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SMART AND GREEN TRANSPORTATION

THE CASE IN VIETNAM

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SMART AND GREEN TRANSPORTATION- THE CASE IN VIETNAM

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CONTENTS

CHAPTER 1: CHALLENGES FOR THE ADOPTION OF INTELLIGENT TRANSPORTATION SYSTEMS IN URBAN MOBILITY: A CASE STUDY OF VIETNAM

Abstract

This research investigates the challenges hindering the adoption of Intelligent Transportation Systems (ITS) in urban areas, focusing on Vietnam as a case study. It identifies key barriers including technological, economic, resource, personal, management, and interoperability challenges through a comprehensive review of academic literature and a survey conducted in three provincial cities in Vietnam. The findings highlight that economic and personal challenges, particularly concerns about financial investment and data privacy, are the most significant obstacles to ITS adoption. Technological and management challenges, although relevant, are less influential. The study suggests that policymakers should prioritize financial incentives, stronger data protection regulations, and infrastructure improvements to support the implementation of ITS. These efforts will facilitate the shift toward ITS, enhancing urban transportation efficiency, safety, and sustainability. The results offer valuable insights for both local and global applications of ITS in rapidly urbanizing regions.

Keywords: Intelligent Transportation Systems; Economic challenges; Personal challenges; urban transportation

1. Introduction

The rapid growth of urbanization has increased the need for transportation systems that are efficient and sustainable. Traditional transportation methods face several challenges, including traffic congestion, air pollution, and safety concerns. Intelligent Transport Systems (ITS) have been developed to address these difficulties and improve smart urban transportation (Abbas et al., 2021). ITS denotes an advanced network of technology and solutions used for transportation and traffic management. Intelligent Transportation Systems (ITS) use diverse components, including sensors, data connectivity, sophisticated algorithms, and real-time data processing, to enhance the efficiency, safety, and efficacy of transportation networks. It may include intelligent traffic signals, automated toll collection, GPS navigation, and several advanced features aimed at optimizing traffic flow and improving transportation services.

Challenges to Adoption denote the impediments, difficulties, and hurdles that may obstruct the effective implementation and usage of Intelligent Transportation Systems (ITS) and smart urban mobility solutions. These challenges may include technological difficulties, financial limitations, regulatory obstacles, public acceptability, interoperability concerns, and more factors (Sajjad et al., 2023). Assessing and mitigating these obstacles is essential for the successful implementation of Intelligent Transportation Systems and the achievement of smart urban mobility objectives. Intelligent Transportation Systems (ITS) use advanced technology such as sensors, communication networks, and data analytics to enhance traffic flow, alleviate congestion, and augment safety. However, the implementation of Intelligent Transportation Systems in urban areas has faced considerable challenges (Lamssaggad et al., 2021).

The implementation of Intelligent Transportation Systems in urban settings has faced significant challenges, despite its promise to revolutionize smart transportation in cities. A substantial research gap persists in understanding the aforementioned issues (Goodman & Michalikova, 2021). Previous research has mostly focused on the technical aspects of Intelligent Transportation Systems, including the development of innovative technologies and the improvement of traffic management. However, more academic research is required to examine the challenges hindering the deployment of Intelligent Transportation Systems in Vietnam's urban areas. Vietnam, characterized by its swiftly growing metropolitan areas, exemplifies the challenges involved in deploying smart urban mobility. By analyzing the challenges and prospects unique to this environment, we enhance the local dialogue on sustainable urban transportation while providing insights of wider relevance. The complexities of Vietnam's transportation infrastructure provide a solid basis for deriving significant insights applicable to other rising nations with comparable urbanization issues. Understanding these challenges is essential for the effective implementation of ITS in urban areas. The potential benefits of deploying Intelligent Transportation Systems may only be completely actualized if the obstacles to adoption are well comprehended. Therefore, it is essential to identify and evaluate the barriers obstructing the deployment of Intelligent Transportation Systems in urban areas (Schroder, 2022).

This research examines the challenges of adopting Intelligent Transportation Systems in Vietnam's urban areas. It aims to provide a comprehensive understanding of the barriers to deploying ITS, unlike previous studies that have only focused on the technical aspects of ITS. This research seeks to improve understanding of the social, economic, and political factors influencing the application of Intelligent Transportation Systems in urban areas. This research seeks to evaluate the challenges impeding the deployment of intelligent transportation systems within the framework of smart urban mobility. By achieving the target, this research will provide significant insights into the challenges that must be addressed for the successful implementation of ITS in urban areas.

This article is organized as follows: (1) Introduction, articulating the justification for the research; (2) Related studies, offering a synthesis of current research on ITS adoption and its obstacles; (3) Methodology, explicating our research framework and data acquisition; (4) Results, elucidating the findings and their significance; (5) Discussion, evaluating the ramifications of the results and prospective strategies for mitigating the identified challenges; and (6) Conclusion, recapitulating the principal contributions and delineating prospects for future inquiry.

2. Literature review

2.1. Intelligent transportation system

ITS Implementation for smart urban transportation denotes the integration and deployment of sophisticated technologies and solutions inside urban transportation systems to improve efficiency, safety, and sustainability (Jan et al., 2019). This encompasses the use of sensors, data analytics, communication networks, and automation to enhance traffic flow, mitigate congestion, improve public transit, and provide real-time information to passengers (Nchimbi et al., 2021). The technical dimension includes elements pertaining to technological infrastructure, such as sensor dependability, communication network efficacy, software compatibility, and the durability of ITS components. Resource allocation is essential for the deployment of Intelligent

Transportation Systems. This dimension may include the accessibility of financial resources, proficient labor, and the distribution of tangible assets such as transportation infrastructure. The components of ITS often originate from several manufacturers or sources. Smart Urban Mobility pertains to the use of creative, technology-driven strategies to enhance transportation and mobility in urban environments. It includes many options such as public transportation improvements, ridesharing, bikesharing, electric automobiles, and real-time transportation information systems.

The deployment of sensors is a crucial component of Intelligent Transportation Systems (ITS). Sensors can detect traffic flow, monitor road conditions, and collect data on environmental factors, including air quality (Chavhan et al., 2022). Communication networks are a vital component of Intelligent Transportation Systems (ITS). Communication networks enable the interchange of information between vehicles, infrastructure, and control centers, therefore optimizing traffic flow and reducing congestion. Data analytics is an essential component of Intelligent Transportation Systems (ITS). Data analytics may be used to analyze traffic trends, identify congested regions, and optimize traffic flow (Ehlers et al., 2017).

2.2.Challenges in implementation of intelligent transportation system

Interoperability problems may include guaranteeing that disparate systems can interact effortlessly with one another (Abbas et al., 2021). Efficient project management is crucial for the deployment of Information Technology Systems. This dimension may include matters pertaining to project planning, stakeholder collaboration, and risk management. The acceptability and conduct of end-users are essential for the success of Intelligent Transportation Systems. Elements such as user resistance, awareness, and readiness to embrace new technology may constitute this dimension.

Social issues significantly impact the implementation of Intelligent Transportation Systems in urban environments. Social variables relate to the attitudes, perceptions, and actions humans exhibit about ITS. The lack of public understanding and acceptability of ITS is a significant social element influencing their adoption (Mendiboure, 2022). The notion of Intelligent Transportation Systems (ITS) is not well understood by the public, indicating a need for greater awareness of the potential benefits of these systems. Public awareness initiatives may boost understanding and teach the general audience about the benefits of ITS (Nguyen, 2020; Sheren & Elazb, 2016). The lack of confidence in ITS is a societal factor that affects its adoption. The absence of confidence in the reliability and security of these systems may lead to hesitance in their adoption by people. To address this difficulty, it is essential to develop reliable and secure Intelligent Transportation Systems (ITS) that can foster confidence among people (Alonso et al., 2022; Lilhore, 2022).

Economic constraints relate to the cost-efficiency of ITS adoption. This encompasses the original capital outlay, upkeep expenses, and the prospective return on investment. The implementation of Intelligent Transportation Systems in metropolitan regions encounters a substantial obstacle due to these economic considerations. The phrase "economic factors" refers to the costs involved in the development and upkeep of ITS infrastructure (Javed et al., 2019). The adoption of Intelligent Transportation Systems is significantly influenced by a critical economic element, namely the considerable initial expenditures related to their deployment. Implementing Intelligent Transportation Systems requires significant investments in infrastructure and technology, which may impose financial strain on many metropolitan areas, especially those with limited fiscal resources (Kliestik et al., 2022). To address this difficulty, it is essential to develop economically feasible Intelligent Transportation Systems that may provide significant benefits to urban areas. Inadequate financing for the maintenance and operation of ITS is a significant economic problem affecting their adoption. The maintenance and operation of Intelligent Transportation Systems in metropolitan locations may be a difficulty owing to the substantial financial resources needed (Pauer, 2017; Rudskoy et al., 2021). Public-private partnerships may finance the maintenance and operation of Intelligent Transportation Systems, therefore alleviating the economic burden on urban areas (Lopez-Carreiro & Monzon, 2018).

The implementation of Intelligent Transportation Systems in metropolitan regions is dependent on political influences. ***Political issues*** relate to governmental policies and laws that impact the implementation and operation of Intelligent Transportation Systems (ITS). The lack of coordination among various government agencies is a significant political factor affecting the execution of ITS (Valaskova et al., 2022). The effective implementation of Intelligent Transportation Systems requires collaboration across many government agencies, including those focused on transportation, communication, and public safety (Ali, 2021). Effective coordination among the relevant authorities may guarantee the implementation and operation of ITS (Drop & Garlinska, 2021). The inadequacy of governmental support and financial resources is a political factor that affects the execution of ITS. Implementing Intelligent Transportation Systems in metropolitan areas may need assistance in obtaining government backing and financing, thus hindering its acceptance. Governments may provide financial incentives and support to facilitate the adoption of Intelligent Transportation Systems (Kadłubek, 2021;).

