Factors Promoting Green Transportation Behavior Among Citizens Under the Personal Carbon Credit Scheme: Empirical Evidence from Vietnam.

Vu Thi Anh Tuyet,
tuyetvta@hvnh.edu.vn, Faculty of Business Administration- Banking Academy, Hanoi, Vietnam
Tong Anh Nguyen Viet,
vietanhtonguyen115@gmail.com, Faculty of Business Administration- Banking Academy, Hanoi, Vietnam
Nguyen Hoa Thi Minh,
ntmh273@gmail.com, Faculty of Business Administration- Banking Academy, Hanoi, Vietnam

Abstract:

Transportation is a major contributor to unsustainable energy consumption, relying almost entirely on petroleum-based fuels (Tran et al., 2012; Virender S. et al., 2020). Making transportation behavior more sustainable is an urgent challenge of our time (Evangelia A. et al., 2020); and one of the most effective and essential approaches to building a low-carbon transportation system is to encourage more individuals to shift their habits from using gasoline- and diesel-powered vehicles to adopting greener modes of transportation, such as walking, cycling, subways, and electric vehicles,... This research examines and evaluates the factors influencing green transportation behavior among citizens, with the moderating role of personal carbon credit schemes in Vietnam, by qualitative and quantitative research methods. The research highlights the significance and practical relevance of the topic in the fields of transportation and sustainable development in Vietnam. In addition, the results of the present study provide recommendations for transport enterprises, manufacturers of vehicles, policymakers, and other stakeholders on feasible solutions to promote green transportation behavior among citizens under the personal carbon credit scheme.

Keywords: Green Transportation Behavior; Personal Carbon Credit; Low-Carbon Values; Vietnam's Transportation; Experimental Evidence.

1. Introduction

Nowadays, environmental awareness and responsibility have become pressing global concerns. The concentration of three primary greenhouse gases (GHG) - carbon dioxide, methane, and nitrous oxide - increased in 2023, surpassing the record-high levels of 2022 and continuing to rise without signs of peaking (WMO). Atmospheric CO2 levels have increased by more than 10% in just two decades, with 2024 projected to be the hottest year in recorded history (WMO). Despite prior warnings from the United Nations that the world will fail to meet the 1.5°C warming target set by the Paris Agreement unless urgent action is roused to reduce harmful emissions (UNECE), human activities continue to drive radiative imbalance, severely impacting climate and sustainability (Tiantian Wang et al., 2021; K. Williamson et al., 2018; Hertwich et al., 2009; Jones et al., 2014; Su et al., 2017; Tian et al., 2014). The 2024 Emissions Gap Report by UNEP highlights that the transportation sector accounts for approximately 15% of total GHG emissions and 23% of global CO2 emissions, ranking second only to the electricity sector (26%). Among transportation sources, road transport is the most GHG emitter (11%), followed by aviation (2%) and other transport modes (2%) (UNEP). Global CO2 emissions from the transportation sector increased by 45% from 1990 to 2007 and continue to rise by over 40% from 2007 to 2030 (Khodakaram et al., 2012). As a result, people worldwide face increased health and survival threats due to accelerating climate change, with 10 out of 15 health-related risk indicators reaching record highs (Lancet). In 2021, air pollution became the second leading cause of death, responsible for 8.1 million fatalities among children globally (UNICEF). Given these severe consequences, nations must intensify their climate adaptation efforts, beginning with financial commitments at COP29 and national contributions to global sustainability through mitigation and adaptation strategies (UNEP).

In Vietnam, transportation is a sector that significantly contributes to GHG emissions, releasing 45.5 million tons of CO2, accounting for 18% of the country's total emissions in 2022, and is a major driver of air pollution, severely impacting public health and hindering sustainable development (VR ENERGY). By 2030, CO2 emissions from Vietnam's transportation sector are forecast to reach 89.1 million tons., with road transport responsible for over 80% of total emissions (Duy Khanh, 2024). Additionally, the rapid growth of road vehicles exacerbates the situation. The annual growth rate of automobiles reached 13.3% from 2005-2022, a total of 5 million cars, while motorcycles and scooters increased by 9.3% per year, reaching 72 million registered vehicles (UNEP). It necessitates urgent emission control measures, particularly in road transportation, as the growth in population and travel demands make the issue even more alarming, especially in densely populated urban areas (Duy Khanh, 2024). Green transportation and urban mobility transition have become imperative (Shen et al., 2021; Fu et al., 2011; Huan Yu & Qi Yang, 2024). The Vietnamese government has emphasized this shift through Notice No. 8/TB-VPCP, promoting green vehicle policies to achieve the Net Zero target (Phuong Nhi, 2025). However, infrastructure limitations and entrenched consumer habits regarding private vehicle use have hindered the transition to green transportation (Duy Khanh, 2024). Thus, encouraging individuals to choose green transport is becoming increasingly critical (S Wang et al., 2020). Mass interpersonal behavioral changes can contribute significantly to climate change mitigation (K. Williamson, 2018).

According to Hazen et al. (2017), the personal propensity to adopt green transportation is key to the long-term success and development of the transportation sector and ultimately accelerates the transition to a low-carbon society. When individuals recognize the importance of green transportation, the shift towards low-carbon vehicles yields positive outcomes. However, most people have not yet shown a tendency to replace personal cars with green transportation alternatives (Chen et al., 2016). Research on promoting green transportation behavior remains limited. In particular, no studies have examined the impact of personal carbon credit schemes on individual intentions to adopt and use green transportation. In Vietnam, personal carbon credit schemes are advanced as an effective measure to reduce CO2 emissions and promote green mobility. However, their effectiveness in the Vietnamese context remains unclear (Nguyen et al., 2021). This pioneering research assesses the influence of these programs on individual mobility choices and green transportation adoption in Vietnam to contribute new knowledge and provide empirical evidence on the impact of personal carbon credit schemes. The research integrates psychological factors (perceived risk, perceived usefulness, perceived behavioral control, attitudes, and subjective norms) and economic elements (low-carbon values and personal carbon credits) to establish a solid empirical and theoretical foundation for carbon credit regulations and incentives. Its findings provide valuable policy recommendations for implementing personal carbon credit schemes in Vietnam's CO2 reduction strategy, especially in road transport, to develop carbon-related policies, promote green transportation, and enhance global awareness of low-carbon values and incentive-based mechanisms for sustainability.

2. Literature Review

Green Transportation Behavior

The term “Green Transportation” was first introduced by Bradshaw in 1994, referring to a coordinated system that utilizes low-carbon or environmentally friendly vehicles. Wann-Ming (2019) defined it as an efficient transport system promoting eco-friendly travel modes such as public transit, cycling, and walking. It aims to reduce congestion, pollution, and resource consumption while ensuring sustainable urban mobility (Shen et al., 2021; Wen et al., 2014). Shao (2019) and Jianying Yan (2017) emphasized minimizing personal car use and encouraging cleaner transport alternatives, while Fu et al. (2011) and Huan Yu & Qi Yang (2024) highlighted its role in sustainable transport development. Research by Shen (2017) and Senin (2021) linked green transportation to mitigating climate change. In essence, green transportation involves adopting low-emission vehicles, including bicycles, electric cars, and renewable energy-powered transport. Many governments have implemented policies to promote this shift.

The Netherlands encourages cycling, Guangzhou (China) has banned motorcycles in favor of public transit, and countries like the UK, South Korea, and Japan have developed affordable bike-sharing programs. The European Union remains a leader in green

transportation initiatives (Liu, 2017). In Vietnam, heavy reliance on motorcycles and cars leads to congestion and pollution (Ngoc Hai & Hoang Linh, 2024). Promoting green transportation is crucial for environmental, economic, and social benefits. However, consumer awareness and behavior remain key challenges. Without public recognition of personal carbon emissions, achieving behavioral change will be difficult. This shift is essential for Vietnam to meet its net-zero emissions target by 2050 (Yue-Rong et al., 2023).

