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Searching for the Inflection Point of Travel Well-Being from the Views of Travel Characteristics Based on the Ordered Logistic Regression Model

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Abstract: Travel well-being is the subjective feeling of satisfaction that people have while traveling. Previous research focused on its determinants and relationships with subjective well-being ignored. But no quantitative study discusses the effect of characteristics like weekly income and travel time on travel well-being. To demonstrate the quantitative inflection of travel well-being from characteristics, the relevant factors influencing travel well-being as the dependent variable are identified using Pearson correlation analysis and linear regression in this paper. To overcome the limitations of linear regression techniques, ordered logistic regression is applied to establish an analytical model of travel well-being for predicting the response probabilities for different degrees based on combinations of explanatory variables. Both the linear regression and ordered logistic regression models are calibrated by American residents' travel datasets. The results illustrate that the ordered logistic model fits sample data better than linear regression models. Age, travel time, health status, and resting degree are significantly related to travel well-being. Older people and those who are healthier and better rested are more likely to experience higher levels of travel well-being. Additionally, increased travel time is associated with a significant decrease in travel well-being. Therefore, to enhance people's travel feelings, policymakers and urban planners can enhance the quality of public transportation services and provide diverse transportation options, while also logically constructing transportation hubs to provide more convenient travel plans.

Keywords: travel well-being; travel behavior; ordered logistic regression model; policy measures

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1. Introduction

Subjective well-being, as one of the highest realms of human pursuit, has always received extensive attention in psychology [1], economics [2], social sciences [3], as well as in our daily lives. Well-being not only plays the core role in assessing an individual's mental health and life satisfaction, but it is also regarded as one of the indispensable elements for the prosperity of society and the progress of human civilization. Happiness represents the inner state of an individual, and its connotation goes far beyond material wealth and social status. It encompasses multiple dimensions such as emotion, fulfillment and deeper meaning in life. Most countries and international organizations now regard well-being to be the most complete measure of wealth, replacing gross domestic product (GDP) and other traditional measurements of social indices [4]. According to the World Happiness Report 2023, from 10 years ago, more and more people have come to believe that our success as countries should be judged by the happiness of our people. There is also a growing consensus about how well-being should be measured [5]. Studies found that people with a higher sense of well-being tend to be more successful in other areas of life such as health, marriage, social relationships, and so on [6,7]. Happiness is a goal that people pursue. Along with the continuous improvement of people's living standards, people's measurement of the quality of life is increasingly focusing on well-being rather than sheer economic gains.

Subjective well-being (SWB) is a fundamental concept in the fields of psychology and social science. It is often considered synonymous with happiness [8]. SWB covers an individual's subjective perception and evaluation of his life and is also defined as an indicator that reflects people's subjective happiness or life satisfaction [9]. SWB is often conceptualized as comprising three related components: life satisfaction, positive affect, and negative affect. Life satisfaction describes the cognitive evaluation of life. Positive and negative affect include positive and negative feelings.

As an essential part of human daily life, travel is inextricably linked to people's lives. Travel serves as a bridge for commuting, working, recreation, visiting friends and relatives, and other activities demands [10–12]. Travel is important to economic development [13,14]. The sense of travel well-being can be considered as the subjective well-being of travelers during their trips. A commuting trip is not merely a simple act of transportation, but it is also associated with real-life experience and emotion. The experiences and emotional feelings of travelers during their trips significantly influence the overall sense of well-being in life [15]. So, travel well-being could influence an individual's emotions, psychological state, and overall subjective well-being in life. Extensive researches have confirmed that changes in travel behavior and travel well-being, or changes in satisfaction with other activities and their effects, can impact an individual's SWB [16,17].

At present, with the development of urbanization and the diversification of traffic modes, people's travel habits and experiences are undergoing profound changes [18–21]. Additionally, the current issues of urban built-up area expansion, poor travel environment, long travel time, traffic congestion, and frequent traffic accidents also exacerbate the feeling of travel anxiety, danger, and insecurity, reducing the sense of travel well-being. Therefore, we need a more comprehensive and in-depth understanding of travel well-being in different travel modes and time. Ettema also agreed with the notion that "the ultimate goal of transportation policy is to increase individuals' subjective well-being" [22]. Thus, there is an urgent need to identify the factors influencing peoples' travel well-being and propose a suitable method for estimating peoples' travel well-being levels. More studies have explained the influential determinants of travel well-being, including trip characteristics like traffic mode and travel time, the built environment, subjective features such as trip-related attitudes, personal pressure and mood, and individual demographic characteristics of the traveler. No empirical study quantifies the inflection point of travel well-being from the views of travel characteristics like travel time and travel modes, as well as other determinants. Nobel Prize winners Daniel Kahneman and Angus Deaton [23] point out that happiness stops rising after an individual's annual income exceeds $75,000; happiness and income are not directly proportional, but there is a "happiness inflection point". The Chinese survey also found that while "income" and "happiness" are basically "positive correlations", we found that an annual income of 300,000 yuan forms a happiness inflection point. For families with incomes above 300,000, happiness declines as incomes rise. The happiness of high-income groups with an annual income of more than 1 million yuan is lower than that of families with 80,000 to 120,000 yuan. Analogously, do travel characteristics like traffic mode and travel time have similar regular inflection points for travel well-being? Does the sense of travel well-being and experience decrease significantly when the travel time exceeds a certain threshold? These inflections are important for better decision support for policymakers, urban planners, and traffic managers to optimize the transportation system and improve transportation policies. Therefore, the ordered logistic models utilize data from the American Time Use Survey Dataset to estimate the quantitative variations in travel well-being.

The contributions of this study are the following:

Firstly, this study uses linear regression and ordered logistic regression models to identify the factors that significantly affect travel well-being based on the well-being dataset of the American Time Use Survey (ATUS). The ordered logistic model ameliorates the shortcomings of linear regression and overcomes the limitations of the dependent variable being a discrete variable. More importantly, the response probabilities for different degrees for the combinations of explanatory variables are innovatively generated by the ordered logistics model to qualify the threshold and mechanisms of changes in travel well-being during the trips.

Secondly, the quantitative model is employed to investigate whether changes in the values of the relevant variables would affect individuals' travel well-being. This analysis aims to quantitatively assess the precise relationships between the influential factors and travel well-being. Additionally, this article is innovative in predicting the response probability of different travel well-being levels based on influential factors, clarifying the threshold and inflection points of travel well-being changes.

2. Literature Review

2.1. The Definition of Travel Well-Being

Regarding subjective well-being, it is initially derived from the assumption of utility theory in economics, which posits that behavior is driven by the maximization of self-interest. Diener et al. argued that subjective well-being is composed of positive emotions, negative emotions, domain satisfaction, and life satisfaction, all of which are directly related to personal experience [24,25]. Positive and negative emotions constitute the happy part, while the latter two are components of overall well-being. Well-being is associated with cognitive dimensions, such as individual assessments and attitudes toward life. Happiness primarily resides within the emotional dimension: encompassing an individual's feelings about life and their experiences of positive and negative emotions [26,27]. Ettema also pointed out that subjective well-being refers to overall satisfaction with life, implicitly encompassing various domains such as family life, work life, and leisure, and transcending them. He further noted that travel could lead to cumulative satisfaction with the transportation system, thus influencing global subjective well-being [22]. Regarding the relationship between travel well-being and subjective well-being, relevant studies confirmed that travel well-being is more likely to influence subjective well-being, representing a bottom-up approach [15,28].

