World Electric Vehicle Journal

MDPI

Article

Exploring Factors Influencing E-Bike Adoption Among Filipino Commuters: An Integrated Diffusion of Innovation and Technology Acceptance Model

Ma. Janice J. Gumasing

Department of Industrial and Systems Engineering, Gokongwei College of Engineering, De La Salle University, 2401 Taft Ave., Manila 1007, Philippines; ma.janice.gumasing@dlsu.edu.ph; Tel.: +63-(2)-524-4611

Abstract: This study examines the factors influencing the behavioral intention and usage behavior of e-bikes in Metro Manila and the National Capital Region (NCR) using constructs from the Diffusion of Innovation (DOI) theory, the Technology Acceptance Model (TAM), and external variables such as government policies, infrastructure, social influence, and public awareness. A cross-sectional survey of 340 respondents was analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to explore the relationships among these constructs. The results indicate that perceived usefulness (PU), perceived ease of use (PEOU), social influence, and public awareness significantly affect behavioral intention, which strongly predicts e-bike usage behavior. Infrastructure also positively impacts ease of use, while trialability enhances perceived usefulness. However, the relationships between government policies and perceived usefulness, as well as between trialability and ease of use, were insignificant, reflecting contextual limitations in the Philippine setting. The findings highlight the importance of behavioral intention as a primary driver of e-bike adoption. To address barriers, practical recommendations include expanding bike lanes, implementing e-bike sharing systems, strengthening government incentives, and launching public awareness campaigns that highlight the benefits of e-bikes, such as cost savings and environmental sustainability. This study also contributes to theory by integrating DOI and TAM frameworks, offering a comprehensive understanding of e-bike adoption in developing urban settings. These insights provide actionable strategies for policymakers, manufacturers, and stakeholders to promote sustainable transportation in the Philippines and similar contexts.

Keywords: e-bike; TAM; DOI; PLS-SEM; behavioral intention

check for updates

Academic Editor: Peter Van den Bossche

Received: 27 January 2025
Revised: 11 February 2025
Accepted: 17 February 2025
Published: 19 February 2025

Citation: Gumasing, M.J.J. Exploring Factors Influencing E-Bike Adoption Among Filipino Commuters: An Integrated Diffusion of Innovation and Technology Acceptance Model. *World Electr. Veh. J.* **2025**, *16*, 113. https://doi.org/10.3390/wevj16020113

Copyright: © 2025 by the author. Published by MDPI on behalf of the World Electric Vehicle Association. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The rapid urbanization and worsening traffic congestion in Metro Manila and the National Capital Region (NCR) have significantly increased the demand for alternative transportation solutions [1]. E-bikes have emerged as a cost-efficient, environmentally friendly, and practical option for navigating congested urban areas [2]. However, despite their potential benefits, e-bike adoption in the Philippines remains relatively low, primarily due to socio-economic, technological, and infrastructural barriers. Understanding the key factors influencing Filipino commuters' willingness to adopt e-bikes is essential for promoting sustainable urban mobility and reducing dependence on traditional fuel-powered vehicles.

Although e-bikes are often regarded as a sustainable transportation alternative due to their lower carbon footprint and energy efficiency [3], their actual environmental impact

depends on the country's energy mix, which is still largely reliant on fossil fuels [4]. Thus, a holistic approach—including policy reforms, infrastructure development, and public awareness initiatives—is necessary to encourage widespread e-bike adoption.

The growing interest in e-bikes in the Philippines is primarily driven by severe traffic congestion, rising fuel costs, and the need for more affordable and convenient transport options. A comparison of transportation costs highlights e-bikes' economic advantage. Daily commuting expenses for a typical public transport user—including buses, jeepneys, and MRT—range from ₱100 to ₱200 per day, or approximately ₱3000 to ₱6000 per month. Motorcycle users spend an estimated ₱1500 to ₱3500 per month on fuel, plus maintenance and registration fees. In contrast, e-bikes have significantly lower operating costs, requiring only ₱200 to ₱500 per month for electricity charging, with minimal maintenance expenses. Over time, this cost advantage makes e-bikes a financially sustainable choice, particularly for low- to middle-income commuters.

Recognizing the economic benefits, convenience, and environmental impact of e-bikes is crucial for assessing their potential as a viable transportation alternative. Addressing key adoption barriers through targeted policies, improved infrastructure, and greater public awareness can further promote their widespread use.

Studying Filipino commuters' usage behavior toward e-bikes is crucial for promoting their adoption and addressing key challenges in urban mobility. First, understanding how Filipinos perceive e-bikes can help policymakers, manufacturers, and urban planners develop targeted strategies to encourage widespread use. Second, analyzing the behavioral and psychological factors influencing e-bike adoption supports efforts to enhance sustainable transportation, aligning with global initiatives to reduce carbon emissions and traffic congestion. Lastly, identifying barriers such as inadequate infrastructure, public misconceptions, and sociocultural resistance can guide the development of effective policies and urban planning solutions to improve commuting experiences and increase adoption rates. Addressing these factors through policy reforms, infrastructure investments, and awareness campaigns can position e-bikes as a viable, cost-efficient, and sustainable transport alternative for urban commuters in the Philippines.

Several studies have explored the acceptance and adoption of e-bikes in different contexts. For instance, the study by Yasir et al. in China examined how the pandemic reshaped transportation preferences, emphasizing the role of energy efficiency in promoting e-bike adoption. In the Philippine context, the study by Gaspar et al. [2] highlighted the influence of pro-environmental attitudes on the intention to use e-bikes. Meanwhile, international studies by Zhang et al. [5] and Chonsalasin et al. [6] emphasized the role of government policies, perceived benefits, and urban infrastructure in shaping adoption. Similarly, the research by Ravishankar et al. [7] in India provided insights into how behavioral intentions among younger demographics influence e-bike usage.

Furthermore, numerous studies have examined technology adoption in transportation, primarily using the Technology Acceptance Model (TAM) and the Diffusion of Innovation (DOI) theory. TAM focuses on how perceived usefulness (PU) and perceived ease of use (PEOU) shape behavioral intention [8], while DOI explores how innovation attributes, such as relative advantage, compatibility, complexity, observability, and trialability, influence adoption decisions [9]. While previous studies have applied these models independently, recent research suggests that integrating TAM and DOI provides a more comprehensive framework for examining adoption behavior [10,11].

Although studies have combined TAM and DOI to examine technology adoption [12,13], few have applied this integration in the context of e-bike adoption in developing countries, particularly in the Philippines. Most existing studies on e-bike adoption focus on developed economies, where infrastructure and policy support are more es-

tablished [14,15]. In contrast, e-bike adoption in Metro Manila and NCR is influenced by unique contextual challenges, including limited government incentives, inadequate infrastructure, and varying levels of public awareness.

Furthermore, previous research has largely overlooked the role of external factors, such as government policies, infrastructure availability, public awareness, and social influence, in shaping e-bike adoption decisions. While TAM and DOI address individual perceptions and innovation attributes, understanding how external contextual factors influence these perceptions remains an underexplored area in the literature. This study aims to bridge this gap by incorporating external variables into the integrated TAM-DOI framework, offering a context-specific analysis of e-bike adoption in the Philippines.

Given the identified research gaps, this study seeks to explore the key factors influencing e-bike adoption among Filipino commuters by integrating TAM, DOI, and external contextual variables. Specifically, it aims to:

1. Examine the effects of DOI innovation attributes (relative advantage, compatibility, complexity, trialability, and observability) on the perceived usefulness (PU) and perceived ease of use (PEOU) of e-bikes.
2. Analyze the impact of TAM constructs (PU and PEOU) on behavioral intention (BI) and actual usage behavior (UB).
3. Investigate the influence of external factors (government policies, infrastructure availability, social influence, and public awareness) on PU, PEOU, and BI.
4. Assess the overall predictive power of the integrated TAM-DOI model in explaining behavioral intention and e-bike adoption in the Philippine setting.

By addressing these objectives, this study provides theoretical contributions by extending the TAM-DOI integration to a developing country context and practical implications for policymakers, urban planners, and e-bike manufacturers. The findings will inform strategies to improve e-bike infrastructure, government incentives, and public awareness campaigns, ultimately promoting the adoption of sustainable transportation solutions in the Philippines.

2. Conceptual Framework

Figure 1 illustrates the conceptual framework for this study, which integrates two established theoretical models—the Technology Acceptance Model (TAM) and the Diffusion of Innovation (DOI)—to provide a comprehensive understanding of the factors influencing e-bike adoption in the Philippines. The integration of these models offers a holistic perspective that captures both the technological and innovation-related factors affecting behavioral intentions and eventual usage.

2.1. Theory of Acceptance Model

The TAM, developed by Davis [8], emphasizes two key constructs: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). PU reflects the degree to which individuals believe that using a particular technology [16], in this case, e-bikes, will enhance their commuting experience, such as saving time or reducing costs. PEOU, on the other hand, refers to how effortless the technology is perceived to be [16]. These two constructs directly influence the Behavioral Intention to Use (BIU) the technology, which ultimately leads to its Actual Usage (AU) [8]. TAM is particularly relevant in this study because it provides a robust framework for understanding user perceptions of e-bikes as a transportation solution.

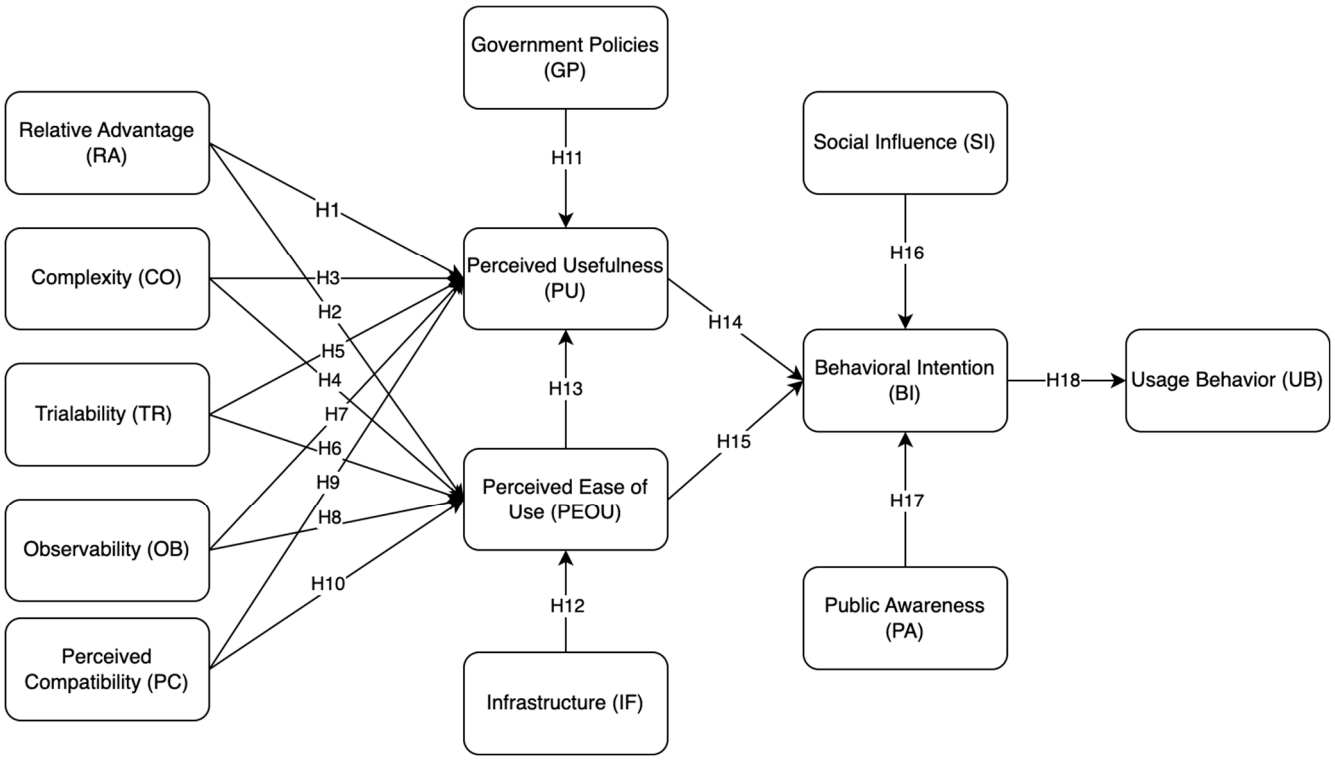


Figure 1. Proposed conceptual framework.

