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Research Article

Autonomous Bus Service Utilization Intention Through the Sustainability Theory of Planned Behavior Model and Valence Framework

Ma. Micaella Kyle M. Dayao[1,2], Daniela Eleanor C. Estacio[1,2], Mary Joyce Nicole L. Manalo[1,2], Ardvin Kester S. Ong[1,2*], Cesar Romeo V. Delos Reyes[3], John Xavier S. Chavez[4]

[1] School of Industrial Engineering and Engineering Management, Mapúa University, 658 Muralla St., Intramuros, Manila 1002, Philippines
[2] Institute for Digital Learning, Mapúa University, 658 Muralla St., Intramuros, Manila 1002, Philippines
[3] School of Foundational Studies and Education, Mapúa University, 658 Muralla St., Intramuros, Manila 1002, Philippines
[4] E. T. Yuchengco School of Business, Mapúa University, Pablo Ocampo Sr., Makati 1204, Philippines
E-mail: aksong@mapua.edu.ph

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Abstract: The emergence of autonomous bus services presents a transformative solution for addressing urban or rural transportation challenges, particularly in developing countries such as the Philippines. There needs to be an evaluation before full deployment for assessment of technology acceptance, people's perception, and people's pro-environmental behavior on actual use of autonomous buses. This study sought to evaluate public utilization intention of autonomous buses by integrating the Sustainability Theory of Planned Behavior with the Valence Framework. The research approach encompassed factors such as Perceived Behavioral Control (PBC), attitude, perceived environmental concerns, economic concerns, perceived authority support, Perceived Costs (PC), Perceived Benefits (PB), and Perceived Risks (PR) to evaluate their impact on Behavioral Intention (BI). A total of 424 responses were collected through online platforms and analyzed using Structural Equation Modeling (SEM). The results indicated that PBC and PB had the most substantial positive impact on BI, followed by notable effects from environmental concern and perceived authority. In contrast, PR showed no influence, suggesting that users are primarily motivated by perceived benefits and control over usage. Unexpectedly, PC was significant even though it was initially assumed to act as a barrier. This outcome may reflect a distinctive feature of the local context. In this sense, cost may be interpreted not as a burden, but as an indicator of quality or status, something that people are willing to pay for. These findings underscored the importance of sustainability values and fill the gaps in rational evaluation in shaping public acceptance of autonomous vehicles. Further implications of management, theoretical basis, and conceptualization were explained.

***Keywords*:** autonomous bus, commuter behavior, public transportation, sustainability theory of planned behavior, valence framework

MSC: 62H12, 62P15, 91B42, 97C20

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1. Introduction

Autonomous Vehicle (AV) technology is steadily reshaping urban transportation. Autonomous bus services are showing strong potential as a solution to long-standing issues such as traffic congestion, air pollution, road safety concerns, and limited access to reliable transit [1]. In line with improving how transportation systems function, autonomous buses also support broader sustainability goals by providing a cleaner and more inclusive alternative than traditional public transit. Autonomous bus services present a promising solution to address these issues and improve the overall travel experience. However, the success of this innovation will largely depend on gaining the trust, confidence, and acceptance of commuters—many of whom may have reservations regarding safety, reliability, and the practical benefits of the technology [2].

Across various parts of the world, autonomous public transport systems are starting to transition from pilot testing to real-world implementation. Over 35 cities have introduced pilot programs or operational services, indicating increasing progress in integrating self-driving buses into everyday transportation [3]. China has made significant advancements, deploying hundreds of electric autonomous buses backed by Artificial Intelligence (AI) and 5G technology [4]. In Southeast Asia, Singapore has taken the lead with a full-scale pilot launched in 2021 and plans for further expansion [3, 5]. The United States has also made substantial investments in autonomous vehicle transit projects, demonstrating strong government support [6, 7]. It is seen that many of these initiatives are closely linked to environmental objectives, relying on electric-powered vehicles to lower emissions and promote sustainable urban mobility [8].