In general, the literature evaluation of the current research clarifies the many social, economic, and political factors that affect the application of ITS in urban areas. Social problems, including inadequate public knowledge and trust, may hinder the adoption of Intelligent Transportation Systems (Okunevičiūtė et al., 2021). The implementation of Intelligent Transportation Systems (ITS) may be hindered by economic issues, particularly expensive initial expenditures and inadequate financing for maintenance and operations. Political concerns, such as insufficient interagency cooperation and poor governmental support and financial resources, may hinder the implementation of ITS (Lanamaki, 2021). By overcoming these challenges, the successful application of ITS in urban areas may be achieved, resulting in transportation systems that are more efficient, sustainable, and safe. The effective execution of Intelligent Transportation Systems (ITS) in urban environments necessitates public awareness initiatives, economically viable ITS solutions, public-private collaborations, governmental backing and financing, and inter-agency coordination (Lyons, 2018). Further inquiry is necessary to comprehend these challenges more thoroughly and develop effective strategies.

3. Research methodology

3.1. Measures

The research technique used to identify problems in adopting Intelligent Transportation Systems (ITS) for smart urban mobility included an extensive literature analysis in the field of ITS. This research performed an extensive evaluation of academic publications obtained from esteemed databases such as Scopus, ScienceDirect and Web of Science. The aim was to have a better understanding of the existing situation of ITS application in urban transportation. The aforementioned papers covered a range of topics, including technical breakthroughs, legislative issues, and the socioeconomic and ecological ramifications of ITS. The literature study enabled the identification of challenges categories related to the implementation of ITS including Technological challenges (TC), Resources challenges (RC), Interoperability Challenges (IC), Management Challenges (MC), Economic Challenges (EC), Personal Challenges (PC).

Then, the questionnaire is developed on these challenges asking respondents which challenges when solved will have significant impacts to their willingness to use ITS. There are in total 30 items or questions used to operationalize the six categories of challenges within the research framework. Respondents were asked to assess which challenges should be solved which will significantly improve their willingness to use ITS. Each item using a five-point Likert scale, ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree") to collect respondents' assessment. A five-point Likert scale (1—"Not at All" to 5—"Very Willing") was used to assess the readiness to willingness to use and participate in some options of the ITS including 6 questions. A preliminary survey was administered to several research academics and commuters. The insights and recommendations from the researchers and commuters significantly enhanced the quality of the questionnaire. Table 1 presents the items of questionnaire used for data collection.

3.1.Data and samples

The assessment was conducted in 3 provincial cities in Vietnam - Can Tho, Vinh Long and Ho Chi Minh - that experience significant congestion and possess superior green transportation networks. The participants were identified as vehicle-using ones who go to work or use motobike or automobile as equipments to work in logistics industry in these cities on a regular basis. the research team conducted survey using purposive sampling technique and distributed questionnaire online form August 2024 to October 2024. the research's questionnaire was segmented into two sections. Demographic parameters, push, pull, and anchoring factors, together with information provision and persons' readiness to shifting to electric vehicle, were gathered in the first phase. About 500 questionnaires were disseminated, 235 were returned, and 206 were deemed legitimate resulting in 41,2 % response rate. The demographic characteristics of the samples are presented in Table 2.

The demographic analysis of the sample population provides key insights into the distribution of gender, age, education, industry involvement, and professional experience. In terms of gender, the sample consists of 55.7% male and 44.3% female participants, indicating a slightly higher representation of males. Age distribution reveals that a majority of respondents (54.4%) are under 25 years old, followed by 33.5% in the 25-34 age group, with smaller proportions in the 35-45 age range (8.3%) and over 45 years (3.9%). Educationally, the largest group (69.42%) has completed a college or university degree, while postgraduate participants represent 15.53%, and those with a high school diploma or below comprise 15.05%. Industry representation shows that 40.29% of respondents work in transport and logistics, followed by 25.24% in finance and banking, and smaller percentages in information technology (5.34%) and marketing and communications (4.37%). A significant portion of the sample (24.76%) falls into other industries. Regarding professional experience, the majority (84.7%) have less than 5 years of experience, 11.17% have 5-10 years, and only 4.36% have over 10 years of experience. This sample highlights a young, educated, and industry-diverse workforce providing a good representation for the young population in Vietnam, which will be the main target group of electric and green transporation in the near future.

Table 1: Questionnaire items and statisitcs

Questions	Mean	Min	Max	SD
TC 1. Issues related to the reliability and safety of urban intelligent transportation systems technology	3.961	1	5	0.756
TC 2. The lack of effective traffic management processes is limiting the feasibility of urban intelligent transportation systems.	3.922	1	5	0.72
TC 3. The lack of a reliable communication network is affecting the ability to deploy urban intelligent transportation systems.	3.951	1	5	0.84
TC 4. Lack of public participation and awareness of smart transportation technologies is a factor that hinders the success of urban intelligent transportation systems.	4.015	1	5	0.753
TC 5. Intelligent transportation systems can increase the risk of traffic congestion in urban areas.	3.655	1	5	1.02
TC 6. Specialized technical skills are a barrier to the deployment and management of urban intelligent transportation networks.	3.796	1	5	0.846
RC 1. Current infrastructure is not sufficient to meet the requirements for the deployment of intelligent transportation systems in urban areas.	3.874	1	5	0.778
RC 2 Urban smart transport system technology is not yet adequate to meet the accessibility requirements of all people, regardless of financial or physical capabilities.	3.874	1	5	0.766
RC 3. Difficulty in adapting smart transport systems to different geographical and cultural conditions.	3.859	1	5	0.839
RC 4. Difficulty in managing and maintaining large fleets of connected vehicles in urban environments is a challenge.	3.85	2	5	0.777
RC 5. Designing urban smart transport systems to suit different geographical and cultural conditions is difficult.	3.903	2	5	0.763
RC 6. Maintaining connected vehicles in urban smart transport systems requires large resources and specialized management systems.	3.806	1	5	0.86
IC 1. Ensuring compatibility between urban smart transport systems and other technologies is a major challenge.	3.937	1	5	0.744
IC 2. The problem of integrating urban smart transport systems with existing transport networks is a major challenge.	3.879	1	5	0.8
IC 3. The lack of standardization in urban smart transport system technology makes it difficult to connect and interact between systems.	3.879	1	5	0.757
IC 4. The transition from traditional transport systems to urban smart systems requires compatibility between different technology platforms.	3.947	1	5	0.808
IC 5. The lack of clear standards in urban smart transport technology is hindering effective implementation and operation.	3.888	1	5	0.752
MC 1. Difficulty in processing large volumes of data from urban smart transport networks	3.893	1	5	0.787
MC 2. Urban smart transport systems are facing the risk of cyber attacks and other security risks.	3.913	2	5	0.82
MC 3. Difficulty in managing and maintaining urban smart transport systems is hindering project development.	3.913	2	5	0.777
MC 4. The lack of coordination between management agencies and stakeholders reduces the effectiveness of urban smart transport system implementation.	3.801	2	5	0.844
MC 5. Current regulatory processes are not flexible enough to adjust and adapt to the new requirements of urban smart transport systems.	3.898	1	5	0.856
EC 1. Difficulty in approving investment for urban smart transport system projects is a major barrier.	3.966	1	5	0.766
EC 2. High costs for implementing and maintaining urban smart transport systems are a major challenge.	3.951	1	5	0.846
EC 3. The return on investment for urban smart transport projects is unclear, causing concerns for investors.	3.922	1	5	0.766
EC 4. The long-term economic benefits of urban smart transport systems are not clearly demonstrated, leading to hesitation in investing.	3.869	1	5	0.805
PC 1. The collection and sharing of personal data in urban transport is raising concerns about privacy and security.	3.961	1	5	0.841
PC 2. The application of urban smart transport systems will affect employment opportunities in the transport sector.	3.738	1	5	0.913
PC 3. Urban smart transportation systems can cause public distrust due to privacy and security issues.	3.767	1	5	0.916
PC 4. Current policies on data security in smart transportation systems are not sufficient to protect citizens' privacy.	3.883	1	5	0.822

Table 2: Demographic characteristics

Classification	Number	%
Gender		
Male	115	55.7
Female	91	44.3
Age		
Under 25 years old	112	54.4
25-34 years old	69	33.5
35-45 years old	17	8.3
Over 45 years old	8	3.9
Education		
College/University	143	69.42
Postgraduate	32	15.53
High School and under	31	15.05
Industries		
Transport and logistics	83	40.29
Finance and banking	52	25.24
Information technology	11	5.34
Marketing and communications	9	4.37
Others	51	24.76
Experience		
Less than 5 years	174	84.7
5-10 years	23	11.17
Over 10 years	9	4.36

4. Data analysis and Resutls

4.1. The challenges analysis

4.1.1. *Technological challenges*

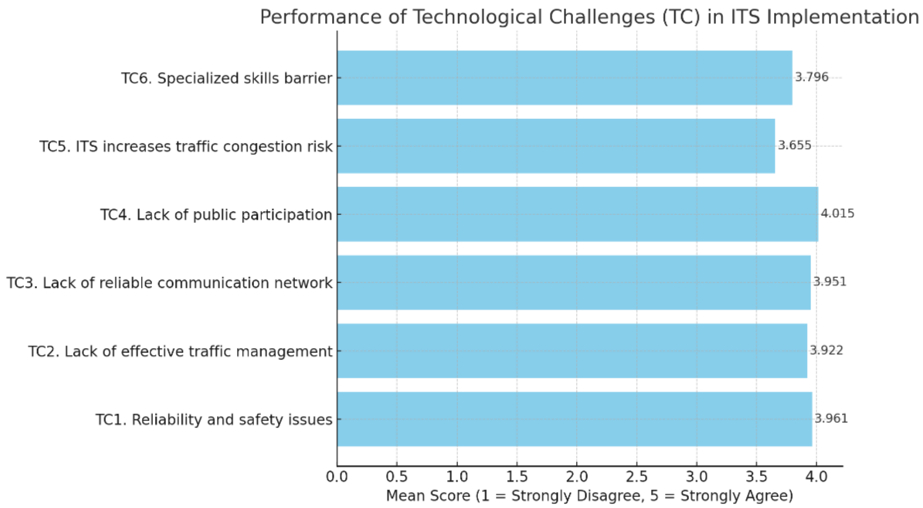

Figure 1: Technological challenges

The analysis of the technological challenges in the adoption of Intelligent Transportation Systems (ITS) for urban mobility reveals several critical insights. Among the identified challenges, public participation and awareness of technologies used for the smart transportation (TC4) emerged as the most pressing issue, with an average score of 4.015. This suggests that stakeholders perceive a lack of engagement and awareness in the technology adoption as a significant barrier to ITS implementation, highlighting the need for initiatives that raise public consciousness and foster community involvement in ITS-related projects. Additionally, the reliability and safety of ITS technology (TC1), alongside the reliability of communication networks (TC3), also scored highly, with average scores of 3.961 and 3.951, respectively. These findings indicate that ensuring robust and dependable technology infrastructure is paramount to the success of ITS in urban settings.

