evening, but not in the morning.

Finally, for *flexibility*, we observe significant but very different effects between car and public transport experiments. Car commuters' MWTP values for commuting time savings are significantly much higher if they have flexible working hours; this is not the case for public transport users.

Table 11. Preference heterogeneity in MWTP for commuting time savings, both car and public transport experiment (Yuan per hour)

	Car experiment				Public transport experiment			
	Long		Short		Long		Short	
	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening
Female								
Male	46.10***	22.89***	32.79***	17.94***	12.18***	0.20	7.50***	8.60***
	(2.78)	(2.75)	(4.73)	(3.44)	(2.17)	(1.07)	(1.64)	(2.01)
Female	36.92***	3.78	25.97***	12.33***	8.67***	0.35	6.44***	11.84***
	(3.36)	(3.39)	(4.88)	(3.59)	(1.83)	(0.89)	(1.55)	(1.78)
T-test	**9.18****	**19.10*****	6.82	5.61	3.51	-0.16	6.82	-3.24
	(4.43)	(4.36)	(6.98)	(5.09)	(2.79)	(1.33)	(6.98)	(2.64)
Education level: have a university level degree or not								
Yes	48.20***	15.87***	26.38***	9.99**	15.96***	-0.87	6.97***	6.39***
	(3.72)	(3.64)	(5.41)	(3.95)	(2.53)	(1.31)	(2.03)	(2.36)
No	38.62***	14.15***	31.44***	18.53***	7.80***	0.76	6.90***	11.91***
	(2.74)	(2.75)	(4.29)	(3.13)	(1.71)	(0.85)	(1.37)	(1.66)
T-test	**9.58****	1.72	-5.05	**-8.55***	**8.16*****	-1.63	0.08	**-5.52***
	(4.82)	(4.68)	(7.01)	(5.11)	(3.06)	(1.55)	(2.48)	(2.92)
Individual income level: Equal to or Higher than 70,000 yuan per year								
Yes	36.90***	12.89***	37.26***	21.67***	9.75***	12.89***	7.99***	9.98***
	(3.42)	(3.40)	(5.12)	(3.72)	(2.49)	(3.40)	(2.26)	(2.57)
No	46.05***	16.17***	23.15***	9.95***	10.35***	16.17***	6.60***	10.50***
	(2.87)	(2.85)	(4.60)	(3.39)	(1.72)	(2.85)	(1.30)	(1.54)
T-test	**-9.15****	-3.28	**14.11****	**11.72****	-0.59	-3.28	1.39	-0.51
	(4.64)	(4.53)	(7.12)	(5.18)	(3.02)	(4.53)	(2.61)	(2.94)
Are there any children under 18 years old in your household?								
Yes	47.28***	20.13***	30.46***	11.93***	9.69***	-0.63	6.16***	10.68***

	(3.37)	(3.29)	(5.08)	(3.72)	(2.34)	(1.16)	(2.20)	(2.53)
No	38.67***	11.07***	28.74***	17.63***	10.41***	0.70	7.18***	10.27***
	(2.82)	(2.83)	(4.36)	(3.18)	(1.73)	(0.85)	(1.30)	(1.56)
T-test	**8.61***	**9.06****	1.72	-5.70	-0.72	-1.34	-1.03	0.40
	(4.50)	(4.35)	(6.70)	(4.88)	(2.85)	(1.38)	(2.55)	(2.91)
Are you allowed without any penalty to be late for work in the morning?								
Yes	44.19***	19.24***	40.81***	22.56***	9.30***	0.63	8.46***	7.25***
	(2.68)	(2.67)	(4.53)	(3.31)	(1.73)	(2.67)	(1.42)	(1.82)
No	39.14***	7.89**	15.83***	6.35*	11.53***	-0.24	4.87***	14.53***
	(3.45)	(3.45)	(4.83)	(3.52)	(2.35)	(3.45)	(1.81)	(1.94)
T-test	5.05	**11.35*****	**24.98*****	**16.21*****	-2.23	0.87	3.59	**-7.28*****
	(4.39)	(4.29)	(6.63)	(4.80)	(2.87)	(1.40)	(2.29)	(2.62)

*Note: For car experiment, all WTPs are calculated with fuel cost. * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

6 Conclusions

Using choice experiment data collected in Beijing, we estimated the marginal willingness-to-pay (MWTP) for commuting time savings during rush hours, for both car drivers and public transport users. We combined a latent class model and a mixed logit model to address attribute non-attendance (ANA). In line with previous studies (Hensher and Rose, 2009; Carlsson et al., 2010), we find that respondents in choice experiments commonly use a heuristic of not considering all attributes.