Meanwhile, the Philippines is still in the early phases of transitioning toward autonomous transport. However, the adoption of autonomous technology remains minimal [9]. Nonetheless, the country is actively pursuing transport modernization mainly through the deployment of electric buses and jeepneys. This is because in the Philippines, persistent problems such as overcrowded public transportation, inefficient traffic management, and limited availability of reliable transit options continue to impact daily commuting [10]. Complementing, national policy directions such as the Philippine Development Plan 2023–2028 emphasize the modernization of the transport sector and the integration of intelligent and sustainable mobility technologies, including electric and potentially autonomous vehicles [11]. In line with this, the Public Transportation Modernization Program of the Department of Transportation seeks to reorganize routes and modernize public utility vehicles, reinforcing the shift toward efficiency, safety, and sustainability [12]. An important development occurred in September 2024 with the launch of the Philippines' first autonomous bus pilot in New Clark City, in collaboration with Japan-based Zenmov Inc. The service operates within designated zones, providing last-mile connectivity through a cloud-based traffic management system [13, 14]. Despite these advancements, wider adoption still encounters significant challenges. These include inadequate infrastructure, high upfront costs, low public awareness of AVs and e-buses, and a lack of well-defined local policies and regulations [6, 15]. Compared to other countries, the Philippines remains behind in both preparedness and adoption of autonomous vehicles. This emphasizes the importance of addressing technical, social, and regulatory challenges to fully realize the potential of autonomous public transportation [16]. This transition is supported by the national government through Republic Act No. 11697, or the Electric Vehicle Industry Development Act (EVIDA), which promotes the manufacture, importation, and adoption of electric vehicles for public transport [17]. Complementing this, the Department of Energy's (DOE) Comprehensive Roadmap for the Electric Vehicle Industry sets clear targets for charging infrastructure and fleet integration across urban areas [18]. Collectively, these initiatives demonstrate the country's proactive commitment to advancing electrified mobility systems that can serve as a foundation for future autonomous transport technologies.

Despite growing technological readiness, the widespread adoption of autonomous buses hinges still on the public's willingness to use them. That is why previous research has only assessed technical challenges, safety perceptions, and general attitudes. Moreover, they have frequently overlooked sustainability-related motivations and value-based assessments [19]. Only a few studies integrate comprehensive behavioral models that explore how psychological, social, and contextual factors interact to shape acceptance, especially in developing countries [20]. Understanding these factors is important for the successful integration of autonomous bus services. Identifying the factors that encourage or hinder individuals from accepting such innovations is critical. Without such insight, initiatives to implement these technologies

may encounter substantial public resistance, ultimately delaying the transition toward a more efficient, sustainable, and commuter-friendly transportation system in the Philippines [9, 21].

Previous research on AV adoption, particularly within public transportation, has offered insights into the factors that influence commuter acceptance. Attention has often centered on technical aspects such as system reliability and safety, along with user perceptions of usefulness and ease of use [22]. A significant portion of this research has been carried out in developed countries, where the focus is placed on trust in automation and the efficiency of operations [23–25]. In developing regions, research tends to focus more on electric vehicles, with limited exploration into autonomous public transport specifically [26]. While some studies address legal concerns and public confidence, the majority emphasize technical feasibility rather than exploring deeper psychological and social dimensions [20, 27].

However, a gap still exists in understanding how concerns about sustainability and values impact user intention and utilization. User decisions are influenced not only by functionality and safety but also by their awareness of environmental impact, economic feasibility, and potential social advantages or disadvantages [2, 27]. Behavioral models used in this field often overlook the combined effects of psychological, social, and contextual factors, as well as sustainability and pro-environmental behavior particularly in developing countries such as the Philippines. Moreover, there is limited understanding of the factors that drive individuals to move from merely intending to use autonomous public transport to consistently using it in practice [28, 29].

To address these gaps, the present study utilized an extended version of the Theory of Planned Behavior (TPB), referred to as the Sustainability Theory of Planned Behavior (STPB) from Ong et al. [30]. This model preserves the core TPB components: attitude, subjective norm, and perceived behavioral control, while incorporating additional sustainability-related dimensions such as perceived environmental concern, perceived economic concern, and perceived authority support [30, 31]. To enhance the analysis, the model incorporated the Valence Framework which examines evaluative perceptions such as the perception on cost, risk, benefits, and ubiquity, representing the positive and negative values that individuals associate with using autonomous technology like AV buses [32].