In contrast, the challenge concerning the risk of increased traffic congestion due to ITS (TC5) received the lowest average score of 3.655, suggesting that while congestion is a concern, it may not be perceived as critically important as other technological barriers. The relatively moderate score for specialized technical skills (TC6), at 3.796, further underscores the need for skilled professionals but indicates that this is not the most pressing issue compared to public engagement and infrastructure reliability. Collectively, the results suggest that public awareness, reliability, and safety are the most significant challenges to address in order to increase the adoption and effectiveness of ITS, whereas concerns about congestion and technical expertise, while still relevant, are comparatively less critical. Addressing these high-priority areas could significantly enhance the willingness of stakeholders to adopt ITS solutions in urban environments.

4.1.2. Resources challenges

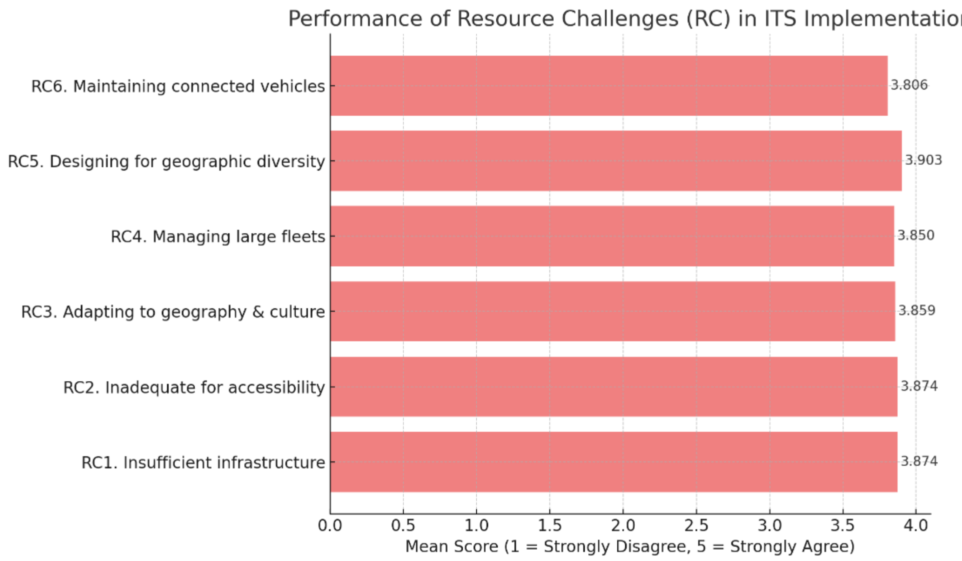

Figure 2: Resources challenges

From the analysis, RC5 (Designing urban smart transport systems to suit different geographical and cultural conditions) stands out with the highest mean score of 3.903. This suggests that respondents view geographical and cultural diversity as one of the most challenging aspects of designing ITS infrastructure, requiring significant resources and tailored approaches to ensure system suitability. Similarly, RC1 (Current infrastructure insufficient for ITS deployment) and RC2 (Inadequate smart transport technology for accessibility) both scored 3.874, indicating that infrastructure and technological inadequacy are perceived as equally important issues. These challenges point to a need for enhanced infrastructure investment and more accessible technology to support a diverse range of urban needs. RC6 (Maintaining connected vehicles requiring large resources) had the lowest mean score of 3.806. Although this is still a relatively high score, it suggests that while maintaining connected vehicle fleets is recognized as a challenge, it may not be as immediate a concern compared to other infrastructure and design-related issues.

4.1.3. Interoperability Challenges

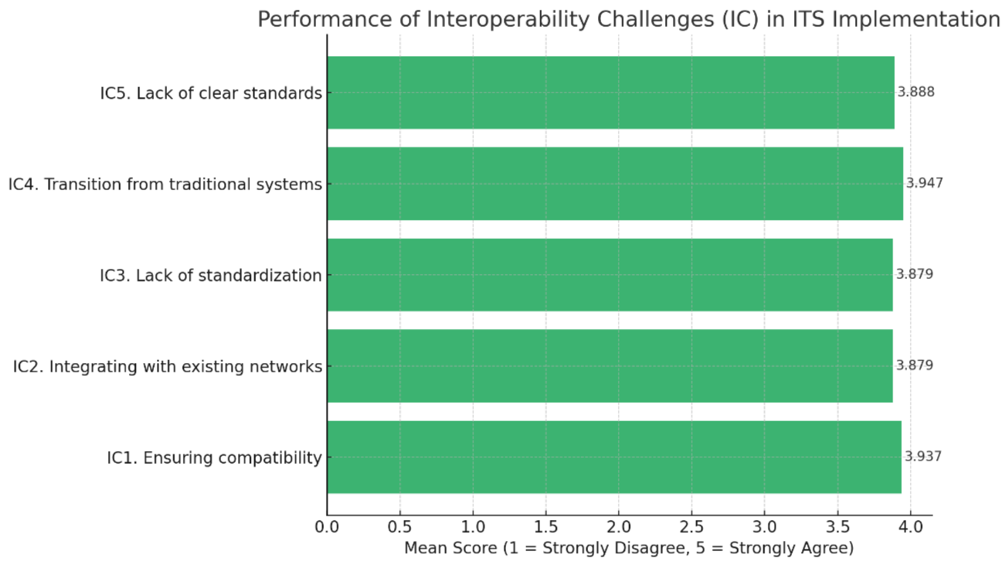

Figure 3: Interoperability Challenges

IC4 (The transition from traditional transport systems to urban smart systems requires compatibility between different technology platforms) received the highest mean score (3.947). This suggests that the transition between traditional and smart transport systems, and ensuring platform compatibility, is considered one of the most significant challenges to successful ITS deployment. The integration of multiple systems and technologies appears to be a major concern. IC1 (Ensuring compatibility between urban smart transport systems and other technologies) and IC5 (Lack of clear standards hindering effective implementation and operation) also scored highly, with means of 3.937 and 3.888, respectively. These scores point to the challenges posed by a lack of unified standards and the complexity of making ITS compatible with existing technologies. Without clear standards and compatibility, the efficiency of ITS could be compromised. Both IC2 (Integrating urban smart transport systems with existing transport networks) and IC3 (Lack of standardization making it difficult to connect and interact between systems) scored slightly lower but still represent significant challenges with scores of 3.879. These findings indicate that while integration and standardization are seen as critical, they are slightly less pressing than the need for compatibility and clear standards.

4.1.4. Management challenges

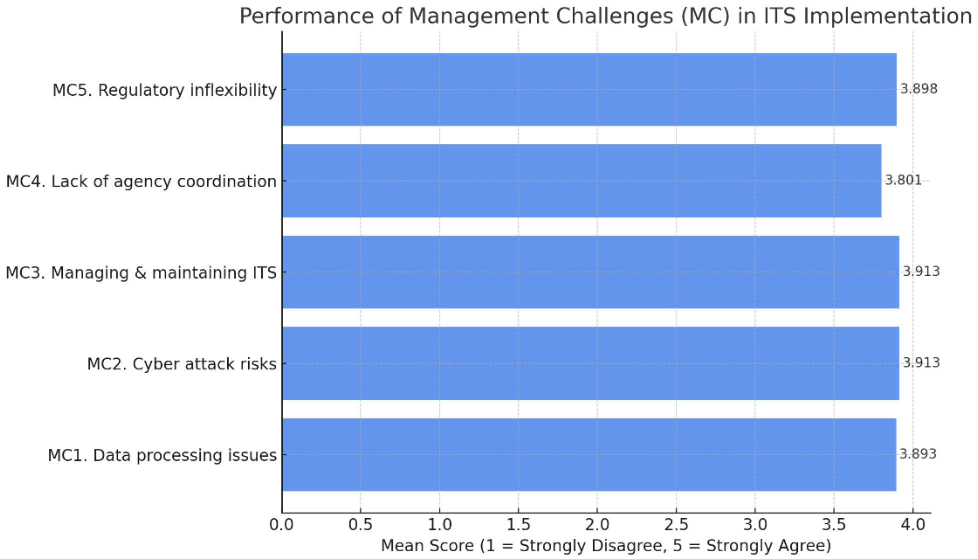

Figure 4: Management Challenges

MC2 (Urban smart transport systems facing cyber-attacks and other security risks) and MC3 (Difficulty in managing and maintaining ITS hindering project development) both share the highest average score of 3.913. This suggests that security risks and management inefficiencies are the most pressing concerns when implementing ITS. These areas are viewed as major barriers to successful development and operation, necessitating strong risk management and operational controls. MC5 (Current regulatory processes not flexible enough to adapt to new ITS requirements) closely follows, with a score of 3.898, indicating that regulatory challenges also play a crucial role in slowing down ITS progress. Policymakers and regulators may need to revise or update existing regulations to better accommodate the rapid evolution of smart transport systems. MC1 (Difficulty in processing large volumes of data from ITS networks) scored 3.893, pointing to data management as another significant concern. The vast amount of data generated by ITS can overwhelm current data-processing capacities, and addressing this will be essential for efficient ITS operation. MC4 (Lack of coordination between management agencies and stakeholders) scored the lowest at 3.801, but this still represents a notable challenge. Better coordination across various agencies and stakeholders is necessary to ensure a more unified and effective approach to ITS implementation.