Bergstad defined travel well-being as the traveler's satisfaction being influenced by events experienced when using a travel mode [29]. Singleton argued that experiences during purpose-driven trips affect specific SWB [30]. Ma et al. suggested that travel well-being is the emotional well-being linked to travel-related positive and negative emotions in people's daily activities [31]. Chen summarized the literature by broadly defining travel well-being as an individual's cognitive evaluation and emotional experience during a specific travel process. She distinguished happiness during travel from overall travel well-being (overall perceptions of daily travel modes) [27]. Therefore, travel well-being can be understood as an individual's emotional experiences during certain trips. The ATUS survey data used in this study pertains to a person's experiences during a particular travel chain. Therefore, understanding an individual's travel well-being is more suitable.

2.2. Measurement of Travel Well-Being

In the assessment of travel well-being, some scholars utilize the Satisfaction with Travel Scale (STS), developed by Ettema et al. [22], to measure peoples' travel well-being from both cognitive and emotional dimensions [29–33]. The STS consists of six questions within two emotional dimensions (positive and negative affect, activation, and deactivation), as well as three questions within the cognitive dimension. The STS scale has been examined and confirmed for its high reliability by numerous scholars both domestically and internationally [26]. Another method for assessing well-being is through self-report rating scales. Some studies use positive and negative affect scales [34] or the Swedish Core Affect Scale (SCAS) [32] to measure subjective well-being in terms of emotions. Bradburn [35] and Kahneman et al. [36] evaluated well-being using the Affect Balance Scale, which represents overall emotional well-being. In the research on travel well-being, Archer [37], Morris [38,39], Chen [27], and others have confirmed that the net affect value (the average score of positive emotions minus the average score of negative emotions) derived from the Affect Balance Scale is a reliable predictor of self-reported happiness. Travel net affect value is capable of effectively explaining people's travel well-being.

There are various methods available to analyze the relationship between variables and travel well-being. For instance, Abou-Zeid et al. used the structural equation model to investigate the impact of social comparisons on travel well-being and behavior. They found that comparing one's commuting experience with others can increase overall commuting satisfaction or utility [40]. Chen combined optimal scale regression, factor analysis, and an analytic hierarchy process to assess the relative importance of various trip and personal factors influencing travel emotions [27]. Sukhov employed a model with a configuration method and applied fuzzy-set qualitative comparative analysis (fsQCA) to explore the relationship between satisfaction with service quality attributes and high travel well-being [41]. Yin utilized Gradient Boosting Decision Trees to examine the potential relationship between the built environment, commuting time, and happiness. The study concluded that commuting duration and happiness have a nonlinear relationship, and different commuting modes have nonlinear relationships with happiness [42]. Abenoza applied the Three-Factor Theory (basic factors, performance factors, and incentive factors) to test whether service attributes have nonlinear and asymmetric effects on overall travel experiences [43]. Hu used linear regression modeling to explore the effect of travel mode discordance on travel well-being [44]. Humagain used the difference in travel satisfaction between the chosen and alternative mode, referred to as the travel satisfaction gap, to measure commuters travel satisfaction [45]. Some scholars also used models like logistic regression to investigate the correlation and interaction effects of different variables with travel well-being [17,46].

2.3. Common Influences on Travel Well-Being

Previous scholars have explored many factors that influence travel well-being. The results show that socio-economic characteristics such as age, gender, income, and marital status affect travel well-being. Higgis et al. found that older individuals have a higher tolerance for commuting, and compared to women, men are more likely to feel "very satisfied" with their commute [47]. Veronique et al. also found that older adults and respondents with fewer children generally have a more positive perception of their commuting trips [15]. Groups with higher household incomes generally have higher levels of travel well-being [27]. Wheatley suggested that women with children tend to have lower emotional experiences during medium to long-distance commuting. However, this finding does not apply to fathers with longer commuting times [48]. Olsson et al. examined the different effects of commuting to work and commuting from work on travel well-being and found that well-being may be different when going home than going to work [49]. Fan et al. found that the built environment has a significant direct effect on commuting well-being and a significant indirect effect on commuting well-being through car driving, buses, bicycles, and subways [50]. Existing research has also confirmed that physical health and emotional well-being significantly influence individuals' travel well-being. Clark et al. examined the relationships between commuting and mental health using the General Health Questionnaire (GHQ-12) survey. They found that respondents with higher stress levels and poorer mental health have lower satisfaction with their work and leisure time [51]. De Vos found that individuals who positively evaluated their lives may feel more satisfied with their travel compared to those with lower life satisfaction [52]. In addition, Chen et al. confirmed that resting degree and whether one interacts with others during trips are the two most important factors affecting travel well-being [27]. Cao demonstrated that the variables of resting degree, health status, and medication history significantly act on the level of respondents' travel well-being [53].

Travel well-being is dependent on travel characteristics, one of which is travel time. Due to feelings of boredom and social isolation during the trips, longer commuting time generally leads to poorer travel experiences. Some studies indicate that travel duration has a negative impact on travelers' perceptions. Lancée et al. suggested that a longer travel time can inhibit positive emotion, and specific combinations of commuting time and mode could have adverse effects on well-being [54]. Travel mode is another factor that influences peoples' travel well-being. Many scholars have studied the relationship between travel mode and travel well-being [55–57]. Respondents who choose active traffic modes of travel, such as walking or cycling, generally have higher levels of well-being, while respondents who use public transit show lower levels of well-being [39]. Additionally, related studies have found that engaging in communication and interaction with others during the trips significantly enhances travel well-being [58].

To sum up, there are differences in the perceived travel well-being among individuals due to variations in their personal variables, health and emotional conditions, and travel attributes. Although previous studies have advanced the understanding of the determinants of travel well-being, it is surprising that almost no empirical study discusses the inflection point of travel well-being from the views of travel characteristics and other variables. Therefore, this study first utilized the 2021 American Time Use Survey (ATUS) dataset and applied both linear regression and ordered logistic regression models to identify the influential factors of travel well-being. Moreover, we innovatively predicted the probability of different levels of travel well-being based on combinations of explanatory variables, thereby elucidating the threshold and mechanisms of changes in travel well-being during the trips. Figure 1 illustrates the research framework, which can assist planners in formulating plans and policies to enhance travel well-being, meet people's travel needs, and improve the efficiency and sustainability of the transportation system.

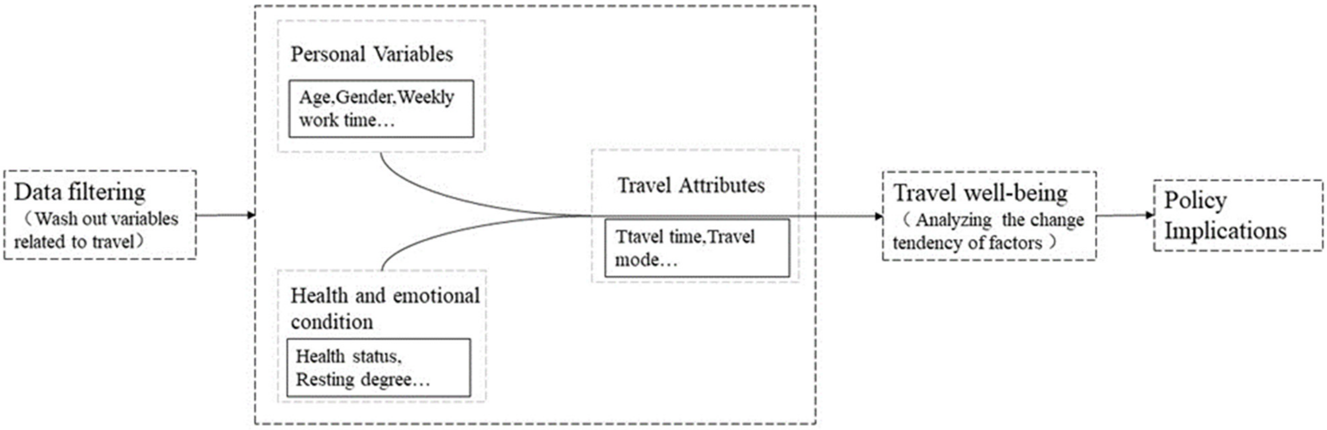


Figure 1. Research framework.

