

Factors influencing low-carbon Travel for Urban residents:

A case study of Chongqing city in China

Zhicheng Wang¹ and Wasin Phromphitakkul²

^{1,2}Management, School of Management, Shinawatra University, Thailand

E-mail: ¹phdcandidate.shinawatra@gmail.com

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Abstract

Starting with the influence mechanism between consciousness and behavior, based on the theory of planned behavior, this paper constructed a conceptual model of influencing factors of residents' low-carbon travel intention, analyzes the influencing factors of urban residents' use of low-carbon travel style when they travel. In this paper, a sample survey was conducted among 400 residents in Chongqing using a questionnaire, Mplus7 was used to analyze the survey data by structural equation model. The results showed that low-carbon travel attitude, low-carbon travel subjective norms, low-carbon travel perceptual behavior control, and individual environmental awareness had a positive impact on Chongqing residents' low-carbon travel intention. In addition, the study showed that individual environmental awareness had a significant positive impact on low-carbon travel attitudes. Finally, it was proposed to optimize the public transport network and improve the relevant infrastructure construction to enhance people's low-carbon awareness and enhance the initiative of the public to participate in low-carbon travel.

Keywords: Low-Carbon Travel; Theory of Planned Behavior; Structural Equation Model; Individual Environmental Awareness

Introduction

China has proposed to give priority to the development of public transport, strive to build a low-carbon travel-friendly environment, make low-carbon travel more attractive, and enhance public awareness of low-carbon travel. However, according to the forecast of the International Renewable Energy Agency, the annual growth rate of the number of private cars in China will slow down in the

future, but the total amount still shows a steady upward trend. Carbon emissions are the biggest factor affecting global warming and thus threatening the living environment of human beings (Peters GPR, 2012), and one of the important reasons for the increase in carbon emissions is the pollutants released by traffic exhaust. However, in the context of the continuous rise of private car travel in China, relying solely on regulatory measures to change the mode of travel can easily lead to social confrontation and contradictions, and it is difficult to cultivate spontaneous green travel behavior (HE,2019). Therefore, it is particularly important to analyze the factors that affect the low-carbon travel intention of urban residents and promote travelers to travel in a low-carbon way.

"Low-carbon economy" is a development model characterized by low energy consumption, low pollution, and low emissions, and it is one of the main ways to deal with climate change recognized by the international community. Chongqing has been listed by the National Development and Reform Commission as a pilot city for the development of a "low-carbon economy" and the construction of a "low-carbon city". It is of great significance to understand and promote low-carbon consumption and the construction of low-carbon cities. Chinese scholars have a certain understanding and reflection on the above issues, which has laid the foundation for the deepening of related research.

Wang (2014) believes that the travel mode of urban residents constitutes the travel structure of the city, determines the efficiency and development of urban transportation, and calls for the cultivation of a low-carbon travel mode for urban residents. (Chai, 2011) and (long, 2014) studied the effects of spatial structure, traveler attributes, psychological consciousness, travel characteristics, the institutional and technical situation on residents' private car purchase rate and green travel. At present, the existing domestic research on residents' low-carbon or green travel mainly starts from the perspective of policy or urban planning, and some scholars study low-carbon travel based on the perspective of behavior. however, there is a lack of systematic or expansive research based on mature behavior theory. Based on the research of previous scholars, based on the theory of planned behavior, Individual environmental awareness variables are introduced, constructed a conceptual model of low-carbon travel intention, and analyzed the data, obtained the social-psychological factors that affect residents' low-carbon travel intention, and put forward the suggestion to government department according to the result of the analysis.

research questions

Model building

Theory of Planned Behavior

According to the theory of planned behavior (Theory of Planned Behavior) (Ajzen, 1991), the three main variables that affect individual intention are behavior attitude, subjective norm, and perceptual behavior control. Among them, an attitude refers to the positive or negative feelings held by the individual towards the behavior, that is, the attitude formed by the conceptualization of the individual's evaluation of particular behavior. Therefore, the composition of attitude is often regarded as a function of an individual's significant belief. Subjective norm refers to the social pressure that an individual feel whether to take a particular behavior. Perceptual behavior control refers to the obstacles that reflect personal past experiences. When individuals think that the more resources and opportunities they have and the fewer obstacles they expect, the stronger their perceptual behavior control will be. There are two ways of its influence, one is that it has the meaning of motivation to the behavior intention, and the other is that it can also directly predict the behavior.

