

illuminating Perceptions Affecting Mode Choice: A Combination of Qualitative Perspective and ICLV Modeling

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Abstract

Understanding travel behavior is one of the most critical challenges in transportation planning. Planners can gain profound insights into travel behavior by exploring people's perceptions and attitudes. Qualitative research as an independent approach or in a combination of a quantitative research can provide a deep understanding of people's perceptions in transportation. This study used both qualitative and quantitative techniques to inspect citizens' perceptions towards travel behavior. The interview results of the qualitative approach indicated that environmental concerns were mainly rooted in spiritual ethics. In addition, the respondents identified comfort, time, safety, and environmental concerns as the critical determinants in travel mode choice. The characteristics of individuals and transportation alternatives as well as environmental concerns were considered to affect mode choice in the quantitative study. The results, extracted from an Integrated Choice and Latent Variable (ICLV) model, showed that environmental concerns influenced people to choose public transportation. Furthermore, the findings indicated that young and middle-aged people preferred to use public transportation. Still, the preference was about quadruple for the middle-aged group.

Keywords: Travel mode, Perception, Mode choice, Environmental concerns

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1. Introduction

Developments in transportation sector, which mainly occur due to increasing vehicle fleet and mobility level, are associated with desirable and undesirable effects such as economic growth, social influences, energy consumptions, and environmental impacts. It is necessary to change individuals' behaviors in favor of sustainable transportation modes and reduce their tendency to use motorized modes (Beirão and Cabral 2007, Gärling and Schuitema 2007, Chen, Chen, and Li 2020). Changing travel behaviors requires an adequate understanding of travel behavior and perceptions influencing mode choice, whose roles are as important as those of the socioeconomic and built environment factors (Vredin Johansson, Heldt, and Johansson 2005, Heinen, Maat, and Van Wee 2011, Schwanen and Mokhtarian 2005, Steg 2005, Fan and Chen 2020).

Qualitative studies have been increasingly conducted as a preliminary phase to identify travelers' perceptions, attitudes, and behaviors (Grosvenor 2000) or to determine the best way of stating questions. Even though qualitative studies can reveal the hidden attitudes of the respondents and provide a deep understanding of people's perceptions about travel mode choices, limited studies have adopted the qualitative approach in transportation planning in developing countries such as Iran.

The present study investigates the influence of individuals' perceptions and attitudes on their travel behaviors. To this end, a qualitative study as a preliminary step to the quantitative one is conducted using either descriptive or exploratory qualitative research techniques to gain a deep understanding of individuals' travel mode choices. Also, an Integrated Choice and Latent Variable (ICLV) model identifies perceptions and attitudes towards two considered mode choices, including public transportation and private car.

Qualitative methods can focus on the subjective experiences of individuals related to travel and

provide better opportunities for respondents to specify factors that are of high importance to them (Beirão and Cabral 2007). Concerning the travel modes investigated in the qualitative studies, some conducted on the topics related to cars with different objectives from principal causes to commute by cars (Gardner and Abraham 2007) to an investigation of car user and non-car user attitudes aimed to explore attitudinal ambivalence about travel modes (Hoffmann et al. 2020); followed by studies focused on public transportation to understand perceptions of public transportation users (Beirão and Cabral 2007), to identify the effects of universal design measures to guide the environment for improved accessibility in public transportation (Aarhaug and Elvebakk 2015), and to obtain a deeper understanding of attitudes towards public transportation (Ramos et al. 2019).

Based on the previous studies, it is common to blend qualitative and quantitative approaches, consecutively or simultaneously (Wall, Devine-Wright, and Mill 2008, Czepkiewicz et al. 2020, Miralles-Guasch, Melo, and Sarda 2014). In the current study, it is aimed at mixing qualitative and quantitative approaches to understand individuals' perceptions and attitudes on travel behavior and quantifying the results gained by this mixture.

To date, most studies on travel behavior have been conducted in developed countries, neglecting the people's perceptions and attitudes in developing countries (like Iran). The qualitative research questions are to identify citizens' preferences in travel mode choice and focus on the role of environmental concerns on travel behavior. Accordingly, five questions are raised in the qualitative phase:

- What are the main factors influencing participants' choice of travel mode?
- What are the participants' attitudes towards environmental concerns about travel mode choice?
- What are the origins of the participants' environmental concerns?

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This study attempts to identify individuals' perceptions and attitudes affecting their mode choice for using private car or public transportation through interviewing. People's attitudes and perceptions are defined as indicators of unobservable factors (latent variables) of the quantitative analysis in an ICLV modeling context. One of the most crowded district in Tehran, the capital city of Iran, is considered as a case study.

As previously described, to deeply understand how perceptions and attitudes influence travel mode choice, this study attempts to make use of two stages of data collection in the Central Business District (CBD) of Tehran. First, qualitative data are collected by individual interviews to gain insights into decision processes as a psychological phenomenon. Then, quantitative data are obtained by 346 questionnaires randomly distributed among private car and public transportation users.

This manuscript is arranged as follows: Materials and methods section presents the methodology framework, the qualitative data collection, analysis and the results of the qualitative stage. Then, the data and description of the quantitative study sample is presented in quantitative approach sub-section, preliminary analysis as well as ICLV modeling are presented and its results are discussed. The last section explains the major findings of the study.

2. Methodology

The current study included two complementary approaches. First, a qualitative research approach was geared toward creating a complete and detailed description of the influence of individuals' perceptions, attitudes, and environmental concerns on their travel behaviors. Then, a quantitative approach that sought to quantify data by a structured data analysis was employed. Figure 1 indicates the methodology framework of this research.

It was an attempt to evaluate people's views and understand the influence of individuals' perceptions on their travel behaviors. The

quantitative study hypothesized that the characteristics of individuals and transportation alternatives as well as unobservable factors could affect the utility of travel modes. Unobservable factors were considered as the latent variables rooted in the results of the qualitative stage, and the effects of variables on the utility of travel modes were examined by Integrated Choice and Latent Variable (ICLV) model.

