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Commuting trip satisfaction in Beijing: Exploring the influence of multimodal behavior and modal flexibility

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ABSTRACT

In the past decade, many studies have explored the relationship between travelers' travel mode and their trip satisfaction. Various characteristics of the chosen travel modes have been found to influence trip experiences; however, apart from the chosen modes, travelers' variability in mode use and their ability to vary have not been investigated in the trip satisfaction literature. This current paper presents an analysis of commuting trip satisfaction in Beijing with a particular focus on the influence of commuters' multimodal behavior on multiple workdays and their modal flexibility for each commuting trip. Consistent with previous studies, we find that commuting trips by active modes are the most satisfying, followed by trips by car and public transport. In Beijing, public transport dominates. Urban residents increasingly acquire automobiles, but a strict vehicle policy has been implemented to restrict the use of private cars on workdays. In this comparatively constrained context for transport mode choice, we find a significant portion of commuters showing multimodal behavior. We also find that multimodal commuters tend to feel less satisfied with trips by alternative modes compared with monomodal commuters, which is probably related to their undesirable deviation from habitual transport modes. Furthermore, the relationship between modal flexibility and trip satisfaction is not linear, but U-shaped. Commuters with high flexibility are generally most satisfied because there is a higher possibility for them to choose their mode of transport out of preference. Very inflexible commuters can also reach a relatively high satisfaction level, however, which is probably caused by their lower expectations beforehand and the fact that they did not have an alternative to regret in trip satisfaction assessments.

1. Introduction

Studying trip satisfaction is valuable for transport policy making. For instance, policies aiming at a shift towards sustainable transport modes will be more effective when travelers are more satisfied with their new travel mode. The relationship between trip satisfaction and transport modes has been examined extensively in recent studies (Abou-Zeid and Ben-Akiva, 2014; Eriksson et al., 2013; Ettema et al., 2013; Olsson et al., 2013; Páez and Whalen, 2010; Turcotte, 2006). Mode-related attributes of cars (e.g., driving conditions), public transport (e.g., reliability of service) and active modes (e.g., crowdedness) have been found to influence trip satisfaction. A common feature of these studies is that they treat trip satisfaction in the context of a single trip made by a single given mode. Hence, they neglect the fact that trip satisfaction may also depend

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on the choice context. This choice context includes the fact that travelers may use various travel modes for a given trip over a longer time period, as well as their perception of alternative modes for that trip. This paper sets out to test the influence of this choice context on trip satisfaction.

The use by travelers of multiple transport modes in a specified period has received much attention in recent studies in Western Europe (Frändberg and Vilhelmson, 2014; Kuhnimhof et al., 2006; Nobis, 2007) and the U.S. (Block-Schachter, 2009; Buehler and Hamre, 2014) and has been termed "multimodality" (Kuhnimhof et al., 2006; Nobis, 2007). It has been found that multimodal travelers generally have more realistic perceptions of available choices and their attributes than single mode travelers (Diana and Mokhtarian, 2008). Additionally, individuals may compare a trip experience by one travel mode with experiences of other travel modes (Schwartz, 2004; Schwarz and Strack, 1999). Hence, due to different reference levels, multimodal travelers may experience the same trip differently than monomodal travelers; however, the extent to which and direction in which this mechanism works has not yet been determined.

In addition to the actual use of multiple travel modes, modal flexibility (i.e., travelers' perceived ability to vary transport modes) may also affect travelers' trip satisfaction because it indicates whether the mode is chosen out of preference or due to a lack of other options. Although the influence of owning a car and living close to public transport facilities on trip satisfaction have been explored (Jakobsson-Bergstad et al., 2011; De Vos et al., 2014; Ettema et al., 2011), these variables cannot be equated with individuals' perceived ability to switch transport modes for a single trip because the latter is also affected by factors such as individuals' attitudes, busy daily activity agendas on specific days or the unavailability of household vehicles due to use by the spouse.

Hence, in regard to trip satisfaction, the effects of neither multimodality nor modal flexibility have been investigated. Exploring the influence of using or having multiple mode choices may provide insights into predicting individuals' satisfaction levels and consequently their behavioral changes when certain transport modes are encouraged or improved in policy making. The current paper will address this gap in the existing literature by investigating urban residents' commuting trip satisfaction in Beijing in relation to commuters' multimodal behavior and modal flexibility based on multiday activity and travel diaries.

The remainder of this paper is organized as follows. The next section reviews the literature on modality and trip satisfaction research and raises hypotheses concerning the relationship between them. Section 3 presents the research design for this study, including data collection, measurements of key concepts and methodology. Descriptive analysis results are shown in Section 4. Further, five two-level regression models have been conducted for trips by specific modes, and the model estimation results are also discussed in Section 4. The conclusion and discussion are presented in the final section.

2. Theoretical background and expectations

2.1. Multimodality and modal flexibility

Although the definitions vary across studies (Block-Schachter, 2009), multimodality is generally defined as the use by a traveler of various transport modes rather than a single mode in a certain time period, usually one week (Buehler and Hamre, 2014; Kroesen, 2014; Kuhnimhof et al., 2006; Molin et al., 2016). Monomodality thus means that a traveler did not change his or her transport mode in a given time period. There are also studies incorporating intensity measures (e.g., frequency of using different modes) and thresholds to distinguish the degree of multi- and monomodality (Diana and Mokhtarian, 2009; Kuhnimhof et al., 2012, 2006). Many studies further identify various modality groups based on the combinations of transport modes that travelers use. For example, Buehler and Hamre (2014) distinguished 3 groups in the U.S. ranging from monomodal car users, multimodal car users, and those who only walk, bike, and/or use public transport, while Kroesen (2014) excluded walking trips and identified five mode profiles in the Netherlands including strict bicycle users, strict car users, immobile traveling (i.e., who travel little by car, public transport or bicycle), joint car and bicycle users, and public transport users. In an empirical study in Germany, Nobis (2007) found that mono car users represent the majority of modality groups.