4.1.5. Economic challenges

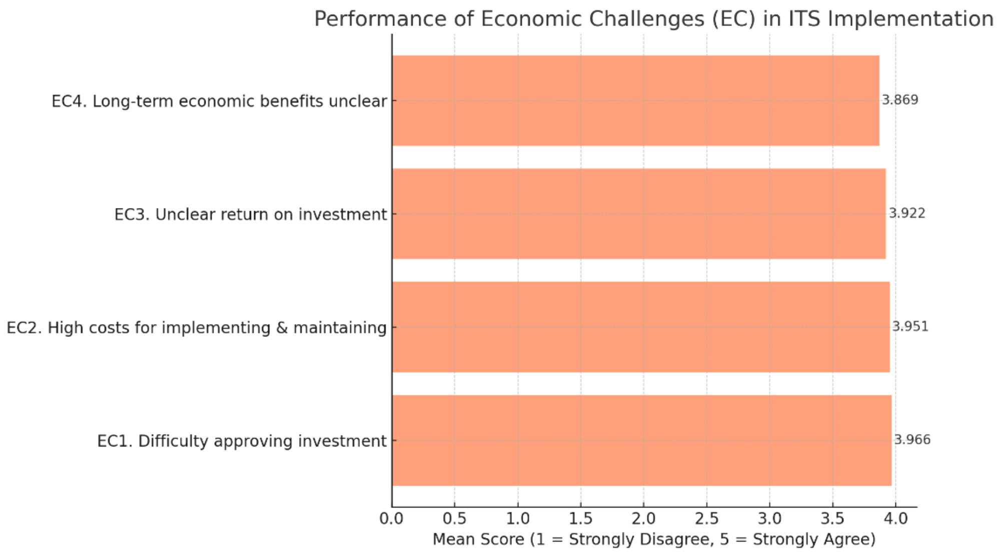

Figure 5: Economic challenges

EC1 (Difficulty in approving investment for urban smart transport system projects), with a mean score of 3.966, emerges as the most significant economic barrier. This suggests that securing the necessary financial approvals is a major challenge, likely due to the complex nature of these projects and the high initial capital requirements. Governments and private investors may be hesitant to commit funds without clear assurances of long-term returns, reflecting a cautious approach to such large-scale infrastructural investments. Closely following is EC2 (High costs for implementing and maintaining urban smart transport systems) with a score of 3.951. This emphasizes the considerable financial burden associated with not only the initial implementation of ITS but also the ongoing operational and maintenance expenses. These costs can be prohibitive, especially for cities with constrained budgets, highlighting the need for cost-effective solutions or alternative financing models, such as public-private partnerships, to mitigate these challenges.

EC3 (Unclear return on investment for urban smart transport projects) scored 3.922, indicating that stakeholders, particularly investors, have significant concerns regarding the financial viability of ITS projects. The uncertainty around how quickly and effectively these systems can generate returns adds to the hesitation in approving or allocating funds. This lack of clarity could stem from the long-term nature of infrastructure projects, where benefits, such as reduced congestion and environmental improvements, may not immediately translate into direct financial gains.

4.1.6. Personal challenges

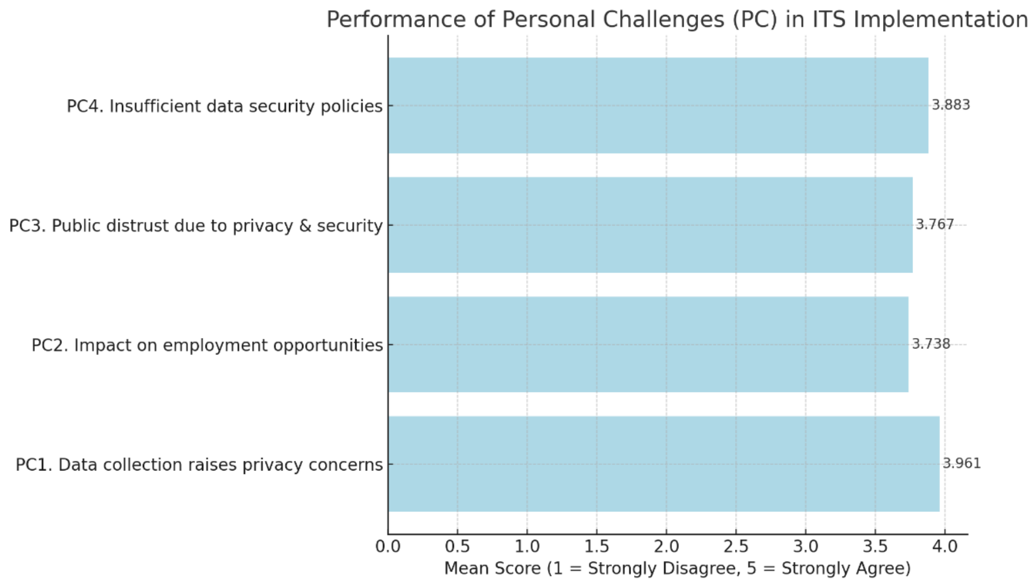

Figure 6: Personal challenges

The analysis of Personal Challenges (PC) in ITS implementation highlights privacy and data security as key concerns. PC1 (Data collection raising privacy concerns) received the highest score (3.961), showing that the public is deeply concerned about how personal data is collected, stored, and used in smart transportation systems. Closely related, PC4 (Insufficient data security policies) scored 3.883, emphasizing that people do not feel current regulations adequately protect their privacy. This reflects a need for stronger legal frameworks and transparency to build public trust. PC3 (Public distrust due to privacy and security issues) scored 3.767, indicating that privacy concerns could lead to broader public skepticism about ITS adoption. Addressing these concerns will require both technical solutions and public communication efforts. PC2 (Impact on employment opportunities), with the lowest score of 3.738, suggests that while job displacement due to automation is a concern, it is less pressing than privacy issues. However, there is a need for proactive retraining programs to ensure the workforce is prepared for the technological shift.

4.2. Structural equation modeling results

4.2.1. Measurement model

Prior to the data analysis, multicollinearity assessments were conducted. The results demonstrated that the data adhere to the principles of normal distribution. The variance inflation factors (VIFs) were evaluated for the assessment of multicollinearity. The results indicated that all variance inflation factors (VIFs) were under 2.8. As a result, multi-collinearity posed no threat to the data analysis. Additionally, common method variance (CMV) may compromise the integrity of the data results (Wang et al., 2018). The Harman single factor test was used to evaluate common method variance (Wang et al., 2018). The CMV analysis revealed that the variables are grouped into five factors, each with eigenvalues above 1.0. The primary component represents less than 50% of the variance at 36.20%, suggesting that common method variance (CMV) is not a substantial concern in this study.

Table 3: Reliability and convergent validity analysis

Construct	Item	Loading	Cronbach Alpha	CR	AVE
Economic Challenges (EC)	EC1	0.792	0.84	0.892	0.675
	EC2	0.847			
	EC3	0.808			
	EC4	0.838			
Interoperability Challenges (IC)	IC1	0.779	0.843	0.888	0.614
	IC2	0.81			
	IC3	0.772			
	IC4	0.769			
	IC5	0.786			
Management Challenges (MC)	MC1	0.724	0.842	0.887	0.612
	MC2	0.791			
	MC3	0.804			
	MC4	0.781			
	MC5	0.807			
Personal Challenges (PC)	PC1	0.799	0.82	0.881	0.65
	PC2	0.78			
	PC3	0.824			
	PC4	0.821			
Resources challenges (RC)	RC1	0.829	0.886	0.913	0.636
	RC2	0.765			
	RC3	0.778			
	RC4	0.823			
	RC5	0.817			
	RC6	0.77			
Technological challenges (TC)	TC1	0.801	0.852	0.89	0.577
	TC2	0.854			
	TC3	0.79			
	TC4	0.751			
	TC5	0.576			
	TC6	0.753			
Willingness to shift (WI)	WI1	0.861	0.906	0.928	0.684
	WI2	0.858			
	WI3	0.867			
	WI4	0.841			
	WI5	0.847			
	WI6	0.770			

Note: AVE = Average Variance Extracted; CR = Composite Reliability

The reliability and validity of the measurement scales must be assessed. The dependability was evaluated with Cronbach's alpha and composite reliability metrics (Fornell and Larcker, 1981). Cronbach's alpha and composite reliability coefficients must above 0.70 (Fornell and Larcker, 1981). Table 3 indicated that the reliability of the constructs was adequate. Factor loadings and average variance extracted (AVE) were used to evaluate convergent validity. Table 2 demonstrated that all the AVE values of the constructs above the minimum criterion of 0.50. The factor loadings of the items must exceed 0.70, and Table 2 shows that all item factor loadings exceeded this threshold (Fornell and Larcker, 1981). Table 4 demonstrates that the square roots of the AVE values surpassed the correlations across constructs, hence confirming discriminant validity (Fornell and Larcker, 1981). As a result, the validity was considered adequate.

Table 4: Discriminant validity analysis

	WI	EC	IC	MC	PC	RC	TC
WI	**0.827**						
EC	0.558	**0.822**					
IC	0.472	0.739	**0.783**				
MC	0.438	0.728	0.771	**0.782**			
PC	0.509	0.643	0.568	0.642	**0.806**		
RC	0.475	0.668	0.685	0.599	0.449	**0.798**	
TC	0.473	0.672	0.755	0.677	0.552	0.614	**0.759**

Note: The bold elements are the square roots of AVEs

4.2.2. Regression results

The regression analysis presented in Table 5 explores the relationship between solving various challenges and the willingness to shift to Intelligent Transportation Systems (ITS). The results indicate that addressing **economic challenges (EC)** has a significant and positive impact on the willingness to adopt ITS, with a coefficient of 0.278 and a p-value of 0.013. This suggests that overcoming financial barriers, such as securing investment and reducing implementation costs, is a critical factor in encouraging ITS adoption. Similarly, solving **personal challenges (PC)**, which includes concerns about privacy and security, also shows a significant positive effect (coefficient = 0.265, p-value = 0.011). This finding highlights the importance of addressing societal concerns, particularly related to data privacy, to build public trust and foster a willingness to embrace ITS. Similarly, **resource challenges (RC)** demonstrate a weak-significant positive relationship with ITS adoption (coefficient = 0.165, p-value = 0.084), suggesting that improving infrastructure and resource management is important but it may not be as influential as economic or personal concerns.

Interestingly, **technological challenges (TC)**, often considered a major barrier to ITS implementation, did not show a significant relationship (coefficient = 0.112, p-value = 0.239). This implies that although technical issues are relevant, they may not be the key drivers of willingness to shift. Additionally, both **interoperability challenges (IC)** (coefficient = 0.003, p-value = 0.973) and **management challenges (MC)** (coefficient = -0.106, p-value = 0.326) failed to show any significant influence on ITS adoption. These results suggest that solving challenges related to financial constraints, public trust, and infrastructure should be prioritized to effectively encourage the shift to ITS, while technological and management issues may play a more secondary role.

