

Campus relocation as a natural experiment to investigate the determinants of commuting satisfaction

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ABSTRACT

A growing body of research has been devoted to studying factors associated with commuting satisfaction, but few studies have examined the causal relationship between them. Opening a new university campus, a typical case of workplace relocation, provides a natural experiment opportunity to study the causal relationship between commuting satisfaction and its determinants. We conducted a retrospective survey of staff at a university in Hangzhou, China, where a campus relocation occurred, assessed the changes in commuting characteristics and satisfaction before and after the relocation, and investigated the determinants of the change in commuting satisfaction using ordered logistic regression. The findings indicate that commuting satisfaction generally decreases after outward campus relocation. The determinants of commuting satisfaction include commuting time, frequency, mode availability, mode preference, travel attitudes, and socioeconomic attributes. Commuting mode availability negatively impacts commuting satisfaction. Primary commuting mode preference fully mediates the impact of primary commuting mode on commuting satisfaction. We offered suggestions for transportation policy and planning to improve commuting satisfaction.

1. Introduction

The literature on commuting satisfaction has increasingly focused on factors that influence commuting satisfaction (De Vos et al., 2019). Studies have confirmed that trip characteristics (e.g., mode, time), travel attitudes (e.g., pro-travel, pro-driving), and socioeconomic attributes (e.g., age, income) are related to commuting satisfaction (Abenoza et al., 2019; Echiburú et al., 2021; Handy and Thigpen, 2019; Kim et al., 2014; Mao et al., 2016; Olsson et al., 2013; St-Louis et al., 2014; Ye and Titheridge, 2016). However, most findings are based on cross-sectional studies, raising concerns about causality (Chatterjee et al., 2020).

Recent studies have used natural experiment opportunities provided by residential or workplace relocation to explore the causal relationship between commuting satisfaction and its determinants (De Vos et al., 2019; Gerber et al., 2020; Schneider and Willman, 2019). The research results have shown that the change in commuting mode, time, and mode-specific travel attitudes affect commuting satisfaction. Although studies have considered mode-specific travel attitudes, such as pro-bike and pro-public transit, they have included these variables directly into the model regardless of whether the mode was the respondents' actual commuting mode. This approach may bias the estimation of the

variable's true impact. Besides, the impact of commuting mode availability on commuting satisfaction has not been fully discussed, particularly within the framework of causal inference.

University campus relocation is a typical case of workplace relocation, which is involuntary, irregular, and specific (Sprumont et al., 2020) and can be considered an exogenous life event for university staff (Zarabi and Lord, 2019). In this study, we used university campus relocation as a natural experiment and used quasi-longitudinal data to explore the change in commuting satisfaction and its determinants. The contributions of this study lie in the following distinguishing features: 1) take university campus relocation as a natural experiment to reveal possible causal relationships between the change in commuting satisfaction and its determinants; 2) use a retrospective survey design to collect quasi-longitudinal data while minimizing respondents' recall bias; 3) investigate the impact of primary commuting mode preference and commuting mode availability on commuting satisfaction. Finally, this study provides more comprehensive and compelling evidence for improving university staff's commuting satisfaction.

The remainder of this study is organized as follows. The next section reviews literature related to commuting satisfaction. Section 3 presents the study case, conceptual model, data, and analysis method. Section 4

