Analysis of Urban Traffic Engineering Planning Based on Travel Well-being

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Abstract. Traffic engineering system is one of the most important infrastructure in urban. The built environment and operation impact everyday life in urban. In order to build modern integrated transportation system of “One Belt and One Road”, travel well-being should be taken into consideration. Ordered logit models were built in this paper to find the pain points of traffic engineering design. Some recommendations were offered to improve the whole quality and efficiency of transportation system.

1. Introduction
Positive psychology, created by some famous psychologists like Martin E.P. Seligman, points out that people who are often in positive emotions are more likely to succeed in all aspects of life, such as marriage, friendship, health and career (Achat et al., 2000; Lyubomirsky, King, and Diener, 2005). Positive emotions are conducive to social intercourse and self-development, and can even prevent psychological disorders such as depression (Lyubomirsky, King, and Diener, 2005). Therefore, the focus of well-being is not only beneficial to individual development, but also help to improve people’s creativity and create a harmonious and healthy social environment. As a daily activity, travel’s well-being affects people’s life and development, especially the residents who face long-distance and long-term commuting every day in the first-tier city. With the increasing number of private cars, “Road rage” has attracted great attention. According to a survey in “Zhejiang Daily”, 23.4% of the respondents admitted to belonging to “Road rage” group. And 76.1% admitted to being anxious in traffic jam. Therefore, the analysis of travel well-being can effectively guide the planning of transportation and make transportation policy, which play a positive role in building a "people-oriented" transportation system. Policy-makers can improve the travel environment according to the bottlenecks that bring people negative emotions. They can also evaluate the effectiveness of the traffic policies on the perspective of travel well-being.

Travel well-being includes two dimensions, cognitive evaluation and emotions. Many empirical studies measuring those two dimensions were conducted in Europe and America. And they mainly focus on the influencing factors of travel well-being. There is a general dearth of literature on the empirical analysis of travel well-being in China. And most of them only consider cognitive evaluation, ignoring the emotions during the travel experience. Additionally, multiple dimensions’ satisfactions of cognitive evaluation have not been considered in the existing scale of travel well-being. Therefore, this paper uses multiple city data establishing regression equation to analyse the influencing factors of travel well-being in various dimensions.
2. Literature review

2.1. Travel well-being
Travel well-being includes cognitive evaluations and emotions. Cognitive dimension is defined as how one thinks about an activity when it comes to goal achievement, comparing the expected and actual comes. Emotional dimension refers how one feels in the experience of one activity, especially positive and negative emotions (Zhu and Fan, 2018a). Ettema et al. (2011) developed satisfaction with travel scale (STS) to comprehensively measure those two dimensions in the travel.

We review the empirical studies on daily travel well-being. And several significant patterns are found: in terms of research area, European studies dominate the literature on emotional dimension of travel well-being, while the research in China pays more attention on the cognitive satisfaction. Only Ye and Titheridge (2017) considers both cognitive and emotional dimensions. Therefore, it is necessary to comprehensively measure the cognitive and emotional dimensions of travel well-being, and compare the different influencing factors of the two dimensions. On the other hand, the reliability of STS has been verified in many European cities (De Vos et al., 2016; Friman et al., 2017; De Vos et al., 2018). A scale of travel well-being which can be applied effectively in China need to be explored and examined. Additionally, only the overall cognitive satisfaction level is measured in STS, but the subdivision dimensions, such as comfort, reliability and safety, are waiting to be studied. From the perspective of research objects, most of studies focus on travel well-being and satisfaction of a certain travel mode, such as subway, rapid transit, private cars (Dan et al., 2016; Ettema et al., 2013). The differential influences of travel modes on both cognitive and emotional aspects are needed to further study.