2.2. Diffusion of Innovation Theory

The Diffusion of Innovation (DOI) theory, introduced by Rogers [9], emphasizes the attributes of an innovation that influence its adoption. In the context of this study, the DOI constructs include several critical factors. Relative Advantage (RA) refers to the perceived superiority of e-bikes over other transportation modes, such as their convenience, affordability, and environmental benefits. Compatibility (PC) pertains to the extent to which e-bikes align with the user's lifestyle, needs, and cultural norms. Complexity (CO) captures the perceived difficulty in learning or using e-bikes, while Trialability (TR) denotes the ability of potential users to experiment with e-bikes before committing to their use. Lastly, Observability (OB) highlights the visibility of e-bike benefits, such as observing others effectively use them. Together, these constructs comprise the innovation-related factors that shape user acceptance and the eventual adoption of e-bikes.

2.3. Integration of Theory of Acceptance Model and Diffusion of Innovation Theory

The integration of TAM and DOI provides a robust framework for examining e-bike adoption by addressing technological, behavioral, and social dimensions. While TAM focuses on individual perceptions of the technology's utility and ease of use [17], DOI offers insights into the attributes of e-bikes as an innovation and their alignment with societal and cultural contexts [18]. This combined framework is particularly relevant in the Philippine setting, where e-bike adoption may be influenced by both individual-level factors, such as usability and perceived benefits, and societal-level factors, such as cultural compatibility and peer influence. By merging these two models, the framework offers a more comprehensive understanding of the factors driving e-bike acceptance.

To enhance the predictive power of the model, external contextual factors—including Government Policies, Infrastructure, Social Influence, and Public Awareness—are incorporated. These factors address the institutional and societal influences that may shape user perceptions and behavioral intention, particularly in the developing country context of the Philippines. Government Policies (GP), including regulations, subsidies, and tax breaks,

can play a significant role in encouraging e-bike adoption. Infrastructure (IF), including the availability of bike lanes, charging stations, and parking facilities, directly impacts the feasibility of e-bike usage. Public Awareness (PA) pertains to how informed individuals are about the environmental benefits of using e-bikes, while Social Influence (SI) refers to the role of societal norms and peer behaviors in shaping adoption decisions. These external variables provide additional layers of understanding, making the framework well-suited for analyzing e-bike adoption in the Philippine context.

Thus, the conceptual model hypothesizes that:

1. DOI innovation attributes influence PU and PEOU. Users are more likely to find e-bikes useful and easy to use when they offer clear benefits, fit their lifestyle, are easy to try, and are widely observable.
2. PU and PEOU influence Behavioral Intention (BI), aligning with TAM's core assumptions that technology perceived as useful and easy to use leads to higher adoption intent.
3. External factors impact PU, PEOU, and BI. Policy support, infrastructure availability, social influence, and public awareness campaigns can shape user perceptions and intentions toward e-bikes.
4. BI strongly predicts actual Usage Behavior (UB), as individuals who intend to use e-bikes are more likely to integrate them into their commuting habits.

2.4. Determinants of Behavioral Intention and Usage Behavior for E-Bike

The Diffusion of Innovation (DOI) constructs, including Relative Advantage (RA), Complexity (CO), Trialability (TR), Observability (OB), and Compatibility (PC), are essential determinants of Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) in e-bike adoption.

Relative Advantage (RA) refers to the perceived superiority of e-bikes over other transportation modes. RA reflects the benefits of e-bikes, such as cost efficiency, convenience, and environmental friendliness, which enhance Perceived Usefulness (PU) [19]. Studies have shown that users are more likely to perceive a technology as useful if it offers clear advantages over existing alternatives [20,21]. Additionally, RA positively influences Perceived Ease of Use (PEOU), as users often perceive technologies with evident benefits as easier to adopt. Prior research confirms that RA enhances ease-of-use perceptions [22]. Based on this, the following hypotheses were proposed:

H1. *Relative Advantage (RA) significantly and positively influences Perceived Usefulness (PU) of e-bikes.*

H2. *Relative Advantage (RA) significantly and positively influences Perceived Ease of Use (PEOU) of e-bikes.*

Complexity (CO) refers to the perceived difficulty in learning or using e-bikes. Higher levels of complexity tend to reduce Perceived Usefulness (PU), as users are less likely to view complex technologies as effective or accessible. Studies on technological adoption consistently indicate that simpler systems are perceived as more useful [23,24]. Similarly, complexity negatively impacts Perceived Ease of Use (PEOU), as users find complex systems harder to operate [25]. Prior research highlights that reducing complexity can significantly enhance ease-of-use perceptions [26,27]. Based on these insights, the following hypotheses were proposed:

H3. *Complexity (CO) significantly and negatively influences Perceived Usefulness (PU) of e-bikes.*

H4. *Complexity (CO) significantly and negatively influences Perceived Ease of Use (PEOU) of e-bikes.*

Trialability (TR) refers to the degree to which users can experiment with e-bikes before committing to their use. The ability to try e-bikes increases PU by reducing uncertainty about their effectiveness. Studies have demonstrated that trialability fosters confidence in new technologies [28,29]. Moreover, TR positively affects PEOU by allowing users to familiarize themselves with the technology, reducing perceived difficulty [30]. Based on this, the following hypotheses were proposed:

H5. *Trialability (TR) significantly and positively influences Perceived Usefulness (PU) of e-bikes.*

H6. *Trialability (TR) significantly and positively influences Perceived Ease of Use (PEOU) of e-bikes.*

Observability (OB) refers to the visibility of e-bike benefits, such as cost savings or convenience, as observed through peers or other users. The visible benefits of e-bikes enhance PU, as they increase users' confidence in the technology [30,31]. Similarly, OB positively influences PEOU, as observing others successfully use e-bikes reduces perceived barriers to adoption, according to studies [32]. Based on this, the following hypotheses were proposed:

H7. *Observability (OB) significantly and positively influences Perceived Usefulness (PU) of e-bikes.*

H8. *Observability (OB) significantly and positively influences Perceived Ease of Use (PEOU) of e-bikes.*

Perceived Compatibility (PC) refers to the extent to which e-bikes align with users' lifestyles, needs, and preferences. Research indicates that compatibility enhances PU, as users find technologies more useful when they align with their existing values and routines [33]. PC also positively influences PEOU by reducing perceived complexity, making the technology easier to integrate into daily activities [34]. Based on this, the following hypotheses were proposed:

H9. *Perceived Compatibility (PC) significantly and positively influences Perceived Usefulness (PU) of e-bikes.*

H10. *Perceived Compatibility (PC) significantly and positively influences Perceived Ease of Use (PEOU) of e-bikes.*

Government Policies (GP), such as regulations, subsidies, and incentives, play a crucial role in influencing the perceived usefulness (PU) of e-bikes by reducing financial and institutional barriers to adoption. Well-designed policies can lower the cost of e-bikes, improve access to necessary infrastructure, and enhance the overall feasibility of e-bike use. Empirical studies suggest that government incentives, such as tax exemptions, purchase subsidies, and infrastructure investments, significantly increase the perceived value of sustainable transportation technologies [35,36].

For example, studies in India and Vietnam found that direct subsidies for electric two-wheelers increased their perceived affordability and usability, leading to higher adoption rates [37,38]. Similarly, research on electric vehicle (EV) adoption highlights that financial incentives, coupled with supportive regulations, reduce perceived risk and enhance PU [39]. Based on this, the following hypothesis was proposed:

H11. *Government Policies (GP) significantly and positively influence Perceived Usefulness (PU) of e-bikes.*

Infrastructure (IF), such as bike lanes and charging stations, has a positive impact on Perceived Ease of Use (PEOU) by reducing logistical challenges and making e-bikes more convenient to use. Research shows that well-developed infrastructure significantly enhances ease-of-use perceptions [40], particularly for e-bikes [36]. Empirical research on sustainable urban mobility highlights that dedicated bike lanes and e-bike-friendly infrastructure encourage adoption by providing a safer and more predictable riding environment [32]. In cities with well-integrated cycling infrastructure, users perceive e-bikes as easier to navigate, reducing perceived barriers to use [41]. Furthermore, the availability of charging stations alleviates concerns about battery life, increasing confidence in the technology and reinforcing ease-of-use perceptions [42]. Based on these findings, the following hypothesis was proposed:

H12. *Infrastructure (IF) significantly and positively influences Perceived Ease of Use (PEOU) of e-bikes.*

Perceived Usefulness (PU) directly influences Behavioral Intention (BI), as users are more likely to adopt technologies they find beneficial. TAM studies consistently demonstrate a strong link between PU and intention to use [17,26]. Furthermore, Perceived Ease of Use (PEOU) impacts BI positively, as technologies that are easier to use reduce adoption barriers, as proved by prior studies [43,44]. The existing literature on sustainable mobility and electric vehicle adoption confirms that PU significantly impacts BI, as commuters prioritize practical benefits such as reduced travel time, fuel cost savings, and environmental advantages [2,45]. Research on e-bike adoption in China [5] and Europe [46] further supports this, showing that when users perceive e-bikes as a superior commuting alternative, their intention to adopt increases significantly.

Similarly, Perceived Ease of Use (PEOU) plays a crucial role in influencing BI, as technologies that are easier to operate and require less effort tend to have higher adoption rates [16]. Studies on urban micro-mobility adoption indicate that PEOU reduces psychological and operational barriers, making users more willing to integrate new transportation modes into their routines [36,45]. Based on this, the following hypotheses were proposed:

H13. *Perceived Ease of Use (PEOU) significantly and positively influences Perceived Usefulness (PU) of e-bikes.*

H14. *Perceived Usefulness (PU) significantly and positively influences Behavioral Intention (BI) to use e-bikes.*

H15. *Perceived Ease of Use (PEOU) significantly and positively influences Behavioral Intention (BI) to use e-bikes.*

Social Influence (SI) refers to the impact of societal norms and peer behaviors on individual choices. Research shows that SI directly affects BI, as social pressure and peer recommendations strongly motivate technology adoption [47,48]. Empirical studies indicate that in collectivist cultures, such as in the Philippines and other Southeast Asian nations, social acceptance and normative beliefs strongly influence consumer behavior [2,49]. For example, research on bike-sharing systems and public transport adoption highlights that when individuals observe friends, colleagues, or community members using a particular transport mode, they are more likely to perceive it as a viable option [14]. Additionally,

studies on micro-mobility and urban transport innovation reveal that word-of-mouth recommendations, influencer endorsements, and social media trends further drive adoption by creating positive perceptions and reducing uncertainty [50,51]. Based on this, the following hypothesis was proposed:

H16. *Social Influence (SI) significantly and positively influences Behavioral Intention (BI) to use e-bikes.*

Public Awareness (PA) campaigns inform users about the benefits of e-bikes, thereby enhancing BI. Studies on green mobility highlight the importance of awareness in shaping behavioral intentions [36,45]. Studies on green mobility and sustainable transportation emphasize that effective awareness campaigns significantly shape consumer behavior by highlighting key benefits such as cost savings, environmental sustainability, convenience, and health benefits [14]. For instance, research on electric vehicle (EV) adoption shows that higher levels of public knowledge and exposure to educational campaigns lead to stronger adoption intentions [52,53]. Similarly, studies on bike-sharing and micro-mobility adoption indicate that when people receive information on how and where to use e-bikes, financial incentives, and long-term benefits, their willingness to try and adopt them increases [54]. Based on this, the following hypothesis was proposed:

H17. *Public Awareness (PA) significantly and positively influences Behavioral Intention (BI) to use e-bikes.*

Behavioral Intention (BI) refers to an individual's intention to adopt e-bikes and serves as a direct predictor of Usage Behavior (UB). Both TAM and DOI studies consistently show that BI is a strong determinant of actual technology usage [48,49]. Empirical research on electric vehicle (EV) and micro-mobility adoption supports this relationship, indicating that individuals who exhibit high intention to use sustainable transport modes are more likely to integrate them into their daily routines [2,45]. For instance, studies on bike-sharing and e-scooter programs confirm that when users develop a strong preference or commitment to a particular mode of transport, they progress from trial use to regular usage [14,54]. Similarly, Zhou et al. [55] found that higher BI levels toward EVs led to long-term adoption, reinforcing that intention is a key determinant of actual behavior. Based on this, the following hypothesis was proposed:

H18. *Behavioral Intention (BI) significantly and positively influences Usage Behavior (UB) of e-bikes.*

3. Materials and Methods

3.1. Setting

The participants of this study are individuals residing in Metro Manila and the National Capital Region (NCR), areas that represent the urban and economic hub of the Philippines. Metro Manila and NCR were selected as the research locale due to their high population density, severe traffic congestion, and increasing adoption of alternative transportation modes such as bicycles and e-bikes. These areas are ideal for exploring the factors influencing e-bike adoption, given the availability of bike lanes, government initiatives promoting sustainable transportation, and the socio-economic diversity of their residents.