Personal Carbon Credit

Carbon credits originated from California's 1990 Zero-Emission Vehicle Act, which promoted low-emission vehicles through a mandatory market mechanism (Gong Lei et al., 2023). A carbon credit permits the emission of one ton of CO2 or its equivalent (Vasconcelos et al., 2024). By 1996, personal carbon trading was introduced to encourage emission reductions (Fleming, 1996). Under the Emission Trading System (ETS), individuals and organizations receive emission allowances, enabling high emitters to trade with low emitters through Tradable Energy Quotas (TEQs). Between 2005 and 2008, proposals such as personal carbon allowances, household carbon trading, and tradable fuel permits emerged (Fleming, 2005; Starkey, 2005; Niemeier et al., 2008). Given the transportation sector's effect on climate change, carbon credit systems aim to promote sustainable behaviors by incentivizing low-carbon travel options like public transport and cycling (Gong Lei et al., 2023). The market effect encourages efficient energy use across sectors, with gradually decreasing total emission caps in line with national and international agreements (House of Commons). The concept of Personal Carbon Credits (PCC) was introduced in 2006 by David Miliband, the UK's then-Secretary of State for Environment, Food, and Rural Affairs (House of Commons).

PCCs allocate carbon credits to individuals, enabling direct emission control (Wang et al., 2024). Each credit represents a specific CO2 allowance, owned by individuals who actively reduce their verified emissions. Unlike traditional carbon credits, PCC projects operate on a smaller scale, encouraging direct reductions at the consumption level. Experts advocate for cost-effective verification methods to enhance PCC adoption. In 2011, tradable personal carbon permits were integrated into road transport policies (Wadud, 2011). Lahti, Finland, pioneered carbon reward mechanisms via the CitiCAP app, which tracks transport-related CO2 emissions and rewards sustainable travel choices with redeemable points (Uusitalo et al., 2022). Another Finnish initiative proposed carbon accounts where citizens receive monthly carbon allowances, and spending credits on fuel, electricity, and goods, with unused credits tradable (Hong Quang, 2023). The rising demand for carbon credits offers economic benefits (Vasconcelos et al., 2024). At the end of 2023, Vietnam formally entered the carbon credit market, reducing 10.3 million tons of CO2 for the World Bank (The Phong, 2023).

Low-Carbon Values

The term Low-carbon was first introduced in 2003 by the UK government in the Energy White Paper. A low-carbon economy is identified as the top goal in the UK's energy strategy (Peixin An, 2021), emphasizing technological innovation and policy regulations to promote

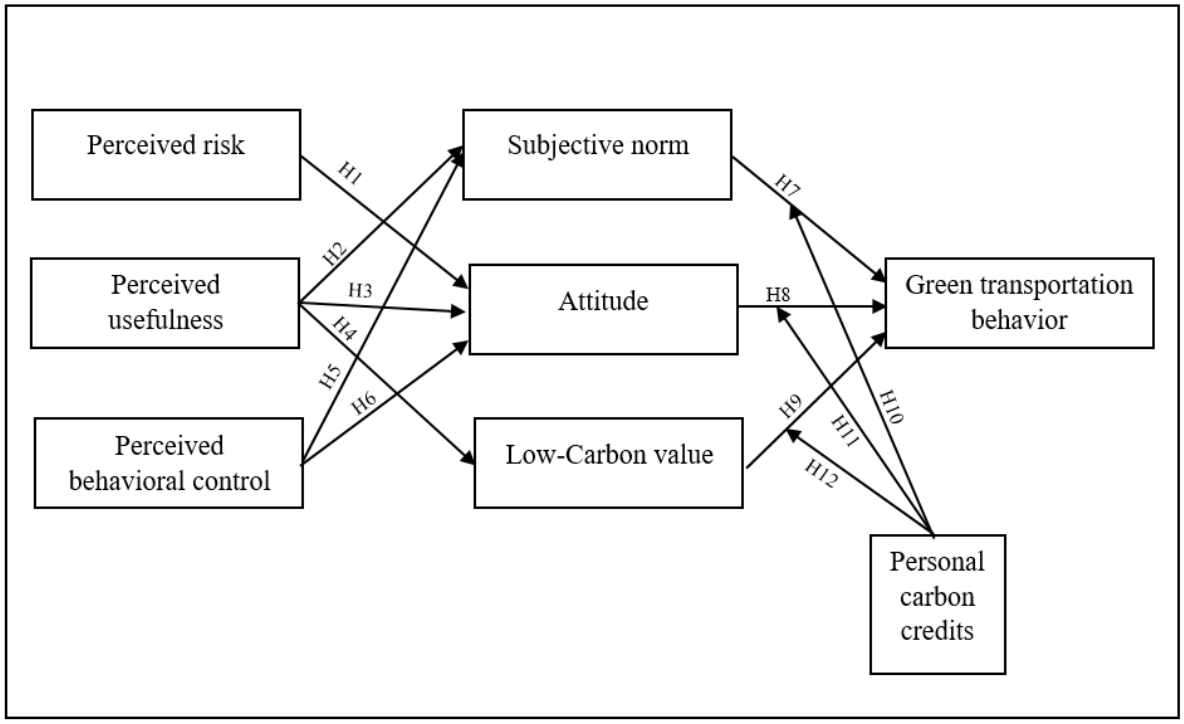
energy development and establish a new economic model with reduced greenhouse gas emissions and climate change mitigation (Qian Shi, 2013). Low-carbon value measures a business contribution to the overall ecosystem within a low-carbon economy (Yu, 2022). It directly reflects the creation of environmental, stakeholder, and corporate value (Shen et al., 2021). Low-carbon value represents societal beliefs and principles regarding low-carbon lifestyles and sustainable development. It encourages proactive environmental actions, consumption habit changes, and sustainable growth, fostering a healthier, more sustainable future (Li et al., 2023). However, declining public trust in governments can undermine official campaigns promoting low-carbon values, potentially causing resistance (Yael Parag and Shahar Ayal, 2023). According to Jia Wei et al. (2016), urban resident's low-carbon values can drive eco-friendly behaviors.

To summarize, low-carbon value, which signifies individual and corporate contributions to carbon reduction, rooted in sustainability beliefs, governmental trust, and environmental responsibility, reflects the transition to a low-carbon economy through technology strategies and policy initiatives planned to reduce GHG emissions. This shift influences perceptions and behaviors, promoting sustainable living, environmental stewardship, and responsible consumption. As climate change intensifies, the low-carbon concept plays an increasing role in urban planning and design (Maohua Xiong et al., 2024). Governments continuously optimize transportation, promote low-carbon values, and implement awareness campaigns to shape behavioral standards for a low-carbon society (Jia Wei et al., 2016).

3. Research hypothesis

The authors propose a research model by combining the theories and models mentioned above, including (1) the Theory of Reasoned Action (TRA), (2) the Theory of intended behavior or planned behavior (TPB), (3) the Technology acceptance model (TAM) and (4) Theoretical framework by Li et al. (2023). Although all of these theories have been applied by several international researchers, in Vietnam, through the information the group compiled, the authors found that not many domestic authors have exploited and researched in depth the impact of factors affecting green traffic behavior under the carbon credit program that applies the above three theories. Therefore, this research model aims to fill the theoretical gap, while providing practical insights into the factors that promote green transportation behavior, especially in the regulatory role of the individual carbon credit program.

Figure 1: Research model



Source: Research model proposed by the author group

Li et al. (2023) examined two psychological factors: perceived behavioral control and perceived risk. Based on perceived risk theory, individuals assess potential risks and uncertainties before making decisions or engaging in behaviors. Hammitt and Graham (1999) demonstrated that perceived risk is a key psychological barrier to sustainable behavior, leading to negative attitudes. When a behavior is associated with higher risks than perceived benefits, individuals tend to avoid participation despite its social or environmental value.