Ajzen believes that the more positive the individual's attitude towards a behavior, the stronger the individual's behavior intention; the more positive the subjective norm of behavior, the stronger the individual's behavior intention; and the more positive the attitude and subjective norm and the stronger the perceptual behavior control, the stronger the individual's behavior intention (figure 1).

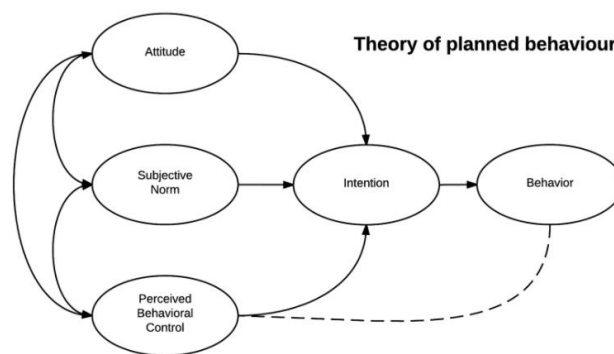


Fig. 1 Planning behavior theory

Source: Ajzen (1991)

Conceptual model and hypothesis

This study combines the theory of planned behavior, individual environmental awareness, and low-carbon travel to build a conceptual model of the low-carbon travel behavior of urban residents

(figure 2). This study holds that when individuals have a more positive attitude toward low-carbon travel, when important friends or family support their low-carbon travel behavior, and when individuals think they have the ability and opportunity to freely choose whether or not to travel, their behavior intention toward low-carbon travel will be enhanced.

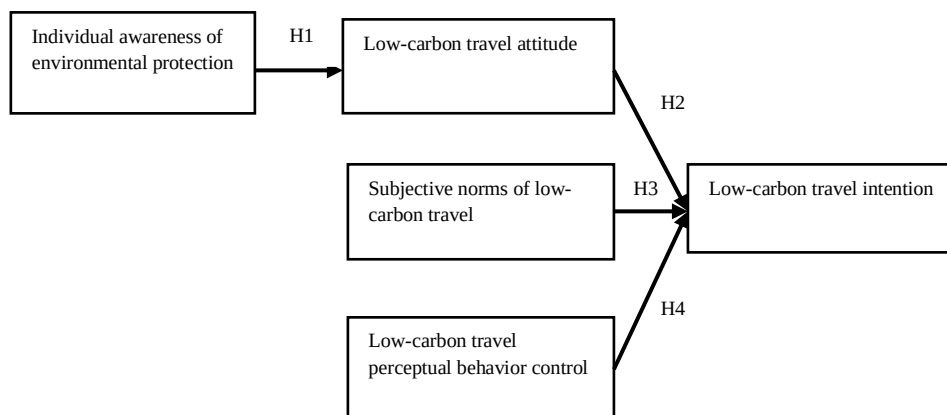


Fig. 2 Planning behavior theory

Source Authors developed from Ajzen (1991) & Yang et al. (2014)

The relationship between individual Environmental Awareness and low-carbon Travel attitude.

Individual environmental awareness refers to the value belief that individuals focus on the inherent value of the natural environment and think that people should not destroy the natural environment. Low-carbon travel attitude refers to an emotional state of whether urban residents support the specific behavior of low-carbon travel or not. Individual environmental awareness has a significant impact on individual attitude, which is the internal driving force of individual attitude. Wang (2010) pointed out that values and environmental attitudes are two different concepts. Values can affect the formation of individual-specific attitudes, and personal values have a positive impact on consumers' environmental attitudes. Sheng (2019) pointed out that ecological values have a positive impact on consumers' willingness to buy green through attitude and subjective norms. Wang (2019) found that the environmental values of urban residents have an indirect effect on their ecological consumption behavior through environmental attitudes. Based on the study, we can draw hypothesis H1.

