August 2021;6(1):21-48
http://dx.doi.org/10.20522/APJBR.2021.6.1.21

What Drives Residents Low Carbon Transportation Commuting? Evidence from China

Liang Li*
School of Business, Nanjing University of Information Science and Technology, Nanjing 210044, China

Meixuen Tan
School of Business, Nanjing University of Information Science and Technology, Nanjing 210044, China

Huaping Sun
School of Finance and Economics, Jiangsu University, Zhenjiang 212013, China

Nuttida Sanitnuan
School of Business, Nanjing University of Information Science and Technology, Nanjing 210044, China

ABSTRACT

Promoting low carbon transportation adoption is important for energy saving. Some prior studies have discussed on environmental values affect low carbon transportation commuting is inconclusive. This study has constructed the environmental values, utility value, and social influence-based low-carbon transportation adoption model through the theory of the technology acceptance model and VBN model and the IS success model. Through the SEM model and stepwise regression analysis, we have found that environmental values positively affect utility value, and utility value also positively affects the behavior adoption of low carbon transportation. The utility value as mediating effect in the relationship between environmental values and low carbon transportation commuting behavior. Besides, we also have found that social influence positively impacts the behavior adoption of low carbon transportation. It better enhances the level of household residents' environmental values and utility values, and social influence for promoting the adoption of low carbon transportation. This present research provides theoretical guidance and suggestions for promoting the development of low-carbon transportation innovation.

Keywords Environmental values, utility value, social influence, low carbon transportation commuting

*Corresponding author: llcwllcw@hotmail.com

1. Introduction

With the rapid development of the Chinese economy and society, air pollution has become a severe environmental issue. As far as China is concerned, automobile exhaust emissions in China are the main factor causing environmental problems such as haze pollution. Meanwhile, the annual consumption of oil increases, and the limited oil resources make the challenging environmental increase. In the face of increasingly serious environmental problems and energy poverty, sharing economies such as sharing new energy vehicles or electric bikes based on the internet and new technologies innovation has become the new direction of urban transportation development in China (Wang et al., 2018; Li et al., 2020a).

Numerous studies have shown that low carbon technology innovation with a sustainable development purpose results in the economy of innovative green products and methods, that reduce the impact of the general or particular activity on the environment (Li et al., 2017; Van Oorschot et al., 2018, Li et al., 2020b). Transportation is one of the significant account contributors and mainly the primary cause of the world's fourth-largest carbon dioxide production, partly through fossil-fuel-powered vehicles. However, low carbon transportation can reduce harmful emissions into the earth's atmosphere (Trappey et al., 2012; Zhang et al., 2018). According to the traffic management bureau under the Ministry of Public Security, the number of car ownership in China reached 240 million by the end of 2018. Private cars continued to grow rapidly, with 189 million vehicles in 2018. In contrast, the development of new energy vehicles has just started, less than 10% of the total[1)].

Meanwhile, as the number of cars increases, this also leads to a rapid rise in urban carbon emissions, exacerbating global warming. Existing research proves that most global climate change and air pollution are vital factors for automobile exhaust emissions[2)]. In north China in the past five years, haze weather occurs, and air pollution is serious; environmental pollution poses a severe threat to People's Daily life and health (Yang et al., 2012; Saleem et al., 2018; Zhang et al., 2018). According to the above discussion, it is necessary to understand the influencing factors on consumers' adoption of low carbon transportation innovation to deal with climate change and promote green innovation performance.

According to the Van Oorschot et al. (2018) and Li et al. (2017) research, the model of the technology innovation adoption model, such as the technology acceptance model (TAM), DeLone and McLean model of information systems success, and the theory of reasoned action (TRA), environmental values and utility value theory, this research proposes the research questions as

1) https://www.sohu.com/a/289100127_188468
2) https://www.sohu.com/a/145729184_123753

following: First, what are the adoption model of low carbon transportation innovation? Secondly, do the environmental values enhance utility value, increasing the residents' low carbon transportation adoption? Third, what are the determinants of low carbon transportation innovation adoption in China? Thus, we answer these questions, based on the environmental values theory from Rokeach (1973); Schwartz and Boehnke (2004); Stern and Dietz (1994) and Stern et al. (1999) and technology acceptance theories (Van Oorschot et al., 2018; Sohn and Kwon, 2020); we have established the environmental values and utility value-based adoption model of low carbon transportation, explore residents low carbon transportation innovation adoption model and its influencing factors. More specifically, it discusses the impact of environmental values, utility value, and social influence on willingness to adopt low carbon transportation, explore the mechanism from environmental values to the adoption of shared low carbon transportation, the mediating role of utility value, and social influence, and then promotes residents' adoption of green low carbon innovation, to promote China's green low-carbon, and sustainable development.

The novelties of this article are as follows: First, we attempt to the environmental values and utility value-based adoption model via structural equation model. Second, we attempt to compare the different effects of environmental values, utility value, social influence, gender, age, education, and income level on adopting low carbon innovation transportation. In addition, we also identify the mechanism of environmental values to utility value, perceived convenience, social influence, and low-carbon transport adoption. Furthermore, we also compare the different determinants of low carbon transportation commuting using across different genders, regions, age, income, education level, and the type of occupation via multiple stepwise regressions.

The structure of this paper: section 2 showed the theoretical background and hypotheses development; section 3 presented the research model; section 4 data collection and testifies different hypotheses; section 5 proposed conclusions and policy implications.

2. Technology innovation acceptance theories and hypothesis development

The TAM model consists of two significant variables: perceived ease of use and perceived usefulness. Perceived ease of use reflects the individuals with the degree of convenience level of the system. Perceived usefulness refers to the productivity and performance perceived by individuals while using the system. Davis (1989) and Davis et al. (1989) have explained the perceived ease of use and perceived usefulness to explain innovation's adoption. Venkatesh and Davis (2000) have compared with perceived ease of use, and the subjective norm has more effect on adopting innovation systems. Venkatesh et al. (2003) based the TAM model, TRA theory and TPB model, to develop the unified theory of acceptance and use of technology (UTAUT) for the adoption of technology innovation, proposed that performance expectancy, effort expectancy, and social influence will affect the adoption of behavioral intention, facilitating conditions will influence user behavior toward innovation systems.

Delone and McLean (1992) (2003) have developed the DeLone and McLean model of information systems success. Mohammadi (2015) have extended the IS success model, proposed the impact of service quality and satisfaction in e-learning application. Zhu et al. (2010) established the self-efficacy-based value adoption model and identified the effect of perceived value and self-efficacy on attitude toward online innovation service. Chen et al. (2016) suggested the TAM model and TPB model in public bike using, identified green value, and positively and significantly influenced repeated bike using. Cai et al. (2019) and Chen et al. (2016) have explored the effect of perceived behavioral control and green values on low carbon commuting through shared bike use. Yoon (2018) extended the TAM model in green innovation adoption and proposed different norms and TAM models for individuals' adoption to use Green IT. Thus, we can see that many researchers had used TAM to explain the intention of technology acceptance and use (Van Oorschot et al. 2018), for example, the acceptance of telemedicine technology (Hu et al., 1999), e-learning (Mohammadi, 2015), and information computer systems (Delone and McLean., 1992, 2003; Venkatesh and Davis. 2000; Venkatesh et l., 2003), e-internet services (Zhu et al., 2010), green IT adoption (Yoon, 2018).

2.1 The role of environmental values and utility value for low carbon transportation innovation adoption

Unlike in the past, the sharing economy's sustained development will help address issues, such as excess capacity and reasonable consumption, climate change and sustainable development, thus pushing society toward affluent and reasonable personal consumption (Mi and Coffman, 2019; Zhang and Mi, 2018). This paper reviews the related studies on low carbon innovation adoption (Yoon, 2018; Van Oorschot et al., 2018), shared electric vehicles, electric cars, low-carbon transportation, and factors affecting sharing new energy vehicles or bikes. However, a few research consider that environmental values and utility value affect low carbon transportation innovation. Thus, this paper will explore environmental values and utility value on residents' adoption of low carbon transportation innovation in China.

