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Exploring the Group Difference in the Nonlinear Relationship between Commuting Satisfaction and Commuting Time

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Abstract: Analyzing commuting-time satisfaction could help to improve the subjective well-being of society. This study aimed to explore the nonlinear relationship between commuting satisfaction and commuting times in different groups and its influencing factors. An empirical study was conducted in Kunming, China. Firstly, applying a random forest algorithm revealed that there was a nonlinear relationship between commuting satisfaction and commuting time. Secondly, the k-means clustering algorithm was used to divide the respondents into three types of commuter: short-duration-tolerant (group 1), medium-duration-tolerant (group 2), and long-duration-tolerant (group 3). It was found that the commuting-time satisfaction of these three clustered groups had different threshold effects. Specifically, the commuting satisfaction of group 1 showed a nonlinear downward trend, which decreased significantly at 12 and 28 min, respectively; the commuting satisfaction of group 2 rapidly decreased at 35 min; the commuting satisfaction of group 3 first increased in the range of 20–30 min, decreased significantly after 45 min, and decreased sharply above 70 min. These time thresholds were consistent with the ideal commuting times (ICTs) and tolerance thresholds of the commuting times (TTCTs) of the three clustered groups, which indicates that the ICT and TTCT had significant effects on commuting satisfaction. Lastly, the results of the multinominal logistic model showed that variables such as the commuting mode, job–housing distance, income, and educational background had significant effects on the three clustered groups. The policy implications of the study are that commuting circles should be planned with the TTCT as a constraint boundary and ICT as the optimal goal; in addition, different strategies should be adopted for different commuting groups to improve commuting satisfaction.

Keywords: commuting satisfaction; commuting time; nonlinearity; group difference; threshold effect; commuting preference and tolerance

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1. Introduction

Commuting satisfaction affects physical and mental health, job performance, life satisfaction, well-being, etc. Studying the influencing factors of commuting satisfaction is important for improving public health, increasing economic efficiency, and promoting social sustainability. Commuting satisfaction is a key indicator for measuring citizens' subjective well-being [1–3], evaluating the level of urban transport services [4,5], and evaluating sustainable social development [6,7]. How to improve commuting satisfaction is a common concern for city managers, planners, and researchers in related fields. The factors affecting commuting satisfaction mainly include the commuting time [8,9], commuting mode [10–13], built environment [14,15], service level [16,17], and perceived attitude [18,19]. For the commuting mode, there are a few reasons why walking or cycling are associated with higher satisfaction, such as moderate commuting times and lower commuting costs [20], more exposure to green space [21], increased social interaction, and the promotion of physical and mental health [22]. Congestion is the reason for low satisfaction with car commuting [23,24]. Service levels regarding transfers, connections, departure frequencies, platform facilities, and information acquisition are the reasons for low satisfaction with public transportation (buses and subways) [25–27]. For built environments, the residents of compact urban neighborhoods have better commuting satisfaction than residents of sprawling suburban neighborhoods [28]; the walking satisfaction can be explained by the safety, lack of congestion, and cleanliness of sidewalks [29]; the availability of bike lanes and whether buses are running along the bike lanes affect the commuting satisfaction for cyclists [30]. For preferences and attitudes, a mismatch between the chosen commuting mode and preferred commuting mode has a negative impact on commuting satisfaction [11,31]; commuters who have a positive attitude towards commuting activities have higher satisfaction levels [32–34].

Commuting time is seen as an important influence on commuting satisfaction, the complex relationship between commuting satisfaction and commuting time has been a focus of attention [9,35,36]. When other variables are controlled, some research argues that there is a negative linear effect of commuting time on commuting satisfaction [37–39]. However, other research found, through hypothetical experiments, that there is a nonlinear relationship between commuting satisfaction and commuting time, with ideal commuting times (10–20 min) and acceptable commuting times (30–40 min) being responsible for this nonlinear relationship [40]. People have the best commuting experience and perceived emotions at the ideal commuting time [41]; conversely, when the commuting time exceeds the acceptable or tolerable threshold, they show significant negative emotions and attitude evaluations [42]. The results of statistical modeling support a weak positive effect of an ideal commuting time on commuting satisfaction [43], while the effect of tolerance thresholds on satisfaction has rarely been empirically studied.

The above results have opened up new perspectives for exploring the complex relationship between commuting satisfaction and commuting time. However, three questions deserve further exploration. Firstly, do the nonlinear characteristics of commuting-time satisfaction differ between hypothetical and actual contexts? Analyzing this issue can help to understand the impact of commuting time on satisfaction from both subjective and objective perspectives, and then formulate more effective policies to improve commuting-time satisfaction. Secondly, although the ideal commuting time has a positive effect on commuting satisfaction, the magnitude of the positive effect is relatively small, which leads to the question of whether all commuting groups are the most satisfied around the ideal commuting time. Studying this question can compensate for the lack of attention in the existing literature to group heterogeneity in satisfaction with ideal commute time. Thirdly, both the ideal commuting time and the tolerance threshold have group differences, and these two subjective time thresholds are the key points at which commuting satisfaction changes; therefore, is there also a group difference in commuting-satisfaction change with commuting time, and which factors can explain these differences? Exploring this question contributes to closing the gap in the published literature on commuting satisfaction in terms of nonlinearity and heterogeneity to develop differentiated and personalized urban transport policies.

To answer the above three research questions, firstly, the overall laws of commuting-satisfaction change regarding the hypothetical commuting time and actual commuting time were compared. Next, *k-means clustering* was conducted by combining the actual, ideal, and tolerance values of the respondents' commuting times, and classifying them into three groups: short-duration tolerance, medium-duration tolerance, and long-duration tolerance. Furthermore, *the random forest algorithm* was applied to examine the group difference in commuting-time satisfaction. Finally, *a multinomial logistic regression model* was developed to identify the explanatory variables significant for the three clustered groups.

The novelty of this study is threefold: firstly, it shows that commuting satisfaction is inconsistent with regard to the hypothetical commuting time and actual commuting time, which means that commuters' attitudes to commuting times in hypothetical scenarios are different from their perceived experiences of actual commuting times. Previous studies focused either on the relationship between commute satisfaction and hypothetical commute time or on the relationship between commute satisfaction and actual commute time; they did not analyze the difference in changes in commute satisfaction between these two scenarios. This findings tells us that when developing an optimization strategy for commute-time satisfaction, we should not only start from hypothetical scenarios, it is also necessary to integrate actual situations. Secondly, a fresh finding is that ideal or moderate actual commuting times have a positive effect on commuting satisfaction only for the long-duration-tolerance commuting group, which is not universal. The implication of this finding is that strategies to improve commuting satisfaction by shortening commuting time to ideal expectations are the most effective for long-duration-tolerance commuters. Lastly, the study reveals that there is a group difference in the nonlinear relationship between commuting satisfaction and the actual commuting time; on this basis, it was verified that the commuting-time boundary points that caused these nonlinear changes were close to the ideal commuting time and tolerance threshold of the commuters. Considering individual preferences and tolerance for commuting, this study provides a new perspective for analyzing the threshold effect of commute time satisfaction. This finding enriches the knowledge of threshold theory in terms of commuting satisfaction nonlinearity and heterogeneity.