To a certain extent, multimodal behavior indicates the degree to which an individual deliberately chooses a mode (Kroesen, 2014), and a multimodal traveler is more likely to be flexible in his/her mode choice (Vij et al., 2011). Individuals may also engage in multimodal behavior due to constraints, however, such as limitations in car availability or budget reasons. For example, more multimodal car travel among young people in Germany is related to lower car availability and incomes among this group (Kuhnimhof et al., 2006; Nobis, 2007). The possibility to vary one's travel mode can be investigated with self-reported modal flexibility. In some studies, researchers investigated the self-reported number of modes that respondents consider available/feasible for travel (Lavery et al., 2013), and some asked about the limitations regarding traveling by certain modes at a certain time of a day and the availability of an automobile when desired (Ory and Mokhtarian, 2005). These self-reported indicators of mode availability reflect commuters' perceptions of feasible options or their perceived ability in travel mode decisions to a certain extent. Mode availability does not equal modal flexibility, however, because individuals' perceived travel mode options are not only related to the number of available transport modes but also may be affected by personal attitudes towards transport modes, activity agendas on specific days and other constraints such as traffic management measures. In this study, we will investigate modal flexibility based on self-reported perception concerning switching mode choice for each commuting trip.

2.2. Trip satisfaction

Many approaches have been developed in recent studies to measure trip satisfaction. Some studies mainly focus on the cognitive part or utilitarian appraisals (i.e., the quality of travel) (Stradling et al., 2007), especially for driving conditions and public transport services. Other studies concentrate on the affective part (i.e., feelings and emotions) of trips like commuting stress (Gatersleben and Uzzell, 2007; Novaco and Gonzalez, 2009). Additionally, concepts such as the Satisfaction with Travel Scale (STS) (Ettema et al., 2010, 2011) and travel well-being (Abou-Zeid and Ben-Akiva, 2014) are proposed as a combination of cognitive and affective evaluations. For example, STS has three components: a cognitive evaluation of the quality of travel, an affective evaluation of feelings during travel ranging from stressed to relax and an affective evaluation of feelings during travel ranging from bored to excited. In this study, we will mainly focus on a general cognitive assessment of individuals' travel experiences. Similar to previous studies, the measurement will use the means of Satisfaction With Life Scale (SWLS) (Diener et al., 1985), which asks respondents to rate statements like 'I am satisfied with my life' on a 7-point Likert scale ranging from "totally disagree" to "totally agree." In our case, the scales will be applied at the trip level and only for the general cognitive assessments (see Section 3.2).

Explanatory factors of travel satisfaction at the individual level include socio-demographic attributes such as age, gender, income, household type, mode availability, individuals' personalities and attitudes towards different modes (Jakobsson-Bergstad et al., 2011; Olsson et al., 2013; Páez and Whalen, 2010; Paige Willis et al., 2013; Susilo and Cats, 2014), and the spatial attributes (e.g., urban or suburban neighborhoods) of individuals' residence (De Vos et al., 2014). Individual subjective well-being is also found to be related with trip satisfaction, that travelers who generally feel glad/passive or with high life satisfaction are more likely to enjoy their trips (Susilo and Cats, 2014; St-Louis et al., 2014). As for the trip level, trip attributes such as trip purpose, travel time and in-vehicle activities (Ettema et al., 2012; Gatersleben and Uzzell, 2007), as well as mode-related attributes for different transport modes (Eriksson et al., 2013; Friman and Gärling, 2001) have been examined. For example, driving conditions including crowdedness, road layout, maintenance works for car drivers (Ettema et al., 2013; Novaco and Gonzalez, 2009), attribute-specific factors such as treatment by employees, reliability of service, simplicity of information (Friman and Gärling, 2001) and "soft" factors like personal safety, cleanliness and atmosphere and specific incidents (Stradling et al., 2007) for public transport users, and crowdedness and air quality for pedestrians (Stradling et al., 2007) have been studied respectively. Comparative studies of trip satisfaction across different commuting modes indicate that active modes (i.e., walking and cycling) commonly show a positive effect on trip satisfaction (Friman et al., 2013; Páez and Whalen, 2010; Turcotte, 2006). This effect may be explained by the fact that these commuters tend to live closer to work, which makes their commute less time-consuming, and also the physical exercise provided by active modes (Friman et al., 2013; Jain and Lyons, 2008). Car trips were ranked higher than bus trips for commuting trip satisfaction in an experimental simulation in Sweden (Eriksson et al., 2013), and car users also scored higher in trip satisfaction than public transport users in a population-based sample in Switzerland (Friman et al., 2013) and the General Social Survey in Canada (Turcotte, 2006).

As for the frequency of using multiple modes, Susilo and Cats (2014)'s study found that the more repetitively one travels by the current mode (twice in a week or more), the lower satisfaction level reported with the trip, especially for car and public transport travelers. However, no significant relations was found in the study by Diana (2012), which examined the relationship between satisfaction with public transport trips and the frequency of using public transport among Italian multimodal users (i.e., users of both car and public transport). The research provides a comparison among travelers with different mode use frequencies, but has not addressed the difference between multimodal and monomodal travelers. Additionally, it is not clear how trip satisfaction can be affected by modal flexibility, while its relation with the context for mode choices has been explored from both objective and subjective aspects. For the objective observations of modal availability, some studies shows that trip satisfaction can be positively affected by access to bus stops (Ettema et al., 2011) and drivers' licenses (De Vos et al., 2014), while other studies found no significant influence of variables like the number of household cars (Jakobsson-Bergstad et al., 2011).

2.3. Hypotheses

In this section, we develop hypotheses regarding the influence of multimodal behavior and modal flexibility on trip satisfaction, respectively. As the hypotheses regarding trip satisfaction are context specific, we first provide information regarding the study location (Beijing).