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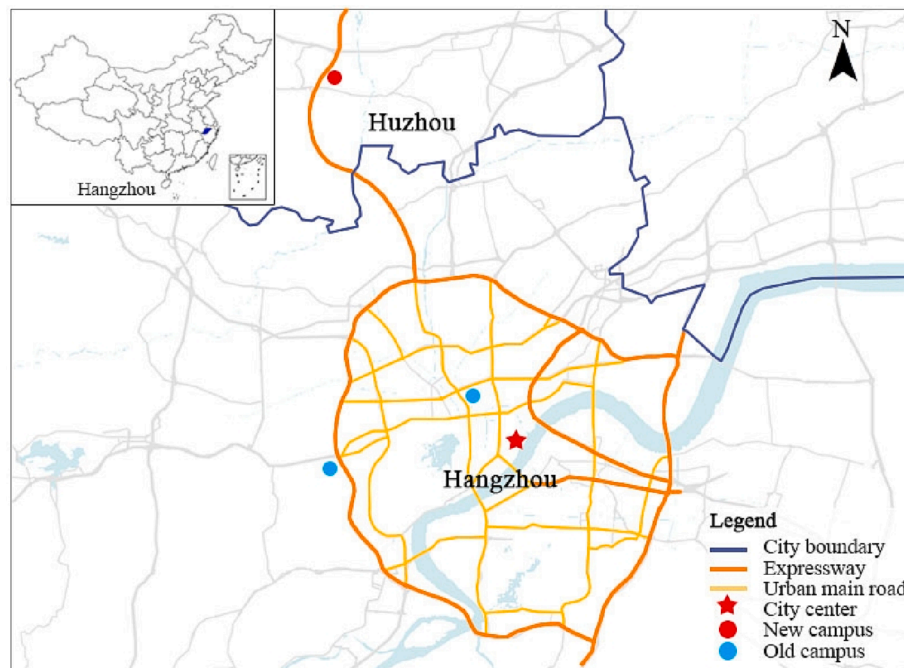


Fig. 1. Map of the study area.

presents the analysis and discussion of the findings. The last section makes conclusions.

2. Literature review

This section reviews the literature on commuting satisfaction. We focus on the influencing factors of commuting satisfaction and natural experiments in commuting satisfaction studies.

2.1. Influencing factors of commuting satisfaction

Commuting satisfaction is an important component of daily travel satisfaction. A growing number of studies have been dedicated to exploring the influencing factors of commuting satisfaction. In terms of travel characteristics, most studies have found that commuting time and distance have a negative effect on commuting satisfaction (Christopher et al., 2018; Ettema et al., 2012; Handy and Thigpen, 2019; St-Louis et al., 2014; Stone and Schneider, 2016), while some studies have suggested that the effect of commuting time on commuting satisfaction may be overestimated, as it may be mediated by commuters' ideal commuting time (Ye et al., 2020). Moreover, commuting mode has an impact on commuting satisfaction. Despite the different research contexts, most studies have suggested that active mode commuters are more satisfied than motorized mode commuters (Handy and Thigpen, 2019; Mao et al., 2016; Olsson et al., 2013; St-Louis et al., 2014), and car commuters are more satisfied than public transit commuters. However, these results are inconsistent. Zhu and Fan (2018) found no differences in commuting satisfaction among bicycle, metro, and car users in Xi'an, China.

Travel attitudes, which include attitudes toward travel in general (e.g., travel-liking attitude) and specific travel modes (e.g., preference for the car mode), have impacts on commuting satisfaction (Deng and Zhao, 2021). Several studies have found that people with positive attitudes toward commuting are more satisfied with their commute than those with negative attitudes, regardless of commuting mode (Gerber et al., 2020; St-Louis et al., 2014; Ye and Titheridge, 2016). When people cannot use their preferred commuting mode, their commuting satisfaction decreases (Ye and Titheridge, 2019). Travel attitudes not only have

a direct impact on commuting satisfaction but also have an indirect impact on commuting satisfaction through commuting mode choice (Ye and Titheridge, 2016).

Individual and household socioeconomic attributes usually have a weaker impact on commuting satisfaction than commuting characteristics and travel attitudes. Some studies have found that female, younger, less healthy, or higher-income commuters are less satisfied with their commutes (Handy and Thigpen, 2019; Lades et al., 2020; Ye and Titheridge, 2016; Zhu and Fan, 2018). Other studies have found that age, gender, and education have no significant effect on commuting satisfaction (de Kruijf et al., 2019; Olsson et al., 2013).