Low carbon transportation commuting refers to the individual behavior of using low carbon or green transportation (Li et al., 2020a; Van Oorschot et al., 2018). It includes using low carbon transportation adoption through shared electric bike, green vehicle or electric bus, shared bike. Low-carbon transportation based on the internet and new energy technology has become the new direction of urban transportation development in China (Ding et al., 2019). Although it has just started at the present stage in China, the new energy automotive industry developments are quick. In transportation, some new business models gradually appeared: sharing new energy vehicles, shared electric cars, and shared bikes. As energy conservation and environmental protection modes of low carbon commuting, such as sharing new energy vehicles, shared electric bikes will gradually become the mainstream of realizing low-carbon and green transportation in the future (Li et al., 2020a). Bicycle sharing, electric bicycle-sharing, and shared new energy vehicle first appeared in Switzerland and Germany in Europe and then rapidly developed in many countries such as North America. By 2019, 33 countries around the world are using and operating shared new energy vehicles. Now China's shared low carbon transformations are still in the initial stage. Many automobile manufacturers, rental companies have begun to promote low carbon vehicles. According to the findings, residents' use and adoption behavior of low carbon vehicles are not only related to the convenience, utility value, subjective norm, as well as the relevant policies of the government, also influenced by consumers' environmental values (Cai et al., 2019).

Human values can be defined as a collective set of essential, useful, and desirable (Rokeach, 1973). Individualism refers to the degree to which society is partitioned into groups. Individualism culture emphasis on self-responsibility; people generally have a high level of self-esteem and independence. However, collectivism focuses on collective goals and emphasizes individual obligations (Gouveia and Ros, 2000; Hofstede, 2001). Rokeach (1973) and Schwartz (1992) and (Schwartz and Boehnke, 2004) proposed the human values concept model. They developed a type of values: self-direction, stimulation, hedonism, achievement, power, security, conformity, tradition, spirituality, benevolence, and universalism. And put forward the compatibility of human values, for example, power and achievement, hedonism and stimulation, universalism and benevolence, tradition and security. And also put forward the conflicts of human values, such as self-direction or stimulation vs. conformity or tradition or security, universalism or benevolence vs. power or achievement.

Environmental values is proposed by Stern et al. (1999) in combination with values theory, normative activation theory and suggested that the environmental values mainly include ecological values and altruistic values. According to the theory of environmental values, the individual who has environmental values will be more aware or concerned about their living environment and began to pay attention to the sustainability of consumption and social development. Trotta (2018) also stated that green innovation adoption behaviors are daily practices in a household that aims at a specific reduction in energy use.

Utility value can be proposed as the consumers perceived economic value toward low carbon transportation. For example, perceive the convenience and economical cost of low-carbon transportation, in the context of the digital and sharing economy, the development of ICT technology has also promoted the intellectual development of transportation, medical treatment, agriculture, manufacturing (Sohn et al., 2019; Sohn et al., 2020). Chen (2016) and Cai et al. (2019) have explored environmental values and positively affect low carbon transportation commuting. However, Cai et al. (2019) pointed out in their research that environmental values have no significant influence on low-carbon transportation commuting, while residual effects are the key factors influencing low-carbon transportation commuting through shared bicycle behavior. The past literature from TAM model. Perceived usefulness is defined as the degree to which individuals believe that using a particular technology will enhance performance (Yoon. 2018). TAM model has been used to explain the intention of technology adoption. While low carbon transportation is new technology compare to traditional transportation. The other important variable in the TAM model is perceived ease of use, which is the low difficulty level. Perceived ease of use has been used to explain the intention of technology adoption.

The perceived convenience has been examined in-service operation. The convenient of transportation for individual depend on the level of easy of use. A previous study stated that the share bicycle station's location was encouraging individuals to use share bicycles, that is, more perceived convenience in place dimension will increase share bicycles (Bachand-Marleau et al., 2012). In the same way, before research showed that the bus service's perceived convenience significantly positively impacted passenger's satisfaction using the bus (Morton et al., 2016). Moreover, recent studies considered influencing factors of engagement of low carbon bicycle sharing in China. This study investigated whether convenience had an inconsistent effect on low carbon commuting behavior through bicycle use (Ding et al., 2019). Thus, we can see that research showed that attitudes and personal environmental values affect consumer behavioral intention. For the adoption of low carbon transportation perspective, in modern economic society with increasing demand for energy, according to Yue et al. (2013) and Moloney and Strengers (2014) and Sun et al. (2019) stated the increased energy efficiency had been linked to overall technological progress. Moreover, low carbon technology is an innovation that can improve energy efficiency by reducing energy consumption. Individuals particularly tend to change their lifestyle to adopt low carbon technology, which also can reduce final energy consumption by increasing efficiency energy (Moloney et al., 2010; Dietz and Whitley, 2018; Lazaric et al., 2019).

According to Stern's VBN theory and environmental values theory, TAM and TRA model, and utility value theory, we proposed if the individual with more environmental values can enhance utility value evaluation. The utility value can be composed of perceived convenience and perceived useful and economic value. According to the TAM model and utility value theory, we propose that the higher the ease of use or perceived convenience and usefulness, the higher the perception of utility value, enhancing residents' adopted and repeated use of the low carbon transportation innovation. The higher the low carbon transportation innovation can improve air quality and reduce air pollution, because low carbon transportation innovation has excellent advantages in energy conservation and emission reduction. It could also help develop low-carbon transportation innovation performance with addressing climate change. Therefore, we propose hypothesis 1 as follow:

Hypothesis 1: *The environmental values has a positive effect on utility value (a) and the adoption of low carbon transportation (b), the utility value would mediate the relationship between environmental values and the adoption of low carbon transportation(c)*

2.2 Effect of Social influence on low carbon transportation commuting

Social influence refers to others' behavior, or social culture would influence an individual's behavior. According to the subjective norm and reference group, the low carbon innovation adoption behaviors can be affected by reference groups behavior such as friends, family, peers, or group leader's behavior. Venkatesh et al. (2003) based on the TAM and TPB model, proposed the UTAUT model, and proposed the social influence diffusion of innovation. Abrahamson and Rosenkopf (1997) and Bandiera and Rasul (2006) have identified the effect of social networks on technology adoption. Bernheim (1994) has identified the conformity theory, Bramoullé et al. (2009) and Goldsmith-Pinkham and Imbens (2013) and Dahl Løken and Mogstad (2014) proposed the role of peer effect in the context of the diffusion of innovations such as SNS. There is a herd behavior in behavioral finance research in the in financial innovation markets (Cipriani and Guarino 2014). According to UTAUT model, social influence is defined as the various influences on behaving a specific action that an individual receives from others in the same group. Xiong et al (2016) proposed the three role of peer effect: information effect, experience effect, and externality effect; also proposed the positive externality effect for adopting the innovation. For instance, a car consumer may be willing to consume new energy vehicles such as electric car when there is a certain number of new energy cars on the road. Or many residents willing to adopt shared electric vehicles or electric buses when there are a certain number of shared electric vehicles or electric buses will likely adopt low carbon transportation. Previous studies have recognized social influence as an important factor for low carbon transportation. Axsen et al. (2013) investigated the roles of social influence on pro-environmental technologies evidence in battery electric vehicle in the UK. The result shows neglect of social influence processes will ignore or underestimate the potential for consumer preference, which strongly bias results of adopting pro-environmental technologies. In addition, environmental policy publicity, a social influence, can encourage residents' willingness to adopt low carbon transportation in Tianjin, China (Liu et al., 2017). Moreover, the social influence experiment on sustainable consumption showed that when an individual received information from family and friends, the individual consumes suitable products more when received information from reference group (Salaza et al., 2012). Venkatesh et al. (2003) also proposed the social influence on the adoption of innovation systems. According to literature, hypothesis 2 is conducted as below

Hypothesis 2: *Social influence positively impact the adoption of low carbon transportation*