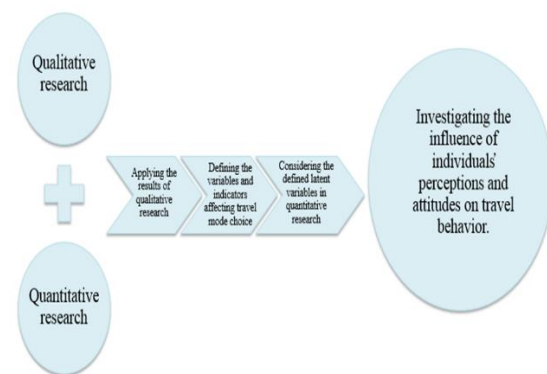


Figure 1. The methodology framework

3. Qualitative Approach

There are many ambiguous aspects in characterizing travel behaviors and mode choices. Thus, it is valuable to conduct a qualitative study to explore individuals' perceptions and attitudes deeply. Two methodological trends are applied within the generated data of qualitative research, namely, focus groups and individual in-depth interviews, which have advantages and disadvantages. Although focus groups are more economical and less time-consuming, in-depth interviews can provide richer information (Stokes and Bergin 2006). In addition, there is considerable scope for investigating individuals' viewpoints and thorough coverage of the study objectives (Ritchie, Lewis, and Elam 2003).

Engaging citizens in decision-making would be a practical solution for problems in cities (Madanipour 1999). Therefore, in this study, interviews were conducted with ordinary citizens, who were expected to face the policies

in their real life, to examine their personal experiences and attitudes towards transportation. The interviewees described their personal context of research issues, and data was analyzed by content analysis (Berelson 1952) which aims to systematically categorize and record features of data. The content analysis does not focus on finding relationships among categories or theory building; instead, it focuses on extracting categories from the data (Hsieh and Shannon 2005).

3.1. Sampling in the Qualitative Approach

The studied area was the CBD of Tehran. This region is one of the oldest districts of Tehran, with an area of about 17 square kilometers and a population of half a million people, and entirely located in the congestion charge zone. This region was selected due to the availability of its more proper infrastructures for public transportation, as compared to other districts in Tehran. Public transportation and specifically bus is accessible almost all over the district. The interviews were conducted during off-peak hours of working days in May 2018.

There was gender segregation throughout the interviews due to cultural reasons and to have a closer relationship with the participants. They were requested to sit on the benches of the streets to avoid exhaustion and incomplete interviews. The respondents' permission was obtained for audio recording the interviews.

Qualitative studies are in-depth and small in size due to the use of non-probability samples. The sample is not intended to be statistically representative (Ritchie et al. 2013). As a rule of thumb, sample sizes under 50 are reasonable in qualitative studies for individual interviews, and it would be difficult to manage and analyze more interviews (Ritchie et al. 2013).

Similar to many qualitative studies, the sample was relatively small in this study. Thus, care should be exercised in generalizing the results. In addition, care was taken to include people from various age groups and educational levels.

A total of 26 residents (12 females, 14 males) aged between 22 and 71 years old ($M=40.96$, $SD= 12.58$) were interviewed. The participants were ensured about the confidentiality and anonymity of the collected data. Table A.1 shows the demographic information of participants.

3.2. Data Analysis of the Qualitative Approach

This study was performed based on qualitative content analysis using an inductive approach to summarize data and establish links between the evaluation and the briefs derived from the interviews and finally develop a framework of the underlying structure of experiences. In the current study, the researchers were involved in data collection and site observation for a month. In addition, the familiarity as well as intensive and long-term involvement of one of the researchers with the site assisted researchers to enhance the quality and validity of the study. As demonstrated by Maxwell, long-term participants help researchers "rule out spurious associations" (Maxwell 1996).

Transcriptions of the interviews were entered into MAXQDA software to facilitate the organization and structuring of the coding process and find relationships between the concepts. The researchers carefully read, ordered, and interpreted the qualitative data in MAXQDA software to manage the analytical process (Figure 2)

The transcripts were thoroughly read by the researchers to become familiar with the content of the data and identify relevant topics. The research was based on three main subjects: factors influencing travel mode choice, perceptions about the use of public transportation and private car, and environmental concerns for travel mode choice, which were used to explore the respondents' perceptions and attitudes towards travel behaviors.

In the first step of coding, descriptive coding was applied to each transcript in which general

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topics of three main research subjects were identified and the act of creating codes using direct quotes from interviewees, was also applied at this stage. Then, the transcripts were revisited using initial coding, in which tentative codes were applied to the data based on emerging ideas. A coherent and logical

structure was presented to provide the content of the descriptive elements, which is considered crucial for analyzing qualitative data (Ritchie et al. 2013). Subsequently, the results were interpreted after checking the structural reliability by the researchers.