3. Methods

3.1. Data Description and Factor Explanation

This data is from the American Time Use Survey (ATUS), the first ongoing survey of time use conducted by the Bureau of Labor Statistics and the U.S. Census Bureau in the United States. The survey recorded respondents' demographic information, occupational income information, and household members. More information on the collection of this data in ATUS is available at https://www.bls.gov/tus/ (accessed on 1 March 2023). The 2021 ATUS survey includes modules on health and well-being. The survey asked respondents whether they interacted with others during activities and rated their emotional experiences during the activities (such as happy, meaningful, sad, pain, stress, tired). The data files were matched and integrated to obtain data related to travel activities. After preprocessing the dataset to remove errors and missing values, a total of 16 variables and 3512 trip records were obtained. The data exhibits good breadth and representativeness, meeting the data requirements for studying travel well-being. ATUS uses a six-digit coding system for the classification of travel purposes, encompassing a total of 75 travel categories. These categories include commuting, leisure and entertainment, shopping for daily necessities, volunteer activities, and more. In theory, "commuting" refers to the travel or activities between two locations, typically involving regular round-trip movements. Therefore, travel mentioned in this research not only encompasses the commuting trips, but also a wide range of other travel activities within various categories.

In order to investigate the relationship between different factors and travel well-being, this study included three types of independent variables: personal variables, health and emotional condition, and travel attributes. Table 1 provides a descriptive analysis of the variables. Figure 2 shows a summary of some respondent's personal characteristics. The results indicate that, among the selected sample, 49.3% are male and 50.7% are female. Respondents belonging to the 31~45 age group are in the largest demographic segment (26.8%), followed by the 46~60 age group (25.0%). Approximately 53.3% of respondents have a weekly income below 57,691, and more than half (54.2%) work for 31~60 h per week. Most respondents are employed. Additionally, 32.7% of the sample are engaged in managerial occupations, and 1.1% work in the agriculture, forestry and fishing industries. About 49.7% of respondents are unmarried, and only 8.5% have children.

Table 1. Variables description.

	Variable Name	Sign	Description
Person variables	Travel well-being	Y	1–5 (Very happy-1; Very unhappy-5)
	Age	X_1	15~85 years old
	Gender	X_2	Female-0; Male-1
	Major occupation category	X_3	Management, professional, and related occupations-1; Service occupations-2; Sales and office occupations-3; Farming, fishing, and forestry occupations-4; Construction and maintenance occupations-5; Production, transportation, and material moving occupations-6; Others-7
	Labor force status	X_4	Work-1; Absent-2; Layoff-3; Looking-4; Not in labor force-5
	Weekly work time	X_5	Continuous variable
	Weekly income	X_6	≤57,691-1; 57,692~115,383-2; 115,384~173,075-3; 173,076~230,768-4; ≥230,769-5
	Marital status	X_7	Unmarried-0; Married-1
	Have children	X_8	No-0; Yes-1
Health and emotional condition	Health status	X_9	1–5, (Very unhealthy-1; Very healthy-5)
	Resting degree	X_{10}	1–4, (Very bad-1; Very good-4)
	History of hypertension	X_{11}	History of illness within five years, (No-0; Yes-1)
	Medication history	X_{12}	Used medication the day before the interview, (No-0; Yes-1)
	Feelings compared to a typical day	X_{13}	Worse-1; Identical-2; Better-3
Travel attributes	Travel mode	X_{14}	Private car (driver)-1; Private car (passenger)-2; Walking-3; Bus-4; Subway-5; Bicycle-6; Taxi-7; Others-8
	Travel time	X_{15}	Continuous variable
	Interacts with others	X_{16}	No-0; Yes-1

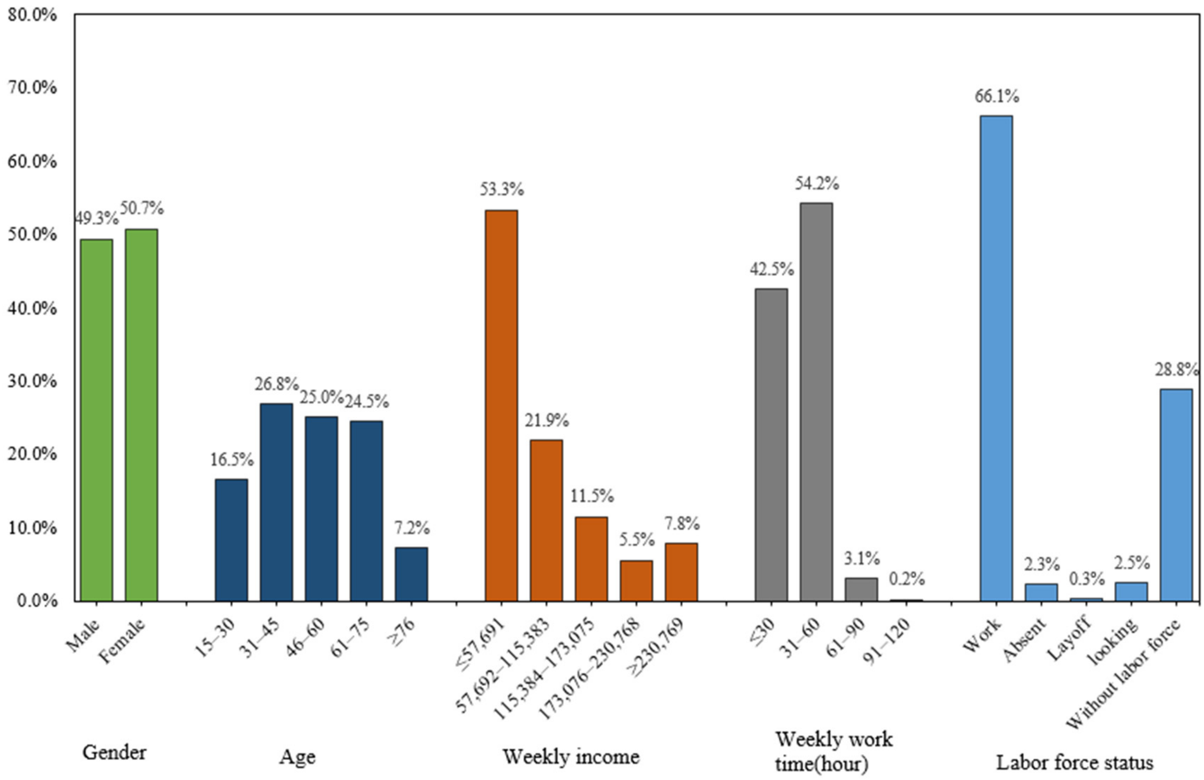


Figure 2. Partial summary of respondents' personal variables.

The indicators of well-being include: happy, meaningful, sad, pain, stress and tired. The respondents are required to rate six indicators on a scale of 0 to 6. Taking the happy indicator as an example, 0 represents not experiencing happiness during the trips, i.e., very unhappy, whereas 6 represents experiencing immense happiness, i.e., very happy. Travel well-being can be calculated using the Affect Balance Scale, and the net affect value during the trips [27,39]. Therefore, the dependent variable is represented by the net affect value to represent travel well-being.