2.3 Theoretical hypothesis model

According to the above discussion, the research model is proposed: we established the theoretical hypothesis model by integrating with environmental values, utility value, and social influence. Following the Du et al. (2018) and Sohn et al. (2020), Venkatesh et al. (2003) theoretical model, in the present study, 2 different hypotheses are put forward. We proposed that environmental values and utility value and social influence might positively impact China's willingness to adopt low carbon transportation innovation. We investigate the theoretical hypothesis model (1) as effects of environmental values on willingness to adoption and use for low carbon transportation innovation, lbi means low carbon transportation innovation, evs refers to environmental values, utv implies the utility value, si represents social influence, r means control variables, a represents constants, and μ represents the unobserved, the model is as follows:

$$lbi_1 = a + \beta_{11} ev + \beta_{12} r + \mu_{13} \tag{1}$$

$$\text{mediation uv}_2 = \alpha_{20} + \beta_{21} ev + \beta_{22} r + \mu_{23} \tag{2}$$

$$lbi_3 = \alpha_{30} + \beta_{31} \mathrm{ev} + \beta_{32} uv + \beta_{33} r + \mu_{34} \tag{3}$$

$$lbi4 = a + \beta_{41} ev + \beta_{42} utv + \beta_{43} si + \beta_{44} r + \mu_{45} \tag{4}$$

3. Methodology

3.1 Survey

Before the formal investigation and research, to avoid the lack of understanding of a questionnaire survey or cognitive biases on measuring items, this paper conducted the preliminary survey research, invited three experts to review the questionnaire, and improved the measurement scale questionnaires. The questionnaire includes two sections. In section one, the sampling characteristics are conducted: gender, age, marriage, income, education, income level, location, occupation.

In section 2, the residents were asked to read statements and determine their degree of agreement. The questionnaire items used in this study were developed and adapted based on the literature review. The questionnaire surveyed environmental values, utility value, social influence, and low carbon transportation innovation adoption based on previous research (Stern et al., 1999; Song et al., 2019; Wang et al., 2020a, b). All variables used 5-point Likert (from 1=strongly disagree to 5=strongly agree). Based on these articles, we total developed nineteen items for testing our research model and hypothesis.

Environmental values was measured by using five items versions of the scales. Example items are "I consider the global warming impact of my action when making decisions". "I like preserving nature and environment".

Utility value was measure by using five items version of the scales, and example items are "Low carbon transportation is helpful reducing carbon dioxide emissions". "In general, I think it is a convenience for me to use low carbon transportation".

Social influence was measure by using five items. Examples are "Peoples around me participate in shared low carbon transportation innovation", "I frequently use shared low carbon transportation innovation".

According to the current development of sharing economy, new energy vehicles are an economic model for consumers to realize cooperation through online and offline linkage, including cooperation in many aspects such as ownership, rental, and use. In this consumption mode, shared electric vehicles or electric bikes are based on the new economic model of sharing economy. Consumers can share products and services with others through cooperation, and in this process, consumers do not own the ownership of products or services. Base on this basis, this paper reviews Ding et al. (2019) and Cai et al. (2019) on the adoption behavior of low carbon transportation, according to the characteristics of the sharing economy and new energy vehicles.

In the present paper, low carbon transportation innovation was measure by using four items. Example items are "I will try to use low carbon transportation if that is possible". "I am willing to use shared low carbon transportation (new energy cars, electric buses, or bike sharing)". "If possible, I would like to consume and use the electric car".

3.2 Sampling

We have invited 30 residents to improve the reliability and validity of the evaluating scale and measurements and review and modify the questionnaire. A formal questionnaire survey was conducted with 20 students from different provinces in China. We also have distributed electronic questionnaires to residents from different regions and cities with ten students on online. Out of the

650 questionnaires survey distributed, 630 were collected. After deleting invalid questionnaires or wrong answers, fill without sincerity. We used 588 for our analysis, representing a 90.5% validity rate.

In this sample, 59.62% of the respondents were male and 40.38% for women, to the male sex ratio at around the age of 18 to 25 people at 32.86%, 28.17% of respondents aged between 26 to 30, 19.25% respondents for 31-35 years old, 11.27% of respondents between 36 and 40 years old, the remaining 8.45% in 40 years of age or older. Besides, 36.15% of the respondents have a college or university education, and 36.62% are graduate students or above. Only 27.23 of the respondents who have studied above education have a monthly income, 24.41% have a monthly payment of less than 5,000 yuan, 38.3% have a monthly income of around 5,000-10,000 yuan, and the rest 37.56% have a monthly income of more than 10,000 yuan.

According to the demographic analysis results, in this sample, we can see that 59.9% of the respondents are males, only a few responses (40.1%) are males. And married is higher than not married families and others (3.3%). According to the different ages, we can see that 69 of respondents aged between 10 to 19, 148 respondents for 20-29s years old, 148 respondents between 30 and 39 years old, the remaining 37.9% in 40 years of age or older. And 152 responses (25.9%) are high school degree, 164 responses (27.9%) are 3-years college, 137 responses are 4-years university degree. 135 answers are masters or Ph.D degrees. According to the different income level, 189 (32.1%) responses are less 5000 RMB monthly, 267 (45.4%) responses are 5001 to 10,000 RMB between, 132 responses are above 10,001 RMB between. Among the different company areas, east area responses (36.2%), followed by central residents (34.5%) and west residents (29.2%). According to the different types of occupation, we can see that under 133 (22.6%) responses are students, 70 (11.9%) responses from the state-owned enterprises, 180 (30.6%) from Sino foreign joint enterprises, 111 (18.9%) responses are a self-operated business, 94 (16%) responses are form government. The demographic characteristics of respondents are summarized in Table 1.

Table1. Demographic characteristics

Measurements	Types	Numbers	Percentage
Gender	Female	236	40.1
	Male	352	59.9
Marriage	Marriage	169	28.7
	Not marriage	400	68.0
	others	19	3.3

Measurements	Types	Numbers	Percentage
Age	10-19s	69	11.7
	20-29s	148	25.2
	30-39s	148	25.2
	40-49s	156	26.5
	Over 50s	67	22.4
Education	High school	152	25.9
	3-years college	164	27.8
	4-years university	137	23.3
	Above Master degree	135	23.0
Income level	Less 5000 RMB monthly	189	32.1
	5001 to 1,0000 between	267	45.4
	Over 10,001 RMB	132	22.5
Location	East areas	213	36.2
	Central area	203	34.5
	West area	172	29.3
Type of organization	University students	133	22.6
	The State-owned enterprises	70	11.9
	Sino-foreign joint enterprises	180	30.6
	Self-operated business	111	18.9
	Government or government agency institution	94	16.0

3.3 Validity and Reliability

To verify the theoretical model's reliability and validity and the research concepts of environmental values, utility value, and social influence. We accordingly conducted an exploratory factor analysis using the principal-components method and varimax rotation (Gujarati, 2012). As shown in Table 2, we assessed the results using specific minimum standards: all loading coefficients were more significant than 0.5. The ratio of the five factors' cumulative variance is 74.06%, the result is shown in Table 2. A total of nineteen measurements were retained, four elements were extracted, namely environmental values are five items, utility value is five measurements, social influence is five measurements, low carbon transportation innovation using are four measurements. Furthermore, the coefficient alpha test was conducted to test the reliability of the variables, and results are shown in Table 2: environmental values (0.862), utility value (0.894), social influence (0.925), and low carbon transportation innovation adoption (0.944), all values are higher than the standard weight of 0.70. Therefore, we can see that the research variables have suitable reliability and validity, that is the consistency or stability of the research concepts.