The second part of the article provides a literature review of the relationship between commuting satisfaction and commuting time. The third section introduces the study's objectives, data, and methods. The fourth section presents the findings and discusses them. The final section draws conclusions and policy implications and outlines the limitations.

2. Literature Review

Commuting satisfaction is a perceptual emotional and cognitive evaluation of the difference between commuters' expectations of service levels and their actual commuting experiences [41]. Higher levels of travel services lead to better perceptions and emotions [44]. Commuting time is a key measure of the service level; it has a significant impact on commuting satisfaction. Some research concludes that commuting satisfaction is negatively correlated with commuting time. Olsson et al. [45] found that the longer the actual commuting time (ACT), the lower the commuting satisfaction. Higgins et al. [24] showed that the proportion of dissatisfied samples became larger as the ACT increased. Zhu et al. [46] revealed that trip duration had a negative association with commuting mood. Two empirical studies in China have also shown that commuting satisfaction decreases with increasing ACT [47,48].

Other research shows a nonlinear relationship between commuting satisfaction and commuting time. Young [49] found that commuting satisfaction rose first and then decreased with the hypothetical commuting time (HCT). Subsequently, the relevant literature on the positive utility of an ideal commuting time and the negative utility of an acceptable (tolerable) commuting time emerged [50–54]. The ideal commuting time (ICT) reflects commuters' preferences for commuting times; people's ICTs are mainly around 10–20 min [55,56], while the tolerance threshold for commuting times (TTCT) reflects commuters' tolerance of commuting times; people's TTCTs was 30–40 min [57,58]. The researchers asked the respondents to evaluate their satisfaction with different hypothetical commuting times; they found that the commuting satisfaction increased before an HCT of 15 min, while it dropped sharply after 30 min, showing significant nonlinear distribution characteristics [36,40,42]. Zhao et al. [59] found that commuting satisfaction was highest when the commuting time was 10–30 min.

Recently published literature strengthens the research on the nonlinearity of commute-time satisfaction. The route-analysis model constructed by Humagain et al. [43] showed that the ICT had a weak positive effect on commuter satisfaction. From the perspective of commuter cognitive dissonance, Ye et al. [41] showed that commuter satisfaction increased before the ICT and decreased after the ICT. Jang et al. [9] obtained an opposite nonlinear relationship through machine learning; that is, commuter-time satisfaction first decreased (0–35 min) and then increased (36–70 min). The reason behind this is that some commuters are willing to accept a longer commuting time to obtain a better living environment. Further research by Humagain et al. [36] observed group differences in the relationship between commuting satisfaction and HCT and showed that the nonlinear relationship only applied to a small number of commuters.

These research findings have opened a new window for exploring the complex relationship between commuting satisfaction and commuting time. However, two questions still need to be explored. Firstly, is there a difference between the hypothetical commuting-time satisfaction (experimental scenario) and actual commuting-time satisfaction (objective reality)? In addition, both the ideal commuting time and the tolerance threshold have group differences, and these two subjective commute time boundary points have a significant impact on commuter satisfaction, which means that it is valuable to reveal group differences in commute-time satisfaction from the perspective of commuters' preferences over and tolerance of commute times.

3. Research Data, Objectives, and Methods

3.1. Implementation of the Survey

As the capital city of China's Yunnan Province, Kunming is a regional international city in Southwest China. *"The Commuting Monitoring Report for 36 Major Cities in 2020, China"* shows that the commuting-monitoring indicators for Kunming are similar to those of other cities [60], which means that using Kunming as a study case is representative. The paper-assisted personal interviewing (PAPI) technology was used to implement the survey. The PAPI implementation steps are "design questionnaires, train investigators, conduct trial surveys, optimize questionnaires, conduct formal surveys, eliminate invalid questionnaires, and establish a database". Although the implementation cost of the PAPI survey method is relatively high, its advantage is that investigators not only provide necessary explanations to respondents' questions through face-to-face interviews, but also directly observe the statuses of the respondents filling in the questionnaires, which is helpful for preliminarily judging the quality of returned questionnaires.

Taking into account the aggregation of the people flow, the spatial distribution of the samples, and the feasibility of the implementation, the survey selected eight core commercial complexes in different locations. The eight commercial complexes were the Joy-City Business Center (Wuhua District), Shuncheng Business Center (Wuhua District), Tongde Plaza (Panlong District), Wanda Plaza (Xishan District), Dadu Shopping Mall (Guandu District), International Ginza Complex (Guandu District), Wuyue Plaza (Chenggong District), and No.1 City of Colorful Yunnan (Chenggong District). The specific survey locations were mostly cafes, milk-tea shops, bookstores, and parent waiting areas in children's training centers. The consumers in these places are generally in a leisure state, and they were more willing to listen to the surveyor's introduction and agree to the survey.

Before the survey was carried out, the supervisor conducted the necessary training for the investigators, so that the investigators could master the precautions and basic skills for a random sampling survey. Two investigators formed a group; one was responsible for instructing the respondents to fill in the questionnaire, and the other was responsible for recording the respondents' times for answering the questionnaire. The investigators uniformly wore white work clothes with a logo and wore the official investigation work permit issued by the institute on their chests, to gain the trust and support of the customers as much as possible. The investigators randomly asked the customers if they were willing to take the survey, and told them that, if they completed the questionnaire, they would receive a red envelope with RMB 10 of cash, which reduced the rejection rate and encouraged the respondents to fill out the questionnaire carefully.

The final version of the questionnaire was revised based on the feedback from the pilot survey in April 2020. Two offline random sample surveys were conducted on commuters in Kunming. The first formal survey was conducted in May 2020, obtaining 352 valid samples (sample 1); the second formal survey was conducted in January 2021, collecting 224 valid samples (sample 2). Through data cleaning, samples that were incomplete and with answering times of less than 8 min (an empirical value obtained in the trial survey) were eliminated, and 576 complete samples were finally obtained. The average commute time of sample 1 and sample 2 were 28.1 and 26.1 min, respectively. The Mann–Whitney U test was performed on these two independent samples, and it was found that their commute-time distributions were not significantly different ($p > 0.1$); The average commuting satisfaction of sample 1 and sample 2 were 4.5 and 4.7, respectively; the Mann–Whitney U test showed that there was no significant difference in the distribution of commuting satisfaction between these two independent samples ($p > 0.1$). These test results demonstrated that there was no statistical difference between the two samples, and they could be combined for this study. Furthermore, in sample 1, the proportions of active commuting, cars, e-bikes, and public transportation were 21.9%, 33.0%, 20.1%, and 25.0%, respectively, while in sample 2, the proportions of these four commuting modes were 25.9%, 26.9%, 16.7%, and 30.6%, respectively. These two sets of data were similar, indicating that there was no obvious deviation between the two samplings.