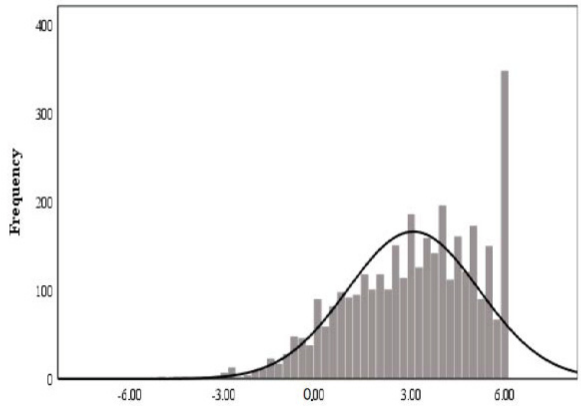
The net affect value was calculated as the mean of the positive emotion scores.

$$A_{ij} = \frac{\sum_{l=1}^{L} PA_{ij}{}^{l}}{L} - \frac{\sum_{k=1}^{K} NA_{ij}{}^{k}}{K} \tag{1}$$

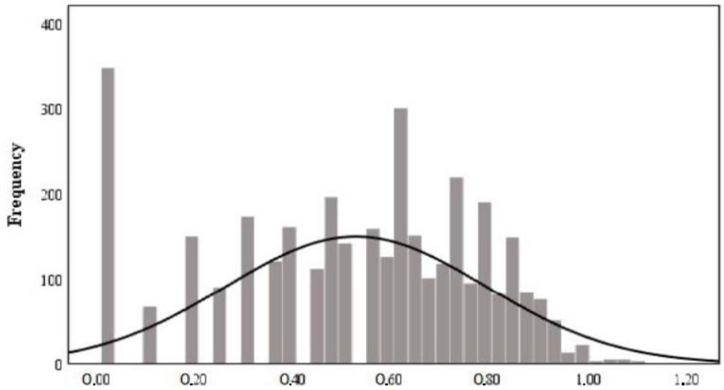
A_{ij} represents a person i's net affect value during trip j,
$PA_{ij}{}^{l}$ is a person i reports for trip j of the affect score of the l-th positive emotion,
$NA_{ij}{}^{l}$ is a person i reports for trip j of the affect score of the k-th positive emotion.

Take the six indicator scores of one respondent as an example. The respondent's happy, meaningful, sad, pain, stress, and tired scores are 5, 0, 0, 1, 0, 3. Then, his net affect value is $A_{ij} = \frac{5+0}{2} - \frac{0+1+0+3}{4} = 2.5 - 1 = 1.5$.

Due to the skewed distribution of the computed net affect value, following the approach of Morris and Cao [40,54] a negative logarithmic transformation was applied to transform the dependent variable to a normal distribution, as shown in Figure 3. After processing, it continues to discretize as $Y \in [1, 2, 3, 4, 5]$; a larger value indicates lower travel well-being. The five letters A–E are used to correspond to five different grades, which are used to express five different travel well-being (TWB) levels of "excellent", "good", "average", "poor", and "terrible" (for example: TWB A = 1, very happy).



(**a**) Histogram of frequency distribution of original net affect value



(**b**) Histogram of frequency distribution of net affect value after normalization

Figure 3. Comparison of normalization treatments for histograms of frequency distributions of net affect value on travel. Note: After the negative logarithmic transformation process, the net affect value of travel changes from a positively skewed distribution (**a**) to a normalized distribution (**b**).

3.2. Representation of Survey Results by a Single TWB Grade

The mean and mode are often used to represent characteristics of data. In this study, individual travel well-being can be intuitively reflected by the net affect value of respondents' travel experiences. However, using the mean as an indicator for measuring the overall level of travel well-being in the study is somewhat awkward. The mean is easily influenced by extreme values, and it can only reach TWB A (excellent) or TWB E (terrible) when very few people almost unanimously consider TWB either excellent or terrible. Moreover, in this study, there is almost no overlap between TWB A and TWB E. Even if the majority of respondents have travel well-being at the TWB A level, just a few respondents with TWB E can significantly shift the overall result to another category. As shown in distribution 1 in Table 2, even if 60% of people have travel well-being at the TWB A level, the mean is still 1.52, closer to 2.00 (TWB B) rather than 1.00 (TWB A). For these sample distributions, the mode behaves as anticipated, but it was excluded because it cannot resolve ties.

Table 2. Representation of survey results by a single TWB grade: distributions and mean of TWB.

TWB	Result, by Distribution				
	1	**2**	**3**	**4**	**5**
A	60%	16%	NA	NA	NA
B	28%	53%	27%	NA	NA
C	12%	31%	56%	31%	13%
D	NA	NA	17%	54%	28%
E	NA	NA	NA	15%	59%
1	B	C	C	D	E
2	B	B	C	D	D
3	A	B	C	D	E

Note: NA = not available; mean for distributions 1–5, respectively: 1.52, 2.15, 2.90, 3.84, and 4.46; mode for distributions 1–5, respectively: 1, 2, 3, 4, 5.

Using the TWB 1 partitioning method, calculate the average from TWB A to TWB E and convert it into letter grades (Tables 2 and 3). It can be seen that for the average values of distribution 1, we cannot obtain TWB A and TWB B, but for the other three example distributions, it performs reasonably well. The row thresholds are marked as TWB 2 partition at the midpoint between the TWB value, and this partitioning method results in distribution 1 and 5 being converted to TWB B and TWB D, respectively, instead of the expected TWB A and TWB E.

Table 3. Representation of survey results by a single TWB grade: TWB mean value threshold schemes.

TWB	Numerical Value	TWB 1, Straight Thresholds	TWB 2, Thresholds Shifted to Midpoints	TWB 3, Compressed Ranges
A	1	Mean $\leq$ 1.00	Mean $\leq$ 1.50	Mean $\leq$ 2.00
B	2	1.00 < mean $\leq$ 2.00	1.50 < mean $\leq$ 2.50	2.00 < mean $\leq$ 2.67
C	3	2.00 < mean $\leq$ 3.00	2.50 < mean $\leq$ 3.50	2.67 < mean $\leq$ 3.34
D	4	3.00 < mean $\leq$ 4.00	3.50 < mean $\leq$ 4.50	3.34 < mean $\leq$ 4.00
E	5	4.00 < mean $\leq$ 5.00	4.50 < mean	4.00 < mean

The rows marked as TWB 3 display the results of converting the average values to letter grades using a compressed threshold range. The compressed range combines the thresholds for TWB B to TWB D, making the range for TWB A and TWB E broader. Under this categorization method, the average values for TWB A range from 1.0 to 2.0, and for TWB E, they range from 4.0 to 5.0. For the five example distributions listed, the performance of the TWB 3 categorization is quite good.

3.3. Correlation Analysis

The Pearson correlation coefficient is used to measure the correlation between two variables [59]. As shown in Figure 4, where we take the absolute value to be 0.01 as the cutoff, we found that there is a very low correlation between gender and travel well-being, filtering out the variable of gender.