2.2. Influencing factors on travel well-being
Travel time and distance have an important impact on travel well-being (De Vos and Witlox, 2017). No matter which travel mode is used, travel time has a negative impact on travel well-being, that is, the longer the travel time is, the more people feel tired and stressful. Meanwhile, the evaluation of travel service quality has declined as well (De Vos et al., 2016; Ettema et al., 2011; Mao, Ettema, and Dijst, 2016; Mokhtarian et al., 2015). In addition, shorter commuting time than others is equal to higher comparative happiness than others (Abou-Zeid and Ben-Akiva, 2011). Long riding and walking are more likely to make people feel tired or even painful (Morris and Guerra, 2015). And multiple transfers and long waiting time of public transit both bring negative emotions (Morris and Guerra, 2015; Lancée, Veenhoven, and Burger, 2017). However, some scholars have made the opposite conclusion that the longer travel distance can bring positive emotions (De Vos and Witlox, 2016). When there is a certain meaning during trip, the increase in travel time or distance will improve travel well-being (Zhu, Fan, and Fan, 2018). Specifically, when the scenery is pleasant, or when people encounter interesting things during the trip, the longer travel time will bring higher travel well-being (Ettema et al., 2011).

Companions are another significant factor. People feel happier when traveling with a partner than alone (De Vos et al., 2018; Mokhtarian et al., 2015). Zhu, Fan, and Fan (2018) further found that the objects of fellow travelers (colleagues, family, couples, friends, etc.) also have an impact on travel well-being. Traveling with child makes individual feel happier and more meaningful, with less negative emotions. On the other hand, Ettema et al. (2012) found that activities carrying out during travel, talking with others, for example, can affect the well-being of travel. For those who take public transits, reading or communicating with others will alleviate negative emotions (De Vos and Witlox, 2016).

There are other relevant factors which also have an impact on the cognitive and emotional dimensions of travel well-being. The accessibility of infrastructure such as subway stations and bus stops, traffic conditions (crowding level), living environment, individual's preference for travel modes, demographic attributes and social comparisons all affect the cognition dimension of travel well-being. Abou-Zeid and Ben-Akiva (2011) found that people travelling by a private car felt more satisfied than others who travel by other travel modes. Similarly, perceived shorter travel time than others will increase cognitive satisfaction. In terms of travel emotions, gender, age, travel time, the locations significantly affect the emotions (Zhu, Fan, and Fan, 2018). Male drivers are more likely to have negative emotions than female...
drivers (Ettema et al., 2013). Elderly commuters have higher positive emotions than younger. Congestion during peak period can easily lead to negative emotions (Ettema et al., 2013). The geographic locations directly affect the accessibility of the transportation infrastructure. People tend to have higher positive emotions as they get an easier access to the bus stations (Xiong and Zhang, 2014).

3. Methods

3.1. Survey design and data collection

Based on the literature review, a survey was developed to quantify the relative importance of the range of factors influencing the travel well-being. The survey consisted of three parts, beginning with the socio-demographic information such as gender, age, education level, occupation, annual income and physical health. The second part included some travel characteristics. Respondents were asked to recall the latest daily travel, fulfilling questions regarding when to travel, total travel time, having an accompany or not, travel purpose, main travel mode (the longest distance) and preference of this mode. Thirdly, both cognitive and emotional dimensions were measured in this survey. The STS, the most widely-used scale, also contains those two dimensions, but only the overall cognitive satisfaction about travel is captured. In this paper, the cognitive satisfaction is subdivided into six dimensions: the evaluations of reliability, accessibility, safety, economy, environmental protection and comfort on travel service quality. In the aspect of emotions, the Positive and Negative Emotion Scale (Watson, Clark, and Tellegen, 1988) and the Swedish Core Emotion Scale (Daniel et al., 2002) are widely used measuring emotional well-being. It is essential to simplify the emotional dimensions if those scales are used in the field of travel. Because some emotions, proud for example, are not suitable in daily travel activities. Therefore, the American Time Use Survey (ATUS), a more authoritative simplified scale, is used in this paper, which includes happiness, meaning, sad, stressful, painful and tired. And this scale has been used in studies on travel well-being (Zhu and Fan, 2018b). The detailed scale and literature sources are as follows:

| Table 1. The measurement scale of travel well-being |
|---------------------------------------------------|
| **Cognitive satisfaction**                        |
| Reliability: punctuality and time-saving          | Van Lierop et al. (2017) |
| Accessibility: simple route with easy connection  | De Oña et al. (2016)     |
| Safety: perfect facilities and personal security  | Ettema et al. (2013)     |
| Economy: reasonable price and discount            | Liu, Jia, and Wang (2016) |
| Environmental protection: environmentally friendly| De Oña et al. (2016)     |
| Comfort: uncrowded and clean                       | Ettema et al. (2013)     |
| Emotional well-being                              |
| Positive emotions                                 |
| happy                                            |
| meaningful                                       |
| sad                                              |
| Negative emotions                                |
| stressful                                        |
| painful                                          |
| tired                                            |