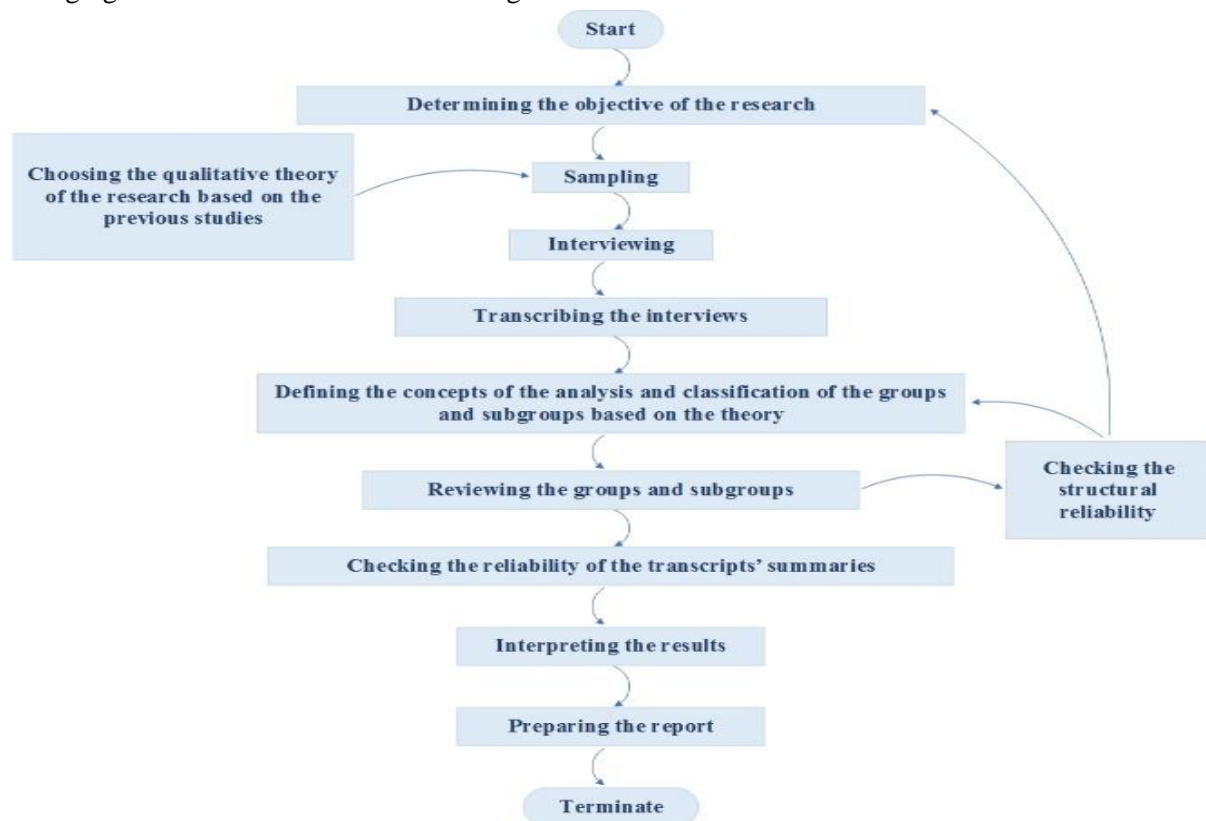


Figure 2. Analytic process of the qualitative research

Once all transcripts had been initially coded, each transcript was revisited for an iterative procedure to apply new and existing codes to the data until no new themes or concepts emerged. Several new codes were also generated at this stage and were applied across all transcripts when applicable. Through working iteratively in this way, the consistent application of codes across the data and reached data saturation were ensured.

Finally, the results of the qualitative phase were used to define the indicators of individuals' perceptions and attitudes towards travel mode choice. The results were used in the quantitative phase to examine the effects of unobservable variables on travel mode choice.

3.3. Results and Discussion of the Qualitative Approach

The participants were first asked to present their general perceptions of different travel modes and the main factors affecting their preference for a specific mode of transportation among other alternatives. This process identified the priorities of people in mode choice and allowed a comparative evaluation between different modes. Then, the participants were asked about the reasons behind their preference for using their private cars and public transportation. Finally, their opinions about environmental concerns were examined. Data extracts were used to determine critical concepts as can be observed for the first research subject in Table

1, prioritized by MAXQDA via coding the most tagged concepts to the least tagged ones. The following is an outline of the key findings, including participants' literal quotes in Table A.2.

Table 1. Code frequencies

	Frequency	Percentage
Comfort	19	73.08
Time	13	50.00
Safety & Security	6	23.08
Eco-friendly modes	2	7.69
Documents with code(s)	23	88.46
Documents without code(s)	3	11.54
Analyzed documents	26	100.00

3.3.1. General Perceptions of Different Travel Modes

The results showed that different factors contributed to the acceptability and desirability of specific transportation modes from the respondents' perspectives. The factors mentioned by the participants were ranked based on the extracts from the most frequent tags to the least ones. Comfort. Being comfortable was an essential factor for all the interviewees. They mainly experienced considerable discomfort while using public transportation. They considered comfort as having available seats and an air condition system as well as the presence of no vendors (e.g., P24). Recession and unemployment have forced many lower-income people to become vendors in the buses or subway. Although street vending is very common in Iran and many other developing countries (Onodugo et al. 2016, Boonjubun 2017), the presence of vendors in Tehran public transportation is a new, unpleasant phenomenon. Different measures have been taken to overcome this problem. However, it has not been solved yet.

Time. Travel time and waiting time were two crucial factors affecting travel mode choice. Most participants (e.g., P21) expressed their preference for the fastest mode, which could

take them to their destination at the shortest time possible. Another factor that specifically addressed public transportation was the degree of certainty related to the timetable of public transportation. Previous research showed that flexibility and lack of reliability could lead to people's dissatisfaction with public transportation (Sen et al. 2019). Having a timetable for public transportation can affect people's perceptions about the reliability of this mode.

Safety and security. Safety was considered to be an essential issue by some respondents. They mostly preferred to choose a mode which they could rely on drivers' skills and vehicle safety in case of accidents (e.g., P21). Mode choice is influenced by tremendous security issues from the interviewees' point of view. It involved both private cars and public transportation (e.g., P15). Also, lack of safe parking and being theft were considered as the main issues regarding the security in using private cars and public transportation, respectively.

Eco-friendly modes. Environmental impacts of transportation were the least frequent conceptual tag in general travel mode choice. Only two participants linked their travel mode choice with its environmental impacts (e.g., P18).

3.3.2. Private Car Users' Preferences

The interviewees were asked about the preferences of private car users from their point of view, and they mentioned different priorities in choosing private car.

Convenience. Regarding the attractiveness of private car use, convenience, and individual freedom were felt as the most important reasons (e.g., P10 and P18), and some participants (e.g., P26) considered inadequate infrastructure of other travel modes, especially public transportation, as an auxiliary cause of choosing private car.

Attachment to the car and its prestige. Some participants (e.g., P10) thought using a private car could induce a sense of superiority. They believed that a private car was a status symbol

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indicating wealth, prestige, and high social rank.

3.3.3. Preferences of Public Transportation Users

Low cost and running fast were considered as two major themes related to the choice of public transportation. However, some interviewees felt coercion as one of the most influential factors for choosing the public transportation.

Low cost. It was confirmed that public transportation is cheaper than private cars, and this preference could be justified since travel cost was an important issue for all interviewees (e.g., P14).

Running fast. In traffic congestions, using fast public transportation, especially Bus Rapid Transit (BRT) and subway, can dramatically reduce travel time (e.g., P21).

Coercion. Paying the toll for entering the congestion charge zone and parking spaces are two factors that discourage private car use, specifically for the residents of the studied area who live in a complete congestion charge zone (e.g., P9).

Some interviewees stated that many people were coerced to choose public transportation as the only available mode of transportation due to their financial problems and congestion charge zone (e.g., P9 and P26).

3.3.4. Environmental Concerns

In the last part of the qualitative interview, participants were asked about their definition of being pro-environmental and the origin of their environmental beliefs.

Being pro-environmental. In the first stage of the qualitative study, just two respondents expressed their environmental concerns regarding travel mode choice. But when it comes to asking directly, almost all participants considered themselves pro-environmental and were confident that being pro-environmental was related to the use of sustainable modes of transportation. Several respondents (12 persons) declared that harming the environment is a sin according to their beliefs. Their responses to the definition of being pro-

environmental were classified into two main categories, namely 'having spiritual ethics and environmental concern' and 'having concerns about air pollution'.