Table 2. The results of exploratory factor analysis and reliability

Research concepts and Measurements	Alphas coefficient	1	2	3	4
Environmental values (Variance = 22.75%)					
[1] I consider the global warming impact of my action when making decisions	α = 0.862	0.172	0.159	0.069	**0.817**
[2] I like preserving the natural environment		0.134	0.142	0.184	**0.869**
[3] Environmental quality will improve if we use less fossil fuels energy		0.129	0.165	0.266	**0.775**
[4] I always concerned about the exhaustion of fossil fuels is a problem		0.126	0.214	0.311	**0.703**
[5] I often care about unity with nature		0.474	0.235	0.375	**0.501**
Utility value (Variance = 18.37%)					
[1] Low carbon transportation innovation is useful to reduce environmental pollution	α = 0.894	0.46	**0.584**	0.08	0.172
[2] Low carbon transportation innovation helps reduce carbon dioxide emissions and save economic cost and smart IT		0.253	**0.695**	0.292	0.148
[3] In general, I think it is convenient for me to use low carbon transportation innovation such as an electric car, or shared electric car		0.206	**0.781**	0.296	0.212
[4] Low carbon transportation innovation adoption is economical		0.23	**0.774**	0.318	0.197
[5] Government offers subsidy policies and easy use low carbon transportation system		0.228	**0.791**	0.272	0.191
Social influence (Variance = 17.97%)					
[1] Peoples around me participate in low carbon transportation innovation (e.g., electric car or new energy car, electric bus commuting)	α = 0.925	**0.809**	0.227	0.175	0.095
[2] Peoples around me frequently use shared low carbon transportation		**0.735**	0.17	0.291	0.115
[3] Peoples around me always use shared low carbon transportation		**0.755**	0.224	0.235	0.155
[4] The policy encourages people to use low carbon transportation for reducing vehicle air pollutant		**0.873**	0.235	0.186	0.165
[5] Many peoples participate in shared low carbon transportation		**0.859**	0.22	0.203	0.16
Low carbon transportation adoption (Variance = 16.79%)					
[1] I will try to adopt and use low carbon transportation innovation, if possible	α = 0.944	0.278	0.32	0.728	0.228
[2] I will use shared low carbon transportation innovation, if possible		0.288	0.308	0.76	0.27
[3] I would like to use low carbon transportation innovation, compare with using the private car		0.296	0.325	0.785	0.269
[4] If possible, I would like to adopt and use an electric car or new energy car		0.285	0.349	0.795	0.254

Note: Cumulative variance is 74.06%,

Next, to test the validity of the above-mentioned environmental values, utility value, social influence, and low carbon transportation innovation adoption, this paper applies validity analysis. The analysis results are shown in Table 3: The weight of the environmental value standard factor is between 0.760 and 0.841, the utility value is between 0.722 and 0.888, social influence is between 0.827 and 0.937, and low carbon transportation innovation adoption is between 0.880 and 0.956, also of them are above the standard value of 0.7 respectively. Composite Reliability (CR) and Average Variance Extracted (AVE) of environmental values are 0.655 and 0.905, respectively. Utility value s is 0.704 and 0.922, respectively; social influence was 0.771 and 0.943, respectively; the adoption of low carbon transportation innovation is 0.857 and 0.960, respectively.

Table 3. The results of confirmation exploratory factor analysis

Latent variables	Observable measurements	Standardized regression weight	AVE	C.R
Environmental values	Environmental values 1	0.760	0.655	0.905
	Environmental values 2	0.845		
	Environmental values 3	0.841		
	Environmental values 4	0.824		
	Environmental values 5	0.774		
Utility value	Utility value 1	0.722	0.704	0.922
	Utility value 2	0.812		
	Utility value 3	0.880		
	Utility value 4	0.888		
	Utility value 5	0.880		
Social influence	Social influence 1	0.850	0.771	0.943
	Social influence 2	0.827		
	Social influence 3	0.850		
	Social influence 4	0.937		
	Social influence 5	0.923		
Low carbon transportation adoption	Low carbon innovation 1	0.880	0.857	0.960
	Low carbon innovation 2	0.918		
	Low carbon innovation 3	0.949		
	Low carbon innovation 4	0.956		

3.4 Correlation Analysis

We conducted descriptive statistics and correlation analysis. Environmental values has a positive correlation with utility value. Environmental values also has a positive 0.6718 correlation with low carbon transportation innovation using. Utility value has a positive 0.717 correlation with low carbon transportation innovation using. Moreover, social influence also has a positive 0.618 correlation with low carbon transportation innovation using. Gender has a negative 0.102 correlation with low carbon transportation innovation adoption. Age, education, and type of occupations are negatively correlated with the low carbon transportation innovation adoption. Income level is positively correlated with low carbon transportation innovation adoption (See table 4).

Table 4. The results of descriptive statistics and correlation analysis

	1	2	3	4	5	6	7	8	9	10	11
ev1	1.000										
utv2	0.583	1.000									
si3	0.522	0.617	1.000								
lbi4	0.672	0.717	0.618	1.000							
gender5	-0.102	-0.023	-0.010	-0.066	1.000						
marriage6	-0.067	-0.071	-0.019	-0.002	0.102	1.000					
age7	-0.067	0.022	-0.024	0.038	-0.082	-0.519	1.000				
education8	-0.023	-0.065	-0.038	-0.061	-0.065	-0.049	-0.153	1.000			
income9	0.009	0.006	0.011	0.008	-0.042	-0.012	-0.050	0.029	1.000		
location10	-0.001	0.028	0.018	0.037	-0.019	-0.019	-0.022	0.015	0.115	1.000	
occupation11	-0.069	0.006	0.027	0.004	-0.038	0.019	-0.106	0.148	-0.004	-0.016	1.000
mean	3.598	3.584	3.329	3.354	1.599	1.745	3.007	2.4337	1.903	1.930	2.9371
sd	0.027	0.032	0.034	0.040	0.020	0.021	0.050	0.046	0.030	0.033	0.056

Note: EV = Environmental values, UTV = Utility value, SI = Social influence, LBI = Low carbon transportation innovation adoption

3.5 Hypotheses testing by using structural equation model

We conducted a structural equation model analysis to test the research hypotheses by using PLS 2.0 statistical software (Keller, 2015; Gujarati, 2012; Hayes, 2017). The following results confirm that according to firstly, environmental values has positively and significantly affected low carbon transportation innovation adoption (β = 0.334, t=3.928), then hypothesis 1a was supported. Second, the utility value has positively affected considerably low carbon transportation innovation adoption (β = 0.383, t=3.677), then hypothesis 1b was supported. Thirdly, environmental values indirectly and positively impact on low carbon transportation innovation adoption through utility value (β = 0.560, t=7.844). Moreover, social influence positively impacts the adoption of low carbon transportation innovation. By comparison, the utility value has the highest effect on low carbon transportation innovation adoption, followed by environmental values, social influence. Thus, it can be seen that the adopt low carbon transportation innovation will increase with the degree of environmental values, utility value, and social influence. Moreover, we have found that the utility value as mediating effect in the relationship between environmental values and low carbon transportation innovation adoption (See table 4).

Table 4. The results of the structural equation model (SEM)

Hypothesis path	Coefficients	t-value	Standard Deviation	Results
Environmental values → low carbon transportation commuting	0.334^{**}	3.928	0.073	Accepting
Utility value → low carbon transportation commuting	0.383^{**}	3.677	0.112	Accepting
Environmental values → utility value	0.589^{**}	9.164	0.076	Accepting
Environmental values → utility value → low carbon transportation commuting	0.560^{**}	7.844	0.071	Accepting
Social influence → low carbon transportation commuting	0.220^{**}	2.550	0.093	Accepting

Note: $^{*}p < .05$, $^{**}p < .01$

3.6 Heterogeneity testing

To verify the reliability of the research results, we have also conducted the following robustness tests in this paper, and we completed the stepwise regression model analysis for testing the research hypothesis by using STATA 13.0. We found robust results; first, the environmental values positively affect low carbon transportation innovation adoption, and utility value also has s stronger effect on low carbon transportation innovation. These results are partially consistent with Cai et al. (2019). Moreover, we found the utility value has the most significant effect on the adoption of low carbon transportation innovation, also the utility value as a mediating effect in the relationship between environmental values and low carbon transportation innovation adoption, these results are partially consistent with Ding et al. (2019) and Li et al. (2020a). We also found the robust results of the social influence has a positive effect on low carbon transportation innovation adoption, and this finding is partially consistent with Dahl et al. (2014) and Cipriani and Guarino (2014).