A self-developed mini program in WeChat, named “Travel Record” was applied to collect data. Both face-to-face and web-based methods were used to solicit respondents in two cities, Beijing and Shenzhen. We distributed the link of our questionnaire via E-mail, WeChat, and websites with an honorarium (5 RMB, about $0.75). On the other hand, we randomly select subway stations (Beijing: Xizhimen, Zhongguancun, Sanyuanqiao) and office buildings and leisure activities areas (Shenzhen: Library, International Chamber of Commerce Building, Museum, etc.). Among the 235 participants, 208 questionnaires were complete and usable. The effective response rate was 88.5%.
3.2. Sample description and analysis

Among 208 valid questionnaires, 98 questionnaires were collected in Beijing and 100 were from Shenzhen. The rest of them were from other cities in China. The demographic characteristics of sample are summarized in Table 2; the ratio of male to female is close to 1:1. Most respondents are between the age of 18 and 45 with great and diverse travel demand. And the ratio of students to workers in the sample is close to 1:1. According to “China Statistical Yearbook of 2018”, the largest proportion of undergraduate citizens is shown in Beijing (23.7%). Therefore, the education level of the first-tier cities is increasing. The sample’s education level is consistent with the characteristic of first-tier cities.

Table 2. The demographic characteristics of the respondents

| Variables       | Attributes   | Proportion | Variables       | Attributes   | Proportion |
|-----------------|--------------|------------|-----------------|--------------|------------|
| Gender          | Male         | 46.2%      | Occupation      | Student      | 47.7%      |
|                 | Female       | 53.8%      |                 | Worker       | 52.3%      |
| Age             | <18          | 6.7%       | Physical health | Normal       | 29.8%      |
|                 | 18-25        | 35.4%      |                 | Healthy      | 39.3%      |
|                 | 25-35        | 30.9%      |                 |              |            |
|                 | 35-45        | 19.7%      |                 |              |            |
|                 | >45          | 7.3%       |                 |              |            |
| Education level | Junior high school | 3.4% | Very healthy | <20,000 | 9.5% |
|                 | Senior high school | 7.9% | Very unhealthy | 15.2% | 24.7% |
|                 | Associate College | 9.0% | Unhealthy | 15.2% | 12.9% |
|                 | Undergraduate | 42.1% | Normal | 29.8% | 23.6% |
|                 | Graduate and above | 37.6% | Healthy | 39.3% | 16.3% |

The mean of every travel well-being dimension varies with different travel mode. As shown in Table 3, regarded as the most popular mode, subway gets higher marks in time reliability, easy to reach the destination, safety and environmental protection. However, it is less competitive than car and walking in comfort and positive emotions. Walking is the happiest mode with highest positive emotions (happy and meaningful) and lowest negative emotions (sad, stressful, painful and tired). In contrast, people have lowest positive emotions when travelling by bus. It is partly because travelling by bus is more likely to make people feel exhausted and irritated. It is also uncomfortable with crowded bus inside and being stuck in the traffic jam. The most prominent advantage of cars is a more comfortable personal space. But it has a poor performance in emotions since traffic congestion will also lead to sad and painful. In terms of riding bikes, it presents the lowest usage proportion. This figure reflects, on the one hand, the habit of travelling by bikes has not been developed after the boom of dockless shared bicycles. On the other hand, bicycles play a subsidiary role in the travel chain, mainly for solving the "last mile" problem. People have great evaluation for its service quality except from comfort. There are higher negative emotions during riding bikes, which shows that the infrastructure and riding environment still need to be improved.