We considered socioeconomic attributes, travel attitudes, and commuting characteristics as determinants and focused on the impact of commuting mode attitudes and availability on commuting satisfaction. We argue that attitudes toward a particular commuting mode have a limited impact on commuting satisfaction if commuters do not use that mode. Including such a variable in the model for all commuters may bias the estimation of the variable's true impact, potentially contributing to the inconsistent results in previous studies on the effect of commuting modes and mode-specific travel attitudes on commuting satisfaction. Ye and Titheridge (2019) revealed that a mismatch between commuting mode choice and travel attitudes reduces commuting satisfaction. However, they only used a dummy variable called "mismatch" to indicate whether commuters had negative attitudes toward their commuting mode. This approach is likely too simplistic to capture the full impact of commuting mode preference, as even negative attitudes can vary in degree. Besides, we argue that commuting mode availability may also affect commuting satisfaction. Only one study has focused on the effect of commuting mode availability on commuting satisfaction (Handy and Thigpen, 2019). However, commuting availability was only represented by a dummy variable of "mode constrained" to indicate whether commuters had only one mode available for commuting in that study. The effect of the number of available modes on commuting satisfaction was not specifically discussed.

2.2. Natural experiments in commuting satisfaction studies

Natural experiments have been used as a method to explore the

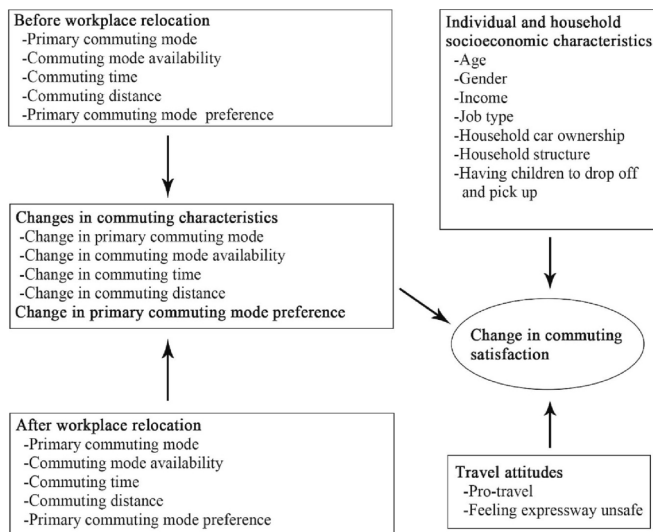


Fig. 2. Conceptual model.

causal relationship between commuting satisfaction and its determinants. Existing studies have used naturally occurring movements of individuals in different environments, such as workplace or residential relocation, as natural experiments (Lee et al., 2022). Rau et al. (2019) found a significant decrease in employees' commuting satisfaction associated with intra-city workplace relocation in Munich, Germany. They argued that intra-city workplace relocation disrupts employees' commuting habits, negatively impacting commuting satisfaction. Gerber et al. (2020) reported an increase in employees' commuting satisfaction after their workplace moved to the city center of Montréal, Canada, due to greater accessibility to all transportation modes. They also found that a reduction in commuting time contributes to higher commuting satisfaction. De Vos et al. (2019) and Wang et al. (2020) focused on residential relocation and analyzed daily trips, including commuting. The results suggested that improved travel satisfaction is associated with a decrease in commuting distance, time, the use of non-motorized travel modes (De Vos et al., 2019), and living environment (Wang et al., 2020). By analyzing the change in commuting satisfaction reported in the campus travel survey, Schneider and Willman (2019) found that commuters with shorter commuting distances and those who switched commuting modes from motor vehicles to walking or biking are more likely to report higher commuting satisfaction after moving.

We used quasi-longitudinal data to reveal the causal relationship between commuting satisfaction and its determinants. Quasi-longitudinal data offers advantages for clarifying causal relationships, similar to genuine panel data, but are more obtainable (Deng and Zhao, 2022). However, quasi-longitudinal data have disadvantages, such as recall bias, which requires a careful survey design to reduce bias.

3. Data and methodology

3.1. Study case

The participants in this study were university staff of *** University in Hangzhou, China, who had relocated to a new campus for work. Fig. 1 shows a map of the study area. The new campus, which opened in September 2020, is located in Huzhou, 38.1 km from the center of Hangzhou. The two old campuses are both located in Hangzhou, 6.8 km and 16.4 km from the city center, respectively. Hangzhou and Huzhou are connected by highway, but there is no public transit connection. The majority of the university staff who relocated to the new campus for work still lived in Hangzhou and commuted by university buses and cars.