3.2. Sampling

This study's total sample size of 340 participants was determined based on the requirements for conducting Partial Least Squares Structural Equation Modeling (PLS-SEM). PLS-SEM, a robust method for testing complex models with multiple constructs and pathways, requires an adequate sample size to ensure the reliability and validity of the results. Specifically, the sample size exceeds the "10 times rule", which dictates that the minimum sample size should be 10 times the maximum number of indicators in the most complex construct or structural path in the model [56]. Additionally, the selected sample size aligns with recommendations from empirical studies, which suggest that a sample size of 300–400 is sufficient for obtaining stable and reliable estimates in PLS-SEM analyses.

To capture diverse perspectives, participants were purposively selected to include individuals who are potential or existing e-bike users and those with varying levels of familiarity with e-bikes. This approach ensures that this study adequately represents the target population and provides comprehensive insights into the factors influencing e-bike adoption in urban settings. The findings derived from this sample will offer valuable implications for promoting e-bike adoption in Metro Manila and other urban areas in the Philippines.

3.3. Instrumentation

The primary data collection instrument for this study was an online survey designed and administered using Google Forms. The survey was deployed through various social media platforms and targeted pages or groups specifically catering to e-bike users for four months (April 2023 to August 2023). This approach was chosen to reach a wide audience of potential and current e-bike users in Metro Manila and NCR while ensuring convenience and accessibility for participants.

The survey was divided into three main sections to capture the necessary data comprehensively. The first section of the survey gathered information about the respondents' demographic characteristics, including age, gender, occupation, income level or allowances, and level of familiarity with e-bikes. This information was used to contextualize the responses and analyze potential variations across different demographic groups. The second section of the survey contained items designed to measure the constructs derived from the Diffusion of Innovation (DOI) theory, including Relative Advantage, Compatibility, Complexity, Trialability, and Observability. These items assessed participants' perceptions of e-bikes as an innovation and their alignment with the users' needs, lifestyles, and values. The third section of the survey included measurement items related to the Technology Acceptance Model (TAM) constructs—Perceived Usefulness (PU), Perceived Ease of Use (PEOU)—as well as external variables such as Government Policies, Infrastructure, Social Influence, and Public Awareness. This section focused on understanding how these factors influence participants' behavioral intention and eventual usage of e-bikes.

All items in the survey were answered using a 5-Point Likert Scale, with options ranging from "1—Strongly Disagree" to "5—Strongly Agree". This scaling method allowed for a nuanced assessment of participants' perceptions, attitudes, and intentions, enabling more precise statistical analysis. The use of an online survey facilitated efficient data collection, while the deployment through social media platforms ensured that this study reached a relevant audience of e-bike users and enthusiasts. This method not only increased participation rates but also allowed this study to gather data from a diverse group of respondents across Metro Manila and NCR, providing valuable insights into the factors influencing e-bike adoption in these urban areas. Table 1 shows the summary of measurement items derived from the existing literature.

Table 1. Construct and measurement items.

Construct	Items	Measures	References
Relative Advantage (RA)	RA1	Using an e-bike saves me time compared to other transportation modes.	[57–59]
	RA2	E-bikes are more cost-effective than other modes of transportation.	
	RA3	E-bikes contribute to reducing environmental pollution.	
	RA4	E-bikes offer greater convenience for daily commuting.	
Complexity (CO)	CO1	Learning to use an e-bike is difficult for me.	[57–59]
	CO2	Operating an e-bike seems complicated.	
	CO3	Maintaining an e-bike requires too much effort.	
	CO4	Charging and managing an e-bike's battery is challenging.	
Trialability (TR)	TR1	I can easily try an e-bike before making a purchase decision.	[57–59]
	TR2	I have the opportunity to test an e-bike to see if it meets my needs.	
	TR3	Experimenting with an e-bike would help me decide whether to adopt it.	
	TR4	Trying an e-bike reduces the risks of making the wrong purchase.	
Observability (OB)	OB1	I often see other people using e-bikes effectively.	[57–59]
	OB2	The benefits of using an e-bike are visible to me.	
	OB3	I can observe how others enjoy the convenience of e-bikes.	
	OB4	The effectiveness of e-bikes is easy to notice in my community.	
Perceived Compatibility (PC)	PC1	E-bikes fit well with my lifestyle and commuting habits.	[57–59]
	PC2	Using an e-bike is compatible with my values and priorities.	
	PC3	E-bikes align with my transportation needs.	
	PC4	E-bikes suit my cultural and social preferences.	
Government Policies (GP)	GP1	Subsidies or incentives make e-bikes more appealing to me.	[60,61]
	GP2	Government regulations encourage the use of e-bikes.	
	GP3	Policies supporting sustainable transportation influence my interest in e-bikes.	
	GP4	Tax benefits or financial aid increase my likelihood of adopting an e-bike.	
Infrastructure (IF)	IF1	Bike lanes make it easier for me to consider using an e-bike.	[60,61]
	IF2	The availability of charging stations makes e-bike usage convenient.	
	IF3	Safe parking spaces for e-bikes encourage me to use them.	
	IF4	Proper infrastructure supports my decision to adopt an e-bike.	
Perceived Usefulness (PU)	PU1	Using an e-bike would improve my commuting efficiency.	[62,63]
	PU2	E-bikes would enhance my overall transportation experience.	
	PU3	E-bikes would reduce the stress of daily commuting.	
	PU4	E-bikes are beneficial for my transportation needs.	

Table 1. *Cont.*

Construct	Items	Measures	References
Perceived Ease of Use (PEOU)	PEOU1	I find e-bikes easy to use.	[62,63]
	PEOU2	Using an e-bike would require minimal effort.	
	PEOU3	Learning to operate an e-bike would be straightforward.	
	PEOU4	It would be simple to maintain and manage an e-bike.	
Social Influence (SI)	SI1	My friends or family members encourage me to use an e-bike.	[48,49,64]
	SI2	People in my community support the use of e-bikes.	
	SI3	Positive opinions about e-bikes influence my interest in using them.	
	SI4	Peer pressure motivates me to consider e-bikes as a transportation option.	
Public Awareness (PA)	PA1	Campaigns promoting e-bikes inform me of their benefits.	[65,66]
	PA2	I am aware of how e-bikes contribute to environmental sustainability.	
	PA3	Public information has influenced my interest in e-bikes.	
	PA4	Awareness programs help me understand the advantages of e-bikes.	
Behavioral Intention (BI)	BI1	I intend to use an e-bike in the future.	[47–49]
	BI2	I would actively recommend e-bikes to others.	
	BI3	I plan to incorporate e-bikes into my daily transportation routine.	
	BI4	I am likely to adopt an e-bike soon.	
Usage Behavior (UB)	UB1	I regularly use an e-bike for commuting or leisure.	[47–49]
	UB2	I actively integrate e-bikes into my daily transportation habits.	
	UB3	I have replaced other modes of transportation with an e-bike.	
	UB4	I frequently use an e-bike for short-distance travel.	

3.4. Structural Equation Modeling

This study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the relationships between the constructs in the conceptual framework. PLS-SEM is a second-generation statistical technique widely used for testing complex models with multiple constructs, paths, and indicators, particularly in exploratory studies [67]. Its flexibility and ability to handle smaller sample sizes compared to covariance-based SEM (CB-SEM) [67] make it ideal for this study.

The conceptual framework integrates constructs from the Diffusion of Innovation (DOI) theory, the Technology Acceptance Model (TAM), and external factors such as government policies, social influence, public awareness, and infrastructure. Given its ability to handle models with multiple constructs and indicators, PLS-SEM ensures robust estimation of relationships.

A key strength of PLS-SEM is its emphasis on prediction and variance explanation, making it ideal for this study, which aims to identify factors influencing behavioral intention and e-bike usage. Its focus on maximizing explained variance aligns with the study's objective of understanding the adoption process.

Despite its advantages, PLS-SEM has limitations. It lacks a global goodness-of-fit measure, is prone to measurement errors, and may introduce bias in parameter estimation

due to its component-based approach [68]. Additionally, it is less suited for rigorous theory testing [67]. However, its strong predictive capabilities and suitability for complex models support its use in this study, ensuring meaningful insights into e-bike adoption factors.

4. Results

4.1. Profile of Demographics

The online survey gathered responses from 340 participants residing in Metro Manila and the National Capital Region (NCR). Table 2 summarizes the demographic characteristics of the respondents.

Table 2. Profile of demographics.

Category	Sub-Category	Percentage
Age	18–24	15%
	25–34	45%
	35–44	30%
	45 and above	10%
Gender	Male	55%
	Female	45%
Employment Status	Full time employed	60%
	Part time/self-employed	10%
	Retirees/unemployed	10%
	Student	20%
Income Level/ Allowances	Below Php 20,000	30%
	Php 20,000–40,000	20%
	Php 40,000–60,000	40%
	Php 60,000 above	10%
E-Bike Familiarity	Users	30%
	Non-users but familiar	40%
	Non-users and unfamiliar	30%

4.1.1. Age

The respondents were predominantly in the 25–34 age group, representing approximately 45% of the total sample. This is consistent with the demographic profile of the working-age population in Metro Manila, who are often active commuters exploring alternative modes of transportation. The second-largest group was the 35–44 age group (30%), followed by 18–24 years old (15%) and respondents 45 years and older (10%). These results indicate that this study reached a range of age groups, ensuring perspectives from both younger and older potential e-bike users.

4.1.2. Gender

The gender distribution was nearly balanced, with 55% male respondents and 45% female respondents. This balance reflects the increasing interest in e-bikes among both men and women, highlighting their potential as a gender-neutral transportation solution. The slight male dominance could be attributed to cultural norms and preferences for motorized vehicles, which might influence adoption rates.

4.1.3. Employment

The majority of respondents (60%) were employed full-time, reflecting the relevance of e-bikes as a commuting solution for working professionals in urban areas. Another 20% were students, while 10% identified as self-employed or freelancers. The remaining 10% included retirees, homemakers, or individuals in other categories. These findings

suggest that the survey captured diverse commuting needs, from daily work commutes to occasional trips.

4.1.4. Monthly Income

The respondents' income levels varied widely, with the largest group (40%) earning between PHP 20,000–40,000 per month. This is reflective of middle-income earners, who are likely to consider e-bikes as a cost-effective alternative to traditional modes of transportation. Approximately 30% received an allowance or earned below PHP 20,000, while 20% earned between PHP 40,001–60,000. The remaining 10% had monthly incomes exceeding PHP 60,000. These income levels indicate that e-bike adoption appeals to a broad economic spectrum, particularly for individuals seeking affordable transportation options.

4.1.5. E-Bike Familiarity

The majority of respondents indicated that they were familiar with e-bikes, with 40% having seen or heard about them and 30% having personal experience using or trying an e-bike. The remaining 30% reported limited familiarity, which could reflect gaps in awareness or accessibility in certain areas of Metro Manila. These findings suggest a significant level of exposure to e-bikes, providing a solid foundation for analyzing adoption factors.

4.2. Initial SEM Result

The initial model used to examine the factors influencing the adoption behavior of e-bike users in Metro Manila and NCR is presented in Figure 2. The model comprises thirteen (13) latent variables and fifty-two (52) indicators, aligned with the theoretical framework integrating technological, innovation-related, and external factors. Prior to data collection, the model underwent rigorous reliability and validity testing to ensure its statistical soundness, adhering to the recommendations of Cheung et al. [69]. These steps confirmed that the measurement instrument was suitable for capturing the constructs relevant to this study.