In the context of this study, perceived risks include uncertainties and deviations about time from initial plans that fail to meet Vietnamese citizens' expectations when using green transportation; inconvenience due to inflexible schedules or unsuitable routes, long waiting times for public transport, insufficient infrastructure such as bus stops and bicycle parking, and safety concerns related to accidents, security, or health. These risks may hinder individuals from adopting green transportation, shaping their attitudes toward its use.

H1: Perceived risk negatively influences public attitudes toward using green transportation.

When individuals perceive a behavior as beneficial to the public, such as environmental protection, they feel implicit social support, even if it is not explicitly expressed (Cialdini et al., 1990). It is particularly relevant in green transportation, where values like carbon reduction and environmental preservation are seen as collective benefits. In addition, perceived usefulness can influence subjective norms by fostering discussion and information diffusion

within social networks. According to Sniehotta et al. (2014), when behavior is positively discussed, its social value increases, leading to stronger promotion and social pressure, which becomes more acceptable. In Vietnam, public campaigns promoting green transportation - such as free bus services during community events or cycling incentives - can enhance perceived usefulness and reinforce social norms. However, the impact of perceived usefulness on subjective norms depends on individuals' trust in their community. If a person lives in an area where motorcycles or cars are preferred, they may feel less social pressure to adopt green transportation despite recognizing its benefits. In these cases, Heath & Gifford (2002) emphasized that policy interventions or educational campaigns are necessary to enhance public awareness and strengthen subjective norms.

H2: Perceived usefulness positively influences subjective norms in green transportation adoption.

The Technology Acceptance Model (TAM) by Davis et al. (1989) highlights the significant positive influence of "perceived usefulness" and "perceived ease of use" on consumer attitudes toward use. Perceived usefulness shapes attitudes toward low-carbon mobility choices, encouraging the adoption of sustainable transport. Thøgersen (2006) confirmed that perceived usefulness not only forwards positive attitudes but also strengthens behavioral intentions. When individuals recognize that public transport reduces traffic congestion or that cycling is cost-effective and health-promoting, they are more likely to favor green transportation. Similarly, Chen and Tung (2014) found that awareness of environmental benefits enhances positive attitudes toward sustainable tourism. In addition, perceived usefulness is related to psychological factors such as trust and motivation. According to Bamberg and Möser (2007), when the advantages of green transportation are communicated transparently, public confidence in its value increases, reinforcing positive attitudes. For instance, if individuals understand that daily walking or cycling reduces cardiovascular disease risk, they are more likely to embrace green mobility.

H3: Perceived usefulness positively influences attitudes toward choosing green transportation.

According to Bandura (1977), personal behavior and values are often shaped by specific experiences and perceptions of the benefits that behavior brings. Research by Chan and Lau (2012) suggests that when people perceive that sustainable behavior brings them specific benefits, their environmental protection behavior is enhanced. If an individual perceives that using an e-bike helps them increase their health, save on daily commuting costs, and at the same time reduce greenhouse gas emissions, their low carbon value will become stronger and likely to last longer. In addition, not only does perceived usefulness affect low-carbon values at the individual level, but it also spreads to the community level. According to research by Axsen and Kurani (2012), individuals who understand the benefits of sustainable behavior often share that knowledge within their social networks, promoting low-carbon values in the community. Conversely, if individuals do not see direct or short-term benefits from green transportation behavior (due to lack of infrastructure, high initial investment costs, or cultural

barriers), they may not develop strong low-carbon values. Gifford's (2011) research on psychological barriers to sustainable behavior has shown that a lack of clarity about benefits can hinder the formation of environmental values.

H4: Perceived usefulness positively influences low-carbon values.

Perceived behavioral control (PBC) played a more prominent role in determining individuals' intentions and actual behaviors. When individuals believe they can overcome potential barriers and possess sufficient resources or opportunities to perform a behavior, they tend to exhibit greater confidence and a proactive attitude (Tiantian Wang et al., 2021; Ajzen, 1991). Regarding green traffic behavior, PBC includes factors such as access to green transportation options, ease of use, social support, and financial capability to cover associated costs. This perspective is evident by Taylor & Todd (1995), in the context of sustainable behaviors, individuals who perceive that they have adequate resources, knowledge, or competence to engage in action tend to feel more confident in meeting related social expectations. Additionally, the study by Armitage and Conner (2001) confirms the interaction between PBC and subjective norms that individuals with a high perception of their ability to perform a behavior are more likely to adjust their attitudes and responsiveness to social pressure. Bamberg and Schmidt (2003) further clarify that PBC is necessary for transforming social pressure into actual behavioral intentions. Steg & Vlek (2009) conclude that when individuals have strong confidence in their capabilities, they are both influenced by social norms and inspire others, contributing to more positive subjective norms within their community.

H5: Perceived behavioral control positively influences subjective norms.

According to Taylor & Todd (1995), perceptions of the ability to perform the behavior increase feelings of confidence, thereby shaping more positive evaluations of the behavior. Besides, research by Bamberg and Möser (2007) also emphasized that PBC can reduce feelings of stress and psychological barriers when implementing sustainable behaviors. Steg & Vlek (2009) showed that perceived control not only reduces fear of failure but also enhances intrinsic motivation. In addition, research by Heath & Gifford (2002) shows that perceived behavioral control has an indirect impact on attitudes through reducing feelings of insecurity or risk. Conversely, if individuals feel that they have no control over their behavior, such as not having enough time or finances, their attitudes may become more negative. Research by Chen and Tung (2014) in the field of ecotourism in Taiwan demonstrated that individuals with high perceived behavioral control (ecotourism experience or ecological knowledge) often have more positive attitudes.

H6: Perceived behavioral control positively influences attitudes.

The theories of TRA, TAM, and TPB provide a solid theoretical foundation for explaining behavioral intentions and key influencing factors such as "attitude" and "subjective norms." Based on these theories, the hypotheses in this study are proposed as follows:

Firstly, attitude reflects an individual's preference or aversion toward behavior and is one of the most critical factors influencing human actions. According to Ajzen (1991), attitude plays a crucial role in predicting behavior, as it reflects an individual's positive or negative evaluation of a specific action. Specifically, the study by Lei Gong et al. (2023) demonstrated that attitudes toward the carbon credit system directly influence willingness to use it. Similar results were found in the research of Bamberg and Schmidt (2003) on public transportation usage in Germany, where the authors identified attitude as a key determinant in choosing sustainable transportation. Another study by Tarigan et al. (2012) in Greater Stavanger, Norway, from 2006 to 2009 showed that pro-environmental attitudes not only increased public acceptance of hydrogen-powered vehicles but also enhanced individuals' willingness to pay for hydrogen fuel. Nordlund and Garvill (2003) demonstrated that awareness of social responsibility can foster stronger positive attitudes, ultimately influencing actual behavior.

H7: Attitude positively influences green transportation behavior.

Secondly, subjective norms reflect the extent to which Vietnamese citizens are influenced by low-carbon emission policies, social regulations, and significant individuals such as family, friends, colleagues, or the broader community. Bamberg and Moser (2007), in their research on environmental behavior, affirmed that subjective norms play a crucial role in shaping intentions and actual behaviors. Through meta-analysis, they found that social encouragement can enhance individuals' willingness to participate in environmentally friendly activities, including green transportation. If an individual perceives that their family and friends value public transport as a means to reduce carbon emissions, they may experience positive social pressure and be more inclined to adopt this behavior. Another study by Lin et al. (2023) on policy preferences found that individuals with strong social beliefs and adherence to social norms tend to favor personal carbon trading systems. Similarly, Asadi et al. (2021) investigated factors influencing consumers' intentions to adopt electric vehicles in Malaysia and found that perceived social values and subjective norms significantly impact purchasing intentions. According to Schultz et al. (2007), public awareness campaigns and strong messages from social leaders can shape subjective norms, thereby promoting green transportation behaviors. Research by Smith et al. (2012) indicated that if individuals do not feel a strong sense of belonging to a particular social group, the influence of subjective norms diminishes significantly. In the Vietnamese context, studies by Vu Thi Huong et al. (2022) on public transportation choices in Hanoi and by Ha Nam Khanh Giao and Tran Thi Hong Diep [86] on passenger transport behavior between Thua Thien Hue and Ho Chi Minh City both found that subjective norms positively influence the choice of public transportation.