H1: Individual environmental awareness has a significant positive impact on low-carbon travel attitude.

The relationship between low-carbon travel attitude, subjective norms, perceptual behavior control, and low-carbon travel intention.

Low-carbon travel intention refers to the judgment of urban residents on the subjective probability of implementing the specific behavior of low-carbon travel, which reflects the individual's willingness to implement low-carbon travel behavior. The subjective norm of low-carbon travel refers to the social pressure that individuals feel when deciding whether to implement the specific behavior of low-carbon travel. It reflects the impact of important others or reference groups on individual low-carbon travel intentions. Low-carbon travel perceptual behavior control refers to the degree of ease or difficulty that individuals perceive when implementing the specific behavior of low-carbon travel, which reflects the individual's perception of the factors that promote or hinder the implementation of low-carbon travel behavior.

According to the theory of planned behavior, behavior attitude, subjective norm, and perceptual behavior control are all important influencing factors of intention. This study holds that when urban residents have a more positive attitude towards low-carbon travel, when important others or reference groups are more inclined to low-carbon travel, and when individuals think they have the ability and opportunity to choose whether or not to travel freely, their low-carbon travel intention will be enhanced. Chen (2014) found that consumers' green travel attitudes and subjective norms have a significant positive impact on their green travel intention. Wang (2016) study confirmed that the more positive the travel attitude of urban residents, the greater the perceived social pressure, and the stronger the perceptual behavior control, the higher their low-carbon travel intention. Cui (2017) pointed out that behavior attitude, subjective norms, perceptual behavior control, and other factors will have an impact on urban residents' low-carbon travel intention. Chen (2016) took commuters from Beijing and Shanghai as samples and found that commuters' attitudes and subjective norms have a direct impact on green travel intention, while perceptual behavior control has a direct impact on green travel behavior. The results of Chen (2016) show that personal attitude, subjective norms, and perceptual behavior control can effectively predict individuals' intention to engage in energy saving and carbon reduction behavior. To sum up, the following assumptions are put forward:

H2: Residents' low-carbon travel attitude has a significant positive impact on their low-carbon travel intention.

H3: Residents' subjective norms of low-carbon travel have a significant positive impact on their low-carbon travel intention.

H4: Residents' perceived behavior control of low-carbon travel has a significant positive impact on their low-carbon travel intention.

Research methods

Gauge method

This study uses the Likert scale method, the Likert scale is the most commonly used score summation scale, these items belonging to the same structure are scored by the summation method, individual or individual items are meaningless. The scale consists of a group of declarative sentences, each of which has five answers: "very agree", "agree", "general", "disagree" and "very disagree", which are scored as 5, 4, 3, 2 and 1 respectively. The total score of each interviewee is the sum of the scores of his answers, which can indicate his attitude or his different status on the scale (Jamieson, 2005).

Structural equation model

A structural equation model is a statistical method to analyze the relationship between variables based on the covariance matrix of variables. It includes two basic models: the measurement model and the structural model.

The measurement model is composed of latent variables and observation variables, which is a linear function of a group of observation variables; observation variables are the measurement indicators of potential variables and the data obtained by measurement tools such as scales or questionnaires. The structural model is the explanation of the causal relationship model among latent variables, in which individual environmental awareness, subjective norms, perceptual behavior control, behavior attitude, all belong to latent variables, and the questions in the questionnaire are measurement variables.

Questionnaire method

To ensure the reliability and validity of the questionnaire, the maturity scale which has been widely used is selected in this study. This questionnaire investigates the influencing factors of Chongqing citizens' awareness of low-carbon travel. The questionnaire consists of three parts and is designed with a five-point Likert scale. It is divided into five orders of magnitude: very agree, relatively agree, general, compare disagree, disagree at all, and the scores are 5, 4, 3, 2, 1. The questionnaire has two parts. The first part is the basic information of the respondents, including gender, age, education level, family size, car and bus card ownership, and so on. The second part mainly investigates the influencing factors of residents' low-carbon travel and designs it according to the theory of planned behavior and individual environmental protection consciousness. It includes five dimensions: individual environmental awareness,

low-carbon travel attitude, low-carbon travel subjective norms, low-carbon travel perception behavior control, low-carbon travel intention, of which the second part has 17 topics.