First, Beijing is still a public transport-dominant city, where trips by public transport accounted for 44.0% of all trips while trips by private car account for 32.6% (trips on foot excluded) in 2012 (Beijing Transport Research Center, 2013). Instead of the dominance of car user in previous studies in the western contexts, a larger group of multi/mono public transit users can be expected in our dataset. Secondly, although private car ownership increased sharply from 1.8 million cars to 4.2 million cars between 2005 and 2012, it is still markedly lower than that in Western countries. There were still only 63 private cars for every 100 households in Beijing at the end of 2014, while the number was 206 vehicles for every 100 households in the entire U.S. in 2013 (Davis et al., 2013). Car could be unavailable for many individuals, and consequently lower modal flexibility for those lower income travelers. Furthermore, individuals, especially car users could be more likely to engage in multimodal behavior due to necessity or constraints compared to European and North American cities. In addition to the lower car/household member number ratio, a strict vehicle restriction policy has been implemented in Beijing since 2008. Accord-

ing to this policy, private cars are forbidden to enter the 5th ring road on one specific workday based on the last digit on their license plate. Within this specific context, we can assume that a deviation from the habitual mode (i.e., most frequently used mode) could be involuntary. Multimodal travelers' use of an alternative mode may lead to a lower trip satisfaction compared to monomodal travelers who constantly use that mode. Moreover, compared to monomodal travelers, multimodal travelers have the experience of using various modes. Because people may compare their current commuting trip to a previous commuting trip and evaluate their satisfaction accordingly (Abou-Zeid et al., 2012), we can assume that multimodal travelers may rate a trip less satisfying (compared to monomodal traveler) when they have experienced a more satisfying travel mode and vice versa.

As for the possible influence of modal flexibility, two opposite hypotheses can be raised. First, having more options offers a higher probability of finding an alternative that complies with one's wishes (Botti and Iyengar, 2006; Van Hees, 2004), and consequently, travelers' trip satisfaction increases as modal flexibility increases. Second, in opposition to hypothesis one, trip satisfaction may decrease with higher modal flexibility. There are two possible explanations: (1) the absence of alternatives leads to lower expectations and no alternative to regret. The existence of "forgone" alternatives (i.e., alternative that were considered but not chosen) can have a significant impact on post-choice valuation (Inman et al., 1997). When trips are unsatisfying, travelers who have alternative choices tend to assess the trip as being less satisfying compared to those without alternatives. In addition, satisfaction depends on our expectations surrounding choices (Schwartz, 2004). If the experience with the choices does not match clients' expectations, satisfaction will be low and vice versa (MORI, 2002). (2) As mentioned in the introduction, unlike objective observations of modal availability, self-measured modal flexibility is a subjective assessment of mode choice. For such a subjective assessment, the response of "no choice" can refer to different situations (Hannes et al., 2008). An assessment of having no choice not only refers to a situation of having no feasible alternative within monetary and spatio-temporal constraints, but also to a situation in which strong habits or preferences exclude alternatives from consideration, leaving the habitual travel mode as the only option. For the latter case, reporting low or no modal flexibility could result in a high satisfaction with travel by that mode.

3. Research design

3.1. Data collection

The data are from the "Daily Activity and Travel Survey of Beijing, 2012," which was collected from October to December 2012 in Beijing. This survey included socio-demographic characteristics of the respondents, an activity diary filled out for one week and data from GPS loggers carried by the respondents. The sample for the current analysis comprises 3308 direct commuting trips made by 404 commuters over multiple days. Multi-purpose commuting trips have been excluded because an extra stop for non-work activities may influence commuters' mode choice, route choice or departure time and consequently satisfaction with the entire trip. Five transport modes have been identified as the main modes for the trips: walking, bike, bus, subway and car. As for the definition of main modes, trips are regarded as walking trips or cycling trips if the commuters walked or biked at all stages. For the multi-stage trips with different travel modes, the more motorized mode is selected as the main mode for the whole trip. For trips with both active modes and public transport stages reported (283 cases), the main mode is defined as PT (public transport). Among these 283 cases, the average durations for active mode stages and PT stages are 19.7 and 52.3 min respectively. Active modes are likely to be used for the access or egress trips to the public transport facilities. For trips combining active modes and car (31 cases), the main mode is defined as the car. The average durations for active mode stages and car stages are 26.2 and 43.5 min respectively. This could be observed in the households with only one car, where one of the household members needs to complete the whole trip by alternative modes before/after the pick-up/drop-off by the driver. For trips combining car and public transport (73 cases), the mode used for the longest stage has been identified as the main mode. According to these rules, public transport has been identified as the main mode for 60 trips and car for 13 cases. The distribution of modes choices is shown in Table 1, while public transport is the dominant travel mode.

Table 1
Mode choice distribution for all trips.

Mode Choice	No.	Pct. (%)	Notes
Walk	243	8.1	–
Bike	511	17.0	–
Public transport	1580	52.5	Bus 826 cases (27.5%) Subway 754 cases (25.1%)
Car	672	22.3	–
Other	2	0.1	–
Total	3008	100	This is the sample size for descriptive analysis; the sample for regression mode is smaller due to the missing values for certain explanatory variables. Details will be marked in the model.

Our sample is not representative for the Beijing population. The survey was conducted in the Shangdi-Qinghe area of Beijing, which is located northeast of Beijing's 5th ring road. This suburban area is a residential center with 240,000 residents, and also functions as a job sub-center with more than 5000 companies and 160,000 jobs. Respondents have been selected from the communities and companies in this area. Trips by public transport accounted for 52.5% of all direct commuting trips in our dataset, and household car ownership was 50.4%. Therefore, our sample shows lower car availability (63% in Beijing) and also less influence (as located outside the 5th ring road) from the vehicle regulation policy compared to the general situation in Beijing.

3.2. Measurements

3.2.1. Trip satisfaction

Trip satisfaction is in this study regarded as a cognitive evaluation of the trip. Commuters were asked to rate their satisfaction with their commuting trips on a 5-point scale ranging from "very unsatisfied" to "very satisfied." This method has been widely used to provide a cognitive evaluation of subjective well-being during travel (e.g., Jakobsson-Bergstad et al., 2011; Abou-Zeid et al., 2012; Paige Willis et al., 2013). Respondents stated their satisfaction with each stage of the trip. Among the 3008 commuting trips, 597 trips (19%) are reported as multi-stage trips. The duration-weighted averaging rule, which calculates the sum of all the satisfaction level of all stages weighted by the duration of the stage relative to the total duration, is selected in this study. We are aware that other aggregation rules can be used such as the peak-end rule (Kahneman et al., 1997) or a mechanism by which more painful or longer episodes have a larger weight (Fredrickson, 2000; Redelmeier et al., 2003). However, in the context of commute satisfaction, Suzuki et al. (2014) tested several aggregation rules. Their results show that duration-weighted averaging rule gives a better fit than other aggregation rules for the repetitive commute trips. With this study also focused on direct commute trips, the duration-weighted aggregation rule has been applied in the following analysis.