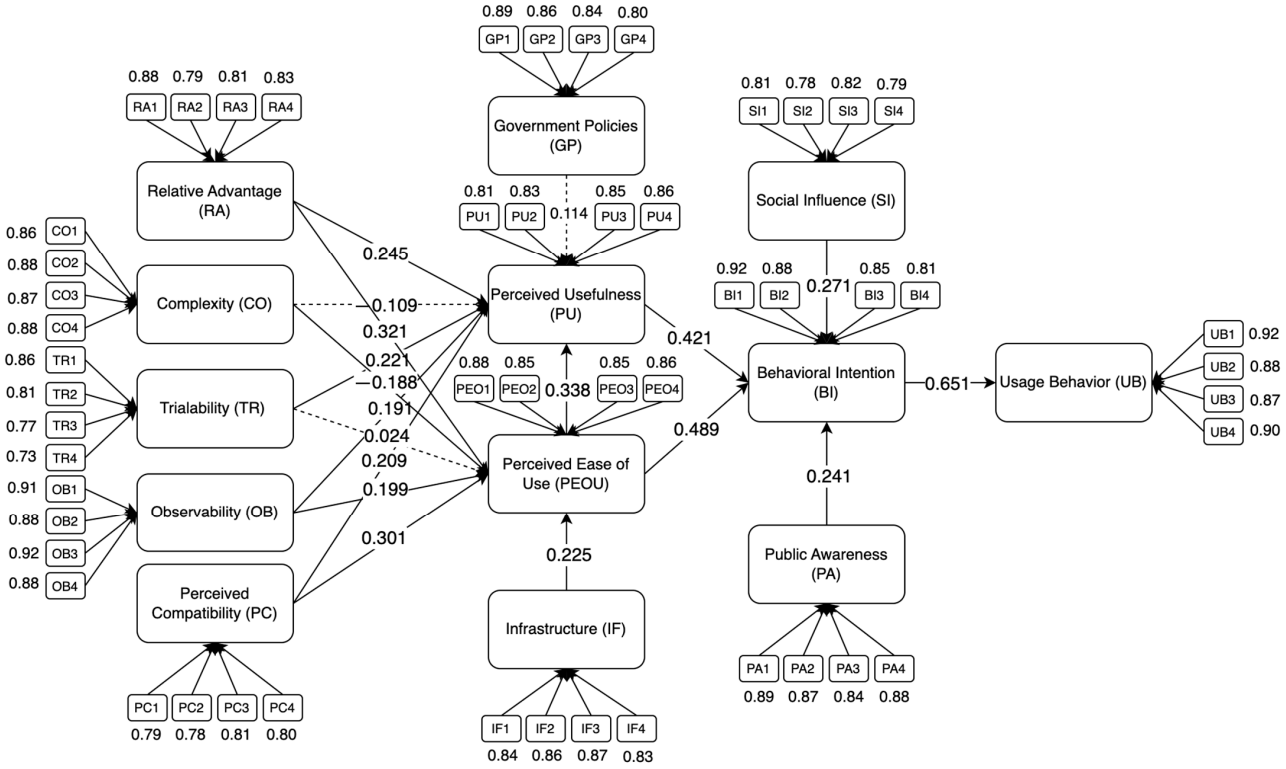


Figure 2. Initial SEM framework.

Reliability was assessed using Cronbach's alpha and composite reliability, while validity was evaluated through the average variance extracted (AVE). According to Haji-Othman and Yusuff [70], a composite reliability and Cronbach's alpha value of at least 0.70 and an AVE value of at least 0.50 are required to establish internal consistency and convergent validity of the constructs. The results of these tests, presented in Table 3, demonstrate that all constructs exceeded the recommended thresholds, establishing the model's reliability and validity.

Table 3. Consistency reliability and convergent validity.

Construct	Item	Mean	S.D.	F.L. (≥0.7)	α (≥0.7)	C.R. (≥0.7)	A.V.E. (≥0.5)
Relative Advantage (RA)	RA1	3.31	1.07	0.88	0.916	0.897	0.685
	RA2	3.20	1.08	0.79			
	RA3	3.59	1.05	0.81			
	RA4	3.72	0.97	0.83			
Complexity (CO)	CO1	3.54	1.06	0.86	0.931	0.927	0.761
	CO2	3.55	1.08	0.88			
	CO3	3.87	0.92	0.87			
	CO4	3.82	1.09	0.88			
Trialability (TR)	TR1	3.94	1.05	0.86	0.891	0.872	0.630
	TR2	3.93	1.16	0.81			
	TR3	3.74	1.13	0.77			
	TR4	3.68	1.09	0.73			
Observability (OB)	OB1	3.69	1.04	0.91	0.951	0.943	0.806
	OB2	3.79	0.95	0.88			
	OB3	3.66	0.91	0.92			
	OB4	3.62	1.09	0.88			
Perceived Compatibility (PC)	PC1	3.56	1.02	0.79	0.880	0.873	0.632
	PC2	4.11	1.23	0.78			
	PC3	3.90	1.01	0.81			
	PC4	3.83	1.02	0.80			
Government Policies (GP)	GP1	3.72	1.06	0.89	0.931	0.911	0.719
	GP2	3.85	1.07	0.86			
	GP3	3.27	1.09	0.84			
	GP4	3.41	1.02	0.80			
Infrastructure (IF)	IF1	3.53	1.06	0.84	0.920	0.913	0.723
	IF2	3.23	1.06	0.86			
	IF3	3.64	0.91	0.87			
	IF4	3.58	1.08	0.83			
Perceived Usefulness (PU)	PU1	3.49	1.03	0.81	0.932	0.904	0.701
	PU2	3.47	0.94	0.83			
	PU3	3.69	1.01	0.85			
	PU4	3.56	1.03	0.86			
Perceived Ease of Use (PEOU)	PEOU1	3.55	1.13	0.88	0.931	0.919	0.740
	PEOU2	3.88	1.19	0.85			
	PEOU33	3.59	1.02	0.85			
	PEOU4	3.40	1.04	0.86			
Social Influence (SI)	SI1	3.58	1.02	0.81	0.891	0.877	0.640
	SI2	3.49	1.08	0.78			
	SI3	3.27	1.06	0.82			
	SI4	3.68	0.91	0.79			

Table 3. *Cont.*

Construct	Item	Mean	S.D.	F.L. (≥0.7)	α (≥0.7)	C.R. (≥0.7)	A.V.E. (≥0.5)
Public Awareness	PA1	3.56	1.02	0.89	0.944	0.926	0.757
	PA2	3.47	1.06	0.87			
	PA3	3.49	0.91	0.84			
	PA4	3.67	1.03	0.88			
Behavioral Intention (BI)	BI1	3.54	1.06	0.92	0.931	0.922	0.750
	BI2	3.48	1.01	0.88			
	BI3	3.49	0.98	0.85			
	BI4	3.65	1.02	0.81			
Usage Behavior (UB)	UB1	3.56	1.02	0.92	0.952	0.940	0.770
	UB2	3.47	1.01	0.88			
	UB3	3.48	0.97	0.87			
	UB4	3.64	1.06	0.90			

The latent variables in the model include constructs from the Diffusion of Innovation (DOI) theory (e.g., relative advantage, compatibility, trialability, observability, complexity), Technology Acceptance Model (TAM) (e.g., perceived usefulness, perceived ease of use), and external variables (e.g., government policies, infrastructure, public awareness, social influence). Additionally, the model includes behavioral intention and usage behavior, reflecting the adoption process. These robust measures ensure that the variables were accurately and consistently captured, laying a strong foundation for subsequent analysis.

Following the recommendations of Henseler et al. [71], this study employed the Fornell–Larcker criterion and the heterotrait–monotrait (HTMT) ratio of correlation to analyze the relationships between the variables influencing the adoption behavior of e-bike users. These methods were used to assess discriminant validity, ensuring that the constructs in the model are sufficiently distinct from one another [72]. Establishing discriminant validity is critical to confirming that each latent variable, such as technological, innovation-related, and external factors, captures unique aspects of the users' behavioral intention and usage behavior.

The HTMT ratio was particularly effective in achieving higher specificity and sensitivity in identifying potential issues with discriminant validity, serving as a complement to the Fornell–Larcker criterion. This dual approach provided a robust evaluation of the constructs. The results, presented in Tables 4 and 5, indicate that all values fell within the acceptable range, confirming that the constructs were distinct and the model met the required standards for discriminant validity.

Table 4. Discriminant validity: Fornell-Larcker criterion.

	BI	CO	GP	IF	OB	PA	PC	PEOU	PU	RA	SI	TR	UB
BI	0.866												
CO	0.450	0.873											
GP	0.165	0.348	0.848										
IF	0.408	0.331	0.211	0.850									
OB	0.400	0.212	0.201	0.240	0.898								
PA	0.561	0.256	0.431	0.384	0.175	0.870							
PC	0.601	0.781	0.751	0.432	0.321	0.561	0.795						
PEOU	0.510	0.623	0.654	0.825	0.123	0.389	0.667	0.860					

Table 4. *Cont.*

	BI	CO	GP	IF	OB	PA	PC	PEOU	PU	RA	SI	TR	UB
PU	0.437	0.531	0.565	0.653	0.708	0.199	0.811	0.781	0.838				
RA	0.576	0.656	0.640	0.673	0.497	0.727	0.786	0.657	0.560	0.873			
SI	0.448	0.611	0.527	0.446	0.329	0.585	0.752	0.711	0.611	0.711	0.800		
TR	0.491	0.720	0.608	0.698	0.526	0.676	0.575	0.544	0.571	0.723	0.321	0.794	
UB	0.487	0.690	0.681	0.675	0.600	0.657	0.473	0.632	0.452	0.432	0.455	0.541	0.893

Table 5. Discriminant validity: Heterotrait–Monotrait (HTMT) ratio.

	BI	CO	GP	IF	OB	PA	PC	PEOU	PU	RA	SI	TR	UB
BI													
CO	0.486												
GP	0.325	0.410											
IF	0.433	0.381	0.525										
OB	0.558	0.212	0.650	0.643									
PA	0.458	0.233	0.501	0.674	0.402								
PC	0.346	0.322	0.419	0.507	0.465	0.622							
PEOU	0.206	0.513	0.339	0.510	0.576	0.528	0.427						
PU	0.324	0.634	0.416	0.434	0.659	0.685	0.293	0.320					
RA	0.330	0.416	0.245	0.519	0.471	0.334	0.447	0.202	0.411				
SI	0.216	0.459	0.404	0.310	0.376	0.376	0.376	0.476	0.276	0.376			
TR	0.486	0.604	0.521	0.334	0.259	0.359	0.559	0.359	0.359	0.359	0.459		
UB	0.525	0.610	0.406	0.219	0.371	0.471	0.471	0.371	0.471	0.271	0.371	0.341	

4.3. Final SEM Result

The hypothesis testing results, as shown in Table 6, highlight the significant factors influencing the behavioral intention and usage behavior of e-bike users in Metro Manila and NCR. Out of the eighteen hypothesized relationships, fifteen were statistically significant, demonstrating that factors such as relative advantage, compatibility, perceived usefulness, perceived ease of use, observability, infrastructure, social influence, and public awareness positively influence behavioral intention. In turn, behavioral intention strongly predicts usage behavior, with a beta coefficient of 0.653 ($p < 0.001$).

However, three relationships—complexity to perceived usefulness, trialability to perceived ease of use, and government policies to perceived usefulness—were found to be statistically insignificant. These results suggest that while complexity and trialability may not directly influence perceptions of usefulness or ease of use in the Philippine context, factors like relative advantage, compatibility, and social influence play a more critical role. Similarly, the limited impact of government policies on perceived usefulness highlights potential gaps in policy implementation or public awareness about government support for e-bike adoption.

This study's final SEM model, based on the proposed framework for understanding behavioral intention and usage behavior of e-bike users, is presented in Figure 3. Solid lines in the model represent significant positive relationships between constructs. The model explains 65.9% of the variance in usage behavior, demonstrating its robustness in identifying key factors influencing e-bike adoption in Metro Manila and NCR. This highlights the

critical role of constructs such as relative advantage, compatibility, perceived usefulness, perceived ease of use, social influence, public awareness, and behavioral intention in promoting the usage of e-bikes.

Table 6. Hypothesis testing.