Population and Sample

Researchers pointed out sample size will influence the analysis result when SEM is applied. Structural equation modeling (SEM) is an increasingly popular choice for quantitative statistical analyses, as it allows researchers to model complex relationships while taking into account the measurement error of latent variables. The stability of the covariance structure matrix, generated by samples less than 100, will be reduced, thus the reliability of the analysis result will be reduced. Different researchers hold different ideas about the minimum sample size for SEM. For instance, some statistics scholars have recommended using the ratio of observations to estimated parameters (N:q) as a guide. Specifically, Kline (2015) recommended that the N:q ratio should be 20 to 1, or 20 observations (participants) for each estimated parameter in the model. Based on suggestions from SEM experts, the best sample size for this study with 4 constructs including 20 observing variables should be over 400. Thus, the sample size is 400 samples.

Data processing

Reliability and validity test

Firstly, KMO (Kaiser–Meyer–Olkin) and Cronbach's α were used to analyze the reliability and validity of the questionnaire. Through the calculation and analysis, the KMO value of the questionnaire is 0.931 and the α value of the famous Cronbach's is 0.902, all of which is higher than 0.9. It shows that the questionnaire used in this paper has good reliability and validity.

CFA test

The statistical software was used to carry out confirmatory factor analysis (CFA) on the measurement model. The adaptation index of the measurement model is $\chi^2(109) = 208.115$ CFI = 0.901 GFI = 0.895 RMSEA = 0.046 p MRE 0.045, which shows that all the indexes are in the acceptable range, and the measurement model fits well (Chang, 1998). In this study, the convergence validity of the measurement model is evaluated by factor load, combination reliability CR and average extracted variance AVE. First of all, the standardized factor loads between the five latent variables and their index items are significant and the load values are all higher than 0.5. Secondly, the combinatorial reliability CR of each variable is higher than the standard of 0.7. In addition,

the average extraction variance AVE of each variable is greater than 0.5. Therefore, the measurement model of this study has good convergence validity (Table 1) .

Table 1 CFA test

Variables and Item	Factor load	AVE	CR
Low-carbon Travel Attitude		0.521	0.762
TA1	0.771 ^{***}		
TA2	0.702 ^{***}		
TA3	0.684 ^{***}		
Subjective Norms of Low-carbon Travel		0.509	0.751
SN1	0.746 ^{***}		
SN2	0.737 ^{***}		
SN3	0.643 ^{***}		
Low-carbon Travel Perceptual Behavior			
Control		0.686	0.894
BC1	0.763 ^{***}		
BC2	0.863 ^{***}		
BC3	0.885 ^{***}		
BC4	0.811 ^{***}		
Individual Awareness of Environmental Protection		0.648	0.875
AE1	0.824 ^{***}		
AE2	0.837 ^{***}		
AE3	0.853 ^{***}		
AE4	0.684 ^{***}		
Low-carbon Travel Intention		0.525	0.766
TI1	0.775 ^{***}		
TI2	0.626 ^{***}		
TI3	0.764 ^{***}		

Structural equation model

In this study, Mplus7 is used to analyze the structural model (figure 2), and the adaptation of the model is shown in Table 4. Each fitting index shows that the fitting of the direct effect structure model is very good, which is suitable for the hypothesis test of direct effect. Among them, χ^2 (111) = 259.811 ($p < 0.001$), χ^2 / df 2.346, TLI was 0.951, TLI was 0.934, RMSEA was 0.064, and SRMR was 0.078. In addition, the R^2 value of residents' low-carbon travel intention in this structural model is 0.543, which shows that more than half of the variables (54.3%) of residents' low-carbon travel intention are explained by this model. Table 4 shows the estimated results of the direct effect structure model. Hypothesis 2, hypothesis 3, and hypothesis 4 are used to test the effect of planned behavior theory on residents' low-carbon travel intention. The results showed that low-carbon travel attitude (0.171), low-carbon travel subjective norm (0.232), and low-carbon travel perceived behavior control (0.406) positively affected residents' low-carbon travel intention ($P < 0.000$). Hypothesis 2, hypothesis 3, and hypothesis 4 were supported respectively. In addition, individual environmental awareness had a significant positive effect on low-carbon travel attitude (0.234 $P < 0.001$), and hypothesis 1 was supported (Table 2).