3.2. Data from the Survey

3.2.1. Commuting Time

Three questions were set in the questionnaire to obtain the respondents' ACTs, ICTs, and TTCTs. Question 1: "On average, how many minutes does it take to commute from your residence to your workplace by your most frequently used commuting mode?" (ACT); question 2: "What is your preferred ideal commute time in minutes from your residence to your workplace?" (ICT); and question 3: "What is the maximum commute time you can tolerate in minutes from your residence to your workplace?" (TTCT). The ACT reflects a retrospective estimate of the respondents' average daily commuting time in actual situations. The ICT presents the respondents' ideal preferences for commuting times in hypothetical situations. The TTCT refers to psychologically tolerable or acceptable commuting times for the respondents.

The average ACT, ICT, and TTCT obtained in this survey were 27.1, 17.5, and 37.8 min, respectively. In addition, as shown in Table 1, the proportion of the respondents whose ACTs were within their ICTs was 29.8%, while that of the respondents whose ACTs exceeded their TTCTs was 18.3%; these findings are similar to those of other researchers. A survey conducted in Kunming in 2014 found that the average ACT, ICT, and TTCT were 28.7, 18.6, and 37.4 min, respectively; in addition, the ACT was less than or equal to the ICT in 28.7% of their samples, and the ACT was greater than the TTCT in 15.3% of their samples [61].

Table 1. The description of the samples.

Variables	Categories	Assignment	Sample Size	Proportion/%
Gender	Male	0	328	56.9%
	Female	1	248	43.1%
Age	18–30 years old	1	304	52.7%
	31–40 years old	2	212	36.8%
	41–60 years old	3	60	10.5%
Education	High school and below	1	94	16.4%
	College and undergraduate	2	421	73.1%
	Postgraduate and above	3	61	10.5%
Monthly income	<RMB 5000	1	260	45.1%
	RMB 5000–7000	2	170	29.5%
	>RMB 7000	3	146	25.4%
Job–housing relationship	Balance (SDTC < 5 km)	1	350	60.7%
	Mild distance (5 km ≤S DTC ≤ 9 km)	2	140	24.4%
	Severe distance (SDTC > 9 km)	3	86	14.9%

Table 1. *Cont.*

Variables	Categories	Assignment	Sample Size	Proportion/%
Commuting mode	Active (walking, cycling, and shared bicycles)	1	138	23.9%
	Car (private cars, taxis, and shared cars)	2	172	29.8%
	E-bikes (e-bicycles, e-mopeds)	3	106	18.5%
	Public transportation (subway and buses)	4	160	27.8%
Commuting time	ACT ≤ ICT	1	172	29.8%
	ICT < ACT < TTCT	2	299	51.9%
	ACT ≥ TTCT	3	105	18.3%

3.2.2. Commuting Mode

The commuting mode in this study refers to the travel mode respondents most frequently used to commute from their residence to the workplace on workdays. All the samples included four types of commuting mode: active commuting (walking, cycling, and shared bicycles), cars (private cars, taxis, and shared cars), e-bikes (electric bicycles, electric mopeds), and public transportation (subway and buses). E-bikes mainly include three types of electric bicycles, electric mopeds, and electric scooters [62]. The e-bikes in this study refer to electric mopeds (motorcycle type, driven by electric motors, without pedals) and electric bicycles (bicycle type, mainly powered by electricity, supplemented by human power, with pedals). In Kunming, the users of such e-bikes need to register them with the relevant government department and apply for a license.

The proportions of cars and public transportation were 29.8% and 27.8%, respectively. These survey data are slightly higher than the corresponding statistical data in the "*Kunming Urban Transportation Annual Development Report in 2019, China*", which reports that the travel sharing rates for cars and public transportation were 25.9% and 25.4%, respectively [63]. Since the report's classification of other commuting modes is inconsistent with this study, no explanation for the sample proportions of active commuting and e-bikes is provided here.

It should also be pointed out that the reason e-bikes are listed separately in this study is that the commuting share rate of e-bikes is not low in Kunming [64]. Furthermore, there are essential differences in the performance functions (speed, acceleration/deceleration, and physical energy consumption) of the e-bike and active modes (walking and cycling) [65]. Listing e-bikes as active commute modes would not be conducive to analyzing the group differences in commuting satisfaction. In addition, during the questionnaire survey, there was no COVID-19 spread in Kunming; its urban commuting system operated as usual; which can be intuitively inferred from the above data on the commuting time and commuting mode.

3.2.3. The Job–Housing Relationship

The questionnaire asked about the names of the communities where the respondents lived and worked. On the Baidu map, the centroid of the community where each respondent lives and works were marked, and each interviewee's job–housing relationship was measured based on the straight-line distance between the two centroids (SDTC). We referred to the indicator of happy commuting (commuting distance within 5 km) and the average commuting distance in Kunming (7.5 km) in "*National Commuting Monitoring Report for Major Cities in 2020, China*" [60]. The respondents' job–housing relationships were divided into three ordered categories: SDTC within 4 km was defined as a job–housing balance; SDTC within the range of 5 to 9 km was defined as the mild job–housing distance; SDTC exceeding 9 km was defined as severe job–housing distance.

3.2.4. Commuting Satisfaction

This study measured commuting satisfaction with the HCT [40]. A total of six hypothetical scenarios were set up, each of which corresponded to a different HCT. An option that matched the respondent's attitude reflection from five satisfaction options (very satisfied, satisfied, neutral, dissatisfied, and very dissatisfied) was chosen. The first scenario had a commuting time of 0 min, with an additional note that it meant "telecommuting"; the second scenario had a commuting time of 15 min because people's ICTs were concentrated in the range of 10–20 min [41,50,55,56]; therefore, setting the items in this way was helpful for analyzing the changes in commuting satisfaction around the ICT; the commuting times of the third and fourth scenarios were 30 and 45 min, respectively, because the respondents' acceptable or tolerable commuting times were mainly concentrated in the range of 30–45 min [36,42,57,58], and the context set in this way helped to reveal the changing characteristics of commuting satisfaction when the commuting time approached or exceeded the TTCT. To analyze the impact of long or extreme commuting [66–69] on commuting satisfaction, the last two scenarios of commuting times of 60 and 75 min were also set.

This study also measured the respondents' satisfaction with their actual commutes. The *scale of travel satisfaction* (STS) focuses on the two dimensions of commuters' cognitive and affective evaluations of commuting activities in reality [70]. A total of nine items were set in the STS to measure commuting satisfaction. The STS has been proven to be practical and reliable by some empirical studies [23,71,72]. To ease the test burden on respondents, Ye et al. [41,73] reduced the items of the STS to seven and applied it to a commuting-satisfaction study of Xi'an citizens, in China. Since their results showed that the reduced version of the STS (STS-R) was still effective, this study also applied it. The seven items of the STS-R are shown in Table 2. In each item, −3 means very dissatisfied, 0 means neutral, and +3 means very satisfied. The reliability and validity of the seven questions of the STT-R were tested; the results showed that *Cronbach's alpha* and *KMO* were 0.923, 0.915, indicating that the internal consistency of the STT-R was good and the seven survey questions were valid.