For both car and public transport experiments, the MWTP values estimated with a model where ANA is taken into account are significantly different from those obtained in a standard RPL model. The estimates from the ANA models are more plausible in terms of expected signs and magnitudes, and have lower standard deviations. Especially in the car experiment where we included two monetary attributes in the choice situations, the ANA model is much preferred because it shows the consistent preferences between fuel cost and congestion charge price. Therefore, ANA should receive attention in future studies about stated preference and in empirical modeling.

As a conclusion of this study, the MWTP for saving one hour in commuting varies according to commuting mode, length of commute, and individual characteristics. Car drivers value their morning time as highly as around 40 yuan per hour, while they have much lower MWTP for evening time, which is less than 20 yuan. By contrast, public transport users have significantly lower values of commuting time savings, at about 10 yuan per hour, and they value the morning and the evening time very similarly. Crowding inside bus and subway carriages is important for passengers as well. Comparing the two experiments, we found more preference heterogeneity – related to gender, for example – in car commuters.

We believe our results are plausible and informative for a number of reasons. First, only commuters and commuting trips are included in our study, rather than leisure trips; second, we tailor different scenarios about congestion charges and public transport sector improvement to the appropriate respondents; and, third, we address attribute non-attendance in the estimation. Because these findings show that car commuters have fairly high MWTP for commuting time savings, smooth traffic with less flow and higher speed, especially in the morning, would greatly improve social welfare. Moreover, monetary-based methods, such as congestion charges, are probably feasible and effective. For public transport users, crowding inside bus and subway carriages is a major source of disutility. Therefore, to encourage car owners to use public transport instead of driving to work, Beijing has to both improve traffic and provide more comfortable public transport.

References

Beesley, M. (1965), The value of time spent in traveling: Some new evidence. *Economica,* 32: 174–185.

Beijing Municipal Commission of Transport, 2015, Beijing Transport Report.

Börjesson, M., Eliasson, J. (2014), Experiences from the Swedish value of time study. *Transportation Research Part A: Policy and Practice,* 59: 144-158

Carlsson, F., Kataria, M., Lampi, E. (2010), Dealing with ignored attributes in choice experiments on valuation of Sweden's environmental quality objectives. *Environmental and Resource Economics,* 47:65-89

Calfee, J., Winston, C. (1998), The value of automobile travel time: implications for congestion policy. *Journal of Public Economics,* 69: 83-102

Fezzi, C., Bateman, I., Ferrini, S. (2014), Using revealed preferences to estimate the value of travel time to recreation sites. *Journal of Environmental Economics and Management*, 67: 58-71

Hensher, D.A. (2001), Measurement of the valuation of travel time savings, *Journal of Transport Economics and Policy*, 35 (1): 71-98

Hensher, D. A., Goodwin, P. (2004), Using values of travel time savings for toll road: avoiding some common errors. *Transport Policy*, 11 (2): 171-181

Hensher, D. A., Rose, J. (2009), Simplifying choice through attribute preservation or non-attendance: Implication for willingness to pay. *Transportation Research Part E: Logistics and Transporation Review*, 45(4): 583-590

Hensher, D. A., Rose, J., Greene, W. H. (2005), The implications on willingness to pay of respondents ignoring specific attributes. *Transportation*, 32: 203–222

Hess, S., Bierlaire, M., Polak, J. (2005), Estimation of value of travel-time savings using mixed logit models. *Transportation Research Part A*, 39: 221-236

Hole, A. R. (2011). Attribute non-attendance in patients' choice of general practitioner appointment. In *Second International Choice Modelling Conference*, Oulton Hall, Leeds.

Hole, A. R., Kolstad, J.R., Gyrd-Hansen, D. (2013), Inferred vs stated attribute non-attendance in choice experiments: A study of doctors' prescription behaviour. *Journal of Economic Behavior & Organization*, 96: 21-31

Lagarde, M. (2013), Investigating attribute non-attendance and its consequences in choice experiments with latent class models. *Health Economics*, 22(5): 554-567

Lam, T.C., Small, K. A. (2001), The value of time and reliability: measurement from a value pricing experiment. *Transportation Research Part E: Logistics and Transportation Review*, 37 (2-3): 231-251

Li, Z., Hensher, D.A. (2012), Estimating values of travel time savings for toll roads: Avoiding a common error, *Transport Policy*, 24: 60-66

Lockwood, M. (1996), Non-compensatory preference structures in non-market valuation of natural area policy, *Australian Journal of Agricultural*, 40(2):84-101

Mackie, P. J., Jara-Díaz, S., Fowkes, A. S. (2001), The value of travel time savings in evaluation. *Transportation Research Part E*, 37: 91-106

Scarpa, R., Gilbride, T. J., Campbell, D., Hensher, D. A. (2009) Modelling attribute non-attendance in choice experiments for rural landscape valuation. *European Review of Agricultural Economics*, 36 (2): 151-174