No	Relationship	Beta Coefficient	*p*-Value	Result	Significance	Hypothesis
1	RA→PU	0.246	<0.001	Positive	Significant	Do not reject
2	RA→PEOU	0.322	0.001	Positive	Significant	Do not reject
3	CO→PU	−0.109	0.511	Negative	Not Significant	Reject
4	CO→PEOU	−0.188	0.031	Positive	Significant	Do not reject
5	TR→PU	0.221	0.002	Positive	Significant	Do not reject
6	TR→PEOU	0.024	0.241	Positive	Not Significant	Reject
7	OB→PU	0.192	0.041	Positive	Significant	Do not reject
8	OB→PEOU	0.201	0.002	Positive	Significant	Do not reject
9	PC→PU	0.211	0.003	Positive	Significant	Do not reject
10	PC→PEOU	0.302	<0.001	Positive	Significant	Do not reject
11	GP→PU	0.114	0.401	Positive	Not Significant	Reject
12	IF→PEOU	0.225	0.003	Positive	Significant	Do not reject
13	PEOU→PU	0.339	0.001	Positive	Significant	Do not reject
14	PU→BI	0.423	<0.001	Positive	Significant	Do not reject
15	PEOU→BI	0.489	<0.001	Positive	Significant	Do not reject
16	SI→BI	0.272	0.002	Positive	Significant	Do not reject
17	PA→BI	0.244	0.003	Positive	Significant	Do not reject
18	BI→UB	0.653	<0.001	Positive	Significant	Do not reject

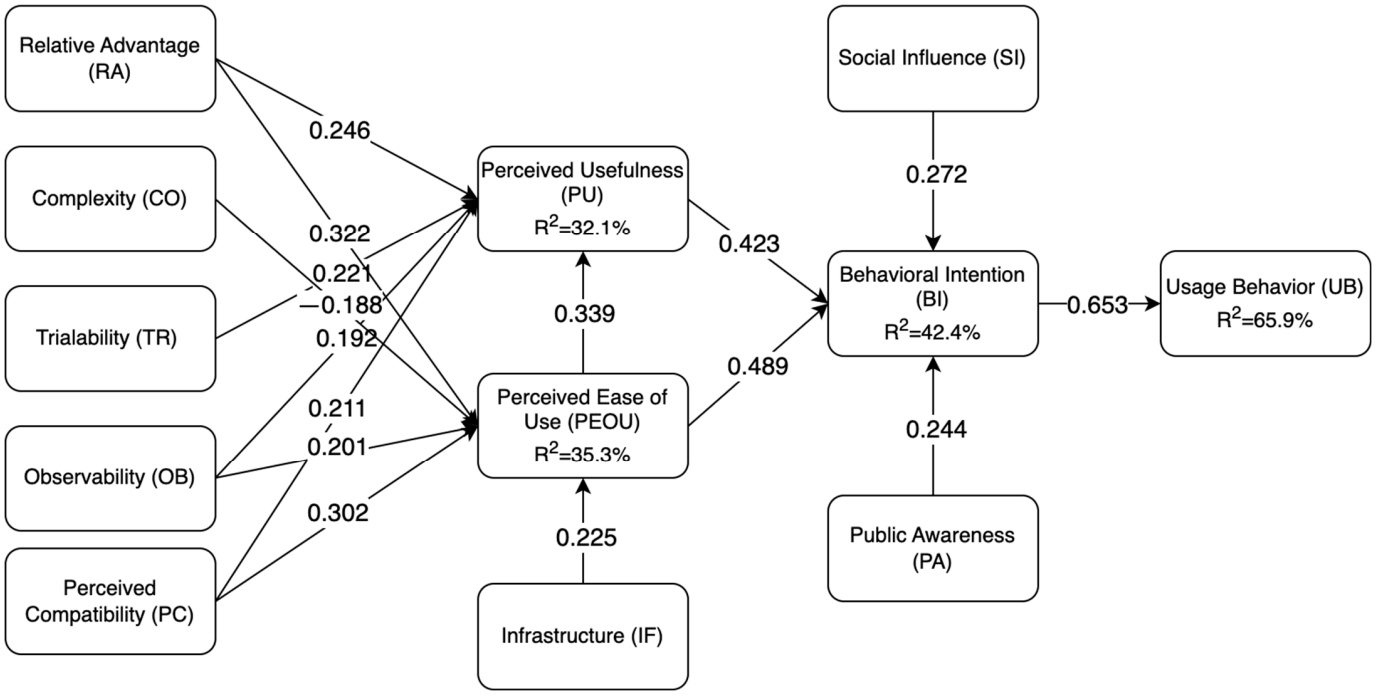


Figure 3. Final SEM framework.

To validate the proposed model, a model fit analysis was conducted using key indices, such as the Standardized Root Mean Square Residual (SRMR), chi-square, and Normed Fit Index (NFI), following established benchmarks from prior research [73]. As presented in Table 7, the results indicate that all parameter estimates meet the minimum thresholds, with SRMR and chi-square/df values within acceptable limits and NFI exceeding the required benchmark. These findings confirm that the model is a valid fit for explaining

the behavioral intention and usage behavior of e-bike users, supporting its applicability in understanding the factors influencing their adoption of e-bikes in Metro Manila and NCR.

Table 7. Model Fit.

Model Fit for SEM	Parameter Estimates	Minimum Cut-Off	Recommended by
SRMR	0.073	<0.08	[73]
(Adjusted) Chi-square/dF	4.24	<5.0	[73]
Normal Fit Index (NFI)	0.912	>0.90	[73]

5. Discussion

This study examined the relationships between constructs derived from the Diffusion of Innovation (DOI) theory, the Technology Acceptance Model (TAM), and external factors influencing the behavioral intention and usage behavior of e-bike users in Metro Manila and NCR. Out of the 18 hypothesized relationships, 15 were found to be statistically significant, while three were insignificant. The findings provide valuable insights into how factors derived from the Diffusion of Innovation (DOI) theory, the Technology Acceptance Model (TAM), and external variables, such as government policies, infrastructure, social influence, and public awareness, shape behavioral intention and usage behavior.

5.1. Relative Adavantage and Perceived Usefulness

First, the relationship between relative advantage and perceived usefulness was found to be significant, with a positive beta coefficient ($\beta = 0.246$, $p < 0.001$). This result highlights the importance of the perceived benefits of e-bikes, such as cost efficiency, environmental sustainability, and convenience, in shaping users' perceptions of their usefulness. Consistent with Taylor's [74] findings, technologies offering clear advantages over existing alternatives are more likely to be perceived as useful. In the Philippine context, where traffic congestion and rising fuel costs are significant challenges, e-bikes provide a practical and sustainable commuting option. Highlighting the tangible benefits of e-bikes, such as savings on transportation costs and reduced travel time, can positively influence adoption. Thus, awareness campaigns and marketing strategies should emphasize these advantages, particularly targeting daily commuters in Metro Manila.

5.2. Relative Advantage and Percceived Ease of Use

The positive influence of relative advantage on perceived ease of use was also confirmed ($\beta = 0.322$, $p = 0.001$). This finding suggests that when users recognize the practical benefits of e-bikes, they are more likely to find them straightforward to operate. Consistent with studies like Wan et al. [75], perceived advantages often reduce the psychological barriers associated with learning new technology. Enhancing perceptions of e-bikes' practical benefits can indirectly make them seem less daunting to use. Thus, test ride programs and demonstrations in public spaces, such as malls and transportation hubs, can help users experience the simplicity and convenience of e-bikes firsthand.

5.3. Complexity and Perceived Usefulness

The relationship between complexity and perceived usefulness was insignificant ($\beta = -0.109$, $p = 0.511$), suggesting that the perceived usefulness of e-bikes is not directly influenced by how complex they are to operate or maintain in the Philippine context. This result highlights a key aspect of Filipino commuters' decision-making priorities which are practical benefits such as cost savings, time efficiency, and environmental contributions outweigh concerns about operational complexity. For instance, even if some users find

e-bikes initially challenging to learn or maintain, their overall utility, such as reducing transportation costs amidst high fuel prices or serving as an eco-friendly alternative in heavily polluted urban areas, remains a compelling factor. This finding aligns with studies indicating that users in resource-constrained settings often prioritize tangible advantages over abstract or operational concerns when adopting new technologies [76,77]. It implies that while complexity may play a role in perceived ease of use, its impact on perceived usefulness is secondary to the benefits that e-bikes can deliver to commuters in Metro Manila and NCR. Thus, manufacturers should continue focusing on user-friendly designs while promoting the cost-effectiveness and sustainability of e-bikes. Also, while continuing to develop user-friendly designs, marketing campaigns should strongly emphasize the economic and environmental benefits of e-bikes, such as lower transportation costs and reduced carbon footprints.

5.4. Complexity and Perceived Ease of Use

The negative relationship between complexity and perceived ease of use was significant ($\beta = -0.188$, $p = 0.031$). As expected, e-bikes perceived as simpler are more likely to be viewed as easy to use, aligning with findings from Davis et al. [8] and Lazard et al. [78]. Similarly, Lee et al. [79] found that simplicity in design and functionality positively influences ease-of-use perceptions, particularly for first-time users. In the Philippine context, where commuters often seek straightforward and practical transportation solutions, reducing the operational complexity of e-bikes is essential for fostering positive user experiences. For example, issues such as unclear operational instructions, difficulty in battery charging, or challenges in basic maintenance could discourage adoption, particularly among less tech-savvy users. To overcome these challenges, manufacturers should provide concise and visually guided manuals in multiple languages, including Filipino, to ensure that users understand how to operate and maintain e-bikes effectively. Also, manufacturers should establish accessible customer support channels, such as hotlines or mobile apps, to address user inquiries and provide immediate assistance for technical issues.

5.5. Trialability and Perceived Usefulness

Trialability was also found to have a significant influence on Perceived Usefulness (PU) ($\beta = 0.221$, $p = 0.002$). This indicates that the ability to try e-bikes reduces uncertainty and helps users better appreciate their benefits. In the Philippine context, trialability can be particularly impactful, as many commuters may be unfamiliar with e-bikes and hesitant to invest in them without fully understanding their potential. Opportunities to test e-bikes can highlight practical advantages, such as cost savings, easier navigation through congested urban areas, and reduced commuting times. This finding aligns with Hayes et al. [30], who emphasize the importance of trialability in technology adoption. In Metro Manila and NCR, where public transportation is often overcrowded and unreliable, introducing trial programs could significantly boost e-bike adoption rates. For instance, a government-supported e-bike sharing system in high-traffic areas like Makati, Ortigas, or Bonifacio Global City could allow commuters to experience e-bikes as a viable transportation alternative. Partnerships with private companies or transportation cooperatives could further scale these programs, ensuring they are both accessible and sustainable for the wider population.

5.6. Trialability and Perceived Ease of Use

The relationship between trialability and perceived ease of use was insignificant ($\beta = 0.024$, $p = 0.241$). This indicates that, in the Philippine context, the opportunity to try e-bikes does not directly affect how users perceive their ease of use. This result may be attributed to two key factors. First, there are limited formal opportunities for e-bike

trials in Metro Manila and NCR, which might dilute the potential impact of trialability on ease-of-use perceptions. Second, e-bikes are generally considered intuitive to operate, similar to traditional bicycles or motorbikes. This inherent simplicity may lead users to form ease-of-use perceptions based on their assumptions or prior experiences, rather than through trial opportunities. This finding aligns with the notion that trialability primarily addresses uncertainty about usefulness rather than ease of use [80]. In Metro Manila and NCR, implementing e-bike sharing systems or test ride stations in public spaces such as parks, malls, or transportation hubs could increase trial opportunities. Pairing these trials with on-site demonstrations or workshops would allow users to gain hands-on experience while addressing potential concerns about ease of use.

5.7. Observability, Perceived Usefulness, and Perceived Ease of Use

This study also found that observability positively influenced both perceived usefulness ($\beta = 0.192$, $p = 0.041$) and perceived ease of use ($\beta = 0.201$, $p = 0.002$), highlighting the significant role visibility plays in e-bike adoption. Observability enhances perceived usefulness by allowing potential users to see the tangible benefits of e-bikes through others' experiences, such as reduced commuting time, cost savings, and environmental contributions. This aligns with Hayes et al.'s [30] findings, which highlight that observable outcomes of an innovation increase its adoption likelihood. In Metro Manila and NCR, where traffic congestion and high transportation costs are prevalent, seeing others successfully use e-bikes as a practical solution reinforces their utility and encourages adoption.