Table 1
Sample characteristics.

| Variable | Mean/ Cases | Std. dev./ Percentage |
|---|----------------|--------------------------|
| Socioeconomic characteristics | | |
| Age | 39.8 | 8.1 |
| Gender | | |
| Female | 70 | 40.2% |
| Male | 104 | 59.8% |
| Income (In thousand Yuan) | 180.0 | 6.5 |
| Job type | | |
| Teaching/Scientific research | 132 | 75.9% |
| Administration/Management | 42 | 24.1% |
| Household car ownership | 0.9 | 0.6 |
| Household structure | | |
| One generation | 54 | 31.0% |
| Two generations | 71 | 40.8% |
| Three generations | 49 | 28.2% |
| Having children to drop off and pick up | | |
| No | 84 | 48.3% |
| Yes | 90 | 51.7% |
| Travel attitudes | | |
| Pro-travel | 2.9 | 1.1 |
| Feel expressway unsafe | 4.3 | 1.0 |
| Change in primary commuting mode preference | -0.3 | 1.4 |
| Change in commuting characteristics | | |
| Change in commuting time (min) | 49.9 | 29.9 |
| Change in commuting distance (km) | 32.6 | 5.0 |
| Change in commuting frequency to the new campus | 4.0 | 1.5 |
| Change in commuting frequency to the old campuses | -3.2 | 2.5 |
| Change in commuting mode availability | -0.4 | 1.1 |
| Primary commuting mode shift | | |
| No change | 48 | 27.5% |
| Car to public transit | 36 | 20.7% |
| Active modes of public transit | 77 | 44.3% |
| Active modes/public transit to car | 13 | 7.5% |
| Change in commuting satisfaction | | |
| No change | 37 | 21.3% |
| One-level decrease | 29 | 16.7% |
| Two-level decrease | 28 | 16.1% |
| Three-level decrease | 21 | 12.1% |
| Four-level decrease | 20 | 11.5% |
| Five-level decrease | 16 | 9.2% |
| Six-level decrease | 23 | 13.2% |

3.2. Conceptual model

Fig. 2 shows the conceptual model of the relationship between the change in commuting satisfaction and its determinants, which include the change in commuting characteristics, travel attitudes, and individual and household socioeconomic characteristics. Because the new campus opened less than one year ago, we assumed that individual and household socioeconomic characteristics and travel attitudes did not change during campus relocation.

3.3. Data

We adopted a retrospective survey to obtain quasi-longitudinal data. The survey was conducted from May 18 to June 4, 2021, and a total of 231 relocated university staff (35% of total relocated university staff) participated. The questionnaire was distributed in official chat groups that included all relocated university staff. To address potential sample bias due to varying willingness to complete the online questionnaire, we employed three measures to encourage participation: first, we offered a monetary reward for completing the questionnaire; second, university officials urged staff in the official chat groups to participate, as the survey was supported by university officials as part of the university staff commuting improvement project; and third, university officials provided us with a list of all relocated university staff, including their

names, genders, and ages. We supplemented the online questionnaire with some offline face-to-face surveys to include staff who did not participate in the online survey and to ensure the sample's gender and age distribution was more representative of the population. The questionnaire consists of four parts: individual and household socioeconomic characteristics, travel attitudes, commuting characteristics and satisfaction after relocation, and commuting characteristics and satisfaction before relocation. Respondents were required to answer after-relocation questions about their current commute and before-relocation questions about their previous commute. Although retrospective surveys have been criticized for being unreliable due to inaccurate memories of prior travel behaviors, we believe their memories in this study were largely reliable for two reasons. First, the time between the opening of the new campus and the survey was relatively short (eight months). Second, although the university staff had moved to the new campus, they sometimes had to commute to the old campuses because many administrative services, meetings, and some classes were still on the old campuses; their previous commute continued. After data cleaning, 174 questionnaires (26% of the total relocated university staff) remained. The sample's gender and age distributions were very similar to the population's gender and age distributions, ensuring population representation to some extent. The sample size is greater than ten times the number of variables and fulfills the rule of thumb of having at least ten observations for each variable in the regression analysis.