This study aims to analyze the factors influencing behavioral intentions of autonomous bus services in the Philippines. Specifically, it focused on how external influences such as sustainability awareness, economic practicality, and governmental support shape public utilization intention. By applying the STPB and Valence Framework, the study presents a holistic approach that bridges behavioral intention theory with sustainability and value-based evaluation, addressing a gap in current literature, especially within the context of developing countries like the Philippines [30, 32]. With the current study, several research questions were formulated to guide the overall study.

1. What drives the behavioral intention for utilization of autonomous buse services in the Philippines?
2. What sustainability factors influenced people's behavior?
3. How do the perception variables affect commuter's behavioral intention?
4. What theoretical contributions could be made from the integrated framework?
5. What practical implications could be made from the results of the study?

Academically, this study contributes to expanding theoretical understanding of technology adoption in public transport [16]. Practically, it offers actionable insights for policymakers, transportation authorities, and technology developers in designing effective, inclusive, and user-centered AV systems. Societally, this research supports the broader shift toward a more sustainable and accessible public transportation landscape through survey-based quantitative analysis [33]. In doing so, it directly advances several United Nations Sustainable Development Goals (SDG), most notably SDG 11: Sustainable Cities and Communities, by promoting safe and accessible transport; SDG 13: Climate Action, by encouraging the shift to low-emission mobility; and SDG 9: Industry, Innovation, and Infrastructure, by supporting the development of resilient and future-ready transport systems. As the Philippines continues to improve its urban transportation, this study provides useful insights to help speed up the shift toward cleaner, smarter, and more widely accepted public transport solutions.

2. Conceptual framework

Based on the related studies reviewed, an integrated conceptual framework (Figure 1) was developed by integrating the STPB with the VF, creating a total of 16 hypotheses and 10 core constructs. This integration sought to comprehensively analyze the factors affecting the intention for utilization of autonomous bus services through the evaluation of behavioral, emotional, and cognitive factors influencing user behavioral intention of this innovative mode of transportation, specifically the autonomous bus service.