3.2.2. Commuter's modality behavior

Commuters have been classified into two categories: monomodal commuters, who have not varied their main commute mode over a time period, and multimodal commuters, who have varied their commute mode at least once over a time period. Intermodal travel (i.e., combining multiple travel modes in one commuting trip) has not been regarded as multimodal behavior. As shown in previous studies, the probability of multimodality is related to the time period under examination (Nobis, 2007). Longer time periods show a higher likelihood of variability in mode choice. Although the examination period in our survey is 1 week (5 workdays), the included days in our analysis differ between individuals after excluding telecommuting, multi-purpose commuting trips and also invalid recorded days. In the end, we have 31.2% commuters with 3 workdays, 30.4% with 4 workdays and 38.4% with 5 workdays included among all the 404 commuters. Almost 32.2% of these commuters varied their main commute modes in the observed period.

Furthermore, we divide the two categories into subgroups according to their habitual commute modes (i.e., most frequently used mode). For example, if a commuter constantly uses his or her car for all commuting trips in the week, he or she would be classified as a mono car user. Then, we have 4 subgroups for monomodal commuters, namely, mono walker, mono cyclist, mono PT user and mono car user. For multimodal commuters using multiple travel modes, the most frequently used mode (with more trips traveled than others) will be regarded as their habitual commute mode. Consequently, there are also 4 subgroups for multimodal commuters, namely, multi walker, multi cyclist, multi PT user and multi car user. In total, 8 categories of modality behavior groups can been distinguished.

3.2.3. Modal flexibility

Commuters were asked "how hard/easy is it to adjust your transport mode" for each specific trip in the survey, according to categories: "very hard," "hard," "medium," "easy" and "very easy." Hence, modal flexibility assessments are based on commuters' subjective perception of their ability to switch modes for each commuting trip.

3.3. Model specification

Because there are multiple observations at the commuting trip level (3308 trips) and for each individual level (404 commuters), multilevel regression modeling is adopted to explore the determinants of trip satisfaction. The random-intercept model is used to control for individual specific unobserved factors that influence multiple trip evaluations of a single individual. Explanatory variables at two levels are shown in Table 2, and specific descriptions of trip satisfaction, multimodal behavior and modal flexibility will be given in the next section.

3.3.1. Commuting trip (level I)

Based on previous empirical studies of trip satisfaction and the explanatory variables in our dataset, trip characteristics include departure time (peak or non-peak hour), commuting duration, trip type (journey to work or from work), and self-perceived modal flexibility (medium level as the reference category). The trip companion variable (with or without companion) has been excluded with no significant influence found.

Table 2
Variables in Regression Models.

Variables	Definition	Walking trips		Cycling Trips		Bus Trips		Subway Trips		Car Trips	
		Dis (%).	M.	Dis (%).	M.	Dis (%).	M.	Dis (%).	M.	Dis (%).	M.
Trip Level											
Departure time	Depart in Peak hour(Ref. = non-peak hour)	79.8	–	73.2	–	73.5	–	84.1	–	71.7	–
Commute Duration	Duration of the entire commuting trip (min)	–	23.5	–	28.3	–	63.5	–	68.9	–	50.8
Trip timing	Journey from work (Ref. = journey to work)	44.0	–	48.3	–	45.6	–	44.7	–	48.4	–
Commute mode choice flexibility	Very inflexible	32.5	–	22.1	–	26.8	–	31.0	–	32.4	–
	Inflexible mode	11.9	–	23.5	–	28.5	–	39.3	–	26.6	–
	Medium (as Ref. Category)	10.3	–	22.5	–	25.3	–	12.9	–	20.4	–
	Flexible	24.3	–	11.5	–	10.5	–	7.0	–	11.8	–
	Very flexible	8.6	–	8.8	–	3.4	–	0.4	–	4.2	–
Individual Level											
Gender	Male (Ref. = female)	38.7	–	40.1	–	46.7	–	45.4	–	50.0	–
Age	Age $\geqslant$ 40 (Ref. = under 40)	34.2	–	31.1	–	15.5	–	8.6	–	21.1	–
Marriage	Married (Ref. = unmarried, including single, divorced and widowed)	74.1	–	80.6	–	63.2	–	61.3	–	85.4	–
Income	Income above RMB4000/Month (Ref. = below RMB4000/m)	34.2	–	35.0	–	50.6	–	55.0	–	61.2	–
Home Location	Home located inside 4th ring road	0.4	–	2.2	–	3.8	–	13.1	–	6.3	–
Work Location	Workplace located inside 4th ring road	2.1	–	10.6	–	21.3	–	32.8	–	19.5	–
Multimodal walker	Multimodal commuter with walking as the habitual mode	29.6	–	0.6	–	1.0	–	0.0	–	1.6	–
Multimodal cyclist	Multimodal commuter with cycling as the habitual mode	3.3	–	30.7	–	2.2	–	0.7	–	3.0	–
Multimodal PT user	Multimodal commuter with bus as the habitual mode	4.1	–	0.8	–	20.2	–	17.4	–	12.4	–
Multimodal car user	Multimodal commuter with subway as the habitual mode	6.6	–	2.0	–	3.9	–	2.8	–	30.1	–
Monomodal commuter	Commuters with a single mode for all commute trips	56.4	–	65.9	–	72.8	–	79.2	–	53.0	–

NOTE: –, not applicable.