3.4. Variables

The descriptive statistics of variables are shown in Table 1 and Table A1. Table 1 shows the variables included in the model, and Table A1 displays the variables not included in the model but used to calculate the variables in Table 1. Individual and household socioeconomic characteristics include age, gender, income, job type, household car ownership, household structure, and having children to drop off and pick up. These variables are directly included in the model.

Travel attitudes include the following statements: (1) I like traveling (abbreviated as pro-travel); (2) I like driving (abbreviated as pro-driving); (3) My travels require driving (abbreviated as require driving); (4) I feel unsafe traveling on expressways (abbreviated as feeling expressway unsafe); (5) I like taking public transit (abbreviated as pro-public transit); (6) I like taking university buses (abbreviated as a pro-university bus); (7) I like active modes (abbreviated as pro-active modes). All these travel attitudes were measured using a five-point Likert Scale to quantify respondents' degree of agreement (from 1 strongly disagree to 5 strongly agree). Among these travel attitudes, the scores of pro-travel and feeling expressways unsafe were directly included in the model. The other five travel attitudes were used to create a new variable called primary commuting mode preference, calculated as follows: if an individual chooses a car as their primary commuting mode, the variable takes the mean value of the scores of pro-driving and require driving; if public transit is chosen, the variable takes the mean value of the scores of pro-public transit and pro-university bus; if active modes are chosen, the variable takes the score of pro-active modes. After campus relocation, people's primary commuting modes may change, and their primary commuting mode preference may change accordingly. For example, if the primary commuting mode changes from public transit to car, the change in primary commuting mode preference equals the difference between the preference for public transit and the preference for cars. The change in primary commuting mode preference was included in the model. As shown in Table 1, respondents' primary commuting mode preference decreases after relocation, suggesting that respondents' primary commuting mode choices may be constrained.

Commuting characteristics include commuting frequency, time, distance, mode availability, and primary commuting mode. Commuting frequency and time were reported by respondents. Commuting distance was calculated using an online map application based on the respondents' reported residential locations and the campuses where they

worked. Commuting mode availability was calculated by counting the number of commuting modes used by respondents. These variables were used to calculate the change in commuting frequency to the new campus, change in commuting frequency to the old campuses, change in commuting time, change in commuting distance, and change in commuting mode availability, all of which were included in the model. As shown in Table 1, respondents' commuting time and distance greatly increase, while commuting mode availability decreases after campus relocation. There are nine options for primary commuting modes. We merged these primary commuting modes into active modes (including bike/e-bike and walking), public transit (including metro, intercity rail, bus, and university bus), and car (including private car, carpooling with colleagues, and taxi/online car-hailing) because some minor commuting modes were rarely chosen. Before campus relocation, active mode, public transit, and car account for 47.1%, 23.0%, and 29.9% of primary commuting modes, respectively, while after campus relocation, public transit (83.9%) and car (16.1%) dominate primary commuting modes. We then included a new variable called primary commuting mode shift in the model, which had four options: no change (27.5%), car to public transit (20.7%), active modes to public transit (44.3%), and active modes or public transit to car (7.5%).

Commuting satisfaction was measured with a seven-point Likert scale based on the degree of agreement (from 1 "strongly disagree" to 7 "strongly agree") with the statement "Overall, I am very satisfied with my commuting before/after relocation." A total of 78.7% of respondents reported their commuting satisfaction decreased after campus relocation, while 21.3% felt no change. The change in commuting satisfaction is taken as the dependent variable in the model, which has seven levels, from no change to a six-level decrease.

3.5. Methodology

In this study, we used an ordered logistic regression model to investigate the determinants of the change in commuting satisfaction. The dependent variable is the change in commuting satisfaction. Theoretically, the true value of commuting satisfaction should be in a continuous range, as well as the true value of the change in commuting satisfaction (y^*). The formula of the model is as follows:

$$y^* = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \tag{1}$$

where y^* is the true value of the change in commuting satisfaction. x_1 is the vector of the socioeconomic variables; x_2 is the vector of the travel attitude variables; x_3 is the vector of the change in commuting characteristic variables; $\beta_1, \beta_2, \beta_3$ are the vectors of regression coefficients.