Table 2 Structural model estimation and hypothesis testing

Hypothesis	Standardized path coefficient	T value	P-value	Hypothesis
AE→TA(H1)	0.234	3.395	0.001	Support
TA→TI(H2)	0.171	2.815	0.001	Support
SN→TI(H3)	0.406	5.301	0.000	Support
BC→TI(H4)	0.232	4.157	0.000	Support

Conclusion and discussion

Based on planned behavior theory, this paper creatively adds variables-individual environmental awareness and constructs a conceptual model of urban residents' low-carbon travel intention. The results show that combining individual environmental awareness and planned behavior theory can better explain the low-carbon travel intention of urban residents. The study found that the stronger the individual environmental awareness of urban residents, the more positive their attitude towards low-carbon travel. Similarly, the more positive the attitude of urban residents towards low-carbon travel,

the stronger the subjective norms and the greater the control of perceptual behavior. Their intention to choose low-carbon travel will be stronger.

Through the above research, individual environmental awareness of residents has a positive impact on low-carbon travel attitude, that is, the stronger the environmental awareness of individual residents, the stronger their attitude towards low-carbon travel. Therefore, government departments should consider raising individual residents' awareness of environmental protection to enhance residents' attitudes towards low-carbon travel. First, the Government can strengthen environmental protection education in the community and organize environmental protection seminars in schools and units to publicize the knowledge of environmental protection. Second, through news, the Internet, and new media, the government informs residents of the importance of environmental protection and calls for low-carbon travel.

The study found that a low-carbon travel attitude is one of the important factors affecting low-carbon travel intention. The formation of a low-carbon travel attitude is inextricably related to its low-carbon travel awareness and related concepts. Therefore, it is suggested that we should try to change the residents' attitude towards low-carbon travel and establish the awareness and concept of low-carbon travel, to make residents have a positive support attitude to low-carbon travel. By widely spreading the various hazards of excessive carbon emissions to residents, such as damage, cancer, etc., let residents have a deep understanding of the serious consequences of the current climate deterioration, and make residents aware of the necessity of energy conservation and emission reduction.

The study found that the subjective norms of low-carbon travel are one of the important factors that affect the intention of low-carbon travel, that is, the important people and reference groups around will have an impact on whether residents are willing to choose low-carbon travel, such as family members, friends and so on. Therefore, it is suggested that the residents' intention for low-carbon travel should be improved by strengthening the communication within the reference group. It is easy to spread within groups, such as posting or pushing positive experiences about low-carbon travel on Weibo or Wechat moments, which is conducive to spreading positive messages about low-carbon travel and promoting the establishment of subjective norms on low-carbon travel.

The study found that low-carbon travel perception behavior control is one of the important factors affecting low-carbon travel intention, but also has a greater degree of influence, and even directly affect low-carbon travel behavior, that is, when residents choose the way of travel, it is still based on the actual travel demand and convenience, and the difficulty and opportunity of implementation will have an impact on whether residents are willing to choose low-carbon travel.

Therefore, the government should vigorously develop urban public transport, create low-carbon travel conditions and develop low-carbon travel modes. First of all, it is suggested that the government should provide external conditions to facilitate low-carbon travel, including convenient public transport facilities (bus, light rail, subway, etc.) and sound policies and systems, such as increasing the frequency and distribution of public transport stations, expanding the area for the implementation of public bicycles, increasing the installation of bicycle lanes and dedicated parking lots, increasing the setting of charging stations, and implementing subsidies for the purchase of electric vehicles. Furthermore, it is suggested that an intelligent traffic management system should be introduced to realize the visual query of public transport through the installation of electronic maps and electronic stop signs, provide residents with the relevant information needed for travel in real-time, and realize the automatic scheduling of vehicles through the application of GPS satellite positioning system, facilitate the transfer between various modes of transport, meet the needs of residents for travel convenience, and effectively reduce the resistance of residents when they expect to take low-carbon travel. It is easy to make residents feel that low-carbon travel is easy.