Origination of environmental beliefs regarding travel mode choice. When asking interviewees about the origination of environmental beliefs, the respondents reckoned that environmental beliefs regarding travel mode choice were originated from family training, spiritual ethics, and media. They believed that family played the most critical role in shaping children's insights into the environment as a sacred essence.

As previously mentioned, we used these results, as the latent variables of ICLV model. It was aimed to evaluate the influential factors and the effect of perceptions on travel mode choice. Based on the responses, especially at the origination of environmental beliefs, the most probable expectation resulting in environmental concerns was the indicators deeply rooted in spiritual ethics.

4. Quantitative Approach

Based on the qualitative stage, the characteristics of transportation alternatives such as cost and time were two mostly mentioned factors by respondents and should be considered affecting the utility of travel modes. The validated data on the cost and time of respondents' trips was not accessible and the researchers had to be content with self-reported travel time of respondents. About perceptions, environmental concerns, comfort, security, and coercion were considered affecting travel mode choice as unobservable variables (latent variables). Indicators of these latent variables were defined by different questions, and the level of respondents' agreement was represented on a five-level Likert scale (1=strongly disagree; 2=disagree; 3=neither agree nor disagree; 4=agree; 5=strongly agree) (Likert 1932). Table 2 shows the indicators of latent variables on a five-level Likert scale.

4.1. Sampling in the Quantitative Approach

Private car and public transportation (subway and bus) were considered as mode choices in this study. The survey was performed face to face during ten working days in July 2019 at bus and subway stations, marginal parking, and car parks (Figure 3).

In the introduction of the questionnaire, the survey objective and a clear privacy disclaimer had been included. The questionnaires were randomly distributed among private car and public transportation users and had three sections, including personal and travel

characteristics of individuals as well as the psychiatrics questions related to the indicators of the latent variable. Personal characteristics included gender, age, educational level, height, and weight to measure BMI (Body Mass Index) and the number of household members and cars. The characteristics of the trip were the purpose and the travel time. The questions were related to the indicators of the latent variables on a five-level Likert scale (Table 2).

Table 2. Indicators of the latent variables

Latent variable	Indicators	Symbol
Environmental concerns	Nature is sacred because God created it.	Ind1
	Nature has an inherent value and power.	Ind2
	Based on spiritual ethics, harming the environment is ingratitude.	Ind3
	Harming nature is an unforgivable sin.	Ind4
	The balance of nature could be easily disturbed.	Ind5
	The earth's capacity to tolerate humans' interference is over.	Ind6
Comfort	My travel mode is the most comfortable one in the market.	Ind7
	I have a peaceful trip with my chosen travel mode.	Ind8
	I do not feel any concern during my trip with this travel mode.	Ind9
Security	According to the security, I can use this travel mode at any time during the day.	Ind10
	I have witnessed or experienced violence argument or quarrel during my trip with this travel mode.	Ind11
	I have witnessed or experienced theft while using this travel mode.	Ind12
Coercion	I had the opportunity to use another travel mode.	Ind13
	While using this travel mode, I can easily accompany my children or take shopping bags.	Ind14

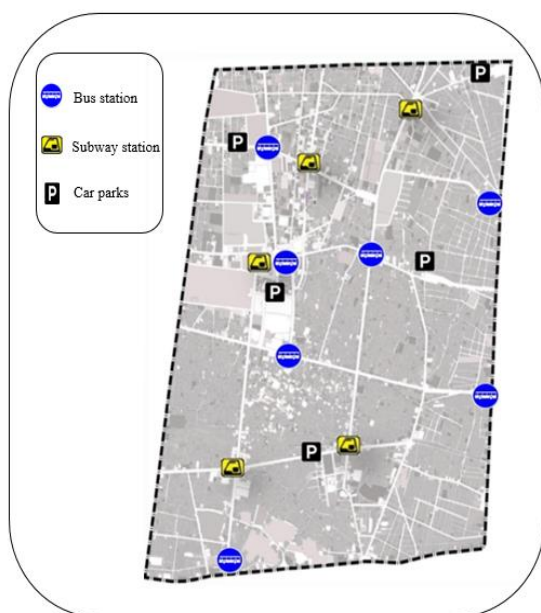


Figure 3. The surveyed location

A total of 346 questionnaires were completed by people aged between 19 and 90 years using private cars (87 questionnaires) or public transportation (109 questionnaires on bus stations and 150 on the subway) in the studied area. From the summary of descriptive statistics presented in Figure 4, it is recognized that public transportation users were younger than private car ones. Also, most of the people using public transportation had a BMI (Body Mass Index), which did not fall within the obesity range.

4.2. Preliminary Analysis of the Quantitative Approach

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Before modeling, we conduct a confirmatory factor analysis using maximum likelihood estimation to test the reliability and validity of the conducted measurement models using the considered latent variables (Figure 5).

Composite reliability (*CR*) as a measure of internal consistency in scale items was estimated to establish construct reliability for the model. Convergent and discriminant validity are both a requirement for excellent construct validity. For convergent validity, factor loadings must be statistically significant, standardized factor loadings must be greater than 0.5, the average variance extracted (*AVE*) is greater than 0.5 and $CR > AVE$. For discriminant validity the maximum shared squared variance (*MSV*) and the average shared

squared variance (*ASV*) must be less than average variance extracted ($MSV < AVE$; $ASV < AVE$). According to Table 3 which provides support for validity and reliability of the model, only environmental concerns variable was considered as the validated and reliable latent variable affecting mode choice.

In the next stage, the effects of the characteristics of individuals and transportation alternatives as well as environmental concerns were examined by an Integrated Choice and Latent Variable (ICLV) modeling approach which integrates latent constructs (e.g., attitudes and perceptions), through traditional choice models, to clarify the actual decision process (Bolduc and Alvarez-Daziano 2010).