Table 5. Results of multivariate regression analysis

VARIABLES	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
	logALI	logALI	logUT	logUT	logALI	logALI
logEV	1.123***	1.129***	0.701***	0.702***	0.740***	0.497***
	(0.0590)	(0.0590)	(0.0426)	(0.0426)	(0.0629)	(0.0608)
logUT						0.597***
						(0.0527)
logSI					0.475***	0.260***
					(0.0409)	(0.0416)
GENDER	-0.00917	-0.00846	0.0190	0.0173	-0.0135	-0.0215
	(0.0246)	(0.0246)	(0.0178)	(0.0178)	(0.0222)	(0.0201)
MARITAL	0.0311	0.0292	-0.0256	-0.0308	0.0395	0.0532**
	(0.0278)	(0.0280)	(0.0200)	(0.0203)	(0.0253)	(0.0229)
AGE	0.00518	0.00508	-0.00519	-0.00797	0.0111	0.0131
	(0.0117)	(0.0120)	(0.00842)	(0.00865)	(0.0108)	(0.00977)
EDUCATION		-0.0148		-0.0175**	-0.00868	-0.00104
		(0.0111)		(0.00806)	(0.0101)	(0.00913)
INCOMELEVEL		-0.00375		-0.00192	-0.00249	-0.00191
		(0.0164)		(0.0119)	(0.0148)	(0.0134)
LOCAL		0.0233		0.00857	0.0236*	0.0183
		(0.0149)		(0.0108)	(0.0134)	(0.0122)
OCCUPATION		0.0185**		0.00693	0.0112	0.0104
		(0.00891)		(0.00645)	(0.00806)	(0.00730)
Constant	-0.305***	-0.367***	0.394***	0.422***	-0.452***	-0.665***
	(0.113)	(0.134)	(0.0817)	(0.0971)	(0.121)	(0.111)
Observations	588	588	588	588	588	588
R-squared	0.387	0.395	0.320	0.327	0.509	0.598

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Gender difference plays a vital role in environmental behavior (Li et al. 2019). Females are more concerned and are more likely to act for environmental issues compared with males' behavior. Thus, we compare the differences between males and females for low carbon transportation innovation adoption. Environmental values have a more effect on females' low carbon transportation innovation adoption, because of that, females are more sensitive to environmental pollution than males. According to Li et al. (2020a) and Shao et al. (2018) findings, compared with the low level of income groups, the different levels of income would increase the willingness to pay for environmental protection, we also found in the high level of income group, the environmental values, and utility value has a more positive effect on the adoption low carbon innovation. However, the social influence has no significant impact on low carbon transportation innovation adoption among high-income group residents. Similarly, according to multivariate regression analysis for different ages, the social influence has no significant effect on low carbon transportation innovation adoption among 10-19 years old residents and above 50 years old residents.

Table 6. Results of multivariate regression analysis for different genders and income level

VARIABLES	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)
	logALI	logALI	logALI	logALI	logALI
	females	**males**	**less 5000 RMB**	**5001 to 1,0000**	**over 10,001**
logEV	0.588***	0.484***	0.644***	0.396***	0.589***
	(0.0987)	(0.0789)	(0.103)	(0.100)	(0.111)
logUT	0.445***	0.694***	0.356***	0.694***	0.748***
	(0.0805)	(0.0721)	(0.0980)	(0.0783)	(0.107)
logSI	0.288***	0.208***	0.345***	0.274***	0.0706
	(0.0575)	(0.0604)	(0.0697)	(0.0632)	(0.0926)
MARITAL	0.0626*	0.0503	0.0264	0.0591*	0.00741
	(0.0336)	(0.0311)	(0.0435)	(0.0320)	(0.0516)
AGE	0.0187	0.0114	-0.000831	0.0114	0.0174
	(0.0147)	(0.0130)	(0.0182)	(0.0150)	(0.0186)
EDUCATION	0.00843	-0.00596	0.00822	-0.00802	-0.00159
	(0.0138)	(0.0122)	(0.0165)	(0.0139)	(0.0173)
LOCAL	-0.00536	0.0346**	0.0438**	0.0277	-0.0437*
	(0.0182)	(0.0161)	(0.0216)	(0.0187)	(0.0236)
OCCUPATION	0.0209*	0.00577	0.00161	0.0242**	0.000653
	(0.0116)	(0.00937)	(0.0126)	(0.0116)	(0.0141)
Constant	-0.692***	-0.752***	-0.641***	-0.753***	-0.566***
	(0.155)	(0.135)	(0.179)	(0.160)	(0.203)
Observations	236	352	189	267	132
R-squared	0.613	0.598	0.628	0.568	0.685

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7. Results of multivariate regression analysis for different ages

VARIABLES	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)
	logALI	logALI	logALI	logALI	logALI
	10-19s	20-29s	30-39s	40-49s	above50s
logEV	0.542***	0.401***	0.426***	0.704***	0.650***
	(0.170)	(0.125)	(0.115)	(0.147)	(0.165)
logUT	0.681***	0.644***	0.680***	0.510***	0.663***
	(0.132)	(0.112)	(0.0990)	(0.127)	(0.147)
logSI	0.182	0.139*	0.173**	0.431***	0.0746
	(0.120)	(0.0840)	(0.0810)	(0.0900)	(0.147)
GENDER	-0.109*	-0.00239	-0.0153	0.0201	-0.0935*
	(0.0579)	(0.0430)	(0.0402)	(0.0408)	(0.0535)
MARITAL	0.155	0.139	0.0515	0.0369	0.165
	(0.122)	(0.105)	(0.0398)	(0.0372)	(0.112)
EDUCATION	-0.00403	-0.0106	-0.0296*	0.0191	0.0242
	(0.0302)	(0.0199)	(0.0174)	(0.0194)	(0.0231)
INCOMELEVEL	-0.0156	-0.0268	0.000786	0.0398	-0.0469
	(0.0344)	(0.0273)	(0.0263)	(0.0285)	(0.0402)
LOCAL	-0.0314	0.00292	0.0122	0.0170	0.0662*
	(0.0362)	(0.0281)	(0.0250)	(0.0242)	(0.0338)
OCCUPATION	0.00466	0.00613	0.0301**	0.0105	-0.0161
	(0.0204)	(0.0162)	(0.0130)	(0.0180)	(0.0182)
Constant	-0.647*	-0.505*	-0.526***	-1.145***	-0.631**
	(0.327)	(0.300)	(0.174)	(0.229)	(0.306)
Observations	69	148	148	156	67
R-squared	0.754	0.572	0.624	0.593	0.711

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The different levels of education and the type of occupations, and different regions analyze the impact of environmental values, utility value, and social influence on the heterogeneity of low carbon transportation commuting among Chinese residents. The analysis results are as expected. Environmental values and utility value, and social impact positively affect low carbon transportation commuting in different marital and different educational levels. However, the environmental values have no positive and significant effect on low carbon transportation commuting adoption among government officials or public agency institution staff. Moreover, the social influence only has no significant impact on self-operated enterprises.

Table 8. Results of multivariate regression analysis for different marge and education level

VARIABLES	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
	logALI	logALI	logALI	logALI	logALI	logALI
	Not MARITAL	MARITAL	High school	3-years college	4-years university	Above Master
logEV	0.612***	0.489***	0.448***	0.707***	0.382***	0.445***
	(0.126)	(0.0722)	(0.113)	(0.134)	(0.124)	(0.145)
logUT	0.394***	0.696***	0.651***	0.524***	0.605***	0.646***
	(0.101)	(0.0630)	(0.106)	(0.103)	(0.118)	(0.114)
logSI	0.364***	0.208***	0.301***	0.227***	0.260**	0.177**
	(0.0875)	(0.0486)	(0.0781)	(0.0726)	(0.110)	(0.0886)
GENDER	0.00394	-0.0263	0.0248	0.0182	-0.0953*	-0.0255
	(0.0379)	(0.0244)	(0.0417)	(0.0338)	(0.0501)	(0.0415)
AGE	0.0303	-0.000869	-0.00186	-0.00788	0.000772	0.00804
	(0.0207)	(0.0120)	(0.0169)	(0.0163)	(0.0181)	(0.0171)
INCOMELEVEL	0.00263	-0.00804	0.000313	0.00127	-0.00184	-0.0211
	(0.0277)	(0.0155)	(0.0279)	(0.0237)	(0.0307)	(0.0286)
LOCAL	0.0369	0.00414	0.0246	0.00798	0.00468	0.0282
	(0.0225)	(0.0150)	(0.0243)	(0.0203)	(0.0328)	(0.0251)
OCCUPATION	0.0174	0.00497	0.0323**	-0.0172	0.0329*	0.00628
	(0.0134)	(0.00887)	(0.0148)	(0.0136)	(0.0170)	(0.0146)
Constant	-0.793***	-0.523***	-0.763***	-0.582***	-0.338*	-0.440**
	(0.185)	(0.107)	(0.172)	(0.177)	(0.184)	(0.203)
Observations	169	400	152	164	137	135
R-squared	0.578	0.626	0.649	0.540	0.574	0.644