Table 2. The scales of commuting satisfaction.

The Worst (−3)	Please Evaluating Real Feeling on Your Commute	The Best (+3)
I felt commute time was pressed	−3 −2 −1 0 +1 +2 +3	I felt commute time was relaxed
I was stressed	−3 −2 −1 0 +1 +2 +3	I was calm
I was tired	−3 −2 −1 0 +1 +2 +3	I was alert
I was bored	−3 −2 −1 0 +1 +2 +3	I was enthusiastic
I felt the service level of the commute was bad	−3 −2 −1 0 +1 +2 +3	I felt the service level of the commute was good
I think this commute worked poorly	−3 −2 −1 0 +1 +2 +3	I think this commute worked well
I think this commute is the worst I can think of	−3 −2 −1 0 +1 +2 +3	I think this commute is the best I can think of

3.3. Objectives and Methods

Research objective 1: Examining differences in commuter satisfaction with changes in HCT and ACT, respectively. On one hand, the commuting satisfaction under the hypothetical scenario was categorized; those who selected "very satisfied" and "satisfied" were defined as the satisfied type, while those who selected "very dissatisfied" and "dissatisfied" were defined as the dissatisfied type, and those who selected the intermediate option were defined as the neutral type. For each HCT, the proportions of respondents in these three categories were counted separately to plot the distribution of the commuting satisfaction along with the HCT. On the other hand, for ease of calculation, 4 was added to each measured value obtained by STS-R, so a score of 1 represented very dissatisfied, a score of 4 represented neutral, and a score of 7 represented very satisfied. On this basis, the arithmetic mean of the seven question items was calculated, which was the actual commuting satisfaction. *A random forest algorithm* was used to explore the nonlinear relationship between actual commuter satisfaction and the ATC.

Research objective 2: Revealing the differences in commuting satisfaction with ACT among clustered groups. First, *the k-means clustering algorithm* [74] was used to divide all the respondents into different groups. Second, *the random forest algorithm* [75] was applied to draw the relationship of local dependency between commuting satisfaction and

ACT for clustered groups. Furthermore, the respective nonlinear characteristics of their commuting-time satisfaction could be intuitively observed. Finally, from the perspective of commuters' psychological preferences and tolerance of commuting times, the ICTs and TTCTs of the clustered groups were introduced and combined with the nonlinear changing characteristics of their commuting-time satisfaction to capture the time-threshold effect of commuting satisfaction.

Research objective 3: Identifying influencing factors of clustered groups with differences in commute time satisfaction. *A multinominal logistic regression model* [76] was set up, with the clustered groups of different commuting-time satisfaction levels as the unordered categorical dependent variable. The independent variables were commuting mode, job–housing relationship, and individual characteristics.

4. Results and Discussion

4.1. Change in Commuting Satisfaction with Hypothetical Commuting Time and Actual Commuting Time

Figure 1 shows the change in the sample proportion distribution of the commuting satisfaction under the hypothetical situation. When the HCT was 15 min, the proportion of respondents who were satisfied was the highest, reaching 81%, which supports the previous research results; that is, when the commuting time is close to the ICT (10–20 min), the commuting satisfaction is the best [36,40,42]. This phenomenon can be explained by cognitive dissonance theory, which states that people's feelings and experiences are the best when attitudes (ideal preferences) and behaviors (real situations) are in harmony [77]. As the HCT of 15 min aligns with people's ideal commute time, this value could offer commuters the best experience. In addition, commuting utility theory can also be used as an explanation for this phenomenon, which holds that ideal commuting time brings positive utility to people [50].

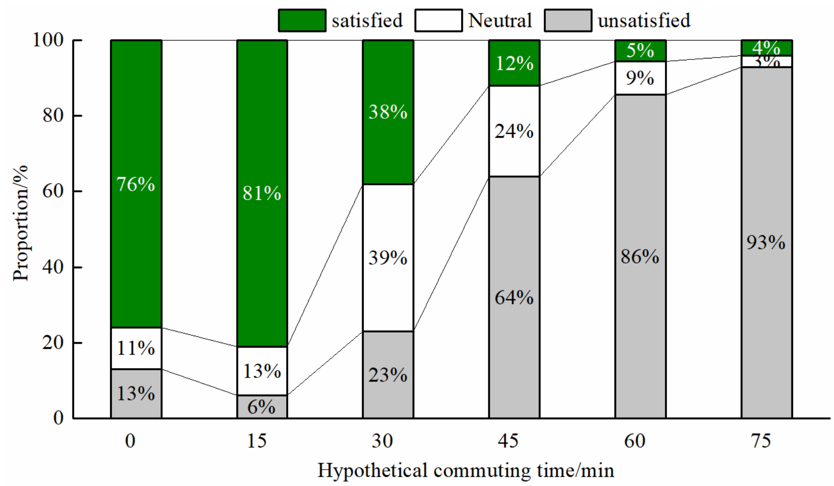


Figure 1. The proportions of commuting satisfaction under hypothetical commuting times.

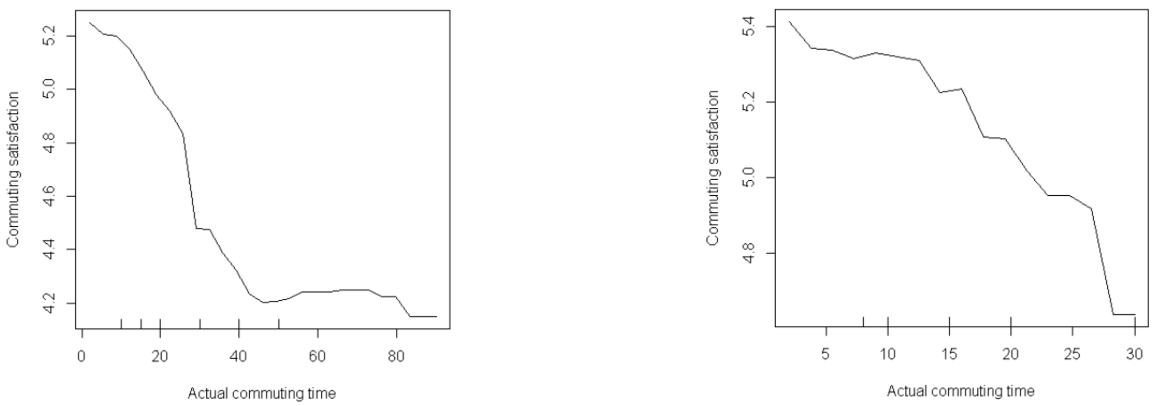
When the HCT was 0 min, the proportion of respondents who were satisfied dropped by 5 percentage points, but it was still as high as 76%, which indirectly shows that the respondents had relatively optimistic responses to telecommuting. Furthermore, this proportion is larger than the findings of other scholars [36,40,42,49] and smaller than those of Humagain [36], which may be related to the differences in the study region, and the possibility that the demand for telecommuting was stronger during the epidemic cannot be ruled out.