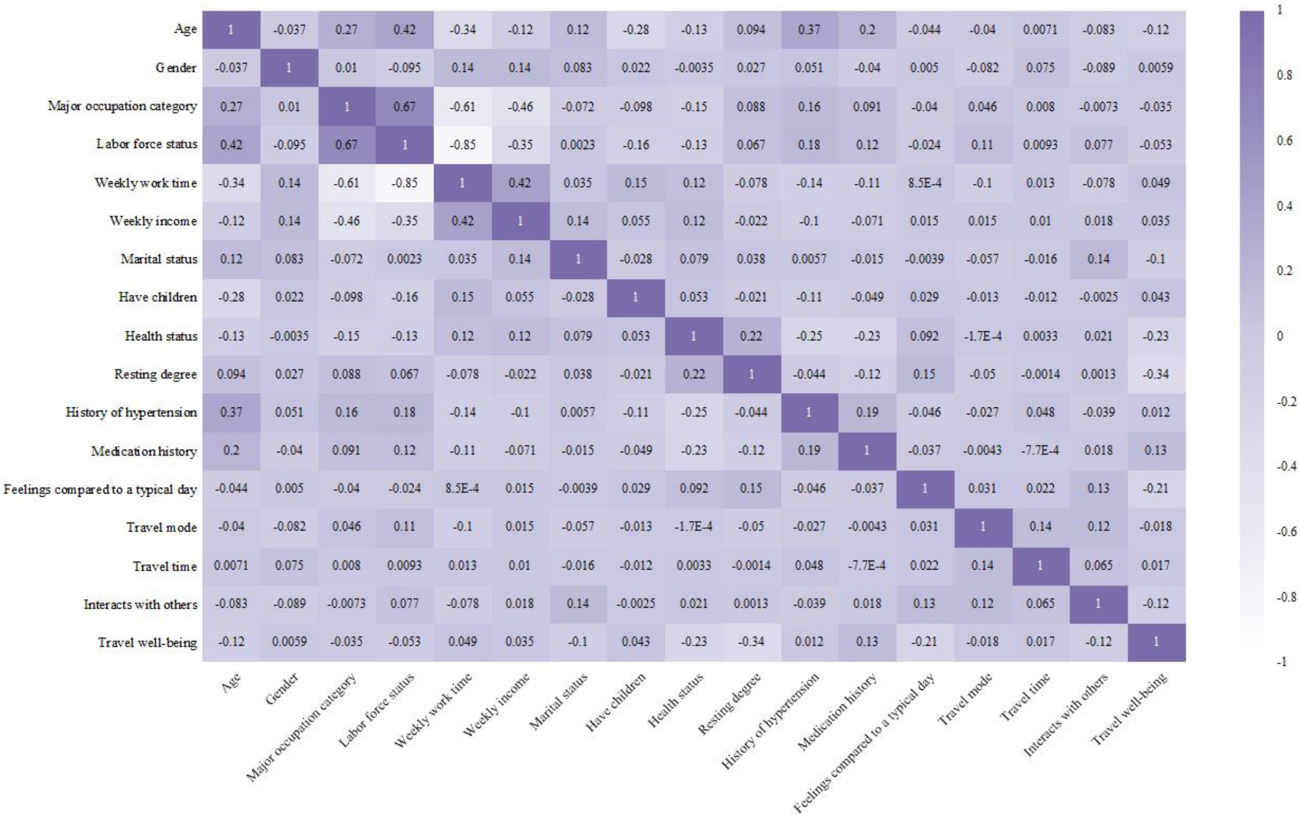


Figure 4. Pearson-related heat map.

The Pearson correlation coefficients of labor force status and weekly work time (ρ = −0.85). The correlation coefficients of weekly work time with labor force status (ρ = −0.85), and major occupational category (ρ = −0.61) all have a large correlation, and there is also a large correlation between major occupation category and labor force status (ρ = 0.67). Therefore, variables with large correlation coefficients were selectively deleted, and labor force status and major occupational category were deleted.

3.4. Linear Regression Tests

To assess the level of travel well-being obtained by each respondent in the data, a linear regression technique was needed to explore whether there was a large number of linear correlations.

A multiple linear regression model is a statistical model used to establish and analyze the relationship between multiple independent variables and a dependent variable. The multiple linear regression model is able to analyze the relationship between multiple independent variables and a dependent variable, and its regression coefficients can provide information about the degree of influence of different independent variables on the dependent variable. Also, it is able to control the independent variables to improve the predictive accuracy of the model. In addition, the multiple linear regression model allows for hypothesis testing to determine which independent variables have a significant effect on the dependent variable.

For variable selection, independent variables are selected from the explanatory variables, and variables unrelated to the dependent variable are excluded. The forward stepwise regression method can improve the predictive ability of the model for the de-pendent variable. The R^2 value is an indicator of the model's predictive ability. The adjusted R^2 value for the entire model is 0.202, which means that only 20.2% of the variation in participants' travel well-being can be estimated by this model. Furthermore, we found that these coefficients are significant within a 90% confidence interval. The results of the stepwise multiple linear regression are shown in Table 4.

Table 4. Multiple Linear Regression Model.

Variable	Coefficient	SE	Sig
Age	−0.008	0.001	0.000
Weekly income	0.042	0.014	0.004
Marital status	−0.137	0.036	0.000
Have children	0.048	0.065	0.456
Health status	−0.190	0.019	0.000
Resting degree	−0.356	0.022	0.000
History of hypertension	−0.037	0.042	0.368
Medication history	0.237	0.042	0.000
Feelings compared to a typical day	−0.284	0.030	0.000
Travel mode	−0.033	0.021	0.094
Interacts with others	−0.213	0.036	0.000
Constant	5.860	0.126	0.000

From the above results, it can be seen that having children and a history of hypertension do not satisfy the significance requirement of $p < 0.1$; therefore, the final model for the evaluation of travel well-being is:

$$Travelwell - being = -0.008X_1 + 0.042X_6 - 0.137X_7 - 0.190X_9 - 0.356X_{10} + 0.237X_{12} - 0.284X_{13} - 0.033X_{14} - 0.213X_{16} + 5.860 \quad (2)$$

As seen in Table 4, we can observe that when respondents have better rest and better physical health, their travel well-being tends to be higher. When their feelings are better than a typical day, there is a higher level of travel well-being. Interacting with others during the trip significantly helps to alleviate feelings of boredom and contributes to a better travel experience. Respondents who have a recent history of medication use and those with children generally have lower levels of travel well-being.

3.5. Limitations of Linear Regression Model

When modeling ordered variables, linear regression may not be the best choice. Linear regression attempts to determine the best-fitting linear equation based on the least squares criterion, minimizing the sum of squared deviations between predicted levels and observed levels to provide the most accurate predictions.

The linear regression model cannot solve situations where there is more than one dependent variable and multicollinearity among independent variables. It also cannot measure certain variables that cannot be directly measured. The variables in this study are highly subjective, and the dependent variable in the regression model, which is travel well-being, is discrete. Linear regression is not well-suited to handle this type of ordinal categorical problem perfectly. Therefore, using a standard linear regression model is not appropriate, and a discrete choice model should be chosen instead.

To overcome these limitations, we used ordered logistic regression to predict the response probability of travel well-being magnitude based on the combination of explanatory variables, which allowed us to fully utilize the screened sample of 3512 data.

4. Results Analysis

4.1. Ordered Logistic Regression

Ordered logistic regression is a kind of ordinal regression model, different from the ordinary binary logit regression model; when the explanatory variables are sequential data, the problem is solved by using ordered multicategory logit model. Logistic regression has the ability to reflect certain real problems more strongly. Therefore, the ordered logit model can be chosen to study the problem of travel well-being. Overall ratings (Rating-Num) of travel well-being in this study ranged from 1 (very happy) to 5 (very unhappy). The Rating-Num required the dependent variable to be continuous to make ordinary linear regression imperfectly explanatory and ordered logistic regression solve the problem of modeling discrete variables with a hierarchical ordering.