Scarpa, R., Zanoli, R., Bruschi, V., Naspetti, S. (2012) Inferred and stated attribute non-attendance in food choice experiments. *American Journal of Agricultural Economics*, 95 (1):165-180

Shen, Y., Kwan, M., Chai, Y. (2013), Investigating commuting flexibility with GPS data and 3D geovisualization: a case study of Beijing, China, *Journal of Transport Geography*, 32: 1-11

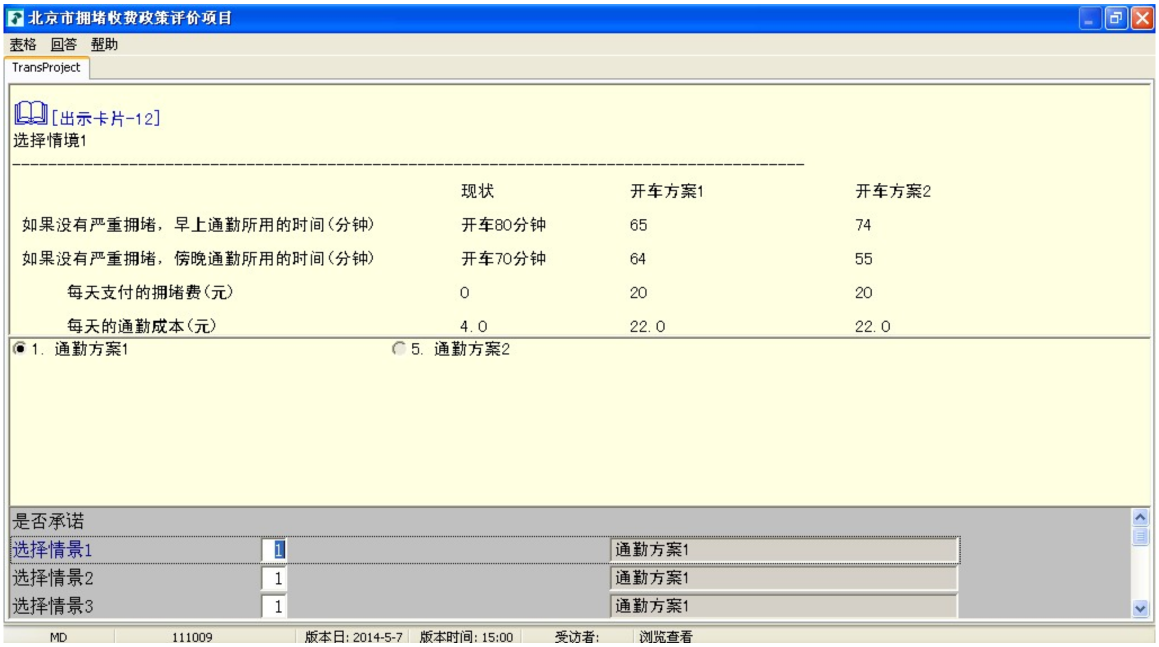
Swait, J. and Louviere, J. (1993), The Role of the Scale Parameter in the Estimation and Comparison of Multinomial Logit Models. *Journal of Marketing Research*, 30(3): 305-314

Tseng, Y., Verhoef, E., (2008), Value of time by time of day: A stated-preference study. *Transportation Research Part B: Methodological*, 42: 607-618

Wang, L., Xu, J. and Qin, P. (2014), Will a driving restriction policy reduce car trips?—The case study of Beijing, China. *Transportation Research Part A: Policy and Practice*, 67: 279-290