Furthermore, the findings suggest that while e-bikes offer a practical solution for urban mobility, their environmental benefits depend on the energy source used for charging. Currently, the Philippines' energy mix consists of approximately 40–42% renewable energy, with the rest coming from fossil fuels [81]. As the country continues expanding its renewable energy capacity, e-bikes could contribute more significantly to sustainability goals. Policies supporting solar-powered charging stations and green energy incentives for e-mobility users could further enhance adoption.

5.8. Observability and Perceived Ease of Use

Observability also significantly impacts perceived ease of use by reducing psychological and operational barriers. Observing others successfully operate e-bikes creates an impression of simplicity, as it demonstrates that the technology can be navigated easily in real-life scenarios. This finding aligns with McCann et al. [82], who noted that visibility of others' usage builds confidence in potential adopters by providing social proof of the technology's manageability. Thus, marketers of e-bikes should launch awareness campaigns that showcase testimonials and success stories of current e-bike users in Metro Manila and NCR. These stories could highlight specific benefits, such as commuting convenience, cost savings, or environmental impact, to resonate with potential adopters.

5.9. Compatibility, Perceived Usefulness, and Perceived Ease of Use

The positive effects of perceived compatibility on both perceived usefulness ($\beta = 0.211$, $p = 0.003$) and perceived ease of use ($\beta = 0.302$, $p < 0.01$) were significant, highlighting the importance of aligning e-bikes with users' needs and lifestyles. This finding supports the work of Venkatesh and Bala [16], who demonstrated that when technologies fit seamlessly into users' routines, values, and preferences, their perceived utility and usability are enhanced. In the context of Metro Manila and NCR, where commuting challenges include heavy traffic, limited parking, and varying infrastructure conditions, compatibility plays a crucial role in shaping e-bike adoption. E-bikes that accommodate the diverse commuting needs of Filipinos, ranging from short trips in urban areas to moderate travel distances in suburban locations, are more likely to be perceived as useful and easy to use. Thus, in

Metro Manila, urban-specific models could be marketed to office workers and students who navigate crowded areas like Makati, Ortigas, or Bonifacio Global City. In suburban parts of NCR, such as Quezon City or Las Piñas, manufacturers could promote durable models with extended battery ranges to appeal to users with longer commutes. Collaborating with LGUs and transportation cooperatives could also further enhance compatibility by integrating e-bike-friendly infrastructure, such as charging stations or parking spaces.

5.10. Government Policies and Perceived Usefulness

The relationship between government policies and perceived usefulness was found to be insignificant ($\beta = 0.114$, $p = 0.401$), suggesting that existing policies in the Philippines have a limited impact on shaping how users perceive the utility of e-bikes. This finding reflects the relatively sparse implementation of e-bike-specific incentives, such as financial subsidies, tax benefits, or dedicated infrastructure projects. This implies that without strong, visible support from the government, potential adopters may not associate e-bikes with sufficient practical or economic advantages, reducing their influence on perceived usefulness. Thus, in Metro Manila, where traffic congestion and commuting inefficiencies are major challenges, targeted subsidies or financial assistance could make e-bikes a more attractive and affordable alternative for commuters. Infrastructure projects, such as expanding bike lanes along EDSA or building charging stations in busy areas like Makati and Bonifacio Global City, would enhance the visibility and practicality of e-bike adoption.

5.11. Infrastructure and Perceived Ease of Use

The relationship between infrastructure and perceived ease of use was significant ($\beta = 0.35$, $p < 0.001$), emphasizing the crucial role of infrastructure in reducing operational barriers for e-bike users. This finding aligns with Corti et al. [83], who demonstrated that well-developed infrastructure, such as dedicated bike lanes and accessible charging stations, enhances e-bike usability by making them safer, more convenient, and practical for everyday use. In the Philippine context, where urban areas like Metro Manila face persistent challenges such as traffic congestion, inadequate public transportation, and limited space for non-motorized vehicles, infrastructure development is key to improving alternative mobility options. Proper infrastructure not only facilitates easier navigation but also builds confidence among users by ensuring safety and reliability during commutes.

However, the lack of dedicated infrastructure has not only hindered e-bike adoption but has also limited the use of traditional bicycles as a viable commuting option. While bicycles are widely used in European cities with well-integrated cycling networks [84], their adoption in Metro Manila and other Philippine urban centers remains restricted. Unlike cities such as the Netherlands or Denmark, where cycling is deeply embedded in urban planning [85], the absence of bike lanes, extreme heat, high pollution levels, and safety concerns discourage Filipino use for daily transportation. Although some non-electric bike rental services exist, they primarily cater to recreational users rather than commuters. Given these challenges, e-bikes emerge as a more practical alternative, allowing users to travel longer distances with less physical exertion while reducing dependency on fuel-powered transport.

Thus, government initiatives should prioritize developing and extending dedicated bike lanes in key urban areas and ensuring these lanes are safe, well-marked, and properly maintained to encourage regular use. Additionally, incorporating e-bike infrastructure into national development programs, such as the Build, Build, Build initiative or similar projects, would align urban planning efforts with sustainable transportation strategies, making cities more e-bike friendly and improving overall accessibility for commuters.

5.12. Perceived Usefulness and Perceived Ease of Use

This study revealed that perceived usefulness (β = 0.423, $p < 0.001$) and perceived ease of use (β = 0.489, $p < 0.01$) significantly influenced behavioral intention, which in turn strongly predicted usage behavior (β = 0.653, $p < 0.001$). This indicates that the more users perceive e-bikes as beneficial and easy to use, the stronger their intention to adopt them, ultimately leading to consistent usage. Furthermore, external factors such as social influence (β = 0.272, $p = 0.002$) and public awareness (β = 0.244, $p = 0.003$) also played a significant role in shaping behavioral intention. Social proof and increased awareness about e-bikes positively influenced users' willingness to incorporate them into their daily lives. These findings highlight that behavioral intention serves as the key driver of actual e-bike usage. Users with strong intentions, shaped by their perceptions of usefulness, ease of use, and external motivators, are more likely to integrate e-bikes into their commuting routines.

This emphasizes the importance of strategies aimed at enhancing both internal motivators (e.g., usefulness and usability) and external motivators (e.g., societal norms and awareness). Therefore, government and other stakeholders should launch nationwide campaigns focusing on the benefits of e-bikes, such as cost savings, environmental sustainability, and convenience. They could also collaborate with media influencers, community leaders, or public figures to normalize e-bike usage. These individuals can showcase the practical advantages of e-bikes, encouraging their followers to adopt them. Messaging that emphasizes how e-bikes can save time and money, combined with visible infrastructure projects, can effectively drive behavioral intention.

6. Conclusions

This study explored the factors influencing the behavioral intention and usage behavior of e-bikes in Metro Manila and NCR, integrating constructs from the Diffusion of Innovation (DOI) theory, the Technology Acceptance Model (TAM), and external variables. The results revealed that perceived usefulness, perceived ease of use, social influence, and public awareness significantly shaped behavioral intention, which strongly predicted e-bike usage behavior. While most hypothesized relationships were significant, a few, such as the effect of government policies on perceived usefulness and trialability on perceived ease of use, were found to be insignificant, reflecting specific contextual challenges in the Philippine setting. The findings highlight the critical role of behavioral intention as the key driver of e-bike adoption, emphasizing the importance of promoting e-bikes' utility, ease of use, and societal acceptance. This study contributes to the growing body of knowledge on sustainable urban mobility and provides actionable insights for policymakers, manufacturers, and other stakeholders aiming to promote e-bike adoption. While e-bikes present a more energy-efficient alternative to conventional gasoline-powered vehicles, their sustainability impact in the Philippines depends on the country's energy mix, which still relies heavily on fossil fuels. However, their potential to reduce urban congestion, lower emissions, and serve as a viable transport alternative remains significant. Future advancements in renewable energy integration for e-bike charging stations can further enhance their role in sustainable urban mobility. Strengthening government policies, expanding infrastructure, and increasing public awareness are essential to promoting e-bike adoption in the Philippines.

6.1. Theoretic Implications

This study makes several theoretical contributions by integrating the Diffusion of Innovation (DOI) theory and the Technology Acceptance Model (TAM) to develop a comprehensive model for understanding e-bike adoption in a developing country context. The findings support the robustness of these theories in explaining behavioral intention and

usage behavior, while also highlighting the influence of external factors such as government policies, social influence, and public awareness. These results align with existing research on technology adoption but also reveal unique insights specific to the Philippine urban setting:

1. This study confirms that perceived usefulness (PU) and perceived ease of use (PEOU) are strong predictors of behavioral intention, consistent with TAM-based studies on mobility technology [8,9]. Similar results were observed in Yasir et al. [86] and Huang et al. [15], where PU and PEOU significantly shaped e-bike adoption. However, unlike studies [5,87] conducted in regions with more developed infrastructure, the present study found that government policies did not significantly impact perceived usefulness. This suggests that in developing contexts, weak policy implementation and limited infrastructure may dilute the effectiveness of government interventions, a point also highlighted by Shaheen et al. [14] in their study on sustainable transportation adoption.
2. This study highlights the interconnectedness of innovation characteristics, technological perceptions, and external motivators in shaping adoption behavior. While past research often treated TAM and DOI constructs separately [17,40,44,59], this study demonstrates that innovation attributes, such as trialability and observability, directly influence users' perceptions of e-bike usefulness and ease of use. These findings are consistent with Moore and Benbasat [88], who emphasized that trialability enhances perceived utility by reducing uncertainty. However, this study found that trialability did not significantly affect PEOU, contrasting with the findings of Zhang et al. [5], where trialability played a critical role in shaping ease-of-use perceptions. This discrepancy suggests that in the Philippine setting, users may already perceive e-bikes as intuitive, making trialability more relevant to usefulness than usability.
3. The present study provides empirical evidence from the Philippines, a country with distinct urban mobility challenges, offering a culturally and contextually nuanced understanding of e-bike adoption. Unlike research conducted in Western and highly urbanized Asian cities (e.g., China and Japan), where infrastructure and policy support are well-developed, the findings suggest that social influence and public awareness play a more critical role in adoption. This aligns with Ajzen's [87] Theory of Planned Behavior and the work of Taylor and Todd [89], which highlight the importance of peer influence in shaping behavioral intentions in developing economies. This study's insights into infrastructure challenges also align with Pojani and Stead [90], who found that inadequate infrastructure acts as a barrier to sustainable transport adoption in emerging markets.

Overall, this study contributes to the theoretical discourse on e-bike adoption by validating and extending the DOI and TAM models in a developing urban context. It confirms established adoption factors while revealing the limited impact of government policies, the strong role of social and public awareness factors, and the context-specific influence of trialability on perceived usefulness rather than ease of use. Future research should further explore these external influences and examine policy interventions to enhance sustainable transportation adoption in similar settings.

6.2. Practical Implications

This study's findings provide actionable insights for promoting e-bike adoption in Metro Manila and NCR:

1. Investments in bike lanes, charging stations, and secure parking are critical for reducing operational barriers and enhancing ease of use. Local governments should prioritize these projects to create a supportive environment for e-bike users.

2. Public campaigns emphasizing the economic, environmental, and practical benefits of e-bikes are essential to address skepticism and build public interest. Success stories and testimonials from current users should be leveraged to reinforce perceived usefulness.
3. Strengthening government policies, such as subsidies, tax incentives, and financial assistance for e-bike purchases, can enhance their appeal, particularly for low- and middle-income commuters. Visible policy initiatives, such as partnerships with manufacturers and infrastructure improvements, can further reinforce public confidence in e-bikes.
4. Manufacturers should develop e-bike models tailored to the commuting needs of Filipinos. Compact, lightweight designs for urban users and robust, long-range models for suburban areas can cater to diverse requirements.
5. Partnerships with influencers, community leaders, and local organizations can amplify social acceptance of e-bikes, encouraging broader adoption. Public events, e-bike demonstrations, and shared systems integrated into urban transportation hubs can further promote e-bike visibility and usability.

By addressing these practical implications, stakeholders can facilitate the transition toward sustainable urban mobility, ensuring that e-bikes become a viable and widely accepted transportation alternative in the Philippines. This study highlights the need for a collaborative approach involving policymakers, manufacturers, and the public to overcome barriers and maximize the potential of e-bikes in addressing urban transportation challenges.