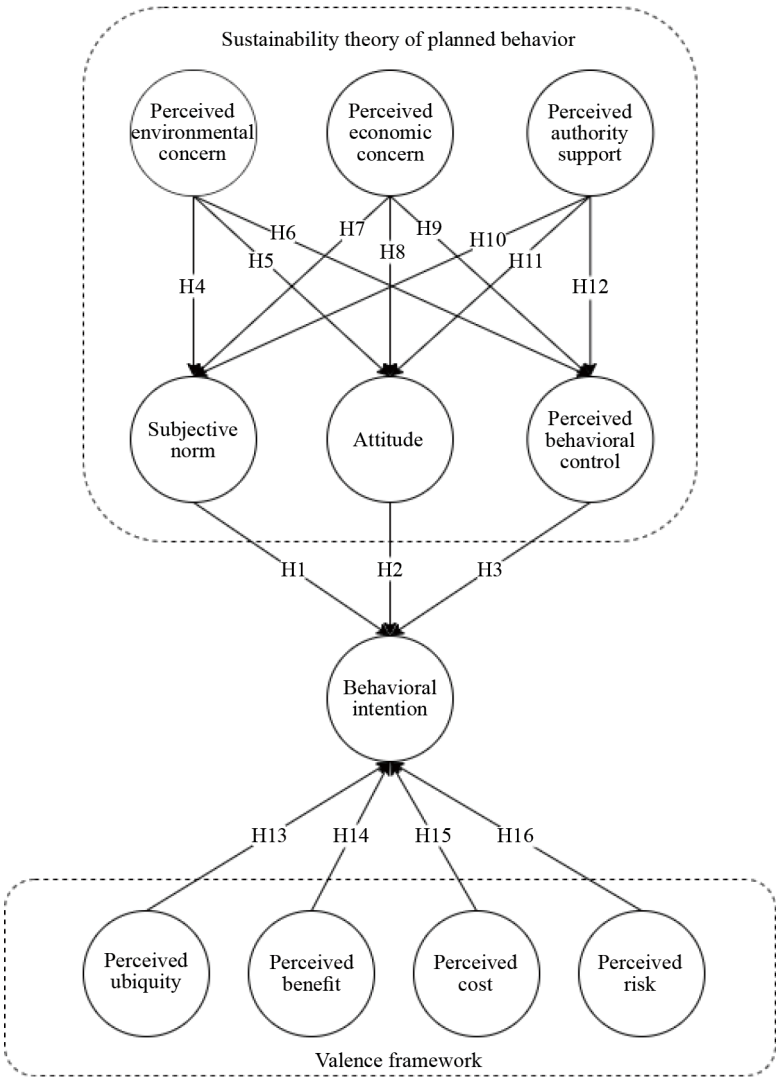

Figure 1. Conceptual framework (Legend: H-hypothesis)

Subjective Norm (SN) relates to the perceived social pressure experienced from others, influencing their behavioral intention. A study by Zong et al. [34] on consumers' intention to adopt hybrid electric vehicles found that subjective norm significantly influences behavioral intentions to adopt Hybrid Electric Vehicles (HEVs). This is because inn cultures like China, social pressure from early adopters and group evaluations plays a vital role, suggesting that strategies like HEV clubs and Word-of-Mouth (WOM) marketing can effectively enhance adoption. Furthermore, they found that perceived behavioral control significantly impacts behavioral intentions. It was explained that when consumers perceive HEVs as

easily accessible, their intention to adopt them increases. Perceived Behavioral Control (PBC) has been established to be a variable that measures the control of a person on their feeling over doing something [35]. Additionally, Gumasing et al. [35] enforces this in their study on Adoption of Electric Jeepneys when they found that subjective norms significantly influence Behavioral Intention (BI) by shaping societal considerations, particularly regarding purchasing decisions. The findings emphasize that social expectations and norms play a critical role in driving consumer intentions. Furthermore, it was found that attitude was the most significant factor for consumer's BI to use Electric Jeepneys. Their results indicated that Attitude (AT) has a significant effect on BI. The results highlighted that among all factors, attitude is the most influential determinant of passengers' intention to utilize e-jeepneys, reflecting how positive perceptions strongly drive behavior. As a reflection, this study defines AT as the positive or negative feeling about doing something. Thus, the following were hypothesized:

H1: SN has a significant effect on BI.

H2: AT has a significant effect on BI.

H3: PBC has a significant effect on BI.

Another influential factor is Perceived Environmental Concern (PELC), which also shapes perceived behavioral control. PELC is the perception of people on their pro-environmental behavior on their intention to do something [30]. The study by Ahmad et al. [36] presented that PELC reflects users' awareness and valuation of sustainable transportation practices, including reducing emissions, conserving energy, and minimizing ecological footprints. This means that individuals who prioritize environmental responsibility are more likely to support and adopt technologies that align with their values, as it improves the users' sense of agency and control over their influence on the surroundings in addition to influencing adoption [37]. Furthermore, environmental concern refers to individual awareness of environmental impacts, shaping perceptions, and encouraging pro-environmental actions. It reflects how people evaluate their relationship with the environment [38].

Chin et al. [39] found that PELC positively influences consumer attitudes and subjective norms on the BI of using eco-products, highlighting its role in promoting green products. Consumers with environmental awareness are more inclined to adopt eco-friendly products, offering an opportunity for companies to emphasize sustainability in their marketing strategies. While PELC has a stronger impact on individual attitudes than societal norms, it still encourages broader acceptance of green practices, benefiting environmentally conscious brands.