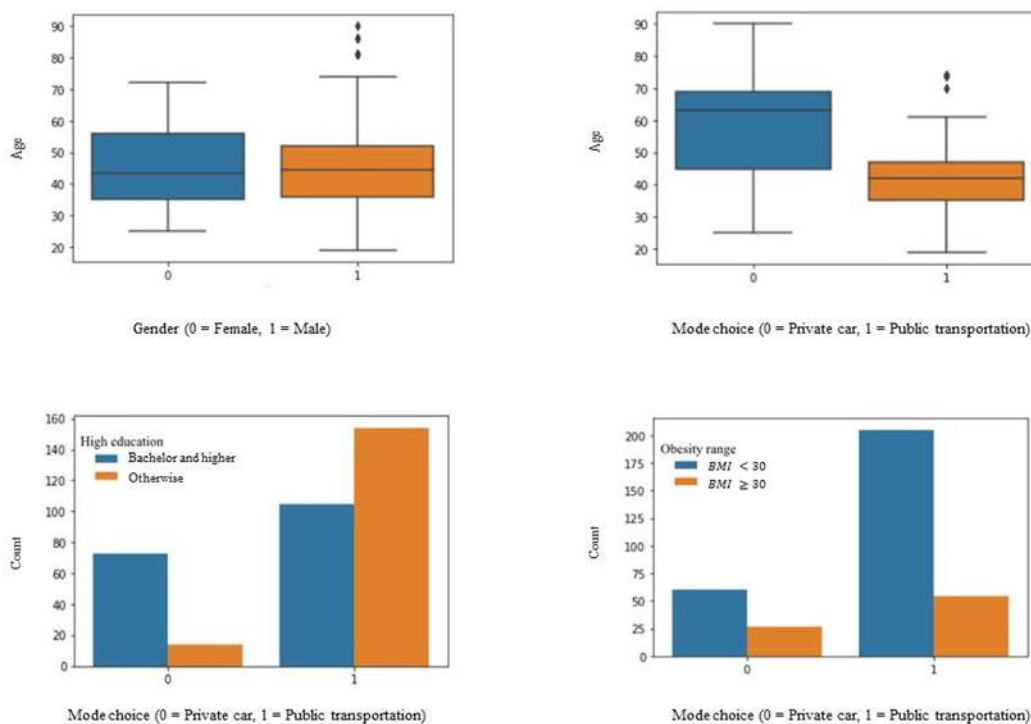


Figure 4. The surveyed location

4.3. ICLV Model of the Quantitative Approach

In the ICLV model, the indicators of the study were based on the Likert scale and considered as discrete variables. Therefore, the measurement equation was estimated as ordered probit regression. Furthermore, the

maximum likelihood method, in which the likelihood function is defined by jointing the probability of the observed choice and the latent component indicators, was applied to estimate the model (Atasoy, Glerum, and Bierlaire 2013). BIOGEME software and Python programming language were used to estimate the behavioral models (Bierlaire 2020). In

addition, Monte Carlo integration was used by considering one latent variable.

Each utility function for the two alternatives (public transportation or other modes of transportation) was assumed as a linear function of the respondents' socio-demographic features, trip characteristics, and attitudes

towards environment. The framework of the estimated model is shown in Figure 6. K-fold cross-validation was utilized as a model validation technique for assessing the generalizability of the results to an independent data set.

Table 3. Reliability and validity of the latent variables

	CR	AVE	MSV	ASV	Environmental concerns	Comfort	Security	Coercion
Environmental concerns	0.80	0.5	2.5	1.3	0.65			
Comfort	0.21	0.1	5.4	4.1	1.57	0.29		
Security	0.03	0.3	5.4	2.7	-0.94	-2.33	0.53	
Coercion	0.01	0.2	4.5	2.3	0.77	2.13	-1.36	0.41