Table 5: Regression results for challenges solved and willingness to shift to ITS

	Sample Mean	Standard Deviation	T Statistics	P Values
EC -> WI	0.278**	0.115	2.495	0.013
IC -> WI	0.003	0.138	0.034	0.973
MC -> WI	-0.106	0.116	0.984	0.326
PC -> WI	0.265**	0.102	2.548	0.011
RC -> WI	0.165*	0.095	1.73	0.084
TC -> WI	0.112	0.092	1.179	0.239

*Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

5. Policy implication and conclusion

5.1. Policty implication

The findings from this research provide several important policy implications for promoting the adoption of Intelligent Transportation Systems (ITS). Firstly, the significant impact of addressing **economic challenges** suggests that policymakers should prioritize financial incentives and funding mechanisms to reduce the costs of ITS implementation. Governments could introduce subsidies, tax incentives, or public-private partnerships to ease the burden on both public and private investors. Additionally, clearer frameworks to demonstrate the long-term economic benefits of ITS, such as reduced congestion and improved efficiency, could encourage more stakeholders to invest in these systems.

Secondly, the significant role of **personal challenges**, particularly concerns around privacy and data security, indicates that policymakers must focus on strengthening data protection regulations. Establishing robust legal frameworks that ensure transparency in data collection, usage, and sharing will help build public trust. Governments should also implement stringent cybersecurity measures to safeguard ITS infrastructure from potential breaches, while communicating these efforts effectively to the public. The significant effect of **resource challenges** implies that improving urban infrastructure is key to supporting ITS deployment. Policymakers should invest in upgrading transportation infrastructure, such as communication networks and smart traffic management systems, to accommodate the needs of ITS. Additionally, creating training programs to build the specialized skills required for ITS management and maintenance can help address capacity gaps.

Interestingly, the results suggest that **technological and management challenges** are not the most immediate concerns for users. However, this does not mean they should be ignored. Policymakers should continue to support research and development in ITS technologies to ensure they remain reliable and scalable. Furthermore, coordination between management agencies and stakeholders can still improve, but it should not be the primary focus of policy initiatives aimed at accelerating ITS adoption.

5.2. Conclusion

This research highlights the key factors influencing the willingness to adopt Intelligent Transportation Systems (ITS) and offers valuable insights for both policymakers and stakeholders.

The study reveals that addressing economic challenges, such as securing investment and managing high costs, along with resolving personal challenges related to privacy and data security, are the most significant drivers of ITS adoption. While resource challenges also play an important role, issues related to technological, interoperability, and management challenges appear to have less direct impact on the public's willingness to shift to ITS. The findings suggest that policies aimed at promoting ITS should focus on providing financial incentives, strengthening data protection laws, and investing in infrastructure development to build public trust and facilitate adoption. By addressing these priority areas, policymakers can effectively accelerate the transition to ITS and unlock its potential to improve urban mobility, reduce congestion, and enhance transportation efficiency.

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CHAPTER 2: TRANSITIONING TO ELECTRIC MOTORBIKES IN LOGISTICS: A PROPOSAL TO REDUCE EMISSIONS AND IMPROVE EFFICIENCY

Abstract

This study examines the factors influencing individuals' willingness to shift from fossil-fuel vehicles to green transportation options of electric vehicles, using the Push-Pull-Mooring (PPM) framework as the theoretical basis. The research identifies perceived environmental threats, perceived inconvenience, green transport policies, and green transport systems as critical factors affecting this behavioral shift. Furthermore, it introduces the role of information provision as a moderator that enhances or diminishes the effect of these factors on willingness to shift. Data were collected through surveys conducted across three cities in Vietnam, and hierarchical regression analysis was used to test the hypotheses. The results show that perceived environmental threats and green transport systems significantly influence individuals' willingness to shift, while green transport policies and perceived inconvenience have less impact. Additionally, information provision positively moderates the effects of perceived environmental threats but attenuates the influence of green transport systems. The study highlights the importance of improving infrastructure and public awareness to encourage the adoption of green transport. Policy implications and recommendations are provided to further promote sustainable transportation behavior in Vietnam.

Keywords:green transportation; electric vehicles; willingness to shift; perceived environmental threats; green transport policies; perceived inconvenience; information provision

1. Introduction

As the purchasing power of Vietnamese citizens has risen, their living standards have improved, leading to an increasing demand for transportation for both commuters and business. Consequently, fossil-fuel vehicles have become accessible and favored modes of transportation for many Vietnamese households and business. The rise in number of fossile-fuel vehicle has resulted in several adverse effects. For instance, the majority of urban residents in major cities have traffic congestion issues in their everyday activities. Despite the fast development of transportation infrastructure, traffic congestion remains significant, particularly during peak hours.

Commuters ensnared in traffic congestion will have prolonged commute durations, thereby increasing the likelihood of tardiness to work. Simultaneously, the disposition of commuters may also become somber. These may significantly impact residents' everyday lives. The promotion and investment in green transportation may diminish the reliance on high-pollution vehicles and accommodate individuals' diverse travel preferences, therefore alleviating traffic congestion and enhancing quality of life. The substantial increase in fossil-fuel vehicles have resulted in environmental issues, including acid rain, air pollution, and urban noise pollution (Fan et al., 2015; Jia, 2018; Zhang et al., 2019). To address these significant issues, minimizing fossil-fuel vehicles and advocating for environmentally sustainable transportation are equally useful strategies. It is imperative and pressing to promote the development of sustainable transportation.

Green transportation denotes a multifaceted transportation system focused on the efficient and effective use of resources, restructuring transport modalities, and promoting environmentally sustainable options such as electric vehicles, carpooling, public transit, cycling, and walking (Wann-Ming, 2019). Green transportation prioritizes the sustainability of urban transit by mitigating traffic congestion, decreasing environmental pollution, enhancing social fairness, and optimizing resource use (Wang et al., 2014). The core principle of green transportation is to create a transportation system that supports sustainable urban growth, fulfills individual mobility requirements, and maximizes traffic efficiency while minimizing societal costs (Maheshwari et al., 2016). Governments have implemented regulations and activities to incentivize citizens to decrease automobile use and transition to more sustainable transportation alternatives. Regrettably, these rules and activities have limited effects. Eco-friendly transportation is significantly underutilized. Nevertheless, very few studies have been undertaken to investigate the variables influencing individuals' transition from fossil-fuel vehicles to sustainable transportation like electric vehicles. To address the research gap, the present study used the Push-Pull-Mooring (PPM) framework as the foundational theoretical model to examine the determinants of changes in willingness and conduct.

This study aims to utilize the PPM as a theoretical framework to gain a comprehensive understanding of how push factors (e.g., perceived environmental threats and perceived inconvenience), pull factors (e.g., green transport policies and campaigns, and green transport systems), and mooring factors (e.g., informaiton provision) influence individuals' transition to electric vehicles. This article examines the moderating influence of anchoring considerations on the interactions among push factors, pull factors, and an individual's inclination to relocate. This research has several contributions. This study enhances the knowledge of how push, pull, and anchoring variables influence an individual's propensity to transition to green transportation. This research incorporates the PPM framework from human geography into the domain of green transportation to analyze individuals' changing willingness towards green transportation, therefore enhancing the study of behavioral shifts. This research aims to elucidate the disparity between the personal factors and shifting intentions regarding green transportation by examining the moderating influence of information supply, so offering a novel explanation for this gap.

2. Theoretical framework and hypothesis development

2.1. Push-Pull-Mooring framework (PPM)

The PPM framework originates from migration literature to explain human switching and shifting behavior. The relocation of persons from one origin to a new destination is termed geographic migration. This migration resembles a kind of switching or shifting behavior (Clark et al., 1996). The PPM framework comprises three components associated with an individual's evolving willingness and behavior: (1) push factors that compel individuals to forsake their current choice; (2) pull factors that entice individuals to embrace the new choice; and (3) mooring factors that present obstacles to the alteration of the choice (Hsu, 2014; Chiu et al., 2011). PPM posits that people are influenced by several circumstances that either compel or attract them to migrate towards alternative options (Hazen et al., 2017). Mooring variables combine with push and pull factors to enhance an individual's propensity to migrate (Bansal et al., 2005). Scholars have used the PPM model to analyze an individual's changing behavior (Amigo and Gagnaire, 2015; Jung et al., 2017; Suh and Kim, 2018). The studies indicated that the PPM serves as an effective framework for comprehending the evolving willingness and conduct (Li and Ku, 2018; Chang et al., 2014). The current research investigates the propensity to transition from fossil-fuel vehicles to sustainable transportation, making the PPM a suitable and relevant framework for analyzing the key factors of individuals' readiness to shift and their actual shifting behavior. Push factors are the criteria that compel people to abandon private automobile commuting in favor of green transportation, whereas pull factors are the incentives that encourage persons to choose green transportation options. Furthermore, the anchoring element illustrates how the contributor engages with push and pull variables to influence changes in willingness. In contrast to previous theories that analyze human intents and actions, the PPM does not need set predictors of push, pull, and mooring elements (Li and Ku, 2018). The PPM framework must take into account the individual study material and then determine the unique push, pull, and anchoring variables (Li and Ku, 2018). The current research seeks to investigate the elements affecting individuals' transition from fossil-fuel vehicles to sustainable transportation; hence, this theoretical framework must include the characteristics of commuting via private automobiles and green transportation. Consequently, push factors denote the constraints associated with commuting by fossil-fuel vehicles, which may enhance an individual's propensity to transition to sustainable transportation. Pull factors signify the advantages and benefits associated with transitioning to green transportation. This study considers individual inertia as the anchoring factor, since person-specific elements may hinder the desire to change. The intricate links among push factors, pull factors, mooring factors, changeable willingness, and conduct are elaborated forth below.