H8: Subjective norms positively influence green transportation behavior.

Li et al. (2023) demonstrated that low-carbon values have a positive impact on behavioral intentions, encouraging individuals to actively engage in environmentally friendly actions, modify consumption habits, promote sustainable development, and contribute to a healthier, more sustainable future. Stern (2000) further asserted that environmental values, particularly low-carbon values, play a crucial role in shaping sustainable behaviors. When individuals

highly value carbon emission reduction, they are more likely to adopt green transportation behaviors to minimize negative environmental impacts. In Vietnam, this value is becoming increasingly important as major cities such as Hanoi and Ho Chi Minh City face severe air pollution caused by transportation. A specific study by Chen and Chai (2010) on green consumption behavior in Asia highlighted that environmental values significantly influence individuals' intentions and behaviors in prioritizing eco-friendly products and services. Moreover, low-carbon values not only exert a direct effect on behavior but also have an indirect influence through behavioral intentions and positive attitudes. According to Kollmuss and Agyeman (2002), individuals who prioritize carbon emission reduction tend to develop stronger behavioral intentions, which subsequently lead to actual pro-environmental behaviors.

H9: Low-carbon values positively influence Vietnamese citizens' green transportation behaviors.

Additionally, through a synthesis of previous research (Gong Lei et al., 2023; Wang et al., 2024; Vasconcelos et al., 2024), the research team identified the moderating role of personal carbon credits in behavioral intention. Consequently, this factor has been incorporated into the model to examine its moderating effect on the influence of attitude, subjective norms, and low-carbon values on green transportation behavior. Specifically, in this study, personal carbon credits enhance the impact of positive attitudes on behavioral intentions. When individuals recognize the tangible benefits of using green transportation modes, they are more likely to feel satisfied and willing to change their behavior. Similarly, personal carbon credits influence subjective norms, when individuals and communities perceive the practical value of personal carbon credits, they tend to strengthen their commitment to green transportation behavior. Furthermore, low-carbon values, representing personal beliefs and principles in favor of environmental impact mitigation, are reinforced by personal carbon credits. This illustrates the connection between environmental benefits and individual behaviors in the transportation sector and beyond, fostering greater awareness of personal responsibility and roles in environmental protection. Accordingly, the following additional hypotheses are proposed:

H10: Personal carbon credits moderate the relationship between subjective norms and Vietnamese citizens' intention to participate in green transportation.

H11: Personal carbon credits moderate the relationship between attitude and Vietnamese citizens' intention to participate in green transportation.

H12: Personal carbon credits moderate the relationship between low-carbon values and Vietnamese citizens' intention to participate in green transportation.

4. Study results

Table 1: Research scale

Constructs	Items	References
Perceived risk	"I am concerned that using green transportation endangers my personal safety and property" "I am worried that green transportation services will disclose my personal information" "I worry about the safety of green transportation" "I'm worried that I won't be able to get on the bus and reach my destination on time using green transportation"	Abrahão et el., 2016
Perceived usefulness	"I think using green transportation is cheaper than other forms of travel" "I think using green means of transportation can make the most of road resources" "I think using green transportation can reduce air pollution" "I think using green transportation can reduce air pollution"	Aoife et el., 2001 Chen et el., 2010
Perceived behavioral control	"I find it easy to choose to use green means of transportation" "It is completely up to me to be able to use green transportation" "The traffic situation in my city is suitable for using green means of transport" "I have enough health and time to use green means of transportation"	Taylor & Told, 1995 Ajzen, 1991
Subjective norm	"My friends and family's attitudes toward green transportation services will influence my use of green transportation" "Most people around me use green means of transportation" "Social advocacy on environmental protection and low-carbon transportation allows me to use green means of transportation" "Someone once introduced me to using green means of transportation"	Taylor & Told, 1995 Ajzen, 1991

Attitude	"I support the use of green means of transportation" "I am satisfied with the current green transportation service" "I think using green means of transportation can meet my travel purposes" "I think the experience of using green transportation is interesting"	Chaniotakis et el.,2010 De Matos et el., 2007
Low-Carbon value	"The low carbon value encourages me to choose to use green means of transportation" "Considering global warming, I think saving energy, reducing emissions and using green transportation are the right choices" "I think we should immediately take effective measures to reduce carbon emissions" "I am often interested in environmental issues and I am worried when I hear about serious environmental problems"	Li et el., 2023
Personal carbon credits	"I understand that personal carbon credits encourage the use of green transportation" "I understand the benefits of personal carbon credits in encouraging the use of green transportation" "The personal carbon credit platform can help me reduce my carbon emissions" "The personal carbon credit platform can help me reduce my daily travel expenses" "The personal carbon credit platform can help me save time on my daily commute" "The personal carbon credit platform can accurately record my green transportation behavior" "The personal carbon credit platform can give me satisfactory rewards" "The personal carbon credit platform can motivate me to choose green transportation behavior" "I will accept the recommendation of relatives and friends to use the personal carbon credit platform"	Gong Lei et el., 2023

Green transportation behavior	"I will accept the recommendation of experts and scholars on the use of the personal carbon credit platform"	Gao et el., 2016
	"I will consider using green transportation"	
	"I will definitely buy and use green transportation in the near future"	
	"I will make an effort to use green transportation in the future"	
	"I will encourage my relatives/friends to use green transportation services"	

Description of the research sample

After conducting the survey of the target groups, the research team collected 373 responses and then continued to screen and eliminate 21 invalid responses. Finally, the authors collected and used 352 valid responses to conduct formal exploration and analysis in the following sections.

Table 2. Research sample

Criteria	Detail	Number (people)	Proportion
Gender	Male	188	53.4%
	Female	164	46.6%
Age	Under 18 years old	23	6.5%
	18 to 25 years old	95	27%
	From 26 to 35 years old	126	35.8%
	From 36 to 45 years old	60	17%
	Over 45 years old	48	13.6%
Education level	High school graduate	9	2.6%

	Secondary - Vocational	10	2.8%
	College	71	20.2%
	University	199	56.5%
	Above university	63	17.9%
Job	Student/ Researcher	123	34.9%
	Office staff	149	42.3%
	Freelance	30	8.5%
	Other	50	14.2%
Income	Under 5 million	32	9.1%
	From 5 million to under 10 million	38	10.8%
	From 10 million to under 20 million	166	47.2%
	From 20 million to under 25 million	77	21.9%
	From 25 million and up	39	11.1%
Owning a personal vehicle that runs on gasoline or diesel (motorbike, car, etc.)	No personal vehicle	78	22.2%
	1 personal vehicle	193	54.8%
	2 personal vehicle	46	13.1%
	3 personal vehicle or more	35	9.9%
	Never	7	2%

Frequency of use of personal vehicles running on gasoline and oil	Seldom	18	5.1%
	Sometimes	63	17.9%
	Frequent	162	46%
	Very often	102	29%
Frequency of participation in green transportation	Never	4	1.1%
	Seldom	174	49.4%
	Sometimes	65	18.5%
	Frequent	56	15.9%
	Very often	53	15.1%
Where do you currently live and work?	Hanoi City	246	69.9%
	Ho Chi Minh City	33	9.4%
	Da Nang City	29	8.2%
	Other	44	12.5%
Have you ever heard of personal carbon credit programs?	Used to	352	100%
	Never	0	0%

Source: Survey results of the research team

In terms of gender structure, 188 survey participants were male, accounting for 53.4%, while 164 were female, accounting for 46.6%. This reflects a positive trend, as awareness of environmental protection and green transportation is no longer limited by gender but has become a common concern in the community.