Appendix

Figure. Choice tasks in CAPI system, both car and public transport experiment



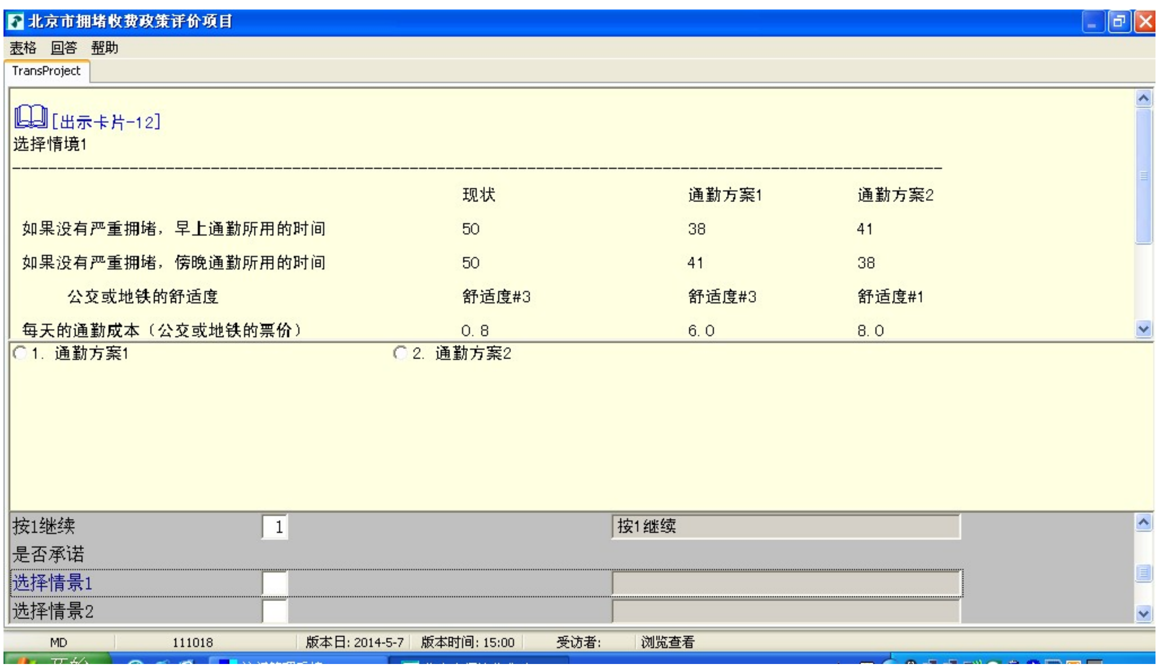


Table. Full results of LCM model, both car and public transport experiment

	Car experiment				Public transport experiment			
	Long group		Short group		Long group		Short group	
Utility parameters in latent class-->> 1								
Morning time	-0.112***	0.009	-0.095***	0.011	-0.059***	0.022	-0.094***	0.014
Evening time	-0.029***	0.008	-0.046***	0.010	0.011	0.010	-0.148***	0.019
Congestion charge/Crowding	-0.150***	0.008	-0.205***	0.007	-0.203***	0.069	-1.315***	0.055
Cost	-0.165***	0.009	-0.202***	0.008	-0.844***	0.150	-0.832***	0.021
Utility parameters in latent class-->> 2								
Morning time	-0.112***	0.009	-0.095***	0.011	-0.059***	0.022	-0.094***	0.014
Evening time	-0.029***	0.008	-0.046***	0.010	0.011	0.010	-0.148***	0.019
Congestion charge/Crowding	-0.150***	0.008	-0.205***	0.007	-0.203***	0.069	-1.315***	0.055
Cost	0.0		0.0		0.0		0.0	
Utility parameters in latent class-->> 3								
Morning time	-0.112***	0.009	-0.095***	0.011	-0.059***	0.022	-0.094***	0.014
Evening time	-0.029***	0.008	-0.046***	0.010	0.011	0.010	-0.148***	0.019
Congestion charge/Crowding	0.0		0.0		0.0		0.0	
Cost	-0.165***	0.009	-0.202***	0.008	-0.844***	0.150	-0.832***	0.021
Utility parameters in latent class-->> 4								
Morning time	-0.112***	0.009	-0.095***	0.011	-0.059***	0.022	-0.094***	0.014
Evening time	0.0		0.0		0.0		0.0	
Congestion charge/Crowding	-0.150***	0.008	-0.205***	0.007	-0.203***	0.069	-1.315***	0.055
Cost	-0.165***	0.009	-0.202***	0.008	-0.844***	0.150	-0.832***	0.021
Utility parameters in latent class-->> 5								
Morning time	0.0		0.0		0.0		0.0	
Evening time	-0.029***	0.008	-0.046***	0.010	0.011	0.010	-0.148***	0.019
Congestion charge/Crowding	-0.150***	0.008	-0.205***	0.007	-0.203***	0.069	-1.315***	0.055

Cost	-0.165***	0.009	-0.202***	0.008	-0.844***	0.150	-0.832***	0.021
Estimated latent class probabilities								
Class 1	0.566***	0.053	0.618***	0.026	0.0	0.77D-05	0.0	0.053
Class 2	0.068***	0.023	0.053***	0.017	0.184***	0.030	0.093***	0.024
Class 3	0.366***	0.048	0.329***	0.12D-08	0.0		0.562***	0.033
Class 4	0.0	0.23D-06	0.0	0.24D-08	0.225	0.641	0.345***	0.059
Class 5	0.0	0.16D-10	0.0	0.64D-08	0.591	0.661	0.0	0.32D-07
McFadden Pseudo R^2	0.153		0.197		0.485		0.518	
No. of groups	248		357		377		365	
No. of observations	2976		4284		4524		4380	

*Note: * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% leve*