Furthermore, Zong et al. [34] highlighted that PELC significantly influences both subjective norms and attitude on consumer BI on HEV, demonstrating its vital role in shaping consumer behavior. Moreover, it was presented that PELC positively impacts subjective norms by fostering social expectations aligned with eco-conscious choices, encouraging collective support for environmentally friendly actions. Similarly, PELC strengthens consumer attitudes, as individuals with high environmental awareness develop a more favorable outlook toward adopting eco-friendly products like HEVs. In the Philippines, The Department of Energy (DOE) is promoting the adoption of Electric Vehicles (EVs) to reduce reliance on imported fuel and encourage cleaner transport options [40]. Thus, the following were hypothesized:

H4: PELC has a significant effect on SN

H5: PELC has a significant effect on AT.

H6: PELC has a significant effect on PBC.

Perceived Economic Concern (PECC) rises as a significant predictor of PBC. PECC is defined as the economic perception, consumer's financial value implications that relates to their feeling to act on something [30]. Since the economic concern sees to users' evaluation of the financial implications associated with autonomous bus services including fare affordability, savings in costs relative to other options, and possible economic incentives, this factor matters greatly as users' willingness to adopt and embrace new technology is frequently limited by financial constraints [36]. According to the study of Wu et al. [41], as individuals regard autonomous buses as economically attainable through affordable fares, decreased daily commute expenses, and economic incentives such as discounts or subsidies, they are more likely to develop a positive attitude toward the service. PBC, which refers to users' perceptions of their ability to successfully perform the behavior, encapsulates this sustainability behavior [42]. For instance, those who have genuine concerns about the economy may feel assured in managing fare systems, planning routes, and keeping track of the costs of taking an autonomous bus. Furthermore, Buenavista et al. [16] showed that PECC significantly influences SN, reflecting how

societal and personal networks value the economic benefits of electric public transportation. These benefits include cost savings, travel efficiency, and environmental advantages, which shape collective attitudes toward its adoption.

On the other hand, the PECC significantly impacts users' AT about the utilization intention of autonomous bus services, as AT indicates an individual's positive or negative evaluation regarding their performance of a specific behavior [42]. Therefore, when individuals regard autonomous buses as economically attainable through affordable fares, decreased daily commute expenses, and economic incentives such as discounts or subsidies, they are more likely to develop a positive AT toward the service. This positive view arises from an understanding that the service provides good value for money, making it a reasonable and practical alternative to traditional modes of transportation. Wu et al. [41] stated that users who see economic benefits have a tendency to develop more favorable viewpoints, particularly when these advantages immediately influence their everyday expenses. Thus, the following were hypothesized:

H7: PECC has a significant effect on SN.

H8: PECC has a significant effect on AT.

H9: PECC has a significant effect on PBC.

German et al. [43] defined Perceived Authority Support (PAS) as an individual's recognition of resources, regulations, procedures, and actions facilitated by an authorized organization or government to enable a specific behavior. A study by Lin et al. [44] on citizen behavior intention on mandatory and voluntary pro-environmental programs showed that PAS affects SN by positively influencing citizens' perceptions of social expectations. Furthermore, a study by Persada et al. [38] on citizens' intention level in environmental impact assessment participation through an extended theory of planned behavior model shows that there is a positive correlation between PAS and SN, showing that government support helps shape social expectations during the Environmental Impact Assessment process. By encouraging collaboration among key stakeholders, this support fosters greater citizen participation.

Furthermore, PAS also directly influences perceived behavioral control. Apart from improving positive behaviors, institutional support helps to solve practical concerns users could have about the reliability and accessibility of services. Users feel more certain that the system is operational and controllable when government organizations and transit authorities provide clear policies, necessary infrastructure, and public education programs concerning autonomous buses [45]. This reassurance lowers perceived complexity, and practical problems include concerns about how to access the services, the payment systems, or rely on technology to run regularly and smoothly [36]. As a result, perceived authority enhances users' perceived ability to control their transportation choices and smoothly integrate autonomous bus usage into their daily routine.