3.3.2. Individual commuter (level II)

At this level, commuters' socio-demographic attributes include gender, age, marriage status and income. Other variables such as driving license and household car ownership have been tested and removed due to insignificant results. For commuters' residence and work locations, we include dummy variables whether they are located inside the 4th ring road in Beijing. As a typical mono-centric city, the urban structure of Beijing is marked by its ring road system. The urban areas inside the 4th ring road are likely to have a better connectivity for public transit (Ji and Gao, 2010), higher density of population and also commercial and facilities (Tian et al., 2010), and therefore offer better conditions for using active travel modes and public transport. Furthermore, we have included commuters' modality behavior with monomodal groups serving as the reference categories.

4. Results

4.1. Descriptive results

4.1.1. Modality behavior

As stated above, almost 32.2% of the commuters have varied their main commute modes in the recorded workday period and can be regarded as multimodal commuters. The distribution of different modality groups is shown in Table 3. Generally, car users show the highest variation while PT users show the lowest. For car users, almost 44% of them have shifted towards other modes of transport at least once. The relatively higher percentage of multimodal car users is probably related to the traffic regulation policy and low car ownership described above. They have to switch modes when their private car is not allowed to reach the destination (inside the 5th ring road), or the only car is occupied by another household member. Comparatively, public transport users seem to be most constant in mode use: monomodal PT users are the largest group in our dataset, and only 23.9% of PT users have switched their main commute mode. This is probably related to the characteristics of public transport trips and the PT users' characteristics, which make it difficult to switch to either active modes or car. On the one hand, the average duration of PT commuting trips is twice as long as active mode trips, which indicates a relatively long commuting distance. This makes it difficult for commuters to travel by active modes. On the other hand, monomodal PT users have much lower car availability (34.7% with a car in the household) compared to monomodal car users (92.7%), thus being constrained in switching their mode towards cars. For walkers and cyclists, the distribution of multimodal behavior is

Table 3
Modality for specific mode users.

Habitual Mode		No.	Pct. (%)	Total
Walker	Monomodal Walker	20	64.5	31
	Multimodal Walker	11	35.5	
Cyclist	Monomodal Cyclist	45	63.4	71
	Multimodal Cyclist	26	36.6	
Public transport User	Monomodal PT user	162	76.1	213
	Multimodal PT user	51	23.9	
Car User	Monomodal Car user	50	56.2	89
	Multimodal Car user	39	43.8	

similar at approximately 36%. These commuters are more likely to live close to their workplace (with an average commute time of less than 30 min) and have more satisfying commuting trips (as trips by active modes are ranked higher than others), but their mode use is likely to be affected by factors such as weather, personal conditions (e.g., sickness) and daily schedules (e.g., chaining a non-work activity).

4.1.2. Modal flexibility

The distribution of modal flexibility across various modes has been presented in Table 2. Generally, commuting trips are constrained in mode choice. More than 60% of the trips were reported as hard to perform by another mode. Less than 5% of the trips can be easily completed using by other modes and in total only 16.7% trips can be labeled as flexible. More than 60% of the public transport trips have little freedom in mode choice. Especially for subway trips, this rate reaches nearly 80%. This finding is consistent with the relatively monomodal behavior of public transport users revealed in Table 3. Although car users rank higher in performing multimodal behavior, however, the perception of modal flexibility for car trips is not very prominent. This indicates that on the one hand, at least some car users must perform their commuting trips by other modes (multimodal behavior), but on the other hand, they probably do not perceive the other modes as viable alternatives.

Further, the distribution of perceived modal flexibility among different modality behavior groups has been examined (Table 4). It seems that monomodal commuters tend to assess their trips as more inflexible. Mono walkers, PT users and car users assess more than 70% of their trips as inflexible. This indicates that these commuters may have few feasible alternative choices in practice, and likely engage in monomodal travel by necessity. Of the multimodal commuters, multi walkers have the highest modal flexibility, which suggests that there is high possibility for them to conduct multimodal behavior by choice; however, inconsistencies can be observed between modality behavior and modal flexibility. This suggests that commuters can also deliberately choose monomodal behavior with high modal flexibility, while multimodal behavior may be conducted by constraints related to low modal flexibility. For example, for multi PT users, occasionally switching to other modes may relate to car sharing with colleagues or a taxi trip when running late, neither option being a typical one for most trips. For multi car users, occasionally switching to other modes may relate to the household car being occupied by the spouse or car regulation policy on a specific day, while these modes may not be taken into consideration when the person makes car trips on ordinary days.

4.1.3. Trip satisfaction

Commuters generally have a positive assessment of their commuting trips. The average score for direct commuting trips is 3.63, which suggests that commuters tend to assess their trips between neutral and satisfying. For trips with specific modes (Table 5), the findings are consistent with previous studies. Trips by active modes are more satisfying, particularly walking: the satisfaction level of walking trips is 4.23 and it also has the lowest standard deviation. Trips by bicycle are rated in second place, followed by trips by car. As for public transport trips, the subway seems more satisfying than the bus.

Table 4
Modal flexibility of different multimodality groups.

Commuter Type	Trip Modal flexibility						
	Very hard (%)	Hard (%)	Sum (%)	Medium (%)	Easy (%)	Very Easy (%)	Sum (%)
Multi walker (75 trips)	9.3	9.3	**18.7**	**8.0**	45.3	28.0	**73.3**
Mono walker (122 trips)	55.7	15.6	**71.3**	**8.2**	20.5	0.0	**20.5**
Multi cyclist (180 trips)	11.1	26.1	**37.2**	**27.8**	26.1	8.9	**35.0**
Mono cyclist (303 trips)	31.7	26.4	**58.1**	**23.4**	7.3	11.2	**18.5**
Multi PT user (362 trips)	28.2	27.1	**55.2**	**25.1**	16.3	3.3	**19.6**
Mono PT user (1116 trips)	32.9	38.1	**71.0**	**19.8**	7.4	1.8	**9.2**
Multi car user (265 trips)	29.1	25.7	**54.7**	**25.3**	17.0	3.0	**20.0**
Mono car user (348 trips)	37.4	33.0	**70.4**	**19.3**	6.3	4.0	**10.3**
Multi user (882 trips)	23.4	24.9	**48.3**	**24.3**	21.0	6.5	**27.4**
Mono user (1889 trips)	35.0	33.8	**68.8**	**19.5**	8.0	3.6	**11.6**

Table 5
Trip satisfaction with different travel modes.