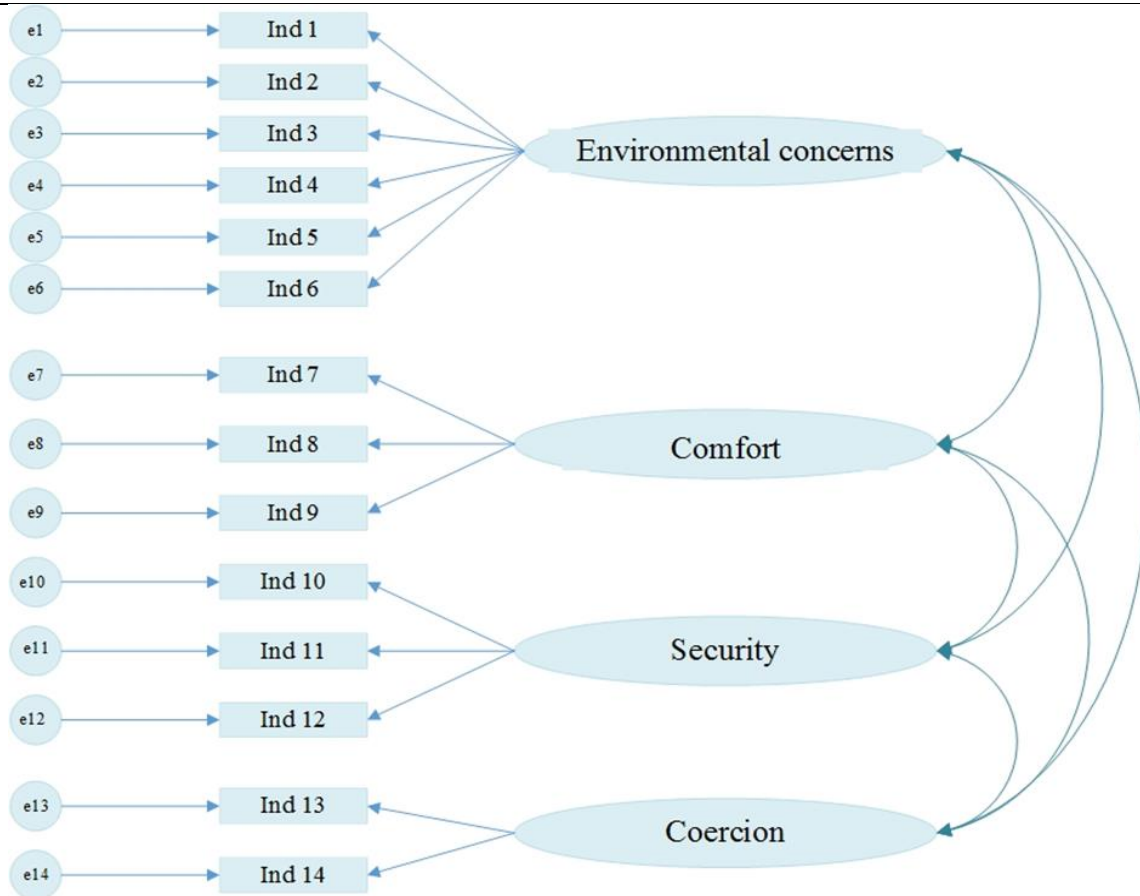


Figure 5. Confirmatory factor analysis model

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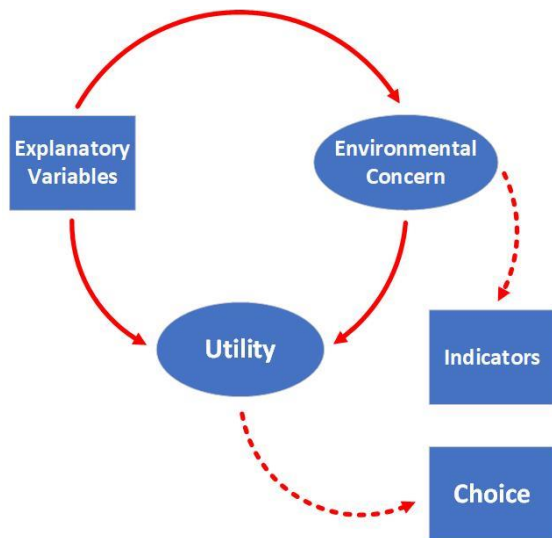


Figure 6. Framework of estimated model

ICLV models have two components, namely, a discrete choice model and a latent variable model. In the discrete choice model, the utility of the alternatives depends on the observed and latent features of the decision-makers and the

$$\begin{aligned}
 proenv_n = & Coef_intrcpt_{proenv} + Coef_Age\ 20 - 44 \times Age\ 20 - 44 + Coef_Age\ 65more \\
 & \times Age\ 65more + Coef_High_edu \times High_edu + Coef_HHcar/HHsize \\
 & \times HHcar/HHsize + \vartheta_n
 \end{aligned} \tag{2}$$

where *Age 20 – 44*: People aged 20-44, *Age 65more*: People aged 65 and more, *High_edu*: High Educational Level (BSc and upper), *HHcar*: Number of cars in the household, and *HHsize*: Household size.

Measurement model *I* is a vector showing individuals' responses to the Likert-scale questions measuring *proenv*. For example, in

$$I_{Ind1,n} = \alpha_{0_Ind1} + \alpha_{Ind1} \times proenv_n + \lambda_{Ind1,n}$$

where $I_{Ind\ i,n}$: The vector showing individuals' responses to the Likert-scale question *i* measuring *proenv*, $\alpha_{0_Ind\ i}$: The vector of intercept for the indicator *i*, $\alpha_{Ind\ i}$: The vector of loadings for indicator *i*, and $\lambda_{Ind\ i,n}$: The vector of measurement errors for indicator *i*.

For the latent variable model, we need the distribution of the latent variables given the

$$U = V(x_n, proenv_n; \beta) + \varepsilon_n = \beta_x x_n + \beta_{proenv} proenv_n + \varepsilon_n \tag{4}$$

From equation (4), choice indicator $y_i = \begin{cases} 1, & \text{if } U_i = \max U_j \\ 0, & \text{otherwise} \end{cases}$ and an assumption about the distribution of the disturbance ε_n ,

alternatives. The latent variable model is defined by structural and measurement equations (Walker and Ben-Akiva 2002). The measurement model indicates the relationship between observable and unobservable variables and determines the relationship between the measurement indicators and the latent variable. In contrast, the structural model demonstrates the relationship between latent variables and their direct and indirect effects on the model. The structural model for the latent variable is shown in equation (1).

$$proenv_n = \gamma x_n + \vartheta_n \tag{1}$$

where x_n : The vector of observed variables, $proenv_n$: Latent (unobserved) variable, γ : Vector of unknown parameters to be estimated based on the data, and ϑ_n : Random disturbance term. More specifically and based on the final estimated model, equation (1) can be written as follows:

indicator 1, α_{0_Ind1} is the vector of intercept, and α_{Ind1} denotes the vector of loadings, and $\lambda_{Ind1,n}$ indicates the vector of measurement errors assumed to be independent and identically distributed multivariate normal with mean zero. Therefore, there are six measurement models for the six indicators of the latent variable.

observed variables $f_1(proenv_n | x_n; \gamma, \Sigma_{\vartheta_n})$ and the distribution of the indicators, conditional on the values of the latent variables $f_3(I_n | x_n, proenv_n; \alpha, \Sigma_{\lambda_n})$.

As traditional choice models, the random utility function, equation (4), has a deterministic part and a random error term.

denoted as $f_2(U | x_n, proenv_n; \beta, \Sigma_{\varepsilon_n})$, choice probability conditional on both observable and latent explanatory variables $P(y | x_n, proenv_n; \beta, \Sigma_{\varepsilon_n})$ is derived.

Assuming the error components ($\vartheta_n, \varepsilon_n, \lambda_n$) are independent, the joint probability of the $f_4(y, I_n | x_n; \alpha, \beta, \gamma, \Sigma_{\varepsilon_n}, \Sigma_{\vartheta_n}, \Sigma_{\lambda_n})$

$$= \int_{proenv} P(y | x_n, proenv_n; \beta, \Sigma_{\varepsilon_n}) f_3(I_n | x_n, proenv_n; \alpha, \Sigma_{\lambda_n}) f_1(proenv_n | x_n; \gamma, \Sigma_{\vartheta_n}) dproenv_n \quad (5)$$

where I_n : Indicators of the latent variable, U_i : Utility of alternative i, U : Vector of utilities, y_i : Choice indicator, y : Vector of choice indicator, α, β, γ : Unknown parameters, $\vartheta_n, \varepsilon_n, \lambda_n$: Random disturbance term, and Σ : Covariance of random disturbance term. Estimating the parameters for this probability is maximizing the observed probability function and the indicators (Ben-Akiva et al. 1998).

4.4. Results and Discussion of the Quantitative Approach

The deterministic terms of the utility functions for the alternatives are described in Equations

$$V_{public} = ASC_{public} + B_{HHcar} \times HHcar / HHsize + B_{Objleisure} \times Objleisure + B_{male} \times male + B_{Age\ 20-44} \times Age\ 20 - 44 + B_{Age\ 45-64} \times Age\ 45 - 64 + B_{proenv} \times proenv \quad (6)$$

$$V_{private} = ASC_{private} + B_{t_time} \times travelttime + B_{Objwork} \times Objwork + B_{Age\ 65\ more} \times Age\ 65\ more \quad (7)$$

where $Objleisure$: Leisure trip purpose, $male$: Gender, $Age\ 45 - 64$: People aged 45-64, $travelttime$: Travel time and $Objwork$: Work trip purpose.