Regarding the age structure, many different age groups are participating in the survey, but the majority of respondents are young. According to the results, the age group under 18 years old has 23 people surveyed (accounting for 6.5%), 18-25 years old is the second largest with 95 votes (27%), followed by the age group from 26-35 years old with the largest proportion with 126 votes (35.8%), 60 votes from 36-45 years old (17%) and there are 48 votes from subjects over 45 years old (13.6%).

Regarding the educational level structure, the majority were university graduates with 199 votes, accounting for 56.5%; postgraduate graduates with 63 votes, 17.9%, 71 people surveyed had college degrees (20.2%). Intermediate-level vocational education had 10 people, equivalent to 2.8%, and high school graduates had 9 people (accounting for 2.6%).

Regarding the occupational structure, the number of office workers participating in the survey was the largest with 149 people (42.3%), followed by 123 students/graduates (34.9%), 30 freelance workers (8.5%,) and finally 50 other subjects (14.2%). Office workers, accounting for the largest proportion, often have a fixed travel habit, mainly between home and work.

Regarding income structure, according to the survey results, the number of subjects with income from 0 - under 5 million is 32 people, accounting for 9.1%, followed by 38 subjects with income from 5 million - under 10 million, accounting for 10.8%, 166 subjects with income from 10 million - under 20 million, accounting for 47.2%, 77 subjects with income from 20 million - under 25 million, accounting for 21.9% and finally the number of subjects with income over 25 million is 39 people, accounting for 11.1%.

Regarding the factor of owning a personal vehicle that runs on gasoline, the majority of respondents, 193, own one vehicle, accounting for 54.8%; 46 people own two or more vehicles, equivalent to 13.1%. There are up to 35 people who own three or more vehicles, accounting for 9.9%; 78 people do not own any personal vehicle that runs on gasoline, accounting for 22.2%.

Regarding the frequency of using personal vehicles running on gasoline and diesel, up to 162 respondents regularly use personal vehicles running on gasoline and diesel, accounting for 46% and 102 people very often use personal vehicles (29%), followed by 63 people who occasionally use personal vehicles (17.9%), 18 people who rarely use personal vehicles (5.1%) and 7 people who never use personal vehicles (2%).

Regarding the frequency of people participating in green transportation, 174 people surveyed rarely use green means of transportation, and 4 people never use green means of transportation. 65 people occasionally use them, accounting for 18.5%, the number of people who regularly use them is 56 (15.9%) and the number of people who very often use them is 53 people, accounting for 15.1%. It can be seen that the number of people using green means of transportation is still limited, there needs to be a solution to promote green transportation of people for a sustainable and comprehensive development future.

Regarding the regional structure, the survey results show that the majority of respondents living and working in Hanoi City are 246 votes, accounting for 69.9%, followed by 33 respondents from Ho Chi Minh City, accounting for 9.4%, 29 respondents from Da Nang City, accounting for 8.2% and finally 44 respondents studying, living and working in other areas, accounting for 12.5%. The survey results clearly reflect the actual traffic and environmental situation in large cities, where population density is high, traffic volume is heavy, and environmental issues are alarming. Hanoi, which has the highest number of respondents, is also one of the most polluted cities in the world.

Reliability testing is based on Cronbach's Alpha scale

Table 3. Cronbach's Alpha scale

Symbol	Observed variables	Cronbach's Alpha
PR	Perceived risk	.764
PU	Perceived usefulness	.863
PBC	Perceived behavioral control	.911
SN	Subjective norm	.769
ATT	Attitude	.945
LCV	Low-Carbon value	.937
GTB	Green transportation behavior	.939
PCC	Personal carbon credits	919

Source: Results obtained after running the model by the authors

All variables through the analysis results show that Cronbach's Alpha coefficient > 0.7 shows that the scale is used more deeply in subsequent studies. In addition, the CITC total correlation coefficient is greater than 0.3, showing that there is enough basis to perform the next analysis, no variables need to be removed from the model.

Results of EFA exploratory factor testing

After testing the reliability of the scale, the research team decided to temporarily keep the proposed group model including 8 variables with criteria expected to affect green brand loyalty and green word-of-mouth intention of customers. Put all data into SPSS software with Principal Axis Factoring data extraction method, Promax square rotation, KMO and Bartlett testing methods to measure the suitability and correlation between observed variables.

*** First EFA analysis for the set of 38 observed variables**

Table 4: KMO and Bartlett's test when running EFA for the first time

KMO Index		.855
Bartlett's Index	Chi-Square	9689.007
	df	666
	Sig.	.000

Source: Research group synthesis

Looking at Table 4.4, we see that the data is qualified for analysis because the KMO coefficient here has reached 0.855 > 0.5. The Sig value (0.000 < 0.05) of Bartlett's Test of Sphericity also satisfies the requirements, in addition, the cumulative total variance value is 78.073% > 50%, showing that the observed variables have interactions with each other in the factor. However, considering the loading factor criterion, variable SN2 is eliminated because the loading factor of variable SN2 needs to be eliminated (has a loading factor of less than 0.5). Because all have factor loading factors greater than 0.5, the remaining variables are accepted for use in later analysis.

*** Second EFA analysis for the set of 37 observed variables after removing variable SN2**

Table 5. KMO and Bartlett's test when running EFA for the second time

KMO Index		.866
Bartlett's Index	Chi-Square	10988.780
	df	666
	Sig.	.000

Source: Research group synthesis

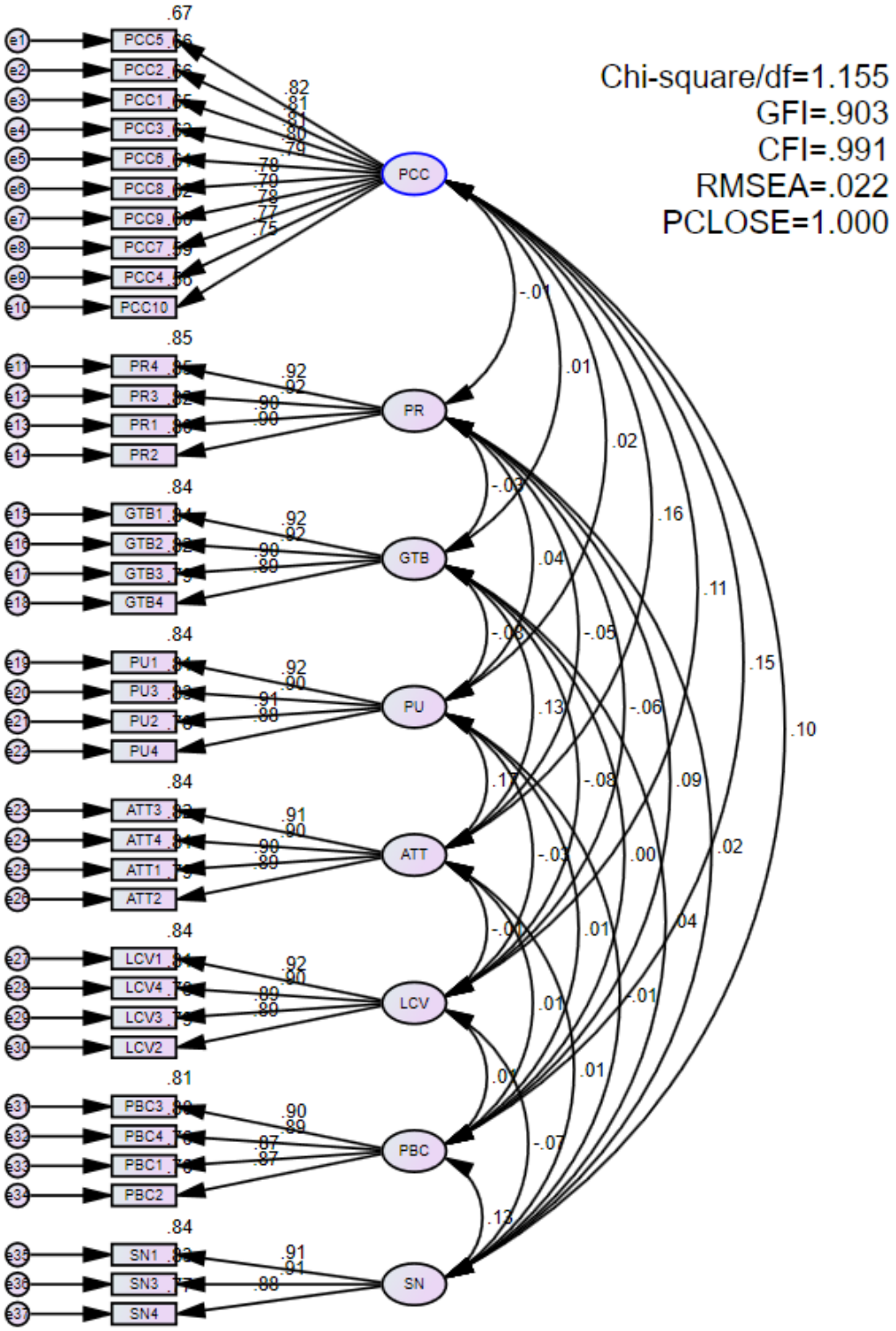
The group conducted the second EFA analysis and the results showed that the KMO index reached 0.866 > 0.5, which means that the data is eligible for analysis. Considering the Sig value of the Bartlett test (0.000 < 0.05), it can be seen that the results met the conditions; the total cumulative variance = 81.158% > 50%, which shows that the observed variables are correlated with each other in the factor. All variables have loading factors greater than 0.5, no variables need to be removed. After 2 EFA analyses, from 38 observed variables, 37 observed variables were extracted into 8 main factors.