The cumulative probability is defined as follows:

$$\ln \frac{P(Y \leq j|x)}{1 - P(Y \leq j|x)} = \alpha' - \beta'(x) \tag{3}$$

where

P denotes the probability,
γ represents ordered variables,
j is the level of Travel well-being, and
x are explanatory variables of the influential factors.

Modify the above equation as:

$$P(Y \leq j|x) = \frac{\exp(\alpha' - \beta'(x))}{1 + \exp(\alpha' - \beta'(x))} \tag{4}$$

The intercept α_j for each cumulative probability is unique, the values of α_j increase with j because $P(Y \leq j|x)$ also increase with j for fixed x. For each j within the model, we assume that $X_1, X_2, X_3 \ldots X_{16}$ have equal effects. To properly interpret the intercept values, we consider a model for two scores j and k, with $j < k$ and the value for $X_1, X_2, X_3 \ldots X_{16}$ as 0. The final result of some algebraic manipulations is as follows:

$$P(Y \leq k|Traveltime) = P(Y \leq j|Traveltime + (\alpha_k - \alpha_j/\beta) \tag{5}$$

4.2. Recommended People TWB Model

The recommended travel well-being rating model above predicts people's average travel well-being ratings, with TWB A being "very happy" and TWB E being "very unhappy".

$$People's\ TWB = mean(TWB) \tag{6}$$

The average TWB rating is the sum of the probabilities of an individual's TWB rating, multiplied by the value of that TWB rating (terrible = 5, excellent = 1).

$$mean(TWB) = \sum_{i=1}^{5} \mathrm{P}(TWB = J) * J \tag{7}$$

The probability that a participant will accurately evaluate a given facility as TWB J is equal to the probability of removing evaluations that are worse than TWB J from the cumulative probability of both TWB evaluations and even worse ones.

$$P(TWB = J) = P(TWB \leq J) - P(TWB \leq J - 1) \tag{8}$$

The cumulative logit model below gives the probability that a respondent's travel well-being rating is TWB or worse as:

$$P(Y \leq J) = \frac{1}{1 + \exp(-\alpha_{(J)} + \sum_{K} \beta_K x_K)} \tag{9}$$

where

$P(Y \leq J)$ is the probability the intersection received a TWB grade J or worse,
$\alpha_{(J)}$ denotes the maximum threshold for TWB grade (Table 5),
β_K is the attribute calibration parameters (Table 5), and
x_K is the variable properties (Table 5).

Table 5. Maximum likelihood estimates for travel well-being model.

Variables	Parameter	Option	Estimate	SE	Wald	DF	Sig	Exp (β)	95% Confidence Interval	
									Lower Bound	**Upper Bound**
	Travel well-being	Y = 1	−1.090 *	0.609	3.196	1	0.074	0.336	−2.286	0.105
		Y = 2	−0.085	0.610	0.019	1	0.889	0.919	−1.279	1.110
		Y = 3	1.580 ***	0.609	6.707	1	0.010	4.855	0.384	2.776
		Y = 4	3.922 ***	0.613	40.789	1	0.000	50.501	2.718	5.126
Personal Variables	Age	X_1	−0.016 ***	0.002	51.327	1	0.000	0.984	−0.020	−0.011
	Weekly work time	X_5	−0.003 *	0.002	1.822	1	0.100	0.997	−0.007	0.001
	Weekly income	$X_6 = 1$	−0.217 *	0.137	2.504	1	0.094	0.805	−0.486	0.052
		$X_6 = 2$	−0.297 **	0.133	4.997	1	0.025	0.743	−0.557	−0.037
		$X_6 = 3$	−0.398 *	0.142	0.004	1	0.062	0.672	−0.286	0.269
		$X_6 = 4$	0.323	0.173	3.485	1	0.952	1.381	−0.016	0.662
		$X_6 = 5$	0 [a]			0		1		

Table 5. *Cont.*

Variables	Parameter	Option	Estimate	SE	Wald	DF	Sig	Exp (β)	95% Confidence Interval	
									Lower Bound	Upper Bound
Personal Variables	Marital status	$X_7 = 0$	0.233 ***	0.064	13.046	1	0.000	1.262	0.108	0.360
		$X_7 = 1$	0 [a]			0		1		
	Have children	$X_8 = 0$	−0.073	0.116	0.394	1	0.530	0.930	−0.299	0.154
		$X_8 = 1$	0 [a]			0		1		
Health and emotional condition	Health status	$X_9 = 1$	1.302 ***	0.214	37.048	1	0.000	3.677	0.883	1.721
		$X_9 = 2$	1.072 ***	0.124	74.930	1	0.000	2.921	0.829	1.314
		$X_9 = 3$	0.615 ***	0.098	39.115	1	0.000	1.850	0.422	0.807
		$X_9 = 4$	0.308 ***	0.094	10.811	1	0.001	1.361	0.125	0.482
		$X_9 = 5$	0 [a]			1		1		
	Resting degree	$X_{10} = 1$	1.850 ***	0.160	133.310	1	0.000	6.360	1.536	2.164
		$X_{10} = 2$	1.253 ***	0.102	151.538	1	0.000	3.501	1.054	1.453
		$X_{10} = 3$	0.703 ***	0.071	99.502	1	0.000	2.020	0.565	0.842
		$X_{10} = 4$	0 [a]			0		1		
	History of hypertension	$X_{11} = 0$	0.081	0.074	1.195	1	0.274	1.084	−0.064	0.226
		$X_{11} = 1$	0 [a]			0		1		
	Medication history	$X_{12} = 0$	−0.422 ***	0.075	31.708	1	0.000	0.656	−0.569	−0.276
		$X_{12} = 1$	0 [a]			0		1		
	Feelings compared to a typical day	$X_{13} = 1$	1.346 ***	0.127	113.089	1	0.000	3.842	1.096	1.592
		$X_{13} = 2$	0.333 ***	0.070	22.964	1	0.000	1.395	0.198	0.470
		$X_{13} = 3$	0 [a]			0		1		
Travel attributes	Travel mode	$X_{14} = 1$	0.518	0.559	0.857	1	0.355	1.679	−0.578	1.614
		$X_{14} = 2$	0.245	0.563	0.190	1	0.665	1.278	−0.857	1.347
		$X_{14} = 3$	0.211	0.579	0.135	1	0.713	1.235	−0.922	1.346
		$X_{14} = 4$	0.948	0.646	2.153	1	0.140	2.581	−0.318	2.215
		$X_{14} = 5$	1.066	0.788	1.831	1	0.174	2.904	−0.478	2.610
		$X_{14} = 6$	−0.342	0.774	0.195	1	0.659	0.710	−1.859	1.176
		$X_{14} = 7$	0.765	0.784	0.951	1	0.329	2.149	−0.772	2.301
		$X_{14} = 8$	0 [a]			0		1		
	Travel time	X_{15}	0.206 **	0.001	4.379	1	0.036	1.229	0.000	0.003
	Interacts with others	$X_{16} = 0$	0.407 ***	0.068	36.136	1	0.000	1.501	0.274	0.539
		$X_{16} = 1$	0 [a]			0		1		

* Significance level of 0.1; ** Significance level of 0.05; *** Significance level of 0.01. 0 [a] indicates reference.

The ordered cumulative logit function's threshold values $\alpha_{(J)}$ and attribute equation coefficients β_K are calibrated using the maximum likelihood estimation technique using paired data of attributes and perceived TWB as reported on survey questionnaires.