The shortcomings of this study are as follows:

Only for Chongqing residents, it is suggested that future research can expand the scope of data collection and cover different regions, different cities, and different types of people as much as possible, to make the research results more universal.

This study is based on the theory of planned behavior, adding individual environmental awareness to explore, although it has a certain research significance, the understanding of urban residents' low-carbon travel intention is still insufficient. It is suggested that future research can improve the whole model through other theoretical models or explore more potential influencing factors.

References

- Ajzen, I., & Madden, T. J.(1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology*,22(5),453–474.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2),179–211.

- Chai, Y. W., Xiao, Z. P., & Liu, Z.L. (2011). Comparative analysis of daily travel carbon emissions of households in Beijing based on spatial behavior constraints. *Science of Geography*, 31(7),843–849.
- Chen, K., & Li, H.J. (2014). Analysis of psychological factors of consumers' green travel. *Economic Management of East China*, 6, 129–134.
- Cui, F., & Zhang, X. (2017). Influencing factors of urban residents' low-carbon travel intention. *Urban problems*, 11, 94–101.
- Chen, K., & Liang, H. (2016). Factors affecting consumers' green commuting. *Eurasia Journal of Mathematics Science and Technology Education*, 12(3), 527–538.
- HE, Z.Q., JIANG, Y.T. (2019). Study on urban low carbon travel choice based on TPB and VBN integration model. *Journal of Arid Land Resources and Environment*, 4(33),89–95.
- Hang, M. K. (1998). Predicting unethical behavior: A comparison of the theory of reasoned action and the theory of planned behavior. *Journal of Business Ethics*, 17(16), 1825–1834.
- International Energy Agency. (2018). *World Energy Outlook 2017 China Special report*. Beijing: International Energy Agency.
- Jamieson, S. (2005).Likert Scale: how to (ab)use them. *Medical Education*, 38(12),1217–1218.
- Mancha, R. M., & Yoder, C.Y. (2015). Cultural antecedents of green behavioral intent: An environmental theory of planned behavior. *Journal of Environmental Psychology*, 43(3),145–154.
- Peters, G. P., Andrew, R. M., & Boden, T.(2012). The challenge is to keep global warming below 20. *Nature Climate Change*, 3(1), 4–6.
- Sebastian, B., Icek, A., & Peter, S. (2003). Choice of travel mode in the theory of planned behavior: The roles of past behavior, habit, and reasoned action. *Basic and Applied Social Psychology*, 25(3),175 –187.
- Sheng, G.H., Gong, S.Y., & Xie, F.(2019). Theoretical basis and empirical Test of Chinese consumers' Green purchase intention: TPB extension Model based on Ecological values and personal perception correlation. *Journal of Social Sciences of Jilin University*, 59 (1), 136–147.
- Wang, G.M., Li, J.X., & Liao, S. X. (2010). Environmental values and consumers' Green purchase behavior: a study on the Mediation of Environmental attitudes. *Journal of Dalian University of Technology (Social Science Edition)*, 31 (4), 41–46.
- Wang, Y.R. (2016). Study on residents' low-carbon travel intention model and its influencing factors. *Journal of Yunnan University for nationalities (Natural Science Edition)*, 25 (3), 280–285.

- Wang, S.J., & Zhou, H. Y. (2019). Environmental values affect ecological consumption behavior: an empirical test based on intermediary variables. *Soft Science*, 33(10), 50–57.
- Yang, R. R., & Long, R.Y. (2014). Discussion on the theoretical model of influencing factors of urban residents' green travel behavior based on rooted theory. *Journal of Wuhan University (philosophy and Social Sciences Edition)*, 5, 13–19.