Travel Mode	No.	Mean	Std.
Walk	243	4.23	0.67
Bicycle	511	3.81	0.75
Bus	826	3.44	0.88
Subway	754	3.49	0.90
Car	672	3.69	0.89
Total	3006	3.63	0.88

Trip satisfaction assessed by different modality groups is shown in Table 6. For multimodal commuters, walkers are more satisfied with their habitual modes while PT users are less satisfied. This may relate to the finding above that trips by active modes are most satisfying while PT trips are most unsatisfying. Comparing multimodal and monomodal travelers with the same habitual travel modes, a significant difference can only be found for PT users. This could be because PT users' experiences with other (more satisfying) modes negatively affect their assessment of PT trips. Furthermore, we can compare the trips made by habitual modes and alternative modes of the multimodal travelers. With walking as the habitual mode, the reference point for multimodal walkers to assess trips by alternative modes could be higher, and the satisfaction levels with those trips are significantly lower. On the contrary, the reference point for multimodal PT users when assessing trips by alternative modes could be lower given their experience with unpleasant PT trips; consequently, their satisfaction levels are rated as significantly higher. For multimodal cyclists and car users, switching to alternative modes does not affect their trip satisfaction significantly compared to their habitual modes.

Fig. 1 describes the change of average satisfaction level as modal flexibility increases. Instead of a linear trend, a U-shaped line is found to describe the relationship between modal flexibility and trip satisfaction. Therefore, the two hypotheses proposed in Section 2.3 have been supported to a certain extent. On the one hand, the fact that very flexible trips are most satisfying can be explained through the higher utility derived from a larger choice set. With higher modal flexibility, it is possible for commuters to choose an alternative mode out of personal preference, which consequently increases their satisfaction level. On the other hand, the finding that inflexible trips are more satisfying than medium flexible trips can be explained by two possible reasons: low expectations and no alternatives to regret for individuals with limited choices; or

Table 6
Trip satisfaction of different modality groups.

Modality group	Trips by most frequently used modes		ANOVA test Sig.	Trips by alternative modes		ANOVA test Sig.
	No.	Trip satisfaction		No.	Trip satisfaction	
Multi walker	72	4.25	0.651	22	3.79	0.028
Mono walker	137	4.29		–	–	–
Multi cyclist	157	3.80	0.852	51	3.66	0.195
Mono cyclist	338	3.81		–	–	–
Multi PT user	298	3.34	0.012	97	3.63	0.008
Mono PT user	1198	3.48		–	–	–
Multi car user	202	3.75	0.347	79	3.76	0.878
Mono car user	357	3.67		–	–	–

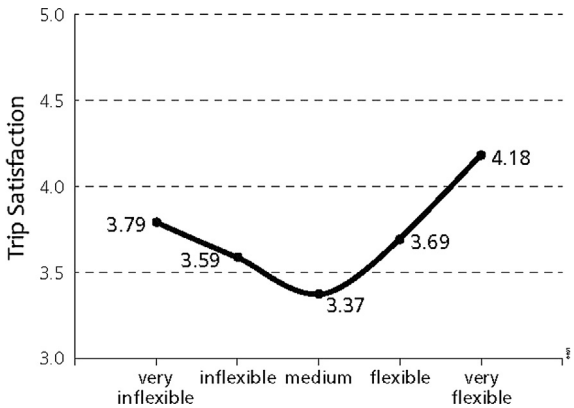

Fig. 1. Modal flexibility and trip satisfaction level.

lower self-measured modal flexibility reported because of no perceived choice options related to individuals' preferences, attitudes or beliefs. The latter factor cannot be clearly identified by our dataset, however, as there is no variable indicating individuals' preferences.

4.2. Multilevel regression results

To further investigate the explanatory variables' influence, 5 multilevel regression models have been conducted for trips with different main transport modes. Table 7 shows the regression results on commuting trip satisfaction.

4.2.1. Trip characteristics and modal flexibility at trip level

Generally, satisfaction with commuting trips by motorized modes could be affected by trip characteristics. As we expected, a longer duration makes motorized trips less satisfying. However, the travel time variables are not significant for the active travel modes, which may related to people's enjoyment of a mode itself (St-Louis et al., 2014). Páez and Whalen (2010)'s study found that, as the most satisfied group, active commuters even prefer longer commute times. Departure in the peak hour significantly reduces bus and car commuters' satisfaction with their trips, due to the crowdedness and congestion in the transport system. The negative impact of departure in the peak hour on subway trips is significant at $\alpha = 0.1$ but not at $\alpha = 0.05$. This is probably because that the subway system has higher time reliability compared to the other two modes, and commuters are less likely to be delayed or trapped in traffic congestion and are consequently less sensitive to commute durations. Additionally, for subway trips, the journey from work is more satisfying than the journey to work. One explanation is that the time window is larger in journeys from work, which lessens time pressure for commuters. However, these trip characteristics show no significant impact on walking or cycling trips.

As for perceived modal flexibility, the "U line" phenomenon revealed in Fig. 1 also appears in the regression model and is significant for walking, bus and car trips. Because these variables are given on a five-point "very hard-medium-very easy" scale, the coefficients indicate the direction and magnitude of the effect with respect to the medium level. Generally, the most unsatisfying trips are those with a medium flexibility level. For bus trips, only "very inflexible" trips are significantly

Table 7
Regression on trip satisfaction of trip with different modes. Dependent variable: trip satisfaction.