4.3. Model Results

The increasing value of the intercept ensures that for each integer value of rat-ing-num, the cumulative probability of travel time is in the correct order for a given value, l, meaning that:

$$\begin{aligned} & P(Y \leq 1 | Traveltime = l) \\ & \leq P(Y \leq 2 | Traveltime = l) \\ & \leq P(Y \leq 3 | Traveltime = l) \\ & \leq P(Y \leq 4 | Traveltime = l) \\ & \leq P(Y \leq 5 | Traveltime = l) \end{aligned} \tag{10}$$

As depicted in Figure 5, as the travel time increases, each value α_j increases, and the value β decreases. The cumulative probability of a particular Rating-Num score (Normalized net affect value) decreases, which is a clear negative slope. A fixed value is selected for each Rating-Num score, and the difference between successive curves of Rating-Num scores determines the probability $P(Y = j | Traveltime)$. For instance, compared to the value $P(Y \leq 1) = P(Y = 1)$ for travel time = 8 min, travel time = 5 min is higher. Moreover, the value $P(Y = 2) = P(Y \leq 2) - P(Y \leq 1)$ is significantly greater when travel time = 8 min than when travel time = 15 min. This suggests that the probability of having a higher level of travel well-being decreases along with the increase in travel time.

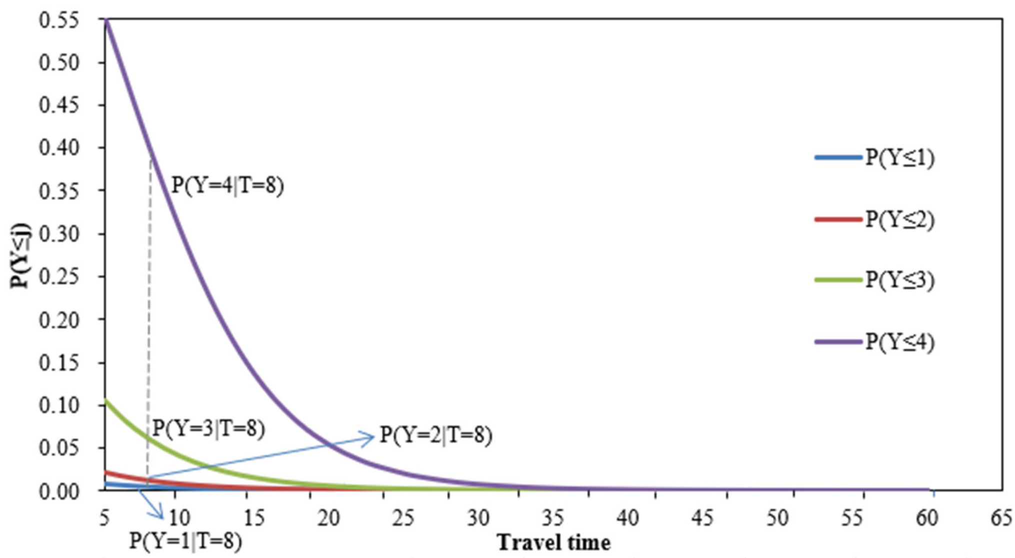


Figure 5. Example cumulative logit distribution of Travel well-being.

After the test, there is no multicollinearity between independent variables, and modeling analysis can be performed. Moreover, the result of the parallelism test $p > 0.05$ allows for ordered logistic regression analysis. In addition to qualitative descriptive indicators of coefficient calibration, OR (EXP (β)) is also commonly used to analyze the relationship between independent and dependent variables. The OR is interpreted as "the odds of the dependent variable increasing by at least one level when the independent variable changes by one unit while holding other factors constant". Logistic regression fitted four regression equations. Table 5 displays the model coefficients and their significance.

Observing the parameter values of the thirteen variables inputted into the model, it can be seen that for age, weekly work time, weekly income, marital status, health status, resting degree, medication history, feelings compared to a typical day, travel time, and interaction with others, the parameter estimates are significant based on their reference choices. This indicates that changes in these 10 variables significantly impact the level of travel well-being.

Based on the parameter estimates from the logistic regression analysis, it can be inferred that for personal variables, elder individuals tend to have higher travel well-being. Married individuals and respondents who work longer hours per week generally possess greater levels of travel well-being. This result may be attributed to the fact that married individuals and elder individuals tend to have lower life stress, while those who work longer hours may have more fulfilling lives, leading to better travel experiences.

Regarding the weekly income variable, the ORs are 0.805, 0.743, 0.672, and 1.381 for travelers with weekly incomes ≥230,769. This indicates that travelers with weekly incomes ≤57,691 are 0.805 times more likely to have lower levels of travel well-being compared to those with weekly incomes ≥230,769. Similarly, it can be analyzed that travelers with a weekly income of 57,692~115,383 are 0.743 times more likely to obtain lower travel well-being than those with weekly income ≥230,769. In contrast, travelers with weekly income of 173,076~230,768 do not significantly differ in their travel well-being levels compared to the reference group. Therefore, it can be inferred that individuals with higher weekly incomes generally have lower levels of travel well-being. This result may be attributed to the fact that people with a higher income also have higher living standards, which can impact their level of travel well-being.

In the variables of health and emotional condition, taking individuals with a health condition of "very healthy" as the reference, the regression coefficients are all positive, and the ORs are 3.677, 2.921, 1.850, and 1.361, respectively. This indicates that the likelihood of very unhealthy respondents feeling very unhappy during a trip is 3.677 times higher than that of very healthy individuals. Similarly, the likelihood of moderately unhealthy respondents feeling very unhappy during a trip is 2.921 times higher than that of very healthy individuals. The decreasing odds ratios show that healthier respondents are more likely to experience higher levels of travel well-being. Taking individuals who have an excellent level of rest as the reference, the regression coefficients are all greater than 0 in the variables of rest condition, and the ORs are 6.360, 3.501, and 2.020, respectively. This indicates that the likelihood of individuals who have a very poor level of rest have the lowest level of travel well-being, being 6.360 times higher than that of individuals who have an excellent level of rest. The results suggest that the better individuals rest for, the higher the likelihood of experiencing higher levels of travel well-being. Furthermore, taking respondents who have not taken medication the previous day as the reference, the regression coefficient for individuals who have taken medication is negative, and the OR is 0.656. This indicates that the likelihood of individuals who have not taken medication feeling unhappy during travel is 0.656 times that of individuals who have taken medication.

Taking individuals who feel better compared to a typical day as the reference, the ORs for individuals who feel worse are 3.842 and 1.395, respectively. This indicates that individuals who feel worse compared to a typical day are 3.842 times more likely to have lower levels of travel well-being compared to those who feel better. Overall, it can be observed that travelers who feel better compared to a typical day generally have better travel experiences.

Regarding travel attributes, the logistic regression results show that the level of travel well-being does not significantly differ among respondents with different modes of travel. The regression estimate for travel time is positive, indicating that the longer the travel time, the lower travel well-being of the travelers. Upon analyzing Figure 5, an increase in travel time results in a significant decrease in the probability of feeling very happy on a trip. Taking the probability curve $P(Y=4) = P(Y \leq 4) - P(Y \leq 3)$, the probability of travel well-being level of 4 decreases from 0.55 to 0.025 when the travel time increases from 5 to 25 min. Incorporating the overall perspective, respondents in this sample tend to have the lowest levels of travel well-being when the duration of their travel is approximately 60 min. Respondents with a travel time between 5 to 20 min exhibit higher levels of travel well-being, while a trip exceeding 20 min generally results in lower levels of travel well-being. This suggests that a travel time of 20 min may serve as a turning point for people's travel well-being. Taking interaction with others during travel as the reference, individuals who have no interaction are 1.501 times more likely to have lower levels of travel well-being compared to those who have interactions. This suggests that engaging in communication and interaction with others during travel significantly enhances travel well-being.