Based on the evaluation through Cronbach's Alpha analysis and EFA exploratory factor analysis, 8 factors were kept intact and there was no change; from 38 observed variables reduced to 37 variables, eliminating variable SN2. However, the proposed research model was kept intact and did not need to be adjusted. The research team used it in the following research steps.

Results of CFA factor testing

The standardized CFA results show as follows: Chi-square/df of 1.155 less than 3 is good; CFI value of 0.991 greater than 0.95 is very good; GFI of 0.903 greater than 0.9 is good. In addition, an RMSEA value of 0.022 less than 0.06 is good and a PCLOSE of 1.000 greater than 0.05 is very good for the variables in the research model. From this standardized CFA result, the research team can conclude that the research model is considered good, suitable, and compatible with market data.

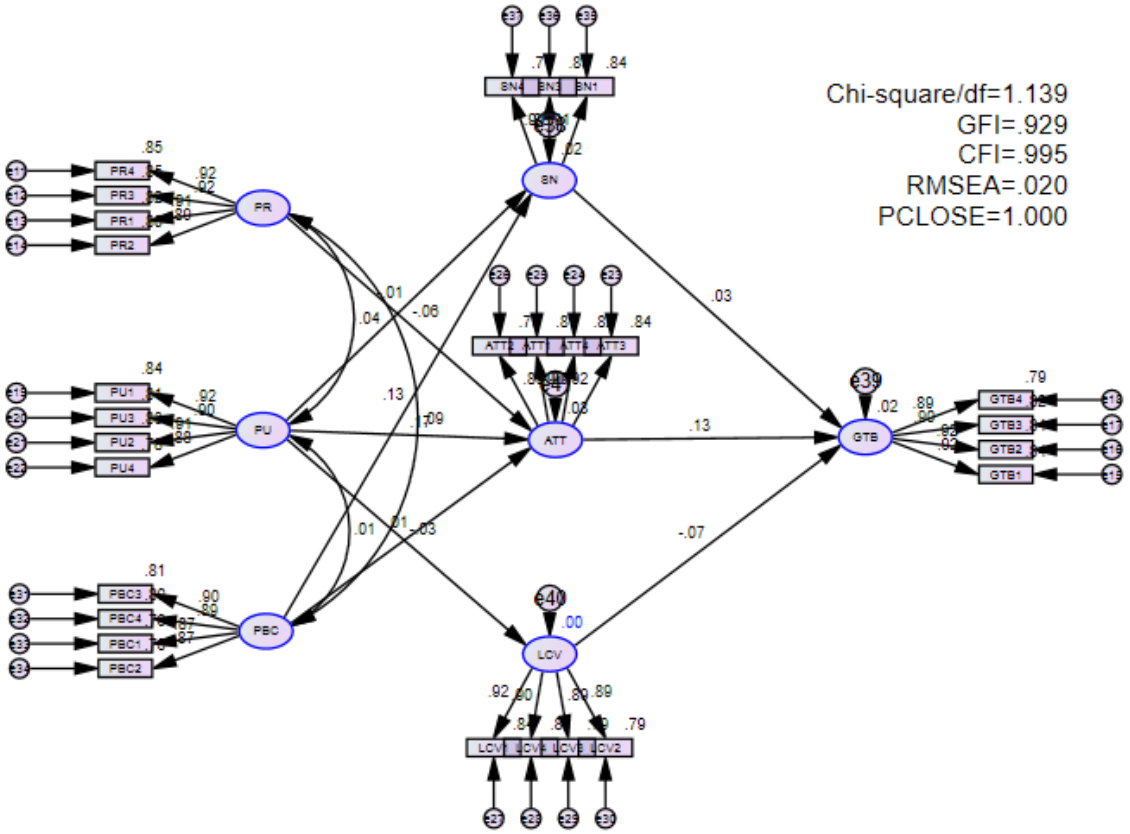
Figure 2. Results of CFA confirmatory factor testing



Source: Research group synthesis

Testing the suitability of the research model

Figure 3. Run the first SEM analysis of the proposed research model with standardized coefficients



Source: Research group synthesis

SEM analysis data shows that the chi-square/df index = 1.139 (< 3), GFI values = 0.929 (> 0.9), CFI = 0.995 (> 0.95); RMSEA = 0.020 (< 0.06), PCLOSE = 1.000 (> 0.05) the analysis results show that the indexes are at a good to very good level, so the research team concludes that the variables of the research model are consistent with the data on the market.

Next, the SEM analysis group modeled the linear structure.