However, for the feasibility of the survey, the observed value of commuting satisfaction was ordered categorically with seven levels, which is a censored version of the true commuting satisfaction. Similarly, the observed value of the change in commuting satisfaction (y) was an ordered categorical variable in seven groups, coded as 6 for no change, 5 for a one-level decrease, 4 for a two-level decrease, 3 for a three-level decrease, 2 for a four-level decrease, 1 for a five-level decrease, and 0 for a six-level decrease. Because the true value of the dependent variable is not measured, different scaling values were used.

$$y = \begin{cases} 0, & \text{if } y^* \leq \mu_1 \\ 1, & \text{if } \mu_1 < y^* \leq \mu_2 \\ 2, & \text{if } \mu_2 < y^* \leq \mu_3 \\ \dots & \\ 6, & \text{if } \mu_6 < y^* \leq \mu_7 \end{cases} \tag{2}$$

where Δy is the observed dependent variable. $\mu_1, \mu_2, \dots, \mu_7$ are threshold values for each level. The coefficients $\beta_1, \beta_2, \beta_3$ and the thresholds $\mu_1, \mu_2, \dots, \mu_7$ can be estimated using maximum likelihood estimation.

Table 2
Model results.

| Variables | Coefficient | z value |
|--|-------------|---------|
| Having children to drop off and pick up (Ref: No) | -0.572* | -1.937 |
| Pro-travel | 0.419** | 2.859 |
| Feeling expressway unsafe | -0.434** | -2.616 |
| Change in primary commuting mode preference | 0.238* | 1.989 |
| Change in commuting time | -0.012o | -2.285 |
| Change in commuting frequency to the new campus | -0.156o | -1.674 |
| Change in commuting frequency to the old campus | 0.141* | 2.411 |
| Change in commuting mode availability | -0.245o | -1.898 |
| Thresholds | | |
| Threshold 1 (six-level decrease five-level decrease) | -4.884 | -4.688 |
| Threshold 2 (five-level decrease four-level decrease) | -4.074 | -3.990 |
| Threshold 3 (four-level decrease three-level decrease) | -3.342 | -3.312 |
| Threshold 4 (three-level decrease two-level decrease) | -2.716 | -2.707 |
| Threshold 5 (two-level decrease one-level decrease) | -1.851 | -1.857 |
| Threshold 6 (one-level decrease no change) | -0.722 | -0.733 |

** , * , o denote significance at the 0.01, 0.05, and 0.1 levels, respectively.

4. Results and discussion

Table 2 shows the final model results. Initially, fifteen independent variables were included in the model. After stepwise regression based on the Akaike Information Criterion (AIC), eight variables remained. The AIC for the final model was 597.8, and the McFadden pseudo R² was 0.10.

4.1. Effects of socioeconomic characteristics and travel attitudes

The majority of socioeconomic characteristics (age, gender, job type, household structure, and household car ownership) have no significant impact on commuting satisfaction. Having children to drop off and pick up lead to a decrease in commuting satisfaction. [Rau et al. \(2019\)](#) found that when commutes lengthen due to workplace relocation, commuters who need to pick up and drop off their children may find it difficult to incorporate these family-oriented trips into their commute, leading to decreased commuting satisfaction. Furthermore, a study in Beijing showed that employees with school-aged children are more likely to quit their jobs following an involuntary suburban workplace relocation ([Qu et al., 2021](#)).

All three travel attitude variables significantly impact commuting satisfaction. A pro-travel attitude is associated with a smaller decline in commuting satisfaction. [Ye and Titheridge \(2016\)](#) and [De Vos and Witlox \(2016\)](#) also found that people with positive attitudes towards travel are more satisfied with their commutes than those who dislike travel. Feeling unsafe on expressway correlate with a decrease in commuting satisfaction. [Ettema et al. \(2013\)](#) found that the perceived lack of safety is negatively associated with commuting satisfaction. A decrease in primary commuting mode preference leads to reducing in commuting satisfaction. Since we assumed that people’s travel mode preferences do not change over time, this decrease resulted from people switching from a more preferred mode to a less preferred mode. [Handy and Thigpen \(2019\)](#) and [St-Louis et al. \(2014\)](#) found that enjoying one’s usual commuting mode is associated with higher commuting satisfaction. [De Vos et al. \(2016\)](#) reported similar results for all travels: a positive attitude toward a specific travel mode positively influences travel satisfaction when using that mode.