Fixed part	Walking trips 207 obsv. 46 groups		Cycling trips 452 obsv. 72 groups		Bus trips 780 obsv. 172 groups		Subway trips 678 obsv. 133 groups		Car trips 641 obsv. 143 groups	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err	Coef.	Std. err
Intercept	**4.14****	**0.27**	**4.08****	**1.99**	**3.86****	**0.16**	**3.88****	**0.18**	**4.21****	**0.19**
Level I (trip)										
Depart in Peak hour(Ref. = non-peak hour)	0.06	0.11	−0.06	0.06	**−0.16****	**0.06**	−0.13	0.07	**−0.32****	**0.07**
Journey from work (Ref. = journey to walk)	−0.05	0.07	−0.01	0.04	0.08	0.05	**0.17****	**0.04**	−0.04	0.05
Commute duration	0.00	0.00	0.00	0.00	**−0.01****	**0.00**	**−0.01****	**0.00**	**−0.01****	**0.00**
Very inflexible mode choice(Ref. = medium)	**0.34***	**0.16**	0.02	0.09	**0.30****	**0.09**	−0.05	0.09	**0.30****	**0.09**
Inflexible mode choice	0.22	0.16	0.10	0.08	−0.01	0.08	0.02	0.08	**0.23****	**0.09**
Flexible mode choice	**0.29***	**0.15**	0.14	0.09	0.10	0.11	−0.03	0.11	0.04	0.12
Very flexible mode choice	**0.65****	**0.23**	0.19	0.14	0.28	0.17	0.22	0.34	**0.50****	**0.19**
Level II (commuter)										
Male (Ref.=female)	0.03	0.16	−0.25	0.14	−0.05	0.11	0.11	0.14	−0.15	0.11
Age>=40 (Ref.= under 40)	−0.21	0.18	0.03	0.16	−0.05	0.16	**−0.44***	**0.23**	−0.01	0.13
Married (Ref.=unmarried)	−0.07	0.21	**−0.35***	**0.18**	0.04	0.12	0.01	0.16	−0.07	0.15
Income above RMB4,000/Month (Ref.= below RMB4000/m)	0.04	0.19	**0.53****	**0.14**	−0.01	0.11	0.23	0.15	0.04	0.12
Home location in urban area	0.04	0.72	**1.12****	**0.42**	0.30	0.27	**0.40***	**0.19**	−0.04	0.22
Work location in urban area	0.67	0.45	−0.26	0.24	−0.01	0.14	−0.28	0.15	−0.22	0.14
Multimodal walker	−0.16	0.24	0.56	0.67	**−0.94***	**0.48**	–	–	0.57	0.32
Multimodal cyclist	**−0.94****	**0.31**	−0.14	0.15	−0.11	0.28	0.65	0.42	−0.07	0.26
Multimodal PT user	−0.15	0.34	0.72	0.42	−0.05	0.13	**−0.60****	**0.17**	−0.08	0.15
Multimodal car user	−0.40	0.26	−0.38	0.29	0.21	0.20	0.04	0.24	0.14	0.14
Monomodal walker	Ref. Category		–	–	–	–	–	–	–	–
Monomodal cyclist	–	–	Ref. Category		–	–	–	–	–	–
Monomodal PTuser	–	–	–	–	Ref. Category		Ref. category		–	–
Monomodal habitual car user	–	–	–	–	–	–	–	–	Ref. Category	
Random part										
Variance at level 1	0.20	0.02	0.13	0.01	0.38	0.02	0.25	0.02	0.40	0.03
Variance at level 2	0.18	0.06	0.23	0.04	0.32	0.05	0.45	0.06	0.27	0.05
Deviance	319.07		665.27		1701.09		1278.86		1413.02	

* Significant at 0.05.
** Significant at 0.01.

more satisfying than medium level trips, while the other extreme of "very flexible" is not significant. Therefore, bus users are easier to satisfy with their trips when they clearly identify no other alternative modes. From one perspective, this may be explained by low expectations caused by a lack of other options. From another perspective, for an unsatisfactory trip like a bus trip, the existence of alternative choices can diminish the post-choice evaluation with the experience. Modal flexibility, however, shows no significant influence for cycling or subway trips. This may be caused by subway trips, which are the most constrained with 77.7% of them being inflexible (15.5% higher than the average level for all trips). In contrast, cycling trips are very flexible, and the rate for very inflexible trips is the lowest (25.0%) across all the transport modes.

4.2.2. Socioeconomic attributes and modality behavior at the individual level

In regard to socioeconomic attributes at the individual level, their influences are found to be significant for cycling and subway trips. Table 2 shows that cycling trips are more often conducted by low income commuters, while the regression results reveal that high income cyclists are more satisfied with their trips. A possible explanation is that Individuals with higher income tend be more appreciative of the intrinsic qualities of active mobility (Lanzendorf, 2002), which could be related to their lifestyles and motivations for choosing the mode. A research on longer distance commuters cyclists (>5 km) also found that these commuters actually have higher income and more choices for mobility, and revealed the importance of the motivations, such as physical exercise as a main motive, for these cyclists (Hansen and Nielsen, 2014). Moreover, married commuters are less satisfied with cycling trips. Compared to unmarried commuters, married commuters may have more household obligations such as grocery shopping or picking up family members, and the relatively lower speed and capacity of cycling could make it difficult for them to combine these activities with their commute. Having a home located inside the 4th ring road (urban area) significantly increases satisfaction with cycling and bus trips. On the one hand, traveling in urban areas with higher density can help active mode users and PT users to gain higher satisfaction because there are more pedestrian/cyclist friendly environments and higher access to public transport facilities in these areas. On the other hand, our sample commuters were selected from a suburban area, and having a home located in an urban area indicates that they must work in our suburban research area. These people experience a reversed commute compared to the major commuting flow between the urban and suburban area. As a consequence, these commuters could suffer less from congestions in peak hours.

For trips by alternative modes, multimodal behavior can negatively influence multimodal commuters' satisfaction with their trips compared with monomodal commuters, especially for walking and bus trips. For walking trips, although they are ranked as the most satisfying trips (Table 5), we find that multimodal commuters are less satisfied than mono walkers, which is significant for multimodal cyclists. The reason may be that for a commuting trip habitually done by bike, switching to walking costs more time and energy. For bus trips, we find that multimodal walkers are significantly less satisfied. Because walking trips are more satisfying than bus trips in general, we can assume that decisions by habitual walkers to switch modes may be due to specific reasons, such as bad weather, thus resulting in a lower assessment of their bus trips. St-Louis et al. (2014)'s comparison in a longer term also confirms that people compare the different modes or commutes they have experienced. Their results also show that, those who use active mode users in the summer, but switches to public transport in the winter may be less satisfied with their transit commute than those who consistently use public transport in the year. The difference between multimodal and monomodal commuters can be explained from the perspective of multimodal travelers' experiences with other modes or their undesirable deviations, and also from the perspective of monomodal commuters who may become familiar with their transport modes and regard these trips as more pleasant themselves. Generally, these finding are consistent with our hypothesis that multimodal commuters are less satisfied than monomodal commuters when deviating from their habitual modes.