When the HCT increased from 15 to 30 min, the proportion of the respondents who answered that they were satisfied quickly dropped from 81% to 39%, while the proportion of the respondents who answered that they were dissatisfied increased from 6% to 23%. Similarly, when the HCT increased from 30 to 45 min, the proportion of respondents expressing dissatisfaction increased significantly, from 23% to 64%. The explanation for these statistical results is similar to the findings of other countries; that is, people have acceptable or tolerable thresholds for commuting times at the psychological level [36,40,42,57]. There was a significant drop in perceived satisfaction when the HCT exceeded 60 min; the majority of the respondents stated that they were dissatisfied; this is in line with reality, because people's perceived moods under long or extreme commuting are mostly negative [38,67]. Interestingly, when the HCTs were 45, 60, and 75 min, 12%, 5%, and 4% of the samples responded with satisfaction, respectively, indicating that a small number of the respondents still showed a willingness to accept long commuting times, which may have been the result of respondents' benefit trade-offs [8]. These results suggest that it is necessary to explore group differences in commuting-time satisfaction.

Generally, there was a nonlinear variation in the commuting satisfaction with the HCT. The participants responded positively to telecommuting. The commuting satisfaction presented a weak growth trend in the range of 0–15 min. When the HCT was in transit from 15 to 30 min, the commuting satisfaction decreased for the first time. When the HCT exceeded 30 min and approached 45 min, the commuting satisfaction decreased significantly for the second time. However, this is only a statistical result under hypothetical conditions it is necessary to further explore the changing characteristics of commute-time satisfaction in actual situations.

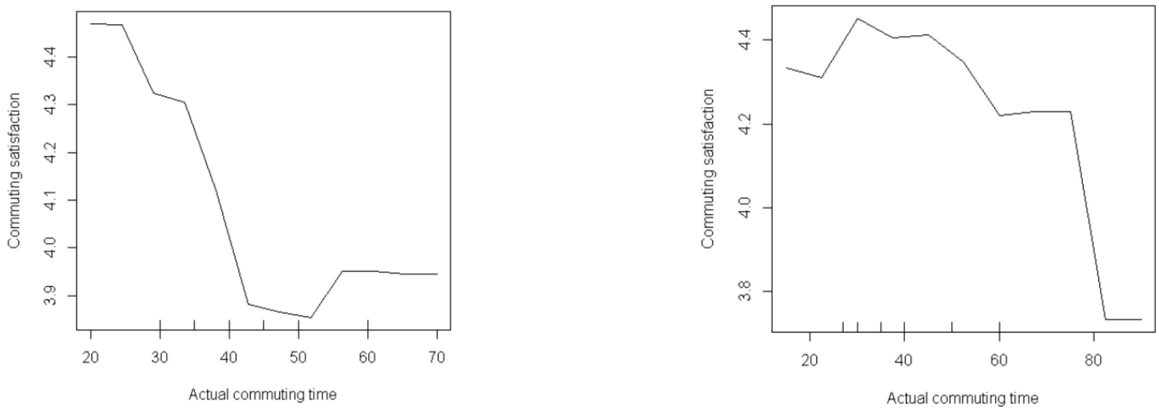
To reveal how commuting satisfaction changes with the ACT, the *random forest algorithm* was used to plot the local dependence relationship of the respondents' commuting satisfaction with the ACT. Taking 70% of the samples as the training set and 30% of the samples as the test set, the goodness-of-fit (explained variability) of the model was 77%. As shown in Figure 2a, the overall trend of the commuting satisfaction decreased nonlinearly as the commuting time increased. The decline in commuting satisfaction was significant before the ACT of 30 min; particularly within the range of 20–25 min, the decline in commuting satisfaction was the greatest; after 30 min, the decline in commuting satisfaction was relatively flat; few upward trends in commuting satisfaction were observed before the ACT of 20 min.

These results suggest that the respondents' stated commuting satisfaction in the hypothetical scenario was not entirely consistent with their perceived commuting satisfaction in the face of the ACT. Although the commuting satisfaction showed nonlinear changes with commuting time in both contexts, the positive effect of a moderate or ideal commuting time on commuting satisfaction was not captured in reality; furthermore, only 5% of the sample showed an increase in commuting satisfaction, even when the HCT increased from 0 to 15 min. Therefore, one question that arises is whether the notion that ideal commute times lead to positive commuting satisfaction is only applicable to a minority of commuters, and not a universal observation.



(**a**) (**b**)

Figure 2. *Cont.*



(**c**) (**d**)

Figure 2. The nonlinear relationship between commuting satisfaction and actual commuting time. Note: (**a**) Total sample; (**b**) Group 1; (**c**) Group 2; (**d**) Group 3.

4.2. Group Differences in the Nonlinear Relationships between Commuting Satisfaction and Actual Commuting Time

The question of whether there was a group difference in the relationship between commuting satisfaction and commuting time was explored. First, the total samples were *k-means* clustered with three indicators: ICT, TTCT, and ACT. These variables reflected the three dimensions of the commuters' ideal preferences, tolerance levels, and actual experiences of commuting times, which is more comprehensive than clustering with only one of them. Because these three indicators are group differences, the clustering groups obtained by them may help to explore the group difference in commuting-time satisfaction.

The theoretical basis for clustering the respondents using these three variables is that the ICT reflects commuters' preferences in terms of commuting times [50,53]. When the ACT is close to the ICT, the perceived satisfaction of commuters is better [41,43,78]. While the TTCT reflects commuters' tolerance of commuting times [57,58], When the ACT approaches or even exceeds the TTCT, the negative motions of commuters significantly increase [54], which leads to a sharp satisfaction decrease [40,42]. In addition, the advantage of clustering respondents in this way is that it not only reflects the relationship between the actual commuting time and commuting satisfaction, but also helps to reveal the specific impact of respondents' subjective commuting-time boundary points on commuting satisfaction.

As shown in Table 3, the average TTCTs for the three commuting groups obtained by clustering were 28.8, 39.0, and 63.7 min, respectively. In addition, the distribution of the TTCTs of the three clustered groups was found to be significantly different ($p < 0.001$) by the *Kruskal–Wallis* non-parametric test, which further illustrates the validity of the clustering. This study refers to the three clusters as "group 1: short-duration-tolerance commuters", "group 2: medium-duration-tolerance commuters", and "group 3: long-duration-tolerance commuters", respectively.

Table 3. Average ICTs, ACTs, and TTCTs for three clustered groups.