Table 3. Mean scores on the twelve indictors of travel well-being by travel mode

| Travel modes and proportion | Car (21.6%) | Bus (17.0%) | Subway (32.0%) | Bikes (4.6%) | Walking (20.9%) |
|-----------------------------|-------------|-------------|----------------|--------------|-----------------|
| Reliability                 | 4.79        | 4.81        | 4.92           | 5.43         | 5.25            |
| Accessibility               | 5.15        | 5.42        | 5.10           | 5.57         | 5.47            |
| Safety                      | 4.67        | 5.19        | 5.39           | 5.00         | 5.16            |
| Economy                     | 2.82        | 5.00        | 4.96           | 5.00         | 5.63            |
| Environmental protection    | 2.73        | 5.08        | 5.37           | 5.71         | 5.78            |
| Comfort                     | 4.94        | 3.77        | 3.92           | 3.57         | 4.47            |
| Happy                       | 3.48        | 2.62        | 3.20           | 3.71         | 4.34            |
| Meaningful                  | 3.61        | 2.81        | 3.67           | 3.57         | 4.19            |
| Sad                         | 0.58        | 0.85        | 0.86           | 1.43         | 0.41            |
| Stressful                   | 1.06        | 1.31        | 0.80           | 1.29         | 0.34            |
| Painful                     | 0.82        | 0.92        | 0.65           | 1.14         | 0.31            |
| Tired                       | 1.45        | 2.50        | 1.55           | 1.43         | 1.19            |
3.3. Ordered logit model

Since the dependent variables in the regression model are objective satisfaction evaluations (6 levels) and multiple emotions (6 levels), a conventional logit regression model is not suitable for estimating the different levels in the response categories. Therefore, the ordered logit model is used here because it is assumed that the responses are on the ordinal scale. The equations are as follows:

\[ Y_n^* = X_n \alpha + \epsilon_n \]  

\[ V_n = X_n \alpha \]  

\[ Y_n = \begin{cases} 
1 & Y_n^* \leq V_0 \\
2 & v_0 < Y_n^* \leq v_1 \\
3 & v_1 < Y_n^* \leq v_2 \\
4 & v_2 < Y_n^* \leq v_3 \\
5 & v_3 < Y_n^* \leq v_4 \\
6 & v_4 < Y_n^* 
\end{cases} \]  

\[ P(Y_n = 1 | X_n) = P(Y_n^* \leq v_0 | X_n) = \phi(v_0 - X_n \alpha) \] 

\[ P(Y_n = 2 | X_n) = P(v_0 < Y_n^* \leq v_1 | X_n) = \phi(v_1 - X_n \alpha) - \phi(v_0 - X_n \alpha) \] 

\[ P(Y_n = 6 | X_n) = P(Y_n^* > v_4 | X_n) = 1 - \phi(v_4 - X_n \alpha) \]  

\[ X_n: \text{explanatory variables}; \alpha: \text{coefficient}; \epsilon_n: \text{random error}; Y_n: \text{ordinal discrete variables, its value is 1,2,3,4,5,6 in this paper}; Y_n^*: \text{continuous variables}; V_n: \text{cutoff points, determines the corresponding relationship between } Y_n \text{ and } Y_n^*. \]

4. Results

4.1. Structure of travel well-being scale

As shown in Table 1, the measurement scale includes two aspects of cognitive evaluation and emotions, which explores 12 subdimensions. Exploratory factor analysis was employed to analyse the scale structure. The KMO coefficient of this scale is 0.762 indicating the validity of the factor analysis. Finally, 4 main factors were extracted and their cumulative contribution rate was 72.7%.

Table 4. Factor loading matrix

|          | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|----------|----------|----------|----------|----------|
| Happy    | -.212    | .801     | .191     | .071     |
| Meaningful | -.053   | .776     | .170     | .136     |
| Sad      | .813     | .084     | -.295    | .100     |
| Stressful | .795     | -.365    | -.070    | -.133    |
| Painful  | .899     | -.131    | -.146    | -.054    |
| Tired    | .780     | -.192    | .041     | -.089    |
| Reliability | -.272  | .273     | .729     | .006     |
| Accessibility | -.057  | .193     | .794     | .109     |
| Safety   | -.054    | .154     | .698     | .269     |
| Economy  | -.005    | .086     | .189     | .883     |
| Environmental protection | -.109 | -.012    | .109     | .913     |
| Comfort  | -.179    | .742     | .229     | -.121    |

Table 4 is the factor loading matrix after orthogonal rotation. A higher absolute value shows better interpretation of the principal factor to a variable. Therefore, travel well-being has four underlying dimensions. The first factor is mainly related to some emotions, like sad, stressful, painful and tired,
reflecting the negative emotions during the trip. The second factor mainly reflects three variables: happy, meaningful and comfort, representing the positive emotions during travel. It can also be seen that the comfort inside and outside the vehicle is highly correlated with the positive emotions. The third factor is the evaluation of travel service quality, which is influenced by reliability, accessibility and safety of travel. The last factor can be summarized as travel cost. It reflects the economy and environmental protection of the trip, which are the financial cost and environmental cost, in other words. Besides, Cronbach’s alpha values are 0.75, 0.85, 0.70, 0.82, indicating satisfactory internal reliability (Santos, 1999). In summary, travel well-being includes four subdimensions: positive emotions, negative emotions, travel service quality and travel cost evaluation. Consequently, potential influencing variables on four dimensions will be explored respectively.