For subway trips, compared with mono subway users, multimodal commuters with public transport as the habitual model find subway trips less satisfying. One possible explanation is that public transport trips are the most unsatisfying trips in empirical studies, and experience with other modes can provide a higher reference point for the these multimodal PT users; consequently, their satisfaction with the subway trips is lower.

5. Conclusion and discussion

Using activity travel diary data collected in Shangdi-Qinghe area of Beijing, this paper presented an investigation of the commuting trip satisfaction of urban residents by different transport modes in Beijing. Consistent with previous studies (Friman et al., 2013; Olsson et al., 2013; Páez and Whalen, 2010), our results show that commuting trips by active modes are generally more satisfying, followed by car trips and public transport trips. It is shown that trip characteristics including trip duration and departure in the peak commuting hour can negatively influence trip satisfaction with motorized modes, and commuting trips from work are more satisfying than trips to work for subway users. As for personal attributes, female, unmarried and higher income commuters are more satisfied with their cycling trips, while older commuters are comparatively less satisfied with bus trips. In addition to previous studies, we further explore the relationship between transport modes and trip satisfaction by examining the influence of commuters' multimodal behavior and their modal flexibility.

A significant contribution of this study is that we investigate the effect of multiday variability in travel mode use (multimodality) and modal flexibility on trip satisfaction. We found a significant portion (33.2% in our dataset) of commuters showing multimodal behavior in practice. Furthermore, we found that multimodal behavior can negatively affect com-

muters' trip satisfaction with alternative modes. For walking and bus trips, multimodal cyclists and multimodal walkers tend to be less satisfied than monomodal commuters. The reasons could be the multimodal travelers' experiences with multiple modes or their undesirable deviation from habitual modes, as well as the repetitive nature of mode choice. In addition, for those less satisfying trips such as subway trips, multimodal subway users could be less satisfied compared to monomodal ones, and their reference point when assessing subway trips could increase after using alternative modes (because PT trips are rated as most unsatisfying trips). We also found that modal flexibility in decision-making can influence commuter's trip satisfaction. More specifically, it presents a U-shaped relationship. According to the "U line", commuters are most satisfied with very high flexibility in mode choice because they are more likely to choose out of their preferences; however, commuters with very low modal flexibility, especially bus users, can achieve a relatively high satisfaction level. This could be explained by the fact that highly constrained commuters would have no or lower expectations for those trips or have no alternative to regret when assessing trip satisfaction. It is also possible that the self-reported low flexibility of some commuters may be due to their habits or preferences.

To conclude, from a theoretical perspective, our research shows that trip satisfaction is not only affected by transport modes themselves but also by the context of travelers' mode choices including travelers' experiences with other modes (due to multimodal behavior) and their freedom in decision making (with different modal flexibility levels). While multimodal behavior in Western countries is regarded as being related to travelers' personal preferences and their increased awareness of automobile-related environmental issues (Buehler and Hamre, 2014; Kuhnimhof et al., 2006; Vij et al., 2011), lower car ownership in Chinese households and vehicle restriction policies in Chinese cities are more likely to affect urban residents' modality behavior and also their modal flexibility.

However, there are several limitations to our study. Subjective factors, such as attitudes towards different modes, travelers' personalities (Lavery et al., 2013; Páez and Whalen, 2010), may play a role in their travel mode usage, their assessments of modal flexibility assessment and further the trip satisfaction. It would be valuable to test if the subjective factors can offer additional explanations in future studies. Another limitation of our study is that, when aiming at the cognitive component of trip satisfaction, we were not able to control the quality of services for the trips across different travel modes. Given the dataset available, we could only test trip characteristics reported by the commuters. These characteristics may indicate the service qualities to certain extent (e.g. crowdedness and congestion when departure in peak hour), but more direct indicators should be collected in further surveys exploring trip satisfaction. Furthermore, our findings could be specific in the studied area, but not representative for the situation in Beijing.

Possible policy implications can be proposed across different segments of commuters in Beijing. Consistent with previous studies, we find that commuters do compare their trips with different modes. Therefore, to encourage the use of more sustainable travel modes, it is crucial to improve commuters' experience with them. For public transport users, relatively high satisfaction level with inflexible trips may indicate that the transit service has fulfilled constrained commuters' basic needs in Beijing at the current stage. However, it is inevitable that more and more constrained public transport users could switch to cars as an alternative mode, with the rapid increase of household car ownership in Chinese cities. Their satisfaction with public transport trips may decrease as their modal flexibility increases. It is important that the public transport infrastructure keeps evolving to higher levels in Beijing. It has been planned that over 100 km of new subway lines will be built in Beijing before 2020, and the public transport system is still heavily subsidized (Zhao, 2014). With the efforts improving public transport service, it could help attracting those multimodal travelers to adopt more PT trips. For the car users, according to the preliminary results in description analysis (Table 6), there is no significant difference between multimodal travelers' car trips and their trips by alternative modes. In other words, it is feasible to encourage occasional mode switches of car users without decreasing their satisfaction levels. We can promote this by raising travelers' environmental awareness in the long term, and also by restrictive travel demand management measures with appropriate limitations, such as the vehicle restriction policy implemented in our research context. Furthermore, a dramatic decline of bicycle ownership and using has been witnessed in Beijing in recent decades. However, our results show that cycling is still ranked as a more satisfying mode of transport by commuters. With cycling trips appreciated by its users, building bicycle facilities and also improving the natural environment (e.g., better air quality, less smog) in the long term, could not only benefit the current commuter cyclists, but also attract more multimodal travelers with satisfying experiences.

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