According to the estimated constant value ($ASC_{private}$) in the estimated values (Table 4), the preference for using private car in the studied sample was negative regardless of other variables, which indicated the disutility of private car among the participants. As previously mentioned in the qualitative research

observable variables y and I_n , conditional on the exogenous variables x_n , is:

(6-7). High environmental concern leads to positive perceptions towards the utility of public transportation (Bouscasse, Joly, and Bonnel 2018). Thus, in the current study, the *proenv* (having environmental concerns) was expected to affect the utility of public transportation mode. Five sub-sets of almost equally distributed data were considered to validate the selected model. Each sub-set was used as a validation set. The process was repeated five times with each of the five folds. The estimated model with the highest validation log-likelihood was selected as the final model.

results, travel time was one of the most crucial factors influencing travel mode choice and discomfort during the trip. It was expressed as people's negative perception about public transportation. Similarly, in the current model, travel time had a positive effect on the utility of private car so that its utility could be increased in longer trips. In contrast, the utility of this travel mode was less among the individuals with working trip purpose and older adults (age group of 65 years and above).

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Table 4. Estimated values

Parameter	Value	t-test	Parameter	Value	t-test	Parameter	Value	t-test
Choice model part			Latent variable model part					
<i>ASC_{private}</i>	-17	-3.61	<i>B_{0_PROENV}</i>	-2.66	-19	<i>B_{Ind2}</i>	0.38	5.98
<i>ASC_{public}</i>	0	-	<i>B_{Age 65 more_PROENV}</i>	-0.43	-4.11	<i>B_{Ind3}</i>	0.21	5.85
<i>B_{Obj_work}</i>	-2.04	-2.48	<i>B_{Age 20-44_PROENV}</i>	0.13	2.09	<i>B_{Ind4}</i>	0.20	5.61
<i>B_{Male}</i>	6.96	4.05	<i>B_{HHcar_PROENV}</i>	0.42	2.54	<i>B_{Ind5}</i>	0.87	5.62
<i>B_{Obj_leisure}</i>	-6.54	-4.12	<i>B_{High_edu_PROENV}</i>	0.18	2.98	<i>B_{Ind6}</i>	-	-
<i>B_{t_time}</i>	0.90	2.25	<i>B_{0_Ind1}</i>	0.24	3.34	<i>σ_{Ind1}</i>	0.11	12.30
<i>B_{Age 20-44}</i>	2.83	2.93	<i>B_{0_Ind2}</i>	0.76	5.14	<i>σ_{Ind2}</i>	0.09	9.39
<i>B_{Age 45-64}</i>	10.30	4.14	<i>B_{0_Ind3}</i>	0.42	4.71	<i>σ_{Ind3}</i>	0.09	11
<i>B_{Age 65 more}</i>	-6.57	-2.68	<i>B_{0_Ind4}</i>	0.38	4.43	<i>σ_{Ind4}</i>	0.09	10.60
<i>B_{HHcar}</i>	-7.23	-2.82	<i>B_{0_Ind5}</i>	1.84	5.11	<i>σ_{Ind5}</i>	0.24	8.05
<i>B_{PROENV}</i>	8.51	3.52	<i>B_{0_Ind6}</i>	-	-	<i>σ_{Ind6}</i>	-	-
			<i>B_{Ind1}</i>	0.16	5.04	<i>σ_{PROENV}</i>	0.38	5.97
Goodness of fit of the estimated model								
$ll^i = -6205.54, \quad ll^* = -2461.54$								
$\rho^2 = 0.603, \quad \bar{\rho}^2 = 0.598, \quad AIC = 4989.08, \quad BIC = 5108.67$								

ll^i = Initial LogLikelihood, ll^* = Final LogLikelihood,

κ = The number of estimated parameters, N = The sample size,

$$\rho^2 = 1 - \frac{ll^*}{ll^i}, \quad \bar{\rho}^2 = 1 - \frac{ll^* - \kappa}{ll^i}, \quad AIC = 2\kappa - 2ll^*, \quad BIC = -2 ll^* + \kappa N$$

As expected, individuals with a higher number of cars in their household and those with leisure trips purpose did not prefer to use public transportation. The utility of this travel mode was more among men according to the positive sign of the male variable. Additionally, this mode of transportation was more preferred by young people (age group of 20-44 years) and middle-aged (age group of 45-64 years) in comparison to older adults. This preference was about quadruple among middle-aged people. The older adults were not likely to use private car modes and preferred to use other modes of transportation.

Environmental concerns make people reduce private car use and choose public transportation (Kim, Fujii, and Lee 2013). In this study, the latent variable of environmental concerns had a positive impact on the utility of public transportation.

The results showed that older adults (65 years and above) were less pro-environmental. However, people with higher educational level (bachelor and higher), young people (age group

of 20-44 years), and people with a higher number of cars in their household had more environmental concerns than others. As demonstrated earlier, being young positively affected the utility of public transportation, which had an incremental interaction effect (positive) by considering the latent variable of environmental concerns.

In the quantitative stage, the most essential factor in predicting public transportation mode choice was middle-aged people, following by the pro-environmental attitude and being male, which all three were positively correlated with the utility of public transportation. However, people with a higher number of cars in their household and those making trips for leisure had a negative inclination towards the use of public transportation. Amongst statistically significant variables, being young (age group of 20-44 years) was the weakest factor in explaining the utility of public transportation mode.

According to the quantitative findings, being old (65 years or more) was the most crucial

component in predicting private car mode choice, followed by those traveling for work, both of which were adversely correlated with the utility of a private car.

In the qualitative research, eco-friendly mode was the mentioned factor by female respondents. That was in line with the findings of previous studies indicating that women tend to have more serious environmental concerns than men (Luchs and Mooradian 2012, Cassell and Symon 2004). However, in the results of the quantitative approach, the gender variable was not statistically significant in the structural equation model of environmental concerns.

5. Conclusion

The findings of the current study highlighted individuals' attitudes towards the use of different travel modes by the recognition of perceptual factors based on qualitative and quantitative results. Although great care should be exercised in generalizing the results of the study, this approach (mixing qualitative and quantitative analyses) shed light on travel mode choice and can assist planners in having a more precise plan for further data studies in predictive modeling and other advanced analytics applications in which the planners are faced with a combination of structured, semi-structured and unstructured data collection.