4.2. Influencing factors of travel well-being

Four ordered logit models were built in this paper. All the significant variables are included in Table 5 and the non-significant ones are omitted here. The Nagelkerke R-squared values for those models were 0.36, 0.029, 0.031, 0.063, which are acceptable in terms of explanatory power (Hu, Shao, and Palta, 2006). The variance expansion factors (VIF) of all variables were less than 10, indicating no multicollinearity (Grewal, Cote, and Baumgartner, 2004).

Table 5. Results of ordered logit models

|                           | Positive emotions | Negative emotions | Travel service quality | Travel cost evaluation |
|---------------------------|-------------------|-------------------|------------------------|------------------------|
| **Demographic characteristics:** |                   |                   |                        |                        |
| Gender                    | -0.758**          | -0.513            | 0.124                  | 0.744**                |
| Education level           | -0.082            | 0.395**           | 0.121                  | -0.128                 |
| Physical health           | 0.383**           | 0.082             | 0.0321                 | 0.235                  |
| Annual income             | -0.170            | -0.068            | 0.353***               | 0.159                  |
| **Travel characteristics:** |                   |                   |                        |                        |
| Total travel time         | 0.194             | 0.616***          | -0.137                 | -0.303*                |
| Travel purpose: commute   | -1.266***         | -0.081            | 1.075***               | -0.338                 |
| Travel mode: car          | -0.236            | -0.589            | -0.205                 | -2.152***              |
| Travel mode: bus          | -1.788**          | 0.621             | 0.161                  | 0.493                  |
| Travel mode: subway       | -1.250*           | 0.145             | 0.075                  | 1.313*                 |
| Travel mode: riding bikes | 0.043             | 1.314             | -0.411                 | 2.315**                |
| Travel mode: walking      | -0.450            | 0.286             | -0.273                 | 1.848**                |
| Ideal travel mode         | 1.085***          | -0.736*           | 2.260***               | -1.292***              |
| Nagelkerke R-squared value| 0.036             | 0.029             | 0.031                  | 0.063                  |

* Note: * p<0.1; ** p<0.05; *** p<0.01

With the respect of positive emotions, women are more likely to have positive emotions than men. And healthier people tend to be more positive. Zhu, Fan, and Fan (2018) also pointed out that the BMI index was negatively correlated with commuting well-being. Additionally, people have lower positive emotions when commuting. Compared with other travel modes, people who travel by public transits (bus and subway) have lower positive emotions; on the contrary, people who use their ideal mode are more likely to have positive emotions. De Vos et al. (2018) found the preference of travel mode affects travel mode choice, which in turn affects travel well-being.

From the dimension of negative emotions, it is consistent with the conclusion of existing studies: the more time spent on trip, the more likely it is to cause negative emotions such as stressful and tired (De Vos and Witlos, 2017; Zhu, Fan, and Fan, 2018). Corresponding to the effect of travel mode preference on positive emotions, people who use the ideal mode are less likely to have negative emotions. Therefore, whether individuals can choose travel mode at their will directly affects emotions during the trip.

In terms of travel service quality evaluation, unlike previous studies, commuters give higher evaluations of travel service quality. Many studies pointed that people had lower happiness or overall satisfaction of travel when commuting (Ettema et al., 2013; Morris and Guerra, 2015). However, these
studies mostly focus on happiness or overall satisfaction, and pay less attention on the subdivision dimensions of travel service quality. Taking Beijing as an example, in order to meet commuting need in peak period, some measures have been taken, like increasing micro-circulation bus routes and adding the trip numbers to shorten the waiting time. The public has been satisfied with the safety, reliability and accessibility of the travel, while the most unsatisfactory aspect is comfort which directly affects positive emotions instead of travel service quality evaluation.