Table 9. Results of multivariate regression analysis for different occupations

VARIABLES	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)	Model(7)	Model(8)
	logALI	logALI	logALI	logALI	logALI	logALI	logALI	logMALI
	East areas	Central area	West area	University students	State-owned enterprises	Sino-foreign joint enterprises	Self-operated enterprises	Goverment or goverment agence
logEV	0.481***	0.579***	0.522***	0.397***	0.523**	0.898***	0.508***	0.222
	(0.108)	(0.0930)	(0.110)	(0.139)	(0.215)	(0.111)	(0.121)	(0.152)
logUT	0.703***	0.681***	0.317***	0.676***	0.571***	0.325***	0.734***	0.599***
	(0.0959)	(0.0743)	(0.102)	(0.127)	(0.173)	(0.105)	(0.120)	(0.103)
logSI	0.223***	0.161***	0.386***	0.280***	0.325***	0.294***	0.0778	0.272***
	(0.0830)	(0.0586)	(0.0708)	(0.104)	(0.105)	(0.0727)	(0.108)	(0.0933)

VARIABLES	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)	Model(7)	Model(8)
	logALI	logALI	logALI	logALI	logALI	logALI	logALI	logMALI
GENDER	-0.0831**	0.0156	0.0188	0.0346	-0.00306	-0.0337	0.0320	-0.0717
	(0.0398)	(0.0265)	(0.0362)	(0.0546)	(0.0520)	(0.0348)	(0.0382)	(0.0517)
AGE	-0.0248	0.00774	0.0303*	0.0110	0.0172	-0.0132	-0.0214	0.0181
	(0.0168)	(0.0104)	(0.0162)	(0.0245)	(0.0185)	(0.0147)	(0.0169)	(0.0178)
INCOMELEVEL	0.0429	-0.0291	-0.0249	-0.00197	-0.0198	-0.0197	0.0125	0.000292
	(0.0264)	(0.0177)	(0.0243)	(0.0371)	(0.0364)	(0.0240)	(0.0238)	(0.0316)
EDUCATION	-0.00935	9.09e-05	-0.00789	-0.00375	-0.0117	0.0122	-0.0179	-0.00834
	(0.0185)	(0.0119)	(0.0157)	(0.0237)	(0.0242)	(0.0155)	(0.0165)	(0.0232)
Constant	-0.437**	-0.589***	-0.368**	-0.612***	-0.483*	-0.793***	-0.331*	-0.0231
	(0.179)	(0.118)	(0.148)	(0.210)	(0.271)	(0.161)	(0.187)	(0.211)
Observations	213	203	172	133	70	180	111	94
R-squared	0.553	0.711	0.606	0.573	0.674	0.621	0.601	0.688

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

3.7 Discussion

According to the green patents by the world intellectual property organization, the green or low carbon technology patents mainly include general environmental management, renewable energy, and non-fossil energy power generation, climate change mitigation technology and emission reduction technology, potential or indirect emission reduction technology, building or construction energy efficiency and transportation (Cai et al., 2019; Ding et al., 2019; Wang et al., 2020 a, b). Low carbon transportation innovations include the shared electric car or electric vehicles or electric bus. New energy electric vehicles or electric bus or shared bikes have many advantages in energy conservation and emission reduction (Li et al., 2017; Mi and Coffman, 2019). To address climate change and promote the market economy, many countries have accelerated strategic deployment to promote the new energy vehicles and related industry.

For example, Du et al. (2018) have found that consumers' adoption of new energy vehicles is significantly positively correlated with their income, low-carbon awareness and government subsidies policy. Kim et al. (2014) proposed that demographic factors are also an important factor affecting consumers' use of new energy vehicles. By investigating and analyzing Dutch residents' adoption willingness to share new energy vehicles, they found that people with male characteristics and high education have a stronger adoption willingness to share new energy vehicles. Petschnig et al. (2014) explored the influencing factors of adoption behavior of new energy vehicles based on innovation diffusion theory and planned behavior theory. Li et al. (2017) proposed that the influencing factors of the adoption of new energy vehicles can be situational, cost factors, technical factors, personal psychology, and social cultural factors. Scenario factors include government policies and new energy vehicle refueling facilities, personal psychology and social factors include subjective norms, social norms, and perceived behavioral control. Shi et al. (2018) analyzed the key influencing factors of shared new energy vehicles and provided policy and management opinions on the operation of shared new energy vehicles. The study of Li et al. (2020a) showed that environmental attitudes can be used as factors to predict the adoption of shared electric vehicles by consumers.

This present study establishes a new model to explore the influence of environmental values and utility value and social influence on consumer adoption behavior of low carbon transportation innovation. Through SEM model analysis, we have found environmental values has a direct effect on low carbon transportation adoption ($\beta = 0.334$, $p<0.01$), the finding is consistent with Dietz and Whitley (2018) findings. In addition, environmental values has an indirect effect on consumers adoption of low carbon transportation innovation ($\beta = 0.560$, $p<0.01$). So we can see that utility value plays a partial mediating role between environmental values and the adoption of low-carbon innovation. These results are partial inconsistent with Cai et al. (2019) and Bain et al. (2012) and Dietz and Whitley (2018) findings. Moreover, social influence positively and significantly affects the adoption of low carbon transportation innovation (Venkatesh et al. 2003; Abrahamson and Rosenkopf 1997; Bandiera and Rasul 2006; Bernheim 1994).

In addition, through stepwise regression analysis, we have found that based on environmental values and utility value and social influence of low carbon transportation adoption model fit is the highest comparison with others. The coefficients for environmental values, utility value, and social influence for total were 0.497, 0.597, 0.260; the equivalent values in females were 0.588, 0.445, 0.288; the equivalent values in males were 0.484, 0.694, 0.208. We can see females' environmental values have a higher effect on males, consistent with Li et al. (2020a) findings. However, social influence had no significant effect low carbon transportation innovation adoption among residents in high level of income. Marriage had a significant impact on females only, also marriage had a significant impact on middle-level income group, but not low level and high level, with coefficients (0.0591). Social influence significantly impacted 20-49s residents group, but not 10-19s and above 50s age groups. Social influence also has no significant impact on self-operated enterprises groups.

4. Conclusions and policy recommendations

4.1 Conclusions

In order to address global warming, to meet before 2060 carbon neutral, achieving economic growth and reducing carbon emission is an important issue in the study of sustainable development management. Many nations worldwide are looking for solutions to the energy crisis and environmental pollution (Dietz and Whitley 2018).

Transportation is fundamental in society and economic growth. With a large number of cars and motorbikes, the energy and environmental, also health issues caused by transportation, such as excessive coal and oil consumption, water consumption, and greenhouse gas emissions, noise and mental problems will become more serious in the future, especially in countries with large populations and developing countries. However, low carbon innovation can protect the ecological environment, mitigate global warming, realize the development of low-carbon economies, and realize economic and society's sustainable development (Sayer and Cassman, 2013; Sun et al., 2020). The concept of low carbon innovation adoption includes the new energy car to minimize greenhouse gases, achieving an environmental economics model that combines social and economic development with environmental protection (Foxon et al., 2008).