6.3. Recommendation and Future Studies

This study offers valuable insights into the factors influencing e-bike adoption in Metro Manila and NCR, but several limitations should be noted:

1. The findings are specific to Metro Manila and NCR and may not apply to rural or semi-urban areas with different commuting patterns and conditions.
2. This study's cross-sectional design only captures data at one point in time, limiting its ability to track changes in perceptions and behavior over time.
3. Self-reported survey responses may be influenced by social desirability bias, where respondents provide favorable answers rather than their true experiences.
4. While this study included external variables like government policies and infrastructure, other factors such as cultural norms, environmental awareness, and technological advancements were not explored.
5. This study did not consider the long-term adoption and sustained use of e-bikes, which could evolve due to future challenges or changing circumstances.

Future research should address these limitations by broadening the scope to include rural and semi-urban areas for a more comprehensive understanding of e-bike adoption in the Philippines. Longitudinal studies could track changes over time, offering insights into the long-term effects of improved infrastructure, policies, and societal attitudes. Adding variables like cultural and environmental factors or technological advancements could enrich the analysis. Mixed methods, combining surveys with interviews or focus groups, could provide deeper insights into users' motivations and barriers. By addressing these areas, future studies can provide more detailed and actionable insights, helping promote e-bike adoption and support sustainable urban mobility solutions in the Philippines and other developing countries.

Funding: This research received no external funding.

Institutional Review Board Statement: This study was approved by the School of Industrial Engineering and Engineering Management Mapua University Research Ethics Committees (FM-RC-22-98 and approval date: 12 February 2023).

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Alvaira, W.; Bello, E.; Cueva, L.; Daguman, H.; Del Rosario, N.; Jayona, A.; Perante-Calina, L. MetroPolice: An Analysis of Metro Manila's Impediments From and Progress Towards Sustainable Urban Development. Master's Thesis, University of the Philippines Diliman, Quezon, Philippines, 25 May 2022.
2. Gaspar, R.M.; Prasetyo, Y.T.; Mariñas, K.A.; Persada, S.F.; Nadlifatin, R. Exploring Consumers' Intention to Use Bikes and E-Scooters during the COVID-19 Pandemic in the Philippines: An Extended Theory of Planned Behavior Approach with a Consideration of Pro-Environmental Identity. *Sustainability* **2023**, *15*, 5193. [CrossRef]
3. Machedon-Pisu, M.; Borza, P.N. Are personal electric vehicles sustainable? A hybrid E-bike case study. *Sustainability* **2019**, *12*, 32. [CrossRef]
4. Saculsan, P.G.; Mori, A. Why developing countries go through an unsustainable energy transition pathway? The case of the Philippines from a political economic perspective. *J. Sustain. Res.* **2020**, *2*, e200012.
5. Zhang, X.; Lim, E.S.; Chen, M. Promoting Sustainable Urban Mobility: Factors Influencing E-Bike Adoption in Henan Province, China. *Sustainability* **2024**, *16*, 10136. [CrossRef]
6. Chonsalasin, D.; Champahom, T.; Jomnonkwao, S.; Karoonsoontawong, A.; Runkawee, N.; Ratanavaraha, V. Exploring the influence of Thai government policy perceptions on electric vehicle adoption: A measurement model and empirical analysis. *Smart Cities* **2024**, *7*, 2258–2282. [CrossRef]
7. Ravishankar, K.; Subramani, A.K.; Akbar Jan, N.; Ramkumar, C. Examining the Factors Influencing the Intention to Use Electric Bikes by Young Adults: Using Extended Theory of Planned Behavior Model. *Asian J. Bus. Res.* **2023**, *13*, 65–85. [CrossRef]
8. Davis, F.D.; Bagozzi, R.P.; Warshaw, P.R. Technology acceptance model. *J. Manag. Sci.* **1989**, *35*, 982–1003.
9. Rogers, E.M. The diffusion of innovations perspective. In *Taking Care: Understanding and Encouraging Self-Protective Behavior*; Cambridge University Press: Cambridge, UK, 1987; pp. 79–94.
10. Houghton, L.; Kerr, D. Diffusion of innovation theory and the problem of context for inter-organizational information systems: The example of feral information systems. In *Inter-Organizational Information Systems and Business Management: Theories for Researchers*; IGI Global: Hershey, PA, USA, 2012; pp. 209–221.
11. Carter, P.E.; Thatcher, J.B.; Chudoba, K.M.; Marett, K. Post-acceptance intentions and behaviors: An empirical investigation of information technology use and innovation. *J. Organ. End User Comput. (JOEUC)* **2012**, *24*, 1–20. [CrossRef]
12. Soon, K.W.K.; Lee, C.A.; Boursier, P. A study of the determinants affecting adoption of big data using integrated Technology Acceptance Model (TAM) and diffusion of innovation (DOI) in Malaysia. *Int. J. Appl. Bus. Econ. Res.* **2016**, *14*, 17–47.
13. Min, S.; So, K.K.F.; Jeong, M. Consumer adoption of the Uber mobile application: Insights from diffusion of innovation theory and technology acceptance model. In *Future of Tourism Marketing*; Routledge: London, UK, 2021; pp. 2–15.
14. Shaheen, S.; Martin, E.; Cohen, A. Public bikesharing and modal shift behavior: A comparative study of early bikesharing systems in North America. *Int. J. Transp.* **2013**, *1*, 35–54. [CrossRef]
15. Huang, G.; Zhang, W.; Xu, D. How do technology-enabled bike-sharing services improve urban air pollution? Empirical evidence from China. *J. Clean. Prod.* **2022**, *379*, 134771. [CrossRef]
16. Venkatesh, V.; Bala, H. Technology acceptance model 3 and a research agenda on interventions. *Decis. Sci.* **2008**, *39*, 273–315. [CrossRef]
17. Wu, B.; Chen, X. Continuance intention to use MOOCs: Integrating the technology acceptance model (TAM) and task technology fit (TTF) model. *Comput. Hum. Behav.* **2017**, *67*, 221–232. [CrossRef]
18. Greenhalgh, T.; Robert, G.; Macfarlane, F.; Bate, P.; Kyriakidou, O.; Peacock, R. Storylines of research in diffusion of innovation: A meta-narrative approach to systematic review. *Soc. Sci. Med.* **2005**, *61*, 417–430. [CrossRef] [PubMed]
19. Yunior, M.C.; Augustine, Y. The Influence of Social Influence, Relative Advantage, User Satisfaction on Cloud-Based E-Learning with Behavioral Intention as a Mediating Variable. *Technium Soc. Sci. J.* **2024**, *56*, 36.
20. Rexfelt, O.; Hiort af Ornäs, V. Consumer acceptance of product-service systems: Designing for relative advantages and uncertainty reductions. *J. Manuf. Technol. Manag.* **2009**, *20*, 674–699. [CrossRef]
21. Bhattacherjee, A.; Limayem, M.; Cheung, C.M. User switching of information technology: A theoretical synthesis and empirical test. *Inf. Manag.* **2012**, *49*, 327–333. [CrossRef]
22. Bandara, U.C.; Amarasena, T.S.M. Impact of relative advantage, perceived behavioural control and perceived ease of use on intention to adopt with solar energy technology in Sri Lanka. In Proceedings of the 2018 International Conference and Utility

Exhibition on Green Energy for Sustainable Development (ICUE), Phuket, Thailand, 24–26 October 2018; IEEE: Piscataway, NJ, USA, 2018; pp. 1–9.
23. Lai, P.C. The literature review of technology adoption models and theories for the novelty technology. *JISTEM-J. Inf. Syst. Technol. Manag.* **2017**, *14*, 21–38. [CrossRef]
24. Sun, J. Why different people prefer different systems for different tasks: An activity perspective on technology adoption in a dynamic user environment. *J. Am. Soc. Inf. Sci. Technol.* **2012**, *63*, 48–63. [CrossRef]
25. Jashapara, A.; Tai, W.C. Understanding the complexity of human characteristics on e-learning systems: An integrated study of dynamic individual differences on user perceptions of ease of use. *Knowl. Manag. Res. Pract.* **2006**, *4*, 227–239. [CrossRef]
26. Almahamid, S.O.U.D.; Mcadams, A.C.; Al Kalaldeh, T.A.H.E.R.; MO'TAZ, A.S.E. The relationship between perceived usefulness, perceived ease of use, perceived information quality, and intention to use e-government. *J. Theor. Appl. Inf. Technol.* **2010**, *11*, 30–44.
27. Bakı, R.; Bırgoren, B.; Aktepe, A. A meta analysis of factors affecting perceived usefulness and perceived ease of use in the adoption of e-learning systems. *Turk. Online J. Distance Educ.* **2018**, *19*, 4–42.
28. Changchun, G.; Haider, M.J.; Akram, T. Investigation of the effects of task technology fit, attitude and trust on intention to adopt mobile banking: Placing the mediating role of trialability. *Int. Bus. Res.* **2017**, *10*, 77–91. [CrossRef]
29. Banerjee, P.; Wei, K.K.; Ma, L. Role of trialability in B2B e-business adoption: Theoretical insights from two case studies. *Behav. Inf. Technol.* **2012**, *31*, 815–827. [CrossRef]
30. Hayes, K.J.; Eljiz, K.; Dadich, A.; Fitzgerald, J.A.; Sloan, T. Trialability, observability and risk reduction accelerating individual innovation adoption decisions. *J. Health Organ. Manag.* **2015**, *29*, 271–294. [CrossRef]
31. Liu, S.; Wang, L. User liaisons' perspective on behavior and outcome control in IT projects: Role of IT experience, behavior observability, and outcome measurability. *Manag. Decis.* **2014**, *52*, 1148–1173. [CrossRef]
32. Lee, K.; Sener, I.N. E-bikes toward inclusive mobility: A literature review of perceptions, concerns, and barriers. *Transp. Res. Interdiscip. Perspect.* **2023**, *22*, 100940.
33. Ismail, H.A. Intention to use smartphone through perceived compatibility, perceived usefulness, and perceived ease of use. *JDM (J. Din. Manaj.)* **2016**, *7*, 1–10. [CrossRef]
34. Faqih, K.M. The influence OF perceived usefulness, social influence, internet self-efficacy and compatibility ON USERS'INTENTIONS to adopt e-learning: Investigating the moderating effects OF culture. *IJAEDU-Int. E-J. Adv. Educ.* **2020**, *5*, 300–320. [CrossRef]
35. Sitinjak, C.; Simic, V.; Babaee Tirkolaee, E.; Bacanin, N.; Simanullang, W.F.; Fajar, R. Uncovering pathways towards sustainable transportation: Investigating factors influencing societal acceptance of end-of-life vehicle management in Indonesia. *Waste Manag. Res.* 2024; *Epub ahead of print*. [CrossRef] [PubMed]
36. Gumasing, M.J.J.; Prasetyo, Y.T.; Ong, A.K.S.; Persada, S.F.; Nadlifatin, R. Analyzing the service quality of E-Trike Operations: A new sustainable transportation infrastructure in Metro Manila, Philippines. *Infrastructures* **2022**, *7*, 69. [CrossRef]
37. Karpurapu, S.; Saikumar, K.; Kocharla, L.; Rao, P.S.; Govathoti, S. Scalable Innovative Factors for Shaping Consumer Intentions on Electric Two-Wheelers Adoptions. *Scalable Comput. Pract. Exp.* **2024**, *25*, 4507–4517. [CrossRef]
38. Trung, N.T.; Urmee, T. Electrifying Vietnam's streets: Identifying the determinants of electric two-wheelers uptake. *Transp. Res. Part D Transp. Environ.* **2024**, *129*, 104116. [CrossRef]
39. Jaiswal, D.; Kaushal, V.; Kant, R.; Singh, P.K. Consumer adoption intention for electric vehicles: Insights and evidence from Indian sustainable transportation. *Technol. Forecast. Soc. Chang.* **2021**, *173*, 121089. [CrossRef]
40. Bokolo, A.J. Examining the adoption of sustainable eMobility-sharing in smart communities: Diffusion of innovation theory perspective. *Smart Cities* **2023**, *6*, 2057–2080. [CrossRef]
41. Zuev, D.; Zuev, D. Introduction: Towards an understanding of e-bike mobility in China. In *Urban Mobility in Modern China*; Springer Nature: Berlin/Heidelberg, Germany, 2018; pp. 1–13.
42. Zabiulla, M.; Sahu, P.K.; Bandhu Majumdar, B. Exploring the factors influencing electric bicycle adoption: A survey among future adopters in India. *Transp. Res. Rec.* **2024**, *2678*, 03611981231220565. [CrossRef]
43. Al-Adwan, A.S. Investigating the drivers and barriers to MOOCs adoption: The perspective of TAM. *Educ. Inf. Technol.* **2020**, *25*, 5771–5795. [CrossRef]
44. Kalayou, M.H.; Endehabtu, B.F.; Tilahun, B. The applicability of the modified technology acceptance model (TAM) on the sustainable adoption of eHealth systems in resource-limited settings. *J. Multidiscip. Healthc.* **2020**, *13*, 1827–1837. [CrossRef]
45. Gumasing, M.J.J.; Ramos, E.D.R.; Corpuz, J.N.C.; Ofianga, A.J.B.; Palad, J.M.R.; Urbina, L.G.B.; Mascariola, M.M.; Ong, A.K.S. Factors Influencing the Adoption of Electric Jeepneys: A Philippine Perspective. *World Electr. Veh. J.* **2024**, *15*, 284. [CrossRef]
46. Kapousizis, G.; Sarker, R.; Ulak, M.B.; Geurs, K. User acceptance of smart e-bikes: What are the influential factors? A cross-country comparison of five European countries. *Transp. Res. Part A Policy Pract.* **2024**, *185*, 104106. [CrossRef]