With the respect of travel cost evaluation, men are more likely to accept higher travel costs. It may because men prefer travelling by car and are less sensitive to the monetary and environmental costs of travel. Many studies have confirmed that travel time, waiting time and transfer time will reduce the overall travel satisfaction (Friman et al., 2017). The results in this paper present that the longer the time spent on trip, the higher the travel cost is. From the perspective of travel modes, it is more expensive travelling by cars. On the contrary, travelling by subways, bicycles and walking is less expensive and has relatively lower negative impacts on the environment. In addition, people who travel in the ideal mode spend more money on travelling. This result also reflects that car is the most ideal mode for most people, indicating that the potential travel demand for cars is relatively large.

5. Conclusion

5.1. Discussion
Analysing the structure of travel well-being firstly, this paper then establishes ordered logit models of dimensions. Results show that travel well-being can be divided into four dimensions: positive emotions, negative emotions, travel service quality evaluation and travel cost evaluation. Among them, the degree of congestion (comfort) is highly correlated with positive emotions, while the evaluations of other aspects of travel service quality (reliability, accessibility, safety) are not correlated with emotions. Travel cost evaluation mainly includes the financial travel cost and the impact on the environment. On this basis, the ordered logit models of four dimensions are established, and the factors affecting each dimension are explored. The main conclusions are as follows:

Demographic variables and travel characteristics have a certain impact on the four dimensions of travel well-being. The results show that women are more likely to have positive emotions than men, and men hold higher tolerance to higher travel costs. And the better their health is, the higher their positive emotions are. The longer they spend time on travel, the more likely they are to have negative emotions such as stressful and tired feelings. Although commuters have lower positive emotions in the trip, they are more satisfied with the quality of travel services such as reliability. Besides, people who travel by bus and subway have lower positive emotions. The cost of travelling by car is the most, and car has the poorest performance on the environment protection.

Four dimensions of travel well-being are affected by the preference for travel modes. People have higher positive emotions and greater evaluation of travel service quality when using their ideal travel mode. Consequently, the negative emotions, such as stressful, are lower. Ye and Titheridge (2017) and De Vos et al. (2018) also pointed out that the preference of travel mode can not only directly affect travel well-being, but also indirectly affect it through travel mode choice. Additionally, it is found that people who travel with an ideal mode have higher travel costs. This result also reflects that car is the most ideal mode for most people, indicating that the potential demand for car is great.

There are several limitations. First, a sampling bias existed to allow for convenient sampling. Individuals have different subjective evaluations of travel well-being. Therefore, it is necessary to increase the sample size to capture diverse perceived travel well-being. Second, different cities have different infrastructures and transit systems. Comparative studies between different cities are essential to learn from each other. Third, activities during the trip, like reading, listening to music, rest, may also have a great impact on travel well-being and are needed to be taken into consideration in future research.
5.2. Suggestions
First, it is essential to improve the comfort of travelling by bus and subway. Compared with cars, bus and subway are more environmentally friendly. The results show that people are satisfied with the reliability and accessibility of public transit services, while the weakness is comfort. With increasing congestion in peak period, positive emotions including evaluation of comfort decrease. Therefore, it is necessary to increase investment in public transit facilities, like increasing the number of specific routes within a reasonable range, optimizing microcirculation buses and customized buses routes, and encouraging companies to provide commuting buses. Secondly, free Wifi and other services can be provided on buses and subways to alleviate the negative emotions caused by congestion.

Secondly, shortening travel time is needed. The increase of travel time will not only produce negative emotions, but also increase the cost of time reducing economy of travel. Reducing travel time helps to improve travel well-being. The government needs to further optimize the transit system and reduce transfer and waiting time. In order to make smooth connection between different travel modes, we need to pay closer attention to the connecting role of shared bicycles. In the long term, occupational-residential balance affects commuting time, which is a significant factor in urban planning.

Thirdly, enriching travel mode choices is of great importance. Using the ideal travel mode will increase travel well-being. But in reality, it is difficult to freely choose the travel mode at one’s will. The government still needs to strive to achieve the fairness of transportation and increase the construction of transportation infrastructure, reaching the goal that people in all regions can easily access to subway, bus, shared bicycles and other travel modes.

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