Previously on the technology adoption model, the TAM model, TRA model, and TPB model have been well validated. However, a few studies about the environmental values, utility value, and social influence-based adoption model for low carbon transportation innovation in China. Besides, some studies suggested that the key influencing factors for adopting shared low carbon transportation are environmentalism and environmental attitudes, and demographic variables (Dietz and Whitley, 2018). Moreover, the impact of the environmental values on low carbon transportation innovation adoption is inconsistent, contribute to the discussion about the effect of environmental values on low carbon behavior, identify the influencing mechanism on low carbon innovation adoption, reducing the beliefs-attitude-behavior gap (Bain et al., 2012; Dietz and Whitley, 2018).

This present study is to use the environmental values and utility value, and social influence theory to establish an empirical model to explore the influence of factors on consumer adoption behavior of low carbon transportation innovation, to promote the further development of China's new energy vehicle industry and practice the urban transportation development of energy-saving, emission reduction, and low-carbon commuting. This paper has found that the environmental values, utility value, and social influence positively affect the residents' low carbon transportation innovation adoption by verifying the hypothesis. That residents adoption of low carbon transportation innovation from their environmental values with positive influence, which is consistent with scholar Stern's previous empirical research on the basic model of Value-Belief-Norm (VBN), the more care about the environmental problems, the more likely they are to have their perception of environmental pollution problems, and more likely to realize the impact of their behavior on environmental issues, to enhance their pro-environmental for environmental protection participation (Bain et al., 2012; Dietz and Whitley, 2018).

In addition, with the development of the economy, the sharing of new energy vehicles will become more and more popular according to the increase in per capita income (Wang et al., 2020a). Residents' the awareness of ecological environment protection will continue to rise, it is better government educate consumers concern about environmental issues makes theirs more adoption of low carbon innovation transportation, we suggested that the government in promoting residents environmental values and environmental awareness of transportation pollution, it is better promote the low-carbon transportation innovation in the western region, Xinjiang and other cities, improve residents and tourists to use low carbon transportation innovation, construct the new low carbon green traffic system, promote the smart of the new energy vehicles operation development, to realize reducing carbon emissions and low carbon development goals.

There are some limitations in this paper, which should be paid attention to by subsequent researchers. Firstly, the research samples are mainly from students and different occupational workers in various locations in China. The samples have demographic limitations, which cannot represent the willingness to adoptions in other less-developed areas to use them. Secondly, it is suggested to expand the sample size, which requires visiting different cities or less developed rural areas and other research areas. Finally, this article extends the technology adoption model theory, TAM model as the research of the based model. The past TAM model, TPB model, TRA model, VBN model have been verified, but the lack of in-depth discussion of the environmental values and utility value and demographic variables have particular limitations. This discussion demographic variables to the adoption of low carbon transportation innovation but found no distinct differences in demographic variables to use the heterogeneity of low carbon transportation innovation, furthermore, the robustness of the results of this study is conclusive and reliable.

Acknowledgment

This study is supported by Social Science Foundation of Jiangsu, China (No. 19GLC015), Philosophy and Social Science Foundation for Colleges and Universities in Jiangsu Province (Nos.

2019SJA0160), the key program of National Social Science Fund of China (Grant No. 21AZD067), Research Start-up Fund of Nanjing University of Information Science and Technology (No. 2018r034), National Research Foundation of Republic of Korea (No. 2019K2A9A2A0602441012).

Many thanks for Long, Wang, Cai, Ding, Jiang, Xie, Liang, Shin, Antonio and Zhu co-author in early studies.

Author Contributions

Liang Li: Conceptualization, Methodology, Data, Visualization, Supervision, Writing - Review & editing; Meixuen Tan, Review & editing; Huaping Sun: Methodology, Writing- Review & editing.

Nuttida Sanitnuan: Writing - review & editing.

Received 10. March. 2021, **Revised** 12. April. 2021, **Accepted** 15. April. 2021

References

Abrahamson, E., & Rosenkopf, L. (1997). Social network effects on the extent of innovation diffusion: A computer simulation. Organization Science, 8(3), 289-309.

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In Action control (pp. 11-39). Springer, Berlin, Heidelberg.

Axsen, J., Orlebar, C., & Skippon, S. (2013). Social influence and consumer preference formation for pro-environmental technology: The case of a U.K. workplace electric-vehicle study. Ecological Economics, 95, 96–107.

Bachand-Marleau, Julie; Lee, Brian; El-Geneidy, Ahmed (2012). Better Understanding of Factors Influencing Likelihood of Using Shared Bicycle Systems and Frequency of Use. Transportation Research Record: Journal of the Transportation Research Board, 2314, 66–71.

Bain, P. G., Hornsey, M. J., Bongiorno, R., & Jeffries, C. (2012). Promoting pro-environmental action in climate change deniers. Nature Climate Change, 2(8), 600-603.

Bramoullé, Y., Djebbari, H., & Fortin, B. (2009). Identification of peer effects through social networks. Journal of Econometrics, 150(1), 41-55.

Cai, S., Long, X., Li, L., Liang, H., Wang, Q., & Ding, X. (2019). Determinants of intention and behavior of low carbon commuting through bicycle-sharing in China. Journal of Cleaner Production, 212, 602-609.

Chan, H. W. (2020). When do values promote pro-environmental behaviors? Multilevel evidence on the self-expression hypothesis. Journal of Environmental Psychology, 71, 101361.

Chen, S. Y. (2016). Using the sustainable modified TAM and TPB to analyze the effects of perceived green value on loyalty to a public bike system. Transportation Research Part A: Policy and

Practice, 88, 58-72.

Chen, S. Y., & Lu, C. C. (2016). Exploring the relationships of green perceived value, the diffusion of innovations, and the technology acceptance model of green transportation. Transportation Journal, 55(1), 51-77.

Cheolho Yoon; Sanghoon Kim (2007). Convenience and TAM in a ubiquitous computing environment: The case of wireless LAN., 6(1), 102–112.

Cipriani, M. and A. Guarino, 2014. "Estimating a structural model of herd behavior in financial markets." American Economic Review 104(1), 224–251.

Crociata, A., Agovino, M., & Sacco, P. L. (2015). Recycling waste: Does culture matter?. Journal of Behavioral and Experimental Economics, 55, 40-47.

Dahl, G. B., Løken, K. V., & Mogstad, M. (2014). Peer effects in program participation. American Economic Review, 104(7), 2049-74.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 319-340.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. Management Science, 35(8), 982-1003.

Delone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: a ten-year update. Journal of Management Information Systems, 19(4), 9-30.

Dietz, T., & Whitley, C. T. (2018). Environmentalism, norms, and identity. Proceedings of the National Academy of Sciences, 115(49), 12334-12336.

Ding, X., Long, X., Li, L., Liang, H., Wang, Q., & Cai, S. (2019). Antecedents of satisfaction and engagement of low-carbon bicycle-sharing using in China. Environmental Science and Pollution Research, 26(9), 8533-8542.

Du, H., Liu, D., Sovacool, B. K., Wang, Y., Ma, S., & Li, R. Y. M. (2018). Who buys New Energy Vehicles in China? Assessing social-psychological predictors of purchasing awareness, intention, and policy. Transportation Research Part F: Traffic Psychology and Behaviour, 58, 56-69.

Foxon, T., Köhler, J., & Oughton, C. (Eds.). (2008). Innovation for a low carbon economy: economic, institutional and management approaches. Edward Elgar Publishing.

Gifford, R., & Comeau, L. A. (2011). Message framing influences perceived climate change competence, engagement, and behavioral intentions. Global Environmental Change, 21(4), 1301-1307.

Goldsmith-Pinkham, P., & Imbens, G. W. (2013). Social networks and the identification of peer effects. Journal of Business & Economic Statistics, 31(3), 253-264.

Gouveia, V. V., & Ros, M. (2000). Hofstede and Schwartz s models for classifying individualism at the cultural level: their relation to macro-social and macro-economic variables. Psicothema, 12(Su1), 25-33.

Gujarati, D. (2012). Econometrics by example. Macmillan.

Hayes, A. F. (2017). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. Guilford publications.

Hofstede, G. (2001). Culture's consequences: Comparing values, behaviors, institutions and organizations across nations. Sage publications.