Variable	Cluster 1	Cluster 2	Cluster 3	All-Sample Average
Average ICT/min	13.61	21.95	23.84	19.80
Average ACT/min	16.05	40.22	42.55	32.94
Average TTCT/min	28.78	38.89	63.75	43.81

Next, the *random forest algorithm* was used to establish the local dependence relationship between the commuting satisfaction and ACT of each clustered group. In each clustered group, 70% of the samples were used as the training set and 30% of the samples were used as the test set. The goodness-of-fit (variability explained) of the *random forest models* for these three cluster groups was 72%, 84%, and 68%, respectively. As shown in Figure 2b, the commuting satisfaction of group 1 changed slowly before the ACT was 15 min, and decreased in the 15–25 min range; when the ACT exceeded 25 min, the commuting satisfaction decreased significantly. As shown in Figure 2c, the commuting satisfaction of group 2 decreased rapidly when the ACT was about 35 min. However, when the ACT exceeded 40 min, the decrease in commuting satisfaction was significantly weakened, and a slight rebound occurred after 50 min. As shown in Figure 2d, when the ACT was between 20 and 30 min, the commuting satisfaction of group 3 showed an upward trend, and it declined after 45 min. Especially when the ACT exceeded 70 min, the commuting satisfaction sharply declined; this is yet another demonstration of the negative impact of extreme commuting on commuting experience.

These nonlinear threshold effects can be clearly explained from the perspective of commuting individuals' preferences regarding and tolerance of commuting times. The average ICT and TTCT for the short-duration-tolerance commuting group were 13.6 and 28.8 min, respectively, which were close to the time thresholds at which the commuting satisfaction for this group decreased significantly. The average ICT and TTCT for the long-duration-tolerance commuting group were 24 and 63.7 min, respectively, which fell exactly in the rising and falling range of the commuting satisfaction for this group. Similarly, the average TTCT for the medium-duration-tolerance commuting group was 39 min, which coincides with the time threshold for a rapid decrease in commuting satisfaction for this group. The behavioral threshold theory is helpful for analyzing changes in commuting-time satisfaction [40]. The theory contends that commuters have an acceptable or tolerable threshold for commuting times. Different commuter groups may have different tolerance thresholds, so the time-threshold effect of commuting satisfaction is also different.

Firstly, these results show that there was a nonlinear relationship between commuting satisfaction and commuting time. The decline in commuting satisfaction with commuting time exhibited nonlinear characteristics that changed significantly at specific thresholds, and these commuting-time thresholds were very close to the average ICT and TTCT. Secondly, there was a group difference in the nonlinear relationship between commuting satisfaction and commuting time. The commuters who tolerated longer commuting times tended to have a larger time threshold, which affected their commuting satisfaction with a significant decrease. Finally, in the lower range of the actual commuting times, the commuting satisfaction of group 1 did not change significantly, and the commuting satisfaction of group 2 decreased slightly, while the commuting satisfaction of group 3 increased. This suggests that ideal or moderate commuting times have no apparent negative perceived utility for the majority of commuters; instead, there is a positively perceived utility for long-duration-tolerance commuters. Without a different group breakdown of the commuters in terms of actual commuting time, the local characteristics of the positive effect of the commuting time on commuting satisfaction would not be visible. It would also not be possible to capture the time threshold that led to a significant decrease in commuting satisfaction among the different commuting groups.

4.3. The Influencing Factors of the Clustered Group with Different Levels of Commuting Satisfaction

To identify the influencing factors of the clustered groups with different levels of commuting satisfaction, we visualized the average satisfaction and the proportional distribution of the three clustered groups for the commuting mode, job–housing relationship, and individual characteristics. Next, we constructed *a multinominal logistic regression* model to test the statistical significance.

As shown in Table 4, group 3 had the largest proportion of public transport commuters, group 1 had the largest proportion of active commuters, and the proportion of car commuters was the largest in group 2. The four commuting modes in descending order of commute satisfaction were walking and cycling (5.33), e-bikes (4.75), public transportation (4.61), and cars (4.50), which is roughly the same as the conclusions of other studies. Active commuting always results in the highest satisfaction [10,12,73]; sometimes car commuting has the lowest satisfaction [19]; and sometimes public transit commuting has the lowest satisfaction [10,13]. This may be related to regional differences.

Table 4. Sample distribution of three clustered commuter groups.

Variable	Categories	Average Satisfaction	Group 1		Group 2		Group 3	
			Sample	Proportion	Sample	Proportion	Sample	Proportion
Commuting mode	Active (walking, cycling, and shared bicycles)	5.33	114	35.1%	13	9.0%	11	10.1%
	Car (private cars, taxis, and shared cars)	4.50	75	23.1%	61	42.3%	36	33.3%
	E-bikes (e-bicycles, e-mopeds)	4.75	75	23.1%	17	11.8%	14	12.9%
	Public transportation (subway and buses)	4.61	60	18.5%	53	36.8%	47	43.5%
Job–housing distance	Balance (SDTC < 5 km)	4.97	239	73.7%	60	41.6%	51	47.2%
	Mild distance (5 km ≤ SDTC ≤ 9 km)	4.56	64	19.7%	45	31.2%	31	28.7%
	Severe distance (>9 km)	4.30	21	6.4%	39	27.0%	26	24.0%
Gender	Male	4.80	173	53.3%	91	63.1%	64	59.2%
	Female	4.74	151	46.6%	53	36.8%	44	40.7%
Age	18–30 years old	4.81	189	58.3%	60	41.6%	55	50.9%
	31–40 years old	4.77	110	33.9%	64	44.4%	38	35.1%
	41–60 years old	4.61	25	7.7%	20	13.5%	15	13.8%
Education	High school and below	4.98	61	18.8%	23	15.9%	10	9.2%
	College and undergraduate	4.74	242	74.6%	98	68.0%	81	75.0%
	Postgraduate and above	4.67	21	6.4%	23	15.9%	17	15.7%
Monthly income	<RMB 5000	4.78	150	46.2%	61	42.3%	49	45.3%
	RMB 5000–7000	4.90	110	33.9%	36	25.0%	24	22.2%
	>RMB 7000	4.63	64	19.7%	47	32.6%	35	32.4%

The largest proportion of respondents whose job–housing distance was balanced belonged to group 1; the largest proportion of respondents whose job–housing distance was mild belonged to group 2. The average commuting satisfaction of the commuters with a balanced job–housing distance was 4.97; that of commuters with a mild job–housing distance was 4.56; and that of the commuters with a severe job–housing distance was 4.30. These data show that the more balanced the job–housing distance, the higher the commute satisfaction.

The smallest percentage of male respondents belonged to group 1, while the largest percentage of female respondents belonged to group 1. The male respondents had a higher average commute satisfaction than the female respondents. The respondents with high-school degrees and below comprised the largest proportion in group 1 and displayed the highest levels of commute satisfaction; the respondents with postgraduate education comprised the smallest proportion in group 1 and had the lowest commute satisfaction. The proportion of respondents with a personal monthly income of more than RMB 7000 in group 1 was 19.7%, and their commuting satisfaction was 4.63, which was lower than for those with a personal monthly income of less than RMB 7000. In terms of the respondents' ages, group 1 had the largest percentage of respondents aged 18 to 30; the respondents were less satisfied with their commute as they grew older.

The above descriptive statistics show that the respondents with different commuting modes, job–housing relationships, and individual characteristics had different likelihoods of belonging to the different clustered groups, and their average satisfaction was also different.