2.2. Push factors and individual’s shifting willingness

Push factors refer to the adverse characteristics of traveling by fossil-fuel vehicles that may deter persons from using this mode of transportation. The adverse characteristics of commuting using fossil-fuel vehicles may be categorized as psychological and situational (Collins and Chambers, 2005). In relation to the study subject, perceived environmental hazards and Perceived inconvenience are identified as push factors that illustrate the adverse attributes of commuting by fossil-fuel vehicles from both psychological and situational perspectives. Perceived environmental threats indicate the degree to which individuals recognize environmental issues as having detrimental ecological effects (Kim et al., 2003). According to protection motivation theory, the impetus for undertaking certain protective measures stems from the assessment of threats within a specific risk setting (Rogers, 1983). Upon perceiving an environmental danger, a defensive response will be activated. Individuals are more inclined to use green transportation when they have unfavorable sentiments toward the environmental issues associated with fossil-fuel vehicles. Horng et al. (2014) contended that the propensity to safeguard the environment is intimately connected to an individual's knowledge of perceived environmental threats. Kim et al. (2013) shown that perceived dangers of climate change correlate favorably with the desire to engage in pro-environmental actions. Consequently, it may be anticipated that as citizens recognize the environmental hazards posed by fossil-fuel vehicles, they are more inclined to choose green transportation alternatives. Consequently, the following hypothesis may be posited:

H1: *Perceived environmental threats positively impact an individual's inclination to use green transportation such as electricity vehicles.*

Perceived inconvenience refers to the degree to which persons experience discomfort from traveling by private automobiles (Wang et al., 2019). The apparent annoyance of traveling by fossil-fuel vehicles may stem from intricate road conditions, the difficulty of locating parking, and the financial responsibilities associated with vehicle maintenance. Offering consumers options that induce a feeling of "inconvenience" will hinder their propensity to make decisions (Chen and Tsai, 2017). Consequently, these inconveniences adversely affect consumers' propensity to use fossil-fuel vehicles for commuting while favorably encouraging the adoption of sustainable transportation options. An individual's propensity to use green transportation is influenced by the perceived difficulties of traveling by fossil-fuel vehicles. Prior study has validated the influence of perceived inconvenience on an individual's behavioral willingness. Chowdhury and Ceder (2013) indicated that perceived difficulty adversely impacts an individual's propensity to use fossil-fuel vehicles. Xu et al. (2017) investigated public perceptions of urban air pollution and proposed that the inclination to reduce automobile use is hindered by Perceived inconvenience and ineffectiveness. Consequently, the following hypothesis is posited:

H2: *The Perceived inconvenience of traveling by fossil-fuel vehicles positively influences an individual's willingness to transition to green transportation such as electricity vehicles.*

2.3. Pull factors and individual's shifting willingness

Pull factors refer to the appealing attributes of green transportation modes that may entice users to transition commuting via these sustainable options. Governments may address the obstacles to green transportation development and encourage citizens to choose for sustainable transportation (Beltramello, 2012). In this context, green transport policies, campaigns, and systems, which are intimately associated with governmental roles, are identified as the pull forces. Additionally, these two pull variables may be categorized as soft environmental pull factors and harsh environmental pull factors. The soft environmental pull factor in this research denotes non-material elements such as ideology, legislation, and culture that entice people to transition to green transportation (Jia, 2018). Consequently, green transportation rules and initiatives were seen as a mild environmental incentive. Green transportation regulations and initiatives seek to encourage citizens to choose environmentally friendly modes of travel. Considering that these green transportation rules and initiatives provide advantages and incentives, people are inclined to conform their behaviors to these policies and initiatives to get those rewards. These government regulations and initiatives may enhance the appeal of green transportation, therefore encouraging citizens to transition to green transportation for their everyday commutes. Consequently, the following theory is proposed:

H3: *Green transport policies and innitiatives positively affect individuals' propensity to use green transportation.*

A green transport system, including green transportation infrastructure and management, is considered a significant environmental pull factor. A green transport system is essential for encouraging citizens to choose for sustainable transportation (Li, 2016; Jia, 2018). For example, Bus Rapid Transit (BRT) systems have been used to mitigate bus congestion during peak hours in many Chinese cities (Jia, 2018). These BRT systems substantially mitigate traffic congestion and promote bus use for commuting. Furthermore, the pleasant waiting areas and accessible transit connections encourage people to choose for green transportation. Consequently, the superior the green transportation infrastructure, the more probable folks will transition to green modes of transport. Based on the above analysis, it can be concluded that green transport system will increase individual’s willingness to shift to green transportation. Therefore, it is posited that:

H4: *A good green transport system positively impacts an individual's propensity to transition to green transportation such as electricity vehicles.*

2.4. Mooring factor and individual’s shifting willingness

Beliefs may be shaped by offering people comprehensive knowledge on certain needs; hence, information provision may significantly promote changing willingness and actual behavioral change (Du et al., 2017; Liu et al., 2017; Aydin et al., 2018). Individuals can comprehensively comprehend and modify their actions only when enough information about those behaviors is made available to them (Du et al., 2017). In the current study, information provision pertains to delivering comprehensive details on energy saving and emissions reduction associated with green mobility, as well as conveying specific transfer information to people. When this information is supplied, people will likely modify their commute behavior and are more inclined to transition to sustainable transportation. Prior research indicated that the disparity between intention and action may be mitigated by the provision of information. Du et al. (2017) demonstrated that supplying people with their real power usage data effectively motivates them to convert their intent to save electricity into tangible saving behavior. The real power usage provided to households has certainly decreased. Liu et al. (2017) posited that objectives and informational feedback positively regulate the link between consumers' propensity to engage in low-carbon behaviors and their actual low-carbon consumption practices. Consequently, this study posits the following hypotheses:

H5: *Information provision moderates the effects of pull factors and push factors on individual's willingness to shift to green transportation.*

3. Research methodology

3.1. Measures

The questionnaire survey approach was used to gather study data on eight latent variables. A five-point Likert scale (1—"Not at All" to 5—"Very Willing") was used to assess the readiness to willingness to shift to electric vehicle. The components of additional latent variables within the study framework were assessed using a five-point Likert scale, ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). The items for all variables were derived from previous research. Four elements of **perceived environmental threats** were derived from the studies conducted by Horng et al. (2014) and Milfont et al. (2010). Three categories of **perceived inconvenience** were established based on the study conducted by Chowdhury and Ceder (2013) and Walle and Steenberghen (2006). Jia (2018) and Liu et al. (2017) created four measuring items to assess green transport policies and initiatives. Three components of the **green transport system** were sourced from the studies of Jia (2018) and Li (2016). Three items of **information provision** were obtained from the studies conducted by Du et al. (2017) and Liu et al. (2018). Three items regarding the **willingness to shift** were selected based on the study of Nordlund and Garvill (2003) and Bamberg (2007). We also survey logistics workers their perspecitve on operation issues, costs, and efficiency of shifting to electric bike.

A preliminary survey was administered to several research academics and logistics experts. The insights and recommendations from the researchers significantly enhanced the quality of the questionnaire.

3.2. Data and samples

The assessment was conducted in 3 provincial cities in Vietnam - Can Tho, Vinh Long and Ho Chi Minh - that experience significant congestion and possess superior green transportation networks. The participants were identified as vehicle-using ones to work in logistics industry in these cities on a regular basis. The study team conducted survey using purposive sampling technique and distributed questionnaire online form August 2024 to October 2024. The study's questionnaire was segmented into two sections. Demographic parameters, push, pull, and anchoring factors, together with information provision and persons' readiness to shifting to electric vehicle, were gathered in the first phase. About 500 questionnaires were disseminated, 235 were returned, and 206 were deemed legitimate resulting in 41,2 % response rate. The demographic characteristics of the samples are presented in Table 1.

The demographic analysis of the sample population provides key insights into the distribution of gender, age, education, industry involvement, and professional experience. In terms of gender, the sample consists of 55.7% male and 44.3% female participants, indicating a slightly higher representation of males. Age distribution reveals that a majority of respondents (54.4%) are under 25 years old, followed by 33.5% in the 25-34 age group, with smaller proportions in the 35-45 age range (8.3%) and over 45 years (3.9%). Educationally, the largest group (69.42%) has completed a college or university degree, while postgraduate participants represent 15.53%, and those with a high school diploma or below comprise 15.05%. Regarding professional experience, the majority (84.7%) have less than 5 years of experience, 11.17% have 5-10 years, and only 4.36% have over 10 years of experience. This sample highlights a young, educated, and industry-diverse workforce providing a good representation for the young population in Vietnam, which will be the main target group of electric and green transporation in the near future.

Table 1: Demographic characteristics

Classification	Number	%
Gender		
Male	115	55.7
Female	91	44.3
Age		
Under 25 years old	112	54.4
25-34 years old	69	33.5
35-45 years old	17	8.3
Over 45 years old	8	3.9
Education		
College/University	143	69.42
Postgraduate	32	15.53
High School and under	31	15.05
Experience		
Less than 5 years	174	84.7
5-10 years	23	11.17
Over 10 years	9	4.36

4. Data analysis and Resutls

4.1. Operation, cost and efficiency of electric bike

4.1.1. Operation issues

The results in Figure 1 indicate that opeation cost is the most significant factor when logistics companies choose between electric and fossil fuel-powered motorcycles, with a high average score of 4.092. This suggests that the financial aspect, including initial purchase price, operational costs, and potential savings from reduced fuel consumption or maintenance, outweighs other considerations. Following cost, infrastructure support (3.981) and efficiency (3.947) are also prioritized by logistics providers, reflecting the importance of having the necessary infrastructure, such as charging stations, and the vehicles' performance in terms of operational output and energy consumption. These two factors are essential for the adoption of electric motorcycles in logistics, as companies require reliable infrastructure to ensure smooth operations, alongside efficient energy usage.

Although environmental impact scores lower (3.82), it remains a relevant consideration, highlighting a growing awareness of sustainability concerns. However, it does not yet surpass cost and infrastructure support in importance. Reliability (3.816), though critical, is perceived as the least influential factor, suggesting that companies may be relatively satisfied with the current reliability levels of electric motorcycles, but this factor alone is not a deciding factor in the transition from fossil fuel-powered vehicles.