4.2. Effects of commuting characteristics

An increase in commuting time leads to a decrease in commuting satisfaction. The negative impact of commuting time on commuting satisfaction has been widely acknowledged by previous studies ([Ettema et al., 2012](#); [Olsson et al., 2013](#)). The impact of commuting distance on commuting satisfaction is insignificant, consistent with previous studies ([Echiburú et al., 2021](#); [Lunke, 2020](#)). Since commuting distance is highly

correlated with commuting time, the impact of commuting distance on commuting satisfaction is largely represented by commuting time. An increase in commuting frequency to the new campus decrease commuting satisfaction, while an increase in commuting frequency to the old campuses increases commuting satisfaction. As the survey indicates, respondents were far less satisfied with their commute to the new campus than their commute to the old campuses; more commutes to the new campus and fewer to the old campuses led to decreased commuting satisfaction.

The change in primary commuting mode does not affect commuting satisfaction, inconsistent with previous studies ([Gerber et al., 2020](#); [Schneider and Willman, 2019](#); [Ye and Titheridge, 2016](#)). Some of these studies did not consider mode-specific travel attitudes ([Gerber et al., 2020](#); [Schneider and Willman, 2019](#)). Others included mode-specific travel attitudes such as pro-walking, pro-bike, pro-public transit, and pro-car directly into the model, regardless of whether the mode was the respondents’ actual commuting mode ([Ye and Titheridge, 2016](#)). The findings of these studies may be influenced by unrelated travel attitude variables. In this study, we created a primary commuting mode preference variable by matching mode-specific attitudes with actual commuting modes, eliminating the effects of unrelated variables. When we removed the variable of the change in primary commuting mode preference in the model, the variable of the change in primary commuting mode becomes significant. This suggests that the impact of the primary commuting mode on commuting satisfaction is completely mediated by the primary commuting mode preference. It is not the primary commuting mode itself, but rather the primary commuting mode preference, that influences commuting satisfaction. It is worth noting that in this study, the relocation was outward, leading to a lopsided change in commuting mode—no one shifted to active modes after relocation. This could be a potential concern regarding the results. The survey results show that the preference for active modes is the highest, followed by university buses, public transit, and car. Previous studies suggested that people who walk or cycle to work are generally more satisfied with their commute than those who travel by car, especially public transit users ([Chatterjee et al., 2020](#)). The ranking of people’s preferences for different travel modes is consistent with the ranking of the impact of different travel modes on satisfaction in previous research. We argue that results about the impact of different modes on commuting satisfaction may be biased if travel mode preferences are not properly accounted for in the model.

A decrease in commuting mode availability leads to a less decline in commuting satisfaction. Commuting mode availability refers to actual commuting modes respondents have used, rather than all potentially available modes. There are two possible reasons. One is that commuters have limited mode choices due to limited transportation options around their homes or workplaces, and they have less experience with competing modes, thus achieving higher commuting satisfaction. Similar results were obtained by [Handy and Thigpen \(2019\)](#) in Davis, U. S. They claimed that commuters with limited commuting mode choices are more satisfied with their commutes. The other reason is that commuters had various commuting mode choices around their homes and workplaces, but they used only one or a few of the available commuting modes because of the obvious advantages these commuting modes had over other potential alternatives. These commuters may have higher commuting satisfaction than those who have used various commuting modes and have to go through choice and rationalization processes because no commuting mode has a clear advantage.