As shown in Table 5, the *likelihood ratio test* of the model was significant, indicating that the independent variables helped to improve the explanatory power of the model. In addition, the *three pseudo-R-square values* (*McFadden, Cox–Snell, and Negorko*) of the model were 0.140, 0.242, and 0.281, respectively, which showed that the model explains about 20% of the variance of the original variable.

Table 5. The fit information for the model.

Model	Model Fitting Conditions			Likelihood Ratio Test		
	AIC	**BIC**	**–2log**	**Chi-Square**	**Degrees of Freedom**	**Sig.**
Intercept only	789.239	797.951	785.238	NA	NA	NA
The final model	677.983	791.241	625.983	159.256	24	0.000
R^2	*McFadden*			0.140		
	Cox–Snell			0.242		
	Negorko			0.281		

As shown in Table 6, the estimation results of each independent variable in the model were as follows. Compared with group 2, the active commuters were more likely to belong to group 1, and this probability was 7.14 (100/14) times that of the public transport commuters; the e-bike commuters were more likely to belong to group 1, and this probability was 3.45 (100/29) times that of the public transport commuters. Compared with group 1, the probability of active commuters, e-bike commuters, and car commuters belonging to group 3 was 0.133, 0.270, and 0.516 times that of the public transit commuters, respectively. These results suggest that the active commuters were the most likely to comprise the short-duration-tolerance commuting group, followed by the e-bike commuters, while the public-transit commuters were the most likely to be in the long-duration-tolerance commuting group, followed by the car commuters. As shown in Table 7, the survey data also showed that the average ACT and TTCT of the public-transport respondents were 34.2 and 42.6 min; those of the respondents who commuted by e-bike were 22.9 and 36.9 min, while those of the active commuters were 16.9 and 31.9 min.

Compared with group 2, the odds of commuters with a balanced job–housing distance being in group 1 were 5.75 (1000/174) times those of commuters with a severe distance between in their job and their housing; the odds of commuters with a mild job–housing distance being in group 1 were 2.50 (1000/400) times those of commuters with a severe job–housing distance. These results show that the more balanced the job–housing distance for the commuters, the more likely they were to belong to the short-duration-tolerance commuting group. Compared with group 1, commuters with a balanced job–housing relationship were 0.225 times more likely to be in group 3 than commuters with a severe distance between their work and their housing; the odds of commuters with mild job–housing distances being in group 3 were 0.424 times those of commuters with severe job–housing distances, which means that the greater the job–housing distance, the more likely the commuters were to belong to the long-duration-tolerance commuting group. Generally, the greater the job–housing distance, the longer the commuting time. The estimated results are in line with reality. In the survey data, the ACT and TTCT of the respondents with balanced job–housing relationships were 22.8 and 35.8 min, respectively, while those of the respondents with severe job–housing distances were 37.2 and 44.4 min, respectively.

Compared with group 1, the odds of commuters with college and undergraduate degrees being in group 2 or 3 were 0.438 and 0.472 times those of commuters with post-graduate degrees and above. Compared with group 3, the odds of commuters with a high-school degree or below being in group 1 were 4.1 (1000/244) times those of commuters with a Master's degree or doctorate. These results show that the commuters with higher education levels were more likely to be in the long-duration-tolerance commuting group, and the commuters with lower education levels were more likely to be in the short-duration-tolerance commuting group. Compared with group 3, the odds of commuters whose monthly incomes were RMB 5000–7000 being in group 1 were 4.99 (1000/502) times those of commuters whose monthly incomes were more than RMB 7000, which indicates that the lower the monthly income, the more likely the commuters were to be in the short-duration-tolerance commuting group.

Table 6. Results of the multinominal logistic regression model.

Variable	Categories	Group 2			Group 3		
		B	Sig.	Exp(B)	B	Sig.	Exp(B)
Commuting mode	Active (walking, bike, and shared bicycles)	−1.966	0.000	0.140	−2.020	0.000	0.133
	Car (private cars, taxis, and shared cars)	−0.280	0.318	0.756	−0.662	0.030	0.516
	E-bikes (e-bicycles, e-mopeds)	−1.238	0.000	0.290	−1.310	0.000	0.270
	Public transportation (ref.)						
Job–housing distance	Balance	−1.746	0.000	0.174	−1.493	0.000	0.225
	Mild distance	−0.917	0.011	0.400	−0.858	0.028	0.424
	Severe distance (ref.)						
Gender	Male	0.466	0.050	1.594	0.309	0.222	1.363
	Female (ref.)						
Age	18–30 years old	−0.386	0.339	0.680	−0.257	0.551	0.773
	31–40 years old	0.227	0.567	1.255	−0.100	0.816	0.904
	41–60 years old (ref.)						
Education	High school and below	−0.760	0.101	0.468	−1.409	0.008	0.244
	College and undergraduate	−0.825	0.034	0.438	−0.751	0.068	0.472
	Postgraduate and above (ref.)						
Monthly income	<RMB 5000	0.253	0.413	1.287	0.122	0.709	1.129
	RMB 5000–7000	−0.497	0.113	0.608	−0.690	0.045	0.502
	>RMB 7000 (ref.)						
Intercept		1.760	0.001	NA	1.798	0.002	NA

A possible reason behind these results is that most of the low-education and low-income groups are migrant workers in cities in China; they rarely own property in the city and usually choose to rent apartments near their work locations or live in company-provided dormitories; therefore, their commuting times are relatively short, which also leads to a low level of commuting tolerance for this group. This reasoning is supported by the data in Table 7; the ACT and TTCT for the respondents with high-school or technical secondary school degrees were 24.2 and 34.5 min, respectively, which were lower than those for those with a college or university educational background (26.7 and 37.5 min) and those with postgraduate educational background (34.5 and 42.8 min). At the same time, the proportion of respondents with a low level of education and a balanced job–housing distance was 69.1%, which was significantly higher than that of the other two categories (61.0% and 45.9%).

The ACT and TTCT for the respondents with monthly personal incomes of less than RMB 7000 were 26.2 and 37.2 min, respectively, both of which were lower than those with monthly personal incomes of more than RMB 7000 (29.6 and 39.9 min). Meanwhile, the corresponding sample shares for these two categories of respondents with balanced job–housing relationships were 65% and 45.9%, respectively.

The model results also suggest that, compared with group 1, male commuters were more likely to be in group 2, and this probability was 1.594 times that of female commuters. In Chinese family structures, women have more family responsibilities, women are more likely to work close to where they live, which leads to women having shorter commuting times. The proportion of male commuters with severe job–housing distance was 2.9% higher than that of female commuters. The age of the commuters did not show statistical significance, which may have been due to the relatively low age of the respondents. Therefore, the samples could not effectively represent the overall characteristics of the commuters.

Table 7. Average commuting times and job–housing relationships of the different commuting groups.