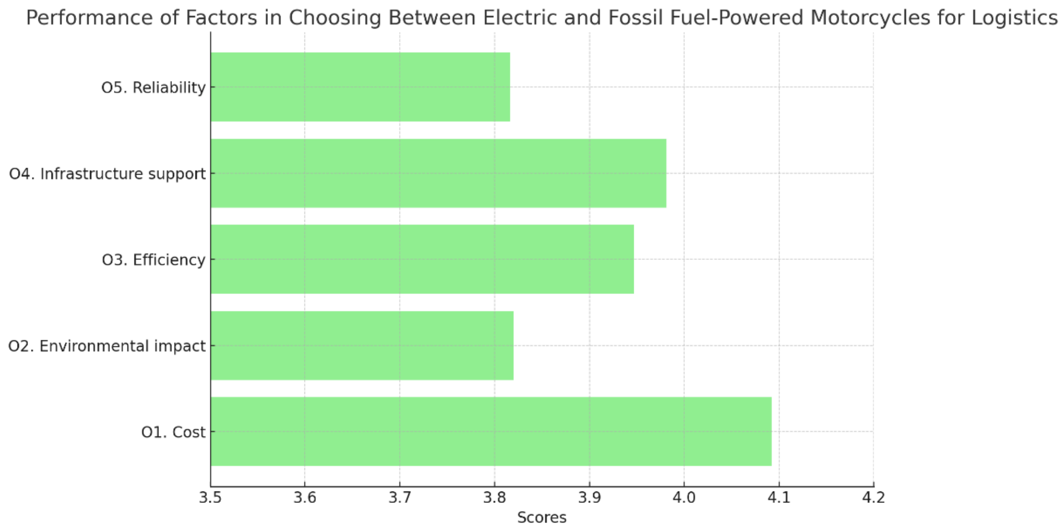

Figure 1: Operation issues

The findings suggest that governments and policymakers aiming to promote the adoption of electric motorcycles in logistics should focus on creating incentives to lower the cost barrier. Policies such as subsidies, tax reductions, or financial support for the initial purchase of electric motorcycles could encourage logistics companies to transition away from fossil fuel-powered vehicles. Additionally, investment in infrastructure, particularly the expansion of charging station networks and battery-swapping facilities, is essential to further support the use of electric vehicles. Finally, while environmental sustainability is important, policymakers might need to enhance awareness of the long-term benefits of reducing emissions and the environmental advantages of adopting electric motorcycles through public campaigns or regulatory frameworks that encourage greener choices. These steps could help balance the importance of financial considerations with environmental benefits, driving more sustainable logistics practices.

4.1.2. Efficiency issues

The results in Figure 2 of efficiency considerations for electric motorcycles in logistics reveals several key insights. The highest-ranked factor is reduced environmental impact, with a score of 4.092, indicating that logistics providers place substantial emphasis on the environmental benefits of adopting electric motorcycles. This finding reflects a growing awareness of sustainability in logistics operations, as companies are increasingly driven by the need to reduce their carbon footprints. Close behind is fuel cost savings, scoring 4.049, highlighting the economic appeal of electric motorcycles due to their reduced reliance on traditional fuel. The lower operational costs associated with fuel savings play a significant role in enhancing the overall efficiency of logistics fleets. Additionally, wading ability, with a score of 3.82, reflects the importance of electric motorcycles' performance in varied weather conditions, which is crucial in ensuring reliability in operations, though it is not the top priority.

Maintenance cost savings also scores relatively high (3.777), pointing to the reduced need for frequent maintenance due to the simpler mechanical structure of electric motorcycles compared to their fossil fuel counterparts. However, increased transport efficiency (3.626) and time optimization (3.578) are of somewhat lesser importance. These lower scores suggest that logistics companies may perceive the performance of electric motorcycles in terms of speed and transport efficiency as comparable to conventional motorcycles, and thus not a critical factor in the decision-making process.

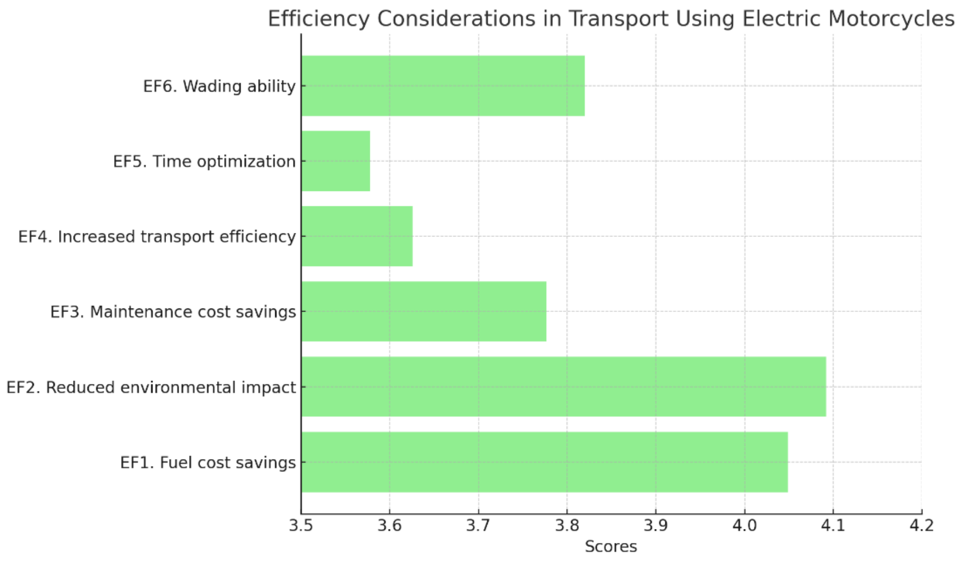

Figure 2: Efficiency issues

The findings have important implications for policymakers looking to support the transition to electric vehicles in logistics. Given the emphasis on environmental impact and fuel cost savings, policymakers should prioritize incentive programs that amplify these advantages, such as offering subsidies or tax incentives for the purchase of electric motorcycles and encouraging fleet operators to shift towards greener options. Additionally, raising public awareness about the long-term environmental and economic benefits of electric motorcycles through educational campaigns and stricter emissions regulations could further drive adoption. Investments in infrastructure to support electric motorcycles' resilience in various environmental conditions, such as improving wading ability and expanding charging station networks, are also necessary to address moderate concerns related to performance and reliability in challenging conditions. These combined policy measures could accelerate the transition to electric vehicles and ensure more sustainable logistics operations.

4.1.3. Cost issues

The chart provides an overview of the cost considerations when operating electric motorcycles for logistics. Fuel cost (CR1) is the highest-scoring factor at 3.369, indicating that reducing fuel expenses remains a primary concern for logistics operators. This reflects the importance of cost savings in energy consumption when shifting towards electric vehicles. Maintenance cost (CR3) follows closely with a score of 3.049, showing that the reduced need for frequent repairs and upkeep is another significant benefit. Other operating costs (CR5) scored 3.005, implying that additional operational expenses, such as electricity costs and routine checks, still play a role but are not as impactful as fuel or maintenance costs. Insurance cost (CR2), with a score of 2.966, suggests that insurance expenses are a moderate consideration but not a decisive factor. Finally, spare parts cost (CR4) received the lowest score at 2.874, indicating that the cost of replacement parts is of relatively low concern, possibly due to the fewer mechanical components in electric motorcycles compared to their fossil-fuel counterparts.

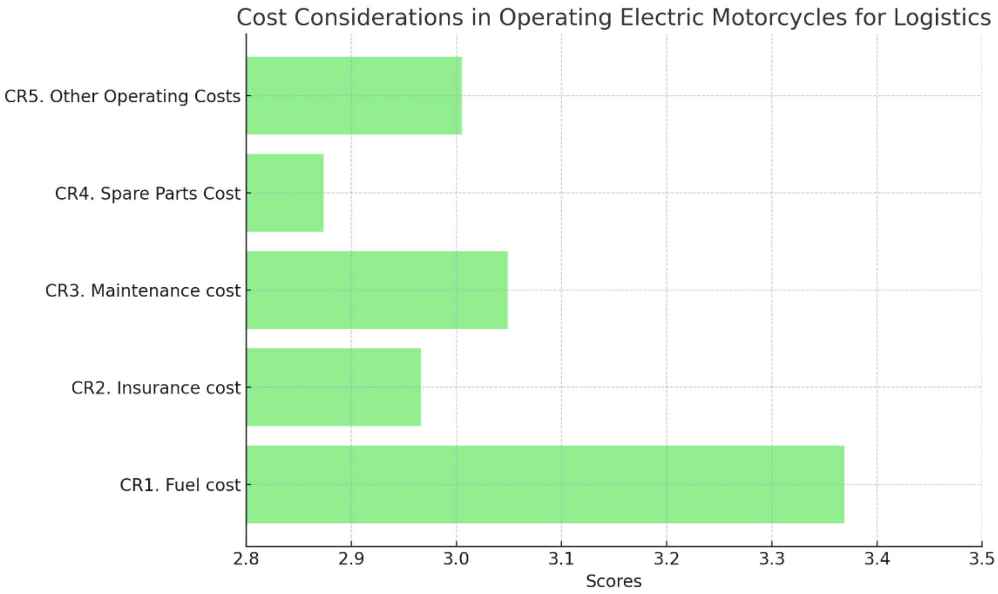

Figure 3: Cost issues

Given the significant concern around fuel costs, policymakers should focus on providing incentives such as fuel subsidies or reduced energy tariffs for logistics companies using electric motorcycles. Additionally, promoting maintenance savings through financial support for service infrastructure could further enhance the attractiveness of electric motorcycles. Policymakers could also consider insurance incentives, such as lower premiums for electric vehicle fleets, to alleviate concerns around insurance costs. These policy measures could help address key cost concerns and encourage a wider adoption of electric motorcycles in the logistics sector.

4.2. Measurement model

Before the data analysis, multicollinearity tests were performed. The findings indicated that the data conform to the premise of normal distribution. The variance inflation factors (VIFs) were assessed for the multicollinearity examination. The findings demonstrated that all variance inflation factors (VIFs) were below 2.8. Consequently, multi-collinearity presented no risk to the data analysis. Furthermore, common method variance (CMV) may jeopardize the quality of the data findings (Wang et al., 2018). The single factor test by Harman was used to assess the common method variance (Wang et al., 2018). The CMV findings indicated that the items of all variables are categorized into five factors with eigenvalues over 1.0. The initial component accounts for less than 50% of the variation at 36.20%, indicating that common method variance (CMV) is not a significant issue in this research.