Table 6. First direct impact test

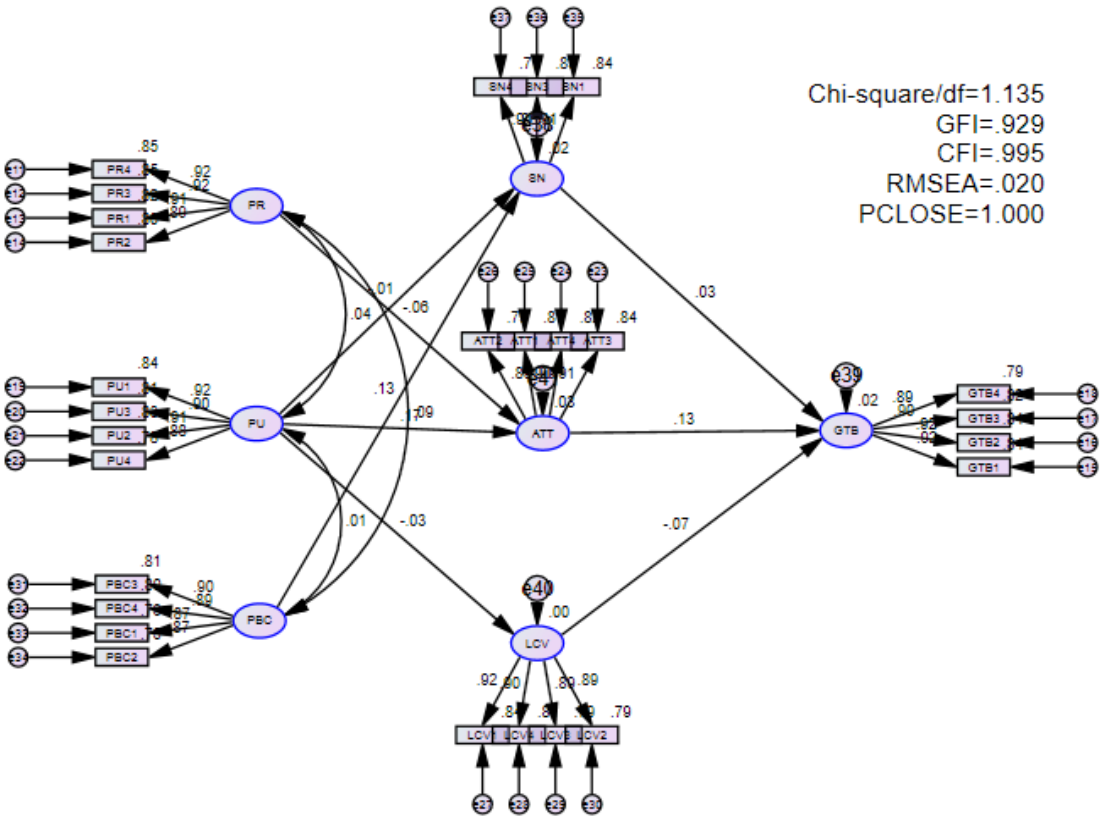
Direct impact	Unstandardized index	SE	CR	P-value	Normalized index
PR → ATT	-0.462	0.034	16,505	***	-0.463
PU → SN	0.220	0.054	4,085	***	0.340
PU → ATT	0.188	0.072	2,618	0.009	0.220
PU → LCV	0.570	0.051	11,212	***	0.622
PBC → SN	0.075	0.053	1,433	0.002	0.402
PBC → ATT	0.164	0.059	2,752	0.224	0.374
SN → GTB	0.455	0.059	7,723	***	0.528
ATT → GTB	0.058	0.040	1,451	0.007	0.504
LCV → GTB	0.706	0.079	8,914	***	0.795

P: significance level; *** = p < 0.001. *Source: Research group synthesis*

In the above results table, shows that there is a relationship with a value that does not meet the required condition (PBC → ATT has p-value = 0.224 > 0.05). Therefore, the research team concluded that Perceived behavioral control (PBC) does not have a direct effect on Attitude (ATT). Therefore, we rejected hypothesis H6 and removed these relationships from SEM, then ran it again for the second time.

After rejecting an unqualified hypothesis H6, the research team obtained the analysis results below:

Figure 4. Second SEM analysis of the proposed research model with standardized coefficients



Source: Research group synthesis

The second SEM analysis data showed that the chi-square/df index = 1.135 (< 3), GFI values = 0.929 (> 0.9), CFI = 0.995 (> 0.95); RMSEA = 0.020 (< 0.06), PCLOSE = 1.000 (> 0.05) the results showed that the indexes were at a good to very good level, so the research team concluded that the impacts of the variables in the research model were consistent with the market data.

Then, the group analyzed the linear structural model with the second SEM:

Table 7. Second direct-impact test

Direct impact	Unstandardized index	SE	CR	P-value	Normalized index
PR → ATT	-0.462	0.034	-16.505	***	-0.463
PU → SN	0.220	0.054	4,085	***	0.357
PU → ATT	0.188	0.072	2,618	0.009	0.287
PU → LCV	0.570	0.051	11,212	***	0.774
PBC → SN	0.075	0.053	1,433	0.002	0.293
SN → GTB	0.455	0.059	7,723	***	0.516
ATT → GTB	0.058	0.040	1,451	0.007	0.661
LCV → GTB	0.706	0.079	8,914	***	0.882

P: significance level; *** = $p < 0.001$. *Source: Research group synthesis*

The results from the analysis table show that all relationships in the model are statistically significant. The impact of the variable Perceived Risk (PR) on Attitude (ATT) is -0.463. The impact of Perceived Usefulness (PU) on Subjective Norm (SN), Attitude (ATT), and Low Carbon Value (LCV) is 0.357; 0.287, and 0.774 respectively; the impact of Perceived Behavioral Control (PBC) on Subjective Norm (SN) is 0.293. The impact of Subjective Norm (SN) on Green Transport Behavior (GTB) is 0.516. Among the remaining impacts on Green Transportation Behavior (GTB), the impact of Low Carbon Value (LCV) is the highest at 0.882, followed by the impact of Attitude (ATT) at 0.661.

Testing the indirect effects of factors

Indirect Effect test results for independent - dependent - mediating variables:

Table 8. Test of mediating effects

Indirect Path	Unstandardized Estimate	Lower	Upper	P-Value	Standardized Estimate
PR --> ATT --> GTB	-0.128	-0.188	-0.073	0.001	-0.258
PU --> SN --> GTB	0.026	0.054	-0.008	0.003	0.314
PU --> ATT --> GTB	0.019	0.040	0.006	0.003	0.283
PU --> LCV --> GTB	0.009	0.021	0.003	0.003	0.334
PBC --> SN --> GTB	0.011	0.026	0.004	0.002	0.371

Source: Research group synthesis

From the analysis data in the results table above, it can be seen that the dependent relationships between the variables are all statistically significant, as the P-value is less than 0.05. The impact of Perceived Risk (PR) through the mediating variable Attitude (ATT) is -0.258. The impact

of Perceived Usefulness (PU) on Green Transportation Behavior through the mediating variables Subjective Norm (SN), Attitude (ATT) and Low Carbon Value (LCV) is 0.314, 0.283, and 0.334 respectively. The impact of Perceived Behavioral Control (PBC) on Green Transportation Behavior (GTB) through Subjective Norm (SN) is 0.371. The model and research hypotheses that the authors analyzed above are consistent with market data.

Testing the moderating role of the Personal Carbon Credit (PCC) variable

Table 9. Testing the moderating role of the PCC variable in the relationship from SN to GTB

	Unstandardized impact factor	**SE**	**t**	**P-value**	**LLCI**	**ULCI**
Constant	2.1488	0.3702	6.3415	0.0000	1.6201	3.0757
SN	0.11697	0.1291	1.3569	0.7568	-0.0786	0.4288
PCC	-0.1775	0.1005	-1.8429	0.0661	-0.3828	0.123
Product	0.0929	0.0341	2.9130	0.0094	0.0323	0.1663

Source: Research group synthesis

Table 9 shows that the P-value of the product SN*PCC = 0.0094 (< 0.05), so the product SN*PCC is considered to have a significant influence on the variation of GC values. From that, it can be concluded that PCC has a moderating role in the impact relationship from SN to GTB.

The unstandardized impact coefficient (coeff) of SN*PCC = 0.0929 (> 0.05). Therefore, when PCC increases, it will increase the impact of SN on GTB.

We have the equation of change in the value of PCC presented as follows:

*PCC = 2.1488+0.11697*SN -0.1775*PCC+ 0.0929*SN*PCC + ei.*

Table 10. Testing the moderating role of the PCC variable in the relationship from ATT to GTB

	Unstandardized impact factor	SE	t	P-value	LLCI	ULCI
Constant	2.5113	0.3955	6.3503	0.0000	1.7339	3.2887
ATT	0.1664	0.1379	0.4816	0.6304	-0.2046	0.3374
PCC	-0.1978	0.1073	3.7057	0.0002	-0.1868	0.6088
Product	0.0781	0.0364	-1.3213	0.0041	0.1197	0.0235

Source: Research group synthesis

Table 10 shows that the P-value of the product ATT*PCC = 0.0041 (< 0.05), so the product ATT*PCC is considered to have a significant impact on the variation of GTB value. From that, it can be concluded that PCC has a moderating role in the impact relationship from ATT to GTB.