In the qualitative research, a few respondents expressed their environmental concerns as a factor affecting their travel mode choice. However, almost all of them acknowledged that being pro-environmental was related to public or active modes of transportation. This finding could imply that they tended to report their environmental concerns but not to act as pro-environmental while choosing their travel mode and although they had the awareness towards environmental problems, some obstacles such as social norms or financial constraints prevented them from acting pro-environmentally.

The effects of psychological factors via pro-environmental attitude to the behavior of using

public transportation were verified. It was observed that besides the enduring concept of "the balance of nature", spiritual ethics played a significant role in pro-environmental attitude. Acknowledging that spiritual ethics can be utilized in environmental policymaking and training system to foster pro-environmental behavior.

The older adults in this study had a negative inclination to use private car and pro-environmental attitudes. It seems that most people in this age group should be addressed in environmental awareness. The rapid increase in the older adults' population has tremendous implications for transportation planning and policymaking. Since most previous studies on mode choice were mainly focused on youths and working-age people, future studies should systematically analyze the travel mode choice of the older adults especially in Iran.

Based on the qualitative stage, the participants rarely considered walking or cycling as modes of transportation. Therefore, it is essential to encourage people to adopt new travel behaviors, along with improving walking and cycling infrastructures. Moreover, public transportation can be described as an active travel mode, which could potentially enhance citizens' health since it typically involves walking or cycling for both sides of the journey. The results of the present study, specifically from the qualitative research, showed that one of the main reasons for the increasing use of private cars is inefficient public transportation. Therefore, it is highly important to make some fundamental improvements in public transportation system (e.g., by setting a timetable), which can encourage people to use this mode.

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Appendices

Table A.1. Demographic information of participants

Participant number	Gender	Age	Education	Number of cars in the household
1	M	25	Bachelor	1
2	F	22	Bachelor	1
3	M	27	High school certificate	1
4	M	48	High school certificate	1
5	F	50	High school certificate	1
6	F	56	High school certificate	1
7	F	34	Master	1
8	F	32	High school certificate	0
9	M	31	Bachelor	1
10	M	63	Primary school	1
11	M	26	High school certificate	1
12	F	46	Associate degree	1
13	F	30	Bachelor	0
14	M	71	High school certificate	0
15	F	35	High school certificate	0
16	M	30	Bachelor	0
17	F	52	High school certificate	2
18	F	38	Bachelor	1
19	M	41	Primary school	2
20	M	56	High school certificate	1
21	M	49	High school certificate	1
22	F	30	Bachelor	1
23	M	51	High school certificate	2
24	F	68	Bachelor	1
25	M	39	Primary school	3
26	M	42	Associate degree	1

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Table A.2. The Respondents' perspectives in the qualitative study

Items	Factors	The respondents' perspective
General perceptions of different travel modes	Comfort	P24: "An acceptable mode of transportation should be safe, comfortable, and fast. It should include vehicles with sufficient number of seats and no vendors. At the moment, the presence of vendors in all kinds of public transportation is irritating for passengers, and especially the way they try to sell things by shouting is much more annoying."
	Time	P21: "To me, time is precious and it is important to be adhered to my schedule. I have a plan for the whole day and I should choose a mode which helps me get to my destinations as fast as possible. Although subway is so crowded in Tehran, I choose it for my daily trips because it has an almost reliable timetable."
	Safety and security	P21: "The vehicle I choose to travel, no matter, it is car, bus or train, should be safe and have passed an international safety standard." P15: "Public transportation, especially the subway, is so crowded and makes it a suitable place for thieves. Once, I was robbed and since then, I have not used any kind of public transportation."
	Eco-friendly modes	P18: "I prefer to choose a mode which uses a type of fuel with low gas emission and innovative technology to protect the environment."
Private car users' preferences	Convenience	P10: "A person feels more relaxed on a trip by his/her private car. I choose my private car to avoid being in touch with others and have the freedom to do whatever I want, for example, listening to my favorite music loudly." P18: "I have privacy in my own car and I can stop anywhere I want. I can control the air conditioner. And above all, I can take a seat to relax, which rarely happens in public transportation modes these days." P26: "Obviously, people have much more freedom in their own car. Also, in this case, choosing a private car seems to be reasonable since there is no efficient public transportation and no fresh air for using active modes of transportation."
	Attachment to the car and its prestige	P10: "Like other parts of our lives, mode choice has become a luxury-oriented issue. Anyone wants to show off or pretend to be rich regardless of its consequences."
Preferences of public transportation users	Low cost	P14: "It is cheaper than any kind of travel mode. If people realized the depreciation cost of their cars, they would choose public transportation as a more economical mode."
	Running fast	P21: "I could reach my destination on time by using public transportation. In BRT, I could enjoy a fast journey without experiencing driving stress especially in the evening when I am very tired."
	Coercion	P9: "It depends on people. Some could pay the toll and use their own car as a travel mode but in my opinion, it does not seem logical. After paying the entrance toll, they must think about their parking space which is scarce in this region." P19: "The toll paid for entering the congestion charge zone is too expensive, and in my opinion, financial wisdom dictates that you should not be spending since public transportation is much more affordable." P26: "Public transportation users might have no other choice or even they cannot afford to buy a car."
Environmental concern	Having spiritual ethics and environmental concerns	P5: "Everyone should respect the environment and should not cause any pollution in any circumstance. The environment should be protected and harming it is a sin." P17: "A pro-environmental does not throw away his/her garbage on the beaches or in the woods. They respect the environment as much as they respect their own family. They believe that the environment is valuable, it is created by God, and it should be preserved for the next generations."

Having concern about air pollution	P14: “A pro-environmental will use public transportation and choose to walk in order to reduce emission of hazardous air pollutants.” P12: “These days, there is a trend among people to pretend being an influencer in social issues such as environmental problems. They suppose that by just picking up some garbage they become a pro-environmental. However, in my opinion, choosing public transportation takes a higher priority.”
Origination of environmental beliefs regarding travel mode choice	P9: “It is rooted in childhood when people start learning in their family. They should be brought up to be grateful for God’s creatures. They will respect the environment in their adulthood if they learn about protecting the environment in their childhood. Also, media plays a significant role in this case. Media can affect how people think or act.” P7: “If people had considered the environment as the most important part of their lives, they would have cared about it more. In addition, harming the environment is a violation of other people’s rights, which is an unforgivable sin. If people reach this level of social understanding and consider themselves responsible for future generations, they will accept some deficiencies in their lives.”