47. Gumasing, M.J.J.; Ong, A.K.S.; Sy, M.A.P.C.; Prasetyo, Y.T.; Persada, S.F. A machine learning ensemble approach to predicting factors affecting the intention and usage behavior towards online groceries applications in the Philippines. *Heliyon* **2023**, *9*, e20644. [CrossRef] [PubMed]
48. Gumasing, M.J.J.; Carrillo, G.Z.D.V.; Guzman, D.M.A.A.; Suñga, C.A.R.; Tan, S.Y.B.; Mascariolam, M.M.; Ongm, A.K.S. Investigating user-centric factors influencing smartwatch adoption and user experience in the Philippines. *Sustainability* **2024**, *16*, 5401. [CrossRef]
49. Gumasing, M.J.J.; Niro, R.H.A. Antecedents of real estate investment intention among Filipino Millennials and Gen Z: An extended theory of planned behavior. *Sustainability* **2023**, *15*, 13714. [CrossRef]
50. D'Acunto, D. *The Future of E-Mobility*; Springer Nature: Berlin/Heidelberg, Germany, 2024.
51. Popov, A.I.; Ravi, Y. Conceptualization of Service Loyalty in Access-Based Services in Micromobility: A Case of e-Scooter Sharing Services. Master's Thesis, Linköping University, Linköping, Sweden, 2020.
52. Jaiswal, D.; Kant, R.; Singh, P.K.; Yadav, R. Investigating the role of electric vehicle knowledge in consumer adoption: Evidence from an emerging market. *Benchmarking Int. J.* **2022**, *29*, 1027–1045. [CrossRef]
53. Sharma, H.; Kovid, R.K.; Tewari, A.; Singh, T.P.; Choudhury, T. Would ecological and technological consciousness shape e-vehicle purchase intentions? Insights from an emerging market. *Socio-Ecol. Pract. Res.* **2024**, *6*, 55–67. [CrossRef]
54. Li, R.; Krishna Sinniah, G.; Li, X. The factors influencing resident's intentions on e-bike sharing usage in China. *Sustainability* **2022**, *14*, 5013. [CrossRef]
55. Zhou, M.; Long, P.; Kong, N.; Zhao, L.; Jia, F.; Campy, K.S. Characterizing the motivational mechanism behind taxi driver's adoption of electric vehicles for living: Insights from China. *Transp. Res. Part A Policy Pract.* **2021**, *144*, 134–152. [CrossRef]
56. Hussain, S.; Fangwei, Z.; Siddiqi, A.F.; Ali, Z.; Shabbir, M.S. Structural equation model for evaluating factors affecting quality of social infrastructure projects. *Sustainability* **2018**, *10*, 1415. [CrossRef]
57. Celik, I.; Sahin, I.; Aydin, M. Reliability and Validity Study of the Mobile Learning Adoption Scale Developed Based on the Diffusion of Innovations Theory. *Online Submiss.* **2014**, *2*, 300–316. [CrossRef]
58. McConnell, E.S.; Corazzini, K.N.; Lekan, D.; Bailey, D.E.; Sloane, R.; Landerman, L.R.; Champagne, M.T. Diffusion of innovations in long-term care measurement battery. *Res. Gerontol. Nurs.* **2012**, *5*, 64–76. [CrossRef]
59. Nehme, E.K.; Perez, A.; Ranjit, N.; Amick, B.C., III; Kohl, H.W., III. Behavioral theory and transportation cycling research: Application of Diffusion of Innovations. *J. Transp. Health* **2016**, *3*, 346–356. [CrossRef]
60. Papadomichelaki, X.; Mentzas, G. e-GovQual: A multiple-item scale for assessing e-government service quality. *Gov. Inf. Q.* **2012**, *29*, 98–109. [CrossRef]
61. Hoque, A.S.M.M. Does government support policy moderate the relationship between entrepreneurial orientation and Bangladeshi SME performance? A SEM approach. *Int. J. Bus. Econ. Manag. Stud.* **2018**, *6*, 37–59.
62. Hess, T.J.; McNab, A.L.; Basoglu, K.A. Reliability generalization of perceived ease of use, perceived usefulness, and behavioral intentions. *MIS Q.* **2014**, *38*, 1–28. [CrossRef]
63. Alsabawy, A.Y.; Cater-Steel, A.; Soar, J. Determinants of perceived usefulness of e-learning systems. *Comput. Hum. Behav.* **2016**, *64*, 843–858. [CrossRef]
64. Kulviwat, S.; Bruner, G.C., II; Al-Shuridah, O. The role of social influence on adoption of high tech innovations: The moderating effect of public/private consumption. *J. Bus. Res.* **2009**, *62*, 706–712. [CrossRef]
65. Sohail, M.T. A PLS-SEM approach to determine farmers' awareness about climate change mitigation and adaptation strategies: Pathway toward sustainable environment and agricultural productivity. *Environ. Sci. Pollut. Res.* **2023**, *30*, 18199–18212. [CrossRef] [PubMed]
66. Chen, W.; Shi, Y.; Fan, L.; Huang, L.; Gao, J. Influencing factors of public satisfaction with covid-19 prevention services based on structural equation modeling (Sem): A study of Nanjing, China. *Int. J. Environ. Res. Public Health* **2021**, *18*, 13281. [CrossRef]
67. Hair, J.F., Jr.; Matthews, L.M.; Matthews, R.L.; Sarstedt, M. PLS-SEM or CB-SEM: Updated guidelines on which method to use. *Int. J. Multivar. Data Anal.* **2017**, *1*, 107–123. [CrossRef]
68. Ahmad, R.; ul Haq, A. Quantifying the Impact of Measurement Errors in Consistent Linear Partial Least Squares Structural Equation Modelling: A Monte Carlo Investigation. *Irasd J. Econ.* **2023**, *5*, 905–923. [CrossRef]
69. Cheung, G.W.; Cooper-Thomas, H.D.; Lau, R.S.; Wang, L.C. Reporting reliability, convergent and discriminant validity with structural equation modeling: A review and best-practice recommendations. *Asia Pac. J. Manag.* **2024**, *41*, 745–783. [CrossRef]
70. Haji-Othman, Y.; Yusuff, M.S.S. Assessing reliability and validity of attitude construct using partial least squares structural equation modeling. *Int. J. Acad. Res. Bus. Soc. Sci.* **2022**, *12*, 378–385. [CrossRef] [PubMed]
71. Henseler, J.; Ringle, C.M.; Sarstedt, M. A new criterion for assessing discriminant validity in variance-based structural equation modeling. *J. Acad. Mark. Sci.* **2015**, *43*, 115–135. [CrossRef]
72. Lim, W.M. A typology of validity: Content, face, convergent, discriminant, nomological and predictive validity. *J. Trade Sci.* **2024**, *12*, 155–179. [CrossRef]

73. Sathyanarayana, S.; Mohanasundaram, T. Fit indices in structural equation modeling and confirmatory factor analysis: Reporting guidelines. *Asian J. Econ. Bus. Account.* **2024**, *24*, 561–577.
74. Taylor, A. The next generation: Technology adoption and integration through internal competition in new product development. *Organ. Sci.* **2010**, *21*, 23–41. [CrossRef]
75. Wan, Z.; Wang, Y.; Haggerty, N. Why people benefit from e-learning differently: The effects of psychological processes on e-learning outcomes. *Inf. Manag.* **2008**, *45*, 513–521. [CrossRef]
76. Rose, E.J. Investigating Resource-Constrained Populations: Developing Design Approaches to Support Agency and Reciprocity. Ph.D. Thesis, University of Washington, Seattle, WA, USA, 2011.
77. Hook, K.; Ametaj, A.; Cheng, Y.; Serba, E.G.; Henderson, D.C.; Hanlon, C.; Ng, L.C. Psychotherapy in a resource-constrained setting: Understanding context for adapting and integrating a brief psychological intervention into primary care. *Psychotherapy* **2021**, *58*, 557. [CrossRef] [PubMed]
78. Lazard, A.J.; Watkins, I.; Mackert, M.S.; Xie, B.; Stephens, K.K.; Shalev, H. Design simplicity influences patient portal use: The role of aesthetic evaluations for technology acceptance. *J. Am. Med. Inform. Assoc.* **2016**, *23*, e157–e161. [CrossRef]
79. Lee, J.; Lee, D.; Moon, J.; Park, M.C. Factors affecting the perceived usability of the mobile web portal services: Comparing simplicity with consistency. *Inf. Technol. Manag.* **2013**, *14*, 43–57. [CrossRef]
80. Oluyinka, S.; Cusipag, M. Trialability and purposefulness: Their role towards Google classroom acceptance following educational policy. *Acta Inform. Pragensia* **2021**, *10*, 172–191. [CrossRef]
81. Republic Act No. 9513: Department of Energy Philippines. Republic Act No. 9513 | Department of Energy Philippines. (n.d.). Available online: https://doe.gov.ph/sites/default/files/pdf/issuances/20081216-ra-09513-gma.pdf (accessed on 23 January 2025).
82. McCann, L.; Gedikoglu, H.; Broz, B.; Lory, J.; Massey, R. Effects of observability and complexity on farmers' adoption of environmental practices. *J. Environ. Plan. Manag.* **2015**, *58*, 1346–1362. [CrossRef]
83. Corti, F.; Iacono, S.D.; Astolfi, D.; Pasetti, M.; Vasile, A.; Reatti, A.; Flammini, A. A comprehensive review of charging infrastructure for Electric Micromobility Vehicles: Technologies and challenges. *Energy Rep.* **2024**, *12*, 545–567. [CrossRef]
84. Reggiani, G.; Salomons, A.M.; Sterk, M.; Yuan, Y.; O'Hern, S.; Daamen, W.; Hoogendoorn, S. Bicycle network needs, solutions, and data collection systems: A theoretical framework and case studies. *Case Stud. Transp. Policy* **2022**, *10*, 927–939. [CrossRef]
85. Pucher, J.; Buehler, R. Making cycling irresistible: Lessons from the Netherlands, Denmark and Germany. *Transp. Rev.* **2008**, *28*, 495–528. [CrossRef]
86. Yasir, A.; Hu, X.; Ahmad, M.; Alvarado, R.; Anser, M.K.; Işık, C.; Choo, A.; Ausaf, A.; Khan, I.A. Factors affecting electric bike adoption: Seeking an energy-efficient solution for the post-COVID era. *Front. Energy Res.* **2022**, *9*, 817107. [CrossRef]
87. Ajzen, I. The theory of planned behavior: Frequently asked questions. *Hum. Behav. Emerg. Technol.* **2020**, *2*, 314–324. [CrossRef]
88. Moore, G.C.; Benbasat, I. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Inf. Syst. Res.* **1991**, *2*, 192–222. [CrossRef]
89. Taylor, S.; Todd, P.A. Understanding information technology usage: A test of competing models. *Inf. Syst. Res.* **1995**, *6*, 144–176. [CrossRef]
90. Pojani, D.; Stead, D. Sustainable urban transport in the developing world: Beyond megacities. *Sustainability* **2015**, *7*, 7784–7805. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.