The unstandardized impact coefficient (coeff) of ATT*PCC = 0.0781 (> 0.05). Therefore, when PCC increases, it will increase the impact of ATT on GTB.

We have the equation of change in the value of PCC presented as follows:

*PCC = 2.5113+0.1664*ATT -0.1978*PCC+ 0.0781*ATT*PCC + ei.*

Table 11. Testing the moderating role of the PCC variable in the relationship from LCV to GTB

	Unstandardized impact factor	SE	t	P-value	LLCI	ULCI
Constant	2.5528	0.4990	5.0168	0.0000	1.5226	3.4846
LCV	0.1253	0.1835	0.1653	0.8688	-0.3304	0.3911
PCC	-0.1857	0.1173	-1.6511	0.0995	-0.4241	0.0369
Product	0.1216	0.0424	2.8178	0.0063	0.0361	0.2028

Source: Research group synthesis

Table 11 shows that the P-value of the product LCV*PCC = 0.0063 (< 0.05), so the product LCV*PCC is considered to have a significant impact on the variation of GTB value. From that, it can be concluded that PCC has a moderating role in the impact relationship from LCV to GTB.

The unstandardized impact coefficient (coeff) of LCV*PCC = 0.1216 (> 0.05). Therefore, when PCC increases, it will increase the impact from LCV on GTB.

We have the equation of change in value of PCC presented as follows:

*PCC = 2.5528+0.1253*LCV -0.1857*PCC+ 0.1216*LCV*PCC + ei.*

Testing research hypotheses

Table 12. Summary of hypothesis testing results

Hypothesis	Content	Impact factor (	Sig coefficient (p-value)	Test results
H1	*Perceived risk has a negative effect on attitude.*	-0.463	***	Accepted
H2	*Perceived usefulness has a positive effect on Subjective Norm*	0.357	***	Accepted
H3	*Perceived Usefulness Has a Positive Effect on Attitude*	0.287	0.009	Accepted
H4	*Perceived usefulness has a positive effect on Low Carbon Value*	0.774	***	Accepted
H5	*Perceived behavioral control has a positive effect on Subjective Norms*	0.293	0.002	Accepted
H6	*Perceived behavioral control has a positive effect on attitudes.*	0.374	0.224	Rejected
H7	*Subjective Norms Have a Positive Impact on Green Transportation Behavior*	0.516	***	Accepted
H8	*Attitudes have a positive impact on Green Transportation Behavior*	0.661	0.007	Accepted

H9	*Low Carbon Values Have a Positive Impact on Green Transportation Behavior*	0.882	***	Accepted
H10	*Personal Carbon Credits Moderate the Relationship Between Subjective Norms and Green Transportation Behavior*	0.0929	0.0094	Accepted
H11	*Personal Carbon Credits Moderate the Relationship Between Attitudes and Green Transportation Behaviors*	0.0781	0.0041	Accepted
H12	*Personal Carbon Credits Moderate the Relationship Between Low Carbon Values and Green Transportation Behavior*	0.1216	0.0063	Accepted

P: significance level; *** = p < 0.001. *Source: Research group synthesis*

5. Discussion and implications

Recommendations for transport and vehicle manufacturing businesses

First, reduce risks through improving safety and ensuring the quality of green transportation services. One of the biggest barriers to green transportation behavior mentioned in the research group's topic is "Perceived risk". People often worry that switching to green transportation such as electric bicycles, electric motorbikes, or electric buses may be unsafe, unreliable, or inconvenient. To address this issue, transportation companies and vehicle manufacturers need to focus on reducing people's feelings of insecurity by ensuring the quality of their products and services.

Second, Provide integrated utilities and expand the benefits of green transportation. The variable “Perceived usefulness” refers to how people evaluate the actual benefits that green transportation or personal carbon credit programs bring to them. In order to promote green transportation behavior, transportation enterprises and vehicle manufacturers need to continuously increase the practical values and utilities that green vehicles bring to users.

Third, Increase people's control over green vehicle use. The variable "Perceived behavioral control" relates to people's feeling that they have control over their participation in green transportation. An important factor in improving this variable is to ensure that people feel that using green vehicles is easy, convenient and within their control. To do this, transport companies and vehicle manufacturers need to invest heavily in developing supporting infrastructure. This could include expanding the network of electric charging stations, ensuring their availability in urban and rural areas, and providing accurate information about the location and operating status of charging stations via mobile applications.

Fourth, "Subjective norm" refers to the influence of social groups, influential individuals, and community culture on an individual's behavioral decisions. In the case of green transportation behavior, subjective norm can help promote this behavior if the community around the consumer has a positive attitude toward using green transportation and reducing carbon emissions. To influence this factor, businesses need to deploy strong strategies to help build a positive social network related to green transportation activities such as collaborating with social organizations, local communities, and influential groups to create propaganda campaigns. Using prominent individuals in society such as celebrities, environmental experts, or even influential people in community groups will create a strong spillover effect.

Fifth, consumers' "attitudes" play an important role in determining whether they are willing to change their transportation habits to switch to green transportation. To change people's attitudes, businesses need to clearly affirm the benefits they will receive from using green transportation, while reducing concerns and doubts about the efficiency of these vehicles. Businesses can organize free test-driving events for electric or hybrid vehicles, helping consumers feel the performance of these vehicles compared to traditional vehicles. This will help reduce concerns about the performance and convenience of electric vehicles, and help them see the real benefits of using low-emission vehicles.

Sixth, "low carbon value" refers to consumers' awareness of the benefits of reducing carbon emissions in their daily lives. If businesses want to promote green transportation behavior, they need to clarify this value, not only from the perspective of environmental protection but also from the financial and health benefits that consumers can receive.

Finally, "Personal Carbon Credits" are an important tool to encourage green transportation behavior, as they not only help reduce emissions but also provide financial benefits to consumers. These platforms can provide transparent information about how credits are calculated and how they can be used, sold, or traded. In particular, businesses can create carbon credit exchanges, allowing consumers to resell unused credits, or offer incentives such as product discounts, electric bus tickets, or environmentally friendly products when consumers reach a certain number of credits.

Recommendations to the government

First, develop and implement a personal carbon credit system. The government needs to develop an effective personal carbon credit management and monitoring system to encourage citizens to participate and practice green transportation behaviors. This can be done through the development of digital technology platforms or mobile applications where citizens can easily track their carbon credits.

Second, Recommendations on the development of policies to support green transport and the use of carbon credits. The government should develop and implement policies to support green transport and integrate carbon credits into public transport, green transport, and sustainable infrastructure development programs. The government can encourage low-emission vehicles such as electric vehicles and electric bicycles through tax incentives, subsidies, or support for enterprises producing green vehicles. These policies will create a favorable environment for the development of green vehicles and at the same time, help reduce emissions from traditional vehicles.

6. Limitations and directions for further studies

Limitations

Limited awareness and participation. Although personal carbon credit schemes have great potential to change people's travel behavior, people's awareness of the benefits and how they work is still limited. Furthermore, there may be resistance from people to change their travel habits, especially in areas with low environmental awareness or poor traffic conditions. This may reduce the representativeness and participation of the study sample, leading to results that do not accurately reflect the factors that drive green travel behavior.

Directions for further studies

This study tested the hypotheses using a survey method using a questionnaire. This method only provides cross-sectional data for the study, so it is not possible to observe the dynamic changes in green transportation behavior, perceived risk, perceived usefulness, perceived behavioral control, subjective norms, attitudes, low-carbon values, and personal carbon credits in different periods. Therefore, future research authors can orient longitudinally to find out the differences in the variables in the model in different periods.

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