Table 2: Reliability and convergent validity analysis

Construct	**Item**	**Loading**	**Cronbach Alpha**	**CR**	**AVE**
Perceived environmental threats (PET)	PET1	0.815	0.911	0.928	0.617
	PET2	0.769			
	PET3	0.813			
	PET4	0.782			
Perceived inconvenience (PI)	PI1	0.831	0.879	0.906	0.581
	PI2	0.798			
	PI3	0.756			
Green transport policies and campaigns (GPC)	GPC1	0.816	0.838	0.885	0.607
	GPC2	0.808			
	GPC3	0.777			
Green transport system (SYS)	SYS1	0.846	0.854	0.896	0.633
	SYS2	0.818			
	SYS3	0.81			
Information provision (IP)	IP1	0.807	0.888	0.913	0.601
	IP2	0.822			
	IP3	0.798			
Willingness to shift (WI)	WI1	0.841	0.921	0.938	0.716

	WI2	0.863			
	WI3	0.861			

Note: AVE = Average Variance Extracted; CR = Composite Reliability

The measuring scales' reliability and validity must be evaluated. The reliability was assessed using Cronbach's alpha and composite reliability values (Fornell and Larcker, 1981). Cronbach's alpha and composite reliability scores must exceed 0.70 (Fornell and Larcker, 1981). Table 2 demonstrated that the dependability of the constructs was satisfactory. Factor loadings and average variance extracted (AVE) were used to assess convergent validity. Table 2 indicated that all the AVE values of the constructions above the minimal threshold of 0.50. The factor loadings of the items must exceed 0.70, and Table 2 demonstrates that all item factor loadings surpassed this benchmark figure (Fornell and Larcker, 1981). Table 3 indicates that the square roots of the AVE values exceeded the correlations across constructs, hence affirming discriminant validity (Fornell and Larcker, 1981). Consequently, the validity was deemed satisfactory.

Table 3: Discriminant validity analysis

	GPC	**IP**	**PET**	**PI**	**SYS**	**WI**
GPC	**0.779**					
IP	0.678	**0.775**				
PET	0.658	0.612	**0.786**			
PI	0.613	0.549	0.595	**0.763**		
SYS	0.693	0.656	0.574	0.528	**0.796**	
WI	0.652	0.733	0.616	0.556	0.696	**0.846**

Note: The bold elements are the square roots of AVEs

4.3. Results of the hierarchical regression analysis

The hierarchical regression analysis presented in this study follows a stepwise approach, similar to the recommendations by Cohen et al. (2014), to test the effects of independent variables, the moderator variable (information provision), and interaction terms. In Model 1, only the independent variables were entered, while Model 2 introduced the moderator variable, and Model 3 included interaction terms between the independent variables and the moderator.

The results indicate that **perceived environmental threats (PET)** (b = 0.211, p = 0.008) and **green transport systems (SYS)** (b = 0.384, p < 0.001) significantly and positively influence the willingness to shift towards green transport options, supporting H1 and H2. In contrast, **green transport policies and campaigns (GPC)** (b = 0.176, p = 0.118) and **perceived inconvenience (PI)** (b = 0.127, p = 0.093) did not exhibit significant effects, although PI approached significance at the 10% level. This suggests that factors related to environmental concerns and the availability of green transport infrastructure have a stronger impact on individuals' willingness to shift compared to the perceived inconvenience or the presence of campaigns.

After introducing **information provision (IP)** as a moderator, the significance of PET decreased slightly (b = 0.141, p = 0.086), though it remained marginally significant at the 10% level. SYS continued to have a strong and significant effect (b = 0.269, p = 0.001), further affirming the importance of transport systems in influencing willingness to shift. Interestingly, IP itself was found to have a highly significant positive impact (b = 0.383, p < 0.001) on willingness to shift, highlighting the critical role of information availability in shaping behavioral intentions.

Table 4: Results of the hierarchical regression analysis

Variable	Model 1	p-value	Model 2	p-value	Model 3	p-value
Step 1: Independent variable						
Green transport policies and campaigns (GPC)	0.176 (0.106)	0.118	0.062 (0.102)	0.560	0.063 (0.101)	0.568
Perceived environmental threats (PET)	0.211 (0.078)	0.008***	0.141 (0.076)	0.086*	0.161 (0.075)	0.034**
Perceived inconvenience (PI)	0.127 (0.073)	0.093*	0.088 (0.064)	0.199	0.088 (0.076)	0.274
Green transport system (SYS)	0.384 (0.100)	0.000***	0.269 (0.086)	0.001***	0.261 (0.083)	0.001***
Step 2:Moderator variable						
Information provision (IP)			0.383 (0.095)	0.000***	0.340 (0.092)	0.000***
Step 3: Interactions						
GPC*IP					0.135 (0.119)	0.222

PET*IP					0.147 (0.058)	0.009***
PI*IP					-0.074 (0.088)	0.466
SYS*IP					-0.248 (0.101)	0.009***
R^2	0.580		0.642		0.677	
Adjusted R^2	0.572		0.634		0.662	

*Note: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard error is in paranthesis.*

In the final model, the interaction effects between the independent variables and the moderator were tested. The interaction between PET and IP (b = 0.147, p = 0.009) was significant and positive, indicating that the effect of perceived environmental threats on willingness to shift is strengthened when information provision is high, supporting H3. Additionally, the interaction between SYS and IP was negative and significant (b = -0.248, p = 0.009), suggesting that the influence of green transport systems on willingness to shift diminishes as information provision increases. This result highlights the current dynamics in Vietnam, where green transport systems (SYS) are an important factor influencing the willingness to shift to sustainable transport, but are not sufficient on their own. The findings suggest that while robust infrastructure is necessary, simply providing transparent information about these systems may, in some cases, diminish the motivation to shift. This could be due to the fact that increased awareness of existing system limitations or challenges—such as accessibility or reliability—may cause individuals to reassess their willingness to adopt green transport options.

Conversely, the interaction terms for GPC*IP (b = 0.135, p = 0.222) and PI*IP (b = -0.074, p = 0.466) were not significant, suggesting that information provision does not significantly moderate the relationship between green transport policies or perceived inconvenience and willingness to shift. This result may indicate that campaigns and policies alone are not as effective when coupled with information provision, or that other variables may play a more important role in influencing these relationships.

The R^2 values increased with the addition of the moderator and interaction terms, with Model 1 explaining 58.0% of the variance, Model 2 explaining 64.2%, and Model 3 explaining 67.7%.

The adjusted R^2 values followed a similar pattern, indicating a better model fit as the moderator and interaction terms were included. This progression demonstrates that information provision, and its interaction with certain key variables, plays a meaningful role in enhancing the willingness to shift towards green transport solutions.

5. Policiy implication and conclusion

5.1. Policy implication

Based on the findings from the regression analyses, several policy implications can be derived to effectively encourage the shift towards green transportation and electric vehicle adoption. First, government should invest in green transport infrastructure (SYS) but address its limitations. The significant positive impact of the green transport system on willingness to shift suggests that improving transport infrastructure is a key driver for behavioral change. However, the diminishing effect observed when information provision (IP) is high indicates that simply informing the public about the current state of green transport systems may reveal gaps or weaknesses that demotivate individuals. Policymakers should focus on both expanding and enhancing the quality of green transport infrastructure, such as improving reliability, coverage, and convenience. At the same time, transparency in information should be paired with efforts to address any identified shortcomings.

Second, the strong positive influence of perceived environmental threats (PET), particularly when moderated by information provision, indicates that individuals are more likely to shift towards green transport when they are aware of environmental risks. Policymakers can capitalize on this by designing public campaigns that clearly communicate the environmental benefits of green transportation, highlighting the potential threats posed by traditional modes of transport. This can include data on pollution, carbon emissions, and climate change impacts to create a sense of urgency and responsibility among the public. Thus, government should leverage perceived environmental threats in awareness campaigns.

Third, from its significant moderating effects of information provision (IP) plays a crucial role in facilitating the shift to green transport, as demonstrated by its strong and significant effects in the models. Policymakers should prioritize delivering accurate, accessible, and engaging information about green transport options. However, care must be taken to ensure that information does not unintentionally highlight limitations, particularly regarding infrastructure. Policymakers can address this by emphasizing positive developments, future improvements, and potential benefits of green transport rather than focusing solely on current system limitations.

Fourth, although green transport policies and campaigns (GPC) showed no significant interaction with information provision, these policies are still essential for creating a supportive regulatory environment. Policymakers should continue developing incentive-based programs such as subsidies, tax reductions, and public transport discounts to encourage adoption. In addition, campaigns should focus on community engagement, fostering collective responsibility, and showcasing the tangible benefits of using green transport, such as improved health outcomes and reduced commute times.

Since younger populations are more open to shifting toward green transport, embedding environmental education within school programs can build long-term behavioral change. Governments should include curriculum elements that teach students about sustainable transport, environmental threats, and the role of infrastructure in mitigating these risks. This can create a more environmentally conscious generation that is naturally inclined towards using green transport options.

Given the evolving nature of public perception, policymakers should establish a framework for regularly monitoring public sentiment towards green transport systems and policies. Surveys, feedback platforms, and public consultations can help identify areas where public perception is changing and guide improvements to the transport system. This ensures that policies remain relevant and aligned with the needs of the population.

5.2. Conclusion

This study provides critical insights into the determinants of individuals' willingness to shift towards green transportation in Vietnam. The findings reveal that perceived environmental threats (PET) and green transport systems (SYS) significantly influence individuals' intention to adopt sustainable transport options. Additionally, information provision (IP) emerged as a crucial moderator, amplifying the effects of environmental concerns and infrastructure availability on the willingness to shift. However, the results also suggest that an overemphasis on transparency regarding existing green transport systems may inadvertently reduce motivation, as individuals become more aware of the system's limitations. These findings underscore the need for comprehensive policy approaches that not only focus on improving green transport infrastructure but also strategically address public perceptions and behavioral inertia. Overall, this research enhances our understanding of the factors driving the adoption of green transport and provides actionable insights for policymakers aiming to promote sustainable transport behavior.

Despite its contributions, this research has several limitations. First, the sample may not fully represent the broader population of Vietnam, particularly in terms of geographical and socio-economic diversity. Future studies should aim to incorporate a larger and more diverse sample to ensure the generalizability of the findings. Second, the use of a cross-sectional design limits the ability to capture changes in willingness to shift over time. Longitudinal studies would be better suited to observe how attitudes and behaviors evolve with the implementation of new policies and infrastructure developments. Third, this study only considered information provision as a moderator, excluding other potentially relevant factors, such as economic incentives, cultural norms, or technological advances. Including a wider range of moderating variables in future research could yield a more nuanced understanding of what drives green transport adoption. Finally, the reliance on self-reported data may introduce bias, as participants' responses could be influenced by social desirability or inaccurate recollections. Incorporating objective behavioral data or tracking actual transport usage could strengthen future analyses.

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