Index		Average Commuting Time/min			Job–Housing Distance					
					Balance		Mild Distance		Severe Distance	
Variable	Category	ICT	ACT	TTCT	Sample	Proportion	Sample	Proportion	Sample	Proportion
Commuting mode	Active	15.09	16.92	31.92	109	79.0%	22	15.9%	7	5.1%
	Cars	18.25	31.05	38.72	84	48.8%	53	30.9%	35	20.3%
	E-bikes	16.36	22.96	36.89	71	67.0%	26	24.5%	9	8.5%
	Public transit	19.93	34.22	42.72	86	53.8%	39	24.4%	35	21.8%
Education	High school and below	15.22	24.17	34.57	65	69.1%	17	18.1%	12	12.8%
	College and undergraduate	18.15	26.63	37.89	257	61.0%	104	24.7%	60	14.3%
	Postgraduate and above	17.59	34.48	42.79	28	45.9%	19	31.1%	14	23.0%
Monthly income	<RMB 5000	16.96	26.31	37.06	180	69.2%	52	20.0%	28	10.8%
	RMB 5000–7000	17.75	26.06	37.35	103	60.5%	38	22.4%	29	17.1%
	>RMB 7000	18.62	29.55	39.90	67	45.9%	50	34.2%	29	19.9%
Gender	Male	18.33	27.25	38.46	197	60.1%	78	23.8%	53	16.1%
	Female	16.66	26.80	37.08	153	61.7%	62	25.0%	33	13.3%
Job–housing distance	Balance	16.72	22.83	35.74	NA	NA	NA	NA	NA	NA
	Mild distance	17.91	31.41	39.14	NA	NA	NA	NA	NA	NA
	Severe distance	20.75	37.16	44.42	NA	NA	NA	NA	NA	NA

5. Conclusions

This study took Kunming as a case study and revealed the nonlinear relationship between commuting satisfaction and commuting time in both hypothetical situations and actual situations. First, it was found that the nonlinear relationship between commuting satisfaction and hypothetical commuting times differed from that between commuting satisfaction and actual commuting times. Second, the three variables of the ideal commuting time, actual commuting time, and commuting-time tolerance threshold of the commuters were integrated to cluster the samples. On this basis, the random forest algorithm was used to reveal the nonlinear relationship between the commuting satisfaction and actual commuting times of the different clustered groups. Furthermore, from the perspectives of their preferences regarding and tolerance of commuting times, the threshold effect of the commuting times on commuting satisfaction was analyzed. Thirdly, some factors that could explain why the nonlinear relationship between commuting satisfaction and commuting time had group differences were extracted.

The conclusions of this study are as follows. Firstly, there was a nonlinear relationship between the commuting satisfaction and commuting times in both the hypothetical and actual situations, but their respective nonlinear features were not consistent. Specifically, the commuting satisfaction was better when the hypothetical commuting times were 0 and 15 min, and there was a slight increase in the range of 0–15 min; when the hypothetical commuting time increased from 30 to 45 min, the commuting satisfaction decreased significantly. In the actual situation, the commuting satisfaction of the whole sample tended to decrease slowly in the range of actual commuting times of 0–15 min, while there was a rapid decrease in the range of 22–28 min, with a continued decrease after the actual commuting time of 30 min, but at a slower rate. It was therefore concluded that the positive effects of moderate or ideal commuting times on commuting satisfaction only apply to a minority of commuters.

Secondly, there was a group difference in the nonlinear relationship between commuting satisfaction and actual commuting times. The commuting satisfaction of the short-duration-tolerance commuting group did not change significantly at 0–15 min, tended to decline above 15 min, and decreased significantly beyond 25 min. The commuting satisfaction of the medium-duration-tolerance commuting group decreased significantly at 35 min. The commuting satisfaction of the long-duration-tolerance commuting group increased with the actual commuting time (20–30 min), then fluctuated downwards (30–60 min), and decreased sharply when the actual commuting time exceeded 70 min. It follows that, when the actual commuting time was within the range of ideal commuting times, the perceived satisfaction of the short-duration-tolerance commuters remained largely unchanged, while the perceived satisfaction of the long-duration-tolerance commuters increased; when the actual commuting time exceeded the tolerance threshold, the perceived satisfaction of three clustered groups was severely reduced; as expected, extreme commuting led to very negative perceived experiences.

Finally, the study also concluded that variables such as the commuting mode, job–housing relationship, and individual characteristics provided significant explanations for differences in commuting satisfaction in the clustered group. The commuters who used active commuting modes, those with balanced job–housing relationships, and commuters with lower levels of education were the most likely to be in the short-duration-tolerance commuting group. Conversely, the commuters who used public transportation, those with severe job–housing distance, and highly educated commuters were the most likely to be long-duration-tolerant commuters.

The policy implications obtained from the conclusions are as follows. First, the results of the hypothetical situational experiment show that since the respondents reported a positive response to the 0 min of hypothetical commuting time, we can try to implement some moderate telecommuting systems to test whether remote working helps to improve commuting satisfaction and subjective well-being. Additionally, a dynamic evaluation of the effect of implementing remote work could be conducted to identify whether people's commuting demands are different in the short, medium, long term, as well as during the epidemic (a special period), which will help to provide policy advice for policymakers to formulate mechanisms for telecommuting.

Second, it is important to plan a commuting circle based on the time-threshold effect of nonlinear changes in commuting satisfaction, to try to use the commuting time tolerance threshold as a constraint boundary, and to move as close as possible to ideal commuting times.

Lastly, according to the group differences in the commuting-time satisfaction and its influencing factors, different strategies should be adopted for different commuting groups when formulating policies for urban transport optimization. For example, the commuting quality of the short-duration -tolerant commuters, most of whom live and work in the same area and use active commuting, may be further improved by enhancing the soft and hard facilities of the active travel system; for the long-duration -tolerant commuters, most of whom have a significant distance between their work and housing and use public transport to commute, the operation and service level of public transport could be improved in the short term to reduce their commuting pressure, and the allocation of resources could be optimized in the long term to achieve a relative balance between work and housing.

The limitation of this study is that the representativeness of the sample was not strong. For example, the proportion of commuters over 40 years old was slightly lower and the proportion of commuters with low education was also relatively small, which is related to the selection of commercial complexes as the survey locations. The method of approaching the respondents needs to be improved to ensure that the sample better captures the overall characteristics of commuters. The two surveys (May 2020 and January 2021) were both conducted in the urban area of Kunming, which inevitably resulted in a respondent answering the same questionnaire twice. Trying to avoid such survey issues could help to improve the data quality. Additionally, there are differences in transportation policies and commuting systems in different cities, which means that the perceived satisfaction of commuters in different cities may also be different. It would be interesting to explore the heterogeneity of commuting satisfaction in cities of different scales and its influencing factors.

Furthermore, this study only focused on the threshold effect of commuting satisfaction for different groups in terms of commuting time. In the future, the complex relationship between the commuting satisfaction and commuting times of different groups, including different commuting modes (especially multimodal commuting), different job–housing distances, and different built environments, could be explored. These studies will have potential value for the formulation of differentiated and humanistic urban transport policies.

It should also be added that future research could explore the correlation between commuting satisfaction and perceived utility; if the correlation is strong, the nonlinear characteristics of commuting satisfaction can be drawn upon to modify the perceived utility function, which may facilitate research on commuting-mode-choice behavior or the mutual transfer of commuting modes.

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