5. Conclusion and implications

Taking campus relocation as a natural experiment, this study explored the determinants of commuting satisfaction based on quasi-longitudinal data. The results show that commuting satisfaction was influenced by commuting characteristics (i.e., time, frequency, and mode availability), travel attitudes (i.e., pro-travel, feeling expressway

Table A1
Sample characteristics.

| Variable | Mean/ Cases | Std. dev./ Percentage |
|--|----------------|--------------------------|
| Travel attitudes | | |
| Pro-drive | 2.7 | 1.2 |
| Require-driving | 3.2 | 1.2 |
| Pro-public transit | 3.0 | 1.1 |
| Pro-university bus | 3.3 | 1.2 |
| Pro-active modes | 3.5 | 1.2 |
| Primary commuting mode preference (before) | 3.7 | 1.0 |
| Primary commuting mode preference (after) | 3.4 | 1.0 |
| Commuting characteristics | | |
| Commuting time (before) (min) | 25.6 | 17.9 |
| Commuting time (after) (min) | 75.5 | 32.6 |
| Commuting distance (before) (km) | 6.8 | 7.2 |
| Commuting distance (after) (km) | 39.4 | 6.8 |
| Commuting frequency to the old campuses (before) | 4.9 | 1.8 |
| Commuting frequency to the old campuses (after) | 1.7 | 2.0 |
| Commuting frequency to the new campus (after) | 4.0 | 1.5 |
| Primary commuting mode (before) | | |
| Walking | 22 | 12.6% |
| Bike/E-bike | 60 | 34.5% |
| Bus | 18 | 10.3% |
| Metro | 8 | 4.6% |
| University bus | 14 | 8.0% |
| Private car | 50 | 28.7% |
| Carpooling with colleagues | 1 | 0.6% |
| Taxi/online car-hailing | 1 | 0.6% |
| Primary commuting mode (after) | | |
| University bus | 145 | 83.3% |
| Private car | 27 | 15.5% |
| Carpooling with colleagues | 1 | 0.6% |
| Intercity railway | 1 | 0.6% |
| Commuting mode availability (before) | 1.9 | 1.1 |
| Commuting mode availability (after) | 1.5 | 0.7 |
| Commuting satisfaction | | |
| Commuting satisfaction (before) | 5.6 | 1.5 |
| Commuting satisfaction (after) | 3.1 | 1.8 |

unsafe, and mode preference), and socioeconomic characteristics (i.e., having children to drop off and pick up). The most interesting findings are that the commuting mode available has a negative impact on commuting satisfaction and that it is not a certain commuting mode but the preference of that commuting mode that determines commuting satisfaction.

These findings have important implications for urban planning and transportation policy-making. First, we found that commuting time has a negative impact on commuting satisfaction. In campus relocations or other government-led workplace relocations, public sectors should consider the distance between new workplaces and residential areas and city centers or provide housing and amenities within accessible distances of new workplaces. Second, although we found that travel mode does not have a significant impact on commuting satisfaction, people's travel mode preferences do. Since people have the highest preference for active modes, followed by university buses, public transit, and cars, providing university staff with convenient university bus service is an important way to improve commuting satisfaction. University bus operators can reduce journey times by matching bus stops with staff's residences and make journey times feel shorter by providing WiFi services for ICT needs. Third, university staff should not bear the costs of long commutes because they did not voluntarily relocate to the new campus. Providing work and meeting places on the old campuses as remote work centers and low-cost hotels on the new campus as accommodations when working late can reduce commutes to the new campus, thus improving commuting satisfaction.

There are two limitations to this study. First, as we used a university campus relocation as a natural experiment, this study only covered one

region and had a small sample size. More studies on university campus relocation and other involuntary workplace relocations are needed to verify whether the findings vary by contextual characteristics, including geographical environment, social atmosphere, and cultural norms. Second, we adopted a retrospective survey design. Although the continuation of the previous commute can reduce respondents' recall bias, it cannot eliminate it. Besides, travel attitudes were regarded as stable over time in the retrospective survey design, ignoring people's learning process of adjusting attitudes to match behaviors in new environments. Future research will benefit from genuine panel data to overcome this limitation.

CRediT authorship contribution statement

Yiling Deng: Conceptualization, Formal analysis, Funding acquisition, Methodology, Writing – review & editing. **Weini Li:** Investigation, Data curation, Formal analysis, Writing – original draft. **Mengwei Chen:** Conceptualization, Writing – review & editing, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

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