Hu, P. J., Chau, P. Y., Sheng, O. R. L., & Tam, K. Y. (1999). Examining the technology acceptance model using physician acceptance of telemedicine technology. Journal of Management Information Systems, 16(2), 91-112.

Keller, G. (2015). Statistics for Management and Economics, Abbreviated. Cengage Learning.

Kim, J., Rasouli, S., & Timmermans, H. (2014). Expanding scope of hybrid choice models allowing for mixture of social influences and latent attitudes: Application to intended purchase of electric cars. Transportation Research Part A: Policy and Practice, 69, 71-85.

Lazaric, N., Le Guel, F., Belin, J., Oltra, V., Lavaud, S., & Douai, A. (2019). Determinants of sustainable consumption in France: the importance of social influence and environmental values. Journal of Evolutionary Economics, 1-30.

Li, D., Zhao, L., Ma, S., Shao, S., Zhang, L. (2019). What influences an individual's pro-environmental behavior? A literature review. Resources, Conservation and Recycling, 146, 28-34.

Li, L., & Park, C. (2016). The effect of perceived value on customer satisfaction and continuous usage intention in SNS. The e-Business Studies, 17(6), 101-119.

Li, L., Msaad, H., Sun, H., Tan, M. X., Lu, Y., & Lau, A. K. (2020b). Green Innovation and Business Sustainability: New Evidence from Energy Intensive Industry in China. International Journal of Environmental Research and Public Health, 17(21), 7826.

Li, L., Zhu, B., Jiang, M., Cai, X., Lau, A. K., & Shin, G. C. (2020a). The role of service quality and perceived behavioral control in shared electric bicycle in China: Does residual effects of past behavior matters?. Environmental Science and Pollution Research, 27(19), 24518-24530.

Li, W., Long, R., Chen, H., & Geng, J. (2017). A review of factors influencing consumer intentions to adopt battery electric vehicles. Renewable and Sustainable Energy Reviews, 78, 318-328.

Liu, D., Du, H., Southworth, F., & Ma, S. (2017). The influence of social-psychological factors on the intention to choose low-carbon travel modes in Tianjin, China. Transportation Research Part A: Policy and Practice, 105

Mi, Z., & Coffman, D. M. (2019). The sharing economy promotes sustainable societies. Nature Communications, 10(1), 1-3.

Mohammadi, H. (2015). Investigating users' perspectives on e-learning: An integration of TAM and IS success model. Computers in Human Behavior, 45, 359-374.

Moloney, S., & Strengers, Y. (2014). Going green? the limitations of behaviour change programmes as a policy response to escalating resource consumption. Environmental Policy and Governance, 24(2), 94-107.

Moloney, S., Horne, R. E., & Fien, J. (2010). Transitioning to low carbon communities—from behaviour change to systemic change: Lessons from Australia. Energy policy, 38(12), 7614-7623.

Petschnig, M., Heidenreich, S., & Spieth, P. (2014). Innovative alternatives take action–Investigating determinants of alternative fuel vehicle adoption. Transportation Research Part A: Policy and Practice, 61, 68-83.

Rokeach, M. (1973). The nature of human values. Free press.

Roy, R. (1994). The evolution of ecodesign. Technovation, 14(6), 363-380.

Salazar, H. A., Oerlemans, L., & van Stroe-Biezen, S. (2012). Social influence on sustainable consumption: evidence from a behavioural experiment. International Journal of Consumer Studies, 37(2), 172–180.

Saleem, M. A., Eagle, L., & Low, D. (2018). Climate change behaviors related to purchase and use of personal cars: Development and validation of eco-socially conscious consumer behavior scale. Transportation Research Part D: Transport and Environment, 59, 68-85.

Sayer, J., & Cassman, K. G. (2013). Agricultural innovation to protect the environment. Proceedings of the National Academy of Sciences, 110(21), 8345-8348.

Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. Advances in Experimental Social Psychology, 25(1), 1-65.

Schwartz, S. H., & Boehnke, K. (2004). Evaluating the structure of human values with confirmatory factor analysis. Journal of Research in Personality, 38(3), 230-255.

Shao, S., Tian, Z., & Fan, M. (2018). Do the rich have stronger willingness to pay for environmental protection? New evidence from a survey in China. World Development, 105, 83-94.

Shi, J., Si, H., Wu, G., & Wang, H. (2018). Using behavior and willingness of urban transportation sharing products from the perspective of sustainable development. China Popul. Environ, 28, 63-72.

Sohn, K. S., Yoo, K. W., & Kwon, O. B. (2019). An Influence of Artificial Intelligence Attributes on the Adoption Level of Artificial Intelligence-Enabled Products. Korea Society Of Management Information Systems, 21(3), 111-129.

Stern, P. C., & Dietz, T. (1994). The value basis of environmental concern. Journal of Social Issues, 50(3), 65-84.

Stern, P. C., Dietz, T., Abel, T., Guagnano, G. A., & Kalof, L. (1999). A value-belief-norm theory of support for social movements: The Case of Environmentalism. Human Ecology Review, 81-97.

Sun, H., Edziah, B. K., Sun, C., & Kporsu, A. K. (2019). Institutional quality, green innovation and energy efficiency. Energy policy, 135, 111002.

Sun, H., Pofoura, A. K., Mensah, I. A., Li, L., & Mohsin, M. (2020). The role of environmental entrepreneurship for sustainable development: Evidence from 35 countries in sub-Saharan Africa. Science of The Total Environment, 140132.

Trappey, A. J., Trappey, C., Hsiao, C., Ou, J. J., Li, S., & Chen, K. W. (2012). An evaluation model for low carbon island policy: The case of Taiwan's green transportation policy. Energy Policy, 45, 510-515.

Van Kempen, E., Fischer, P., Janssen, N., Houthuijs, D., van Kamp, I., Stansfeld, S., & Cassee, F.

(2012). Neurobehavioral effects of exposure to traffic-related air pollution and transportation noise in primary schoolchildren. Environmental research, 115, 18-25.

Van Oorschot, J. A., Hofman, E., & Halman, J. I. (2018). A bibliometric review of the innovation adoption literature. Technological Forecasting and Social Change, 134, 1-21.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management Science, 46(2), 186-204.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS quarterly, 425-478.

Wang, Q., Li, S., & Li, R. (2018). China's dependency on foreign oil will exceed 80% by 2030: Developing a novel NMGM-ARIMA to forecast China's foreign oil dependence from two dimensions. Energy, 163, 151-167.

Wang, Q., Long, X., Li, L., Kong, L., Zhu, X., & Liang, H. (2020a). Engagement factors for waste sorting in China: The mediating effect of satisfaction. Journal of Cleaner Production, 122046.

Wang, Y., Long, X., Li, L., Wang, Q., Ding, X., & Cai, S. (2020b). Extending theory of planned behavior in household waste sorting in China: the moderating effect of knowledge, personal involvement, and moral responsibility. Environment, Development and Sustainability, 1-21.

Xiong, H., Payne, D., & Kinsella, S. (2016). Peer effects in the diffusion of innovations: Theory and simulation. Journal of Behavioral and Experimental Economics, 63,

Yang X., Feng L., & Wei P. (2012). Automobile exhaust pollution and its harm, Frontiers in Science (03), 12-24.

Yoon, C. (2018). Extending the TAM for Green IT: A normative perspective. Computers in Human Behavior, 83, 129-139.

Yue, T., Long, R., & Chen, H. (2013). Factors influencing energy-saving behavior of urban households in Jiangsu Province. Energy Policy, 62, 665-675.

Zhang, X., Chen, X., & Zhang, X. (2018). The impact of exposure to air pollution on cognitive performance. Proceedings of the National Academy of Sciences, 115(37), 9193-9197.

Zhang, Y., & Mi, Z. (2018). Environmental benefits of bike sharing: A big data-based analysis. Applied Energy, 220, 296-301.

Zhu, G., Sangwan, S., & Lu, T. J. (2010). A new theoretical framework of technology acceptance and empirical investigation on self efficacy based value adoption model. Nankai Business Review International.