4.4. Application and Performance of People TWB Models

Line 15 of Table 6 clearly lists the respondents' age, weekly income, marital status, and travel characteristics.

$$mean(TWB) = \sum_{j=1}^{5} P(TWB = J) * J = 0.02 * 1 + 0.58 * 2 + 0.15 * 3 + 0.20 * 4 + 0.05 * 5 = 2.68 = \text{TWB C} \quad (11)$$

Table 6. Evaluation of proposed people TWB Model.

Number	Value, by Variable													Survey TWB	Logistic Model TWB	Linear Model TWB
	X_1	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}			
1	56	60	5	1	0	4	3	1	0	2	1	30	1	C	C	D
2	15	0	1	0	0	4	4	0	0	2	3	10	1	A	A	A
3	15	20	1	0	0	4	4	0	0	2	3	5	1	D	E	D
4	19	0	1	0	0	5	4	0	0	3	1	10	0	D	D	E
5	24	55	3	0	0	3	2	0	0	3	1	5	1	D	C	C
6	22	68	2	0	0	5	4	0	0	2	3	36	1	B	B	B
7	47	35	1	0	0	4	3	0	0	2	2	15	1	B	C	B
8	47	35	1	0	0	4	3	0	0	2	2	20	1	B	A	A
9	26	40	3	1	1	5	1	0	0	1	1	8	0	E	E	D
10	35	45	4	0	0	4	3	0	0	2	1	20	0	D	D	C
11	61	45	5	0	0	3	2	0	0	3	1	25	0	C	C	C
12	54	0	1	0	0	4	3	0	0	1	1	15	1	C	C	B
13	57	45	5	0	0	4	3	0	0	3	1	10	0	E	D	D
14	40	40	1	0	0	2	3	0	0	2	1	30	0	A	A	A
15	55	0	1	0	0	4	4	0	0	2	1	20	0	C	C	C
16	55	0	1	0	0	4	4	0	0	2	1	15	0	D	D	E
17	55	0	1	0	0	4	4	0	0	2	1	15	0	C	B	C
18	36	50	2	0	0	3	4	0	0	2	1	10	0	E	E	E
19	63	0	1	0	0	4	4	0	1	1	1	30	0	C	C	C
20	31	40	3	0	1	4	4	1	0	3	2	20	1	A	A	B

As shown in Table 6, the linear regression TWB model matches 50% of the survey data, while the logistic TWB model achieves a higher match rate of 70%, surpassing it by 20%. All factors directly influence TWB. Through application and comparison, the recommended logistic model demonstrates higher accuracy. From Table 6, it is also evident that all parameters have a direct impact on TWB. The application and evaluation of the model indicate that the ordered logistic regression model can predict people's travel well-being levels with relatively high accuracy.

5. Conclusions and Discussion

5.1. Conclusions

Based on 3512 survey data from ATUS 2021, this study employed linear regression and ordered logistic regression models to explore the relationship between factors and residents' travel well-being from various perspectives. Using an ordered logistic model to explain the varying probabilities of response associated with different combinations of variables, the thresholds and mechanisms of changes in travel well-being during the trip was elucidated. It revealed the influence of personal variables, health and emotional condition, and travel attributes on individuals' travel well-being.

Due to the individual differences of travelers and the complexity of travel environments, people's travel well-being is influenced by various factors that significantly impact their perceived emotional ratings of travel. It is necessary to explore the complex relationship between relevant factors and travel well-being and to employ precise assessment methods to understand how changes in these factors affect the level of travel well-being. The study found that age, marital status, weekly income, and weekly work time significantly influence travel well-being. Elder individuals tend to have higher levels of travel well-being compared to younger individuals. A number of scholars, including Gao, have reached the same conclusion [15,60,61], but Shao's study concludes differently in which the younger (under the age of 30) cohort has a higher level of travel well-being [62]. This may be because older individuals have lower expectations for travel and can appreciate simple pleasures and cherish their travel experiences. Married individuals tend to have higher levels of travel well-being compared to singles. Weekly income and weekly work time are also significantly associated with the travel well-being level, which is consistent with Cao's findings [53]. Higher weekly income and shorter weekly work time are often correlated with lower levels of travel well-being. This may be because individuals with shorter working hours face economic limitations and the impact of work and personal life pressures, leaving them with insufficient time and resources to fully enjoy the travel experience.

Furthermore, individuals who do not take medication and have good health and rest tend to have better travel experiences. Feeling better today compared to a typical day is also correlated with higher levels of travel well-being. Chen's study also concluded that personal health and rest situations are the most important second-level indices [27]. This suggests that health and rest levels have a strong relationship with travel well-being. Longer travel time is associated with lower travel well-being. Some scholars have also found that longer travel time is associated with lower travel well-being [16,17,26,51,61]. Extended travel time can lead to physical and mental fatigue. Engaging in communication with others during travel significantly enhances travel well-being level and helps alleviate boredom with fatigue during the journey.

5.2. Policy Recommendations

Travel well-being is an essential part of a person's daily life, and it has a direct impact on the quality of life and well-being. Based on these results, we can propose the following policy enhancement strategies that transportation planners and policy makers can use to identify key factors, optimize the transportation system, improve transportation policies, and help people improve their travel well-being.

(1) First, we found that the elderly and married people usually have higher travel well-being, and in the future, more attention should be paid to the travel needs of young and unmarried people. By providing diversified travel choices and travel modes, we can meet the diversified needs and preferences of the young and unmarried. Depending on the purpose and circumstances of the trip, they can be helped to choose the right mode of travel to improve their well-being.

(2) Secondly, we found that a higher weekly income is associated with lower travel well-being levels. Individuals with a higher weekly income typically face more work and life pressure. Therefore, the government can improve traffic congestion through reasonable improvement of the travel environment, regional number restrictions and other measures to help people with higher weekly incomes rationalize their schedules and enhance their travel experience.

(3) Individuals who feel better today compared to a typical day tend to have higher levels of travel well-being, indicating that the mood before travel significantly influences the travel experience. Therefore, it is necessary to encourage people to pay attention to emotional management, maintain a positive mindset and emotional state in daily life, practice healthy eating habits, get enough rest and sleep, incorporate relaxation activities, and make appropriate adjustments to travel plans to ensure physical and mental comfort and balance.

(4) Having a healthy body and maintaining a good daily routine play a crucial role in enhancing travel well-being. Implementing an improved system for regular health check-ups for residents and establishing rest service areas could be effective strategies for

enhancing travel well-being. For example, by encouraging residents to engage in regular exercise and physical activity, as well as scheduling adequate rest and relaxation time. Measures should be taken to prevent the negative impacts of fatigue while driving and maintain good physical health in people's travel experiences.

(5) Travel time has a negative impact on travel well-being. Longer trips and frequent traffic congestion can lead to increased stress and anxiety in individuals, which can reduce travel well-being. Interacting with others during travel is significantly associated with higher levels of travel well-being. Therefore, the results of the study call for rational transportation planning to minimize travel distance and travel time, improve transportation hubs, upgrade transportation infrastructure, increase the efficiency of public transportation, and increase the number of route options to help people create a convenient and flexible travel environment.

While previous studies have explored the relationship between travel well-being and influencing factors, there have been few studies based on real-time tracking survey data such as ATUS 2021 that specifically examine the associations between travel well-being and personal variables, health and emotional condition, and travel attributes among the US population. This study also has certain limitations, and it is unclear whether the analysis results would hold in other countries or regions. Future research could investigate data from different regions or countries to determine if the results are universally applicable.

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