The role of people's PAS and AT towards the utilization of autonomous transportation was also seen to be significant by the study of Goldbach et al. [37], as this concept shows how much users believe that the government and institutional supporters are backing the use of autonomous transportation. With the support of using this, it can come in many forms, such as official regulations, safety standards, investments in infrastructure, and public support for self-driving technology [45]. A study by Mouratidis and Serrano [29] concluded that PAS significantly impacts individuals, as they often rely on trustworthy institutions to promote new ideas and reduce uncertainty. People tend to feel more confident in the safety of new technology and trust it when they recognize that their social environment actively promotes and oversees self-driving transportation. This trust translates into more positive attitudes, as users begin to view autonomous buses not only as technologically advanced but also as reliable and socially endorsed alternatives to traditional transportation [46]. Attitude includes factors that people think and feel about self-driving buses, such as whether they are a smart choice for commuting, enjoyable to ride, and overall appealing [47]. Hence, strong PAS tends to encourage favorable attitudes by signaling that autonomous buses have undergone thorough vetting and are supported by their social environment. Thus, the following were hypothesized:

H10: PA has a significant effect on SN.

H11: PA has a significant effect on AT.

H12: PA has a significant effect on PBC.

Shifting focus to Behavioral Intention (BI), Perceived Ubiquity (PU) significantly impacts users' BI to use autonomous buses. PU in the VF is defined as the widespread, ever-present, or unavoidable people feel towards something in their daily lives. PU indicates the point to which autonomous bus services are readily available and seamlessly integrated into users'

everyday commuting routines. This encompasses features such as broad accessibility, adaptable schedules, diverse routes, and the integration of autonomous buses into current transportation systems [46]. Kassens-Noor et al. [48] said when users perceive autonomous buses as easily accessible without disrupting their routines, they develop stronger intentions to use them, since the greater the PU, the more users view autonomous buses as practical and efficient travel options, resulting in heightened BI. Thus, it was hypothesized that:

H13: PU has a significant effect on BI.

Similarly, Perceived Benefits (PB) of autonomous bus services strongly influence BI, as their impact on users' advantages encompasses the perceived security of autonomous buses, their operational dependability, the capacity to reduce traffic congestion, and the capability to quickly recover from disruptions in service or technical malfunctions [46]. When users see these benefits, they develop more favorable behavior toward utilizing autonomous bus services, as emphasizing safety provides confidence in risk management, whereas reliability provides assurance in scheduling and travel planning [48]. As a result, the alleviation of congestion attracts individuals exasperated by traffic delays, while efficient problem recovery indicates the system's resilience, where the cumulative advantages increase the utilization intention of autonomous buses as a transportation option and strengthen the motivation to use the technology. Thus, it was hypothesized:

H14: PB has a significant effect on BI.

Conversely, Perceived Cost (PC) serves as a significant impediment that adversely influences BI, especially when users weigh the affordability of autonomous bus fares relative to perceived service quality [49]. Cost considerations serve as a practical restraint, particularly for price-sensitive populations, and may surpass perceived advantages if the expenses are regarded as excessive [29]. Furthermore, uncertainty regarding prospective expenses or charges can induce reluctance. These economic concerns undermine the strength of consumers' purposes, signifying that pricing remains a critical issue to resolve for wider utilization. Thus, it was hypothesized:

H15: PC has a significant effect on BI.

Another fundamental factor affecting BI is Perceived Risk (PR), as concerns regarding safety, potential accidents, technical problems, and data privacy significantly limit users' willingness to embrace technologies like autonomous bus services [23]. Autonomous vehicles provide unprecedented risks that users may view as hazardous, including system failures and vulnerabilities in cybersecurity. Such apprehensions weaken trust in technology and create hesitance to engage [49]. Therefore, it was hypothesized:

H16: PR has a significant effect on BI.

3. Methodology

3.1 *Participants*

This study targeted participants on social media platforms—specifically Facebook groups, Instagram, and Discord—over a three-month period, alongside face-to-face dissemination of survey (May to June 2025). The questionnaire was disseminated through public posts, story links, and group messages, and was accessible via a Google Forms link shared across these platforms. A convenience sampling method was employed, allowing voluntary participants to access and complete the questionnaire through shared links. This sampling technique is viable since people in the country are knowledgeable of autonomous buses, understood its development, and have established the familiarity of e-vehicles in general [16]. Using the Yamane Taro formula for calculation, a total of 400 diverse respondents would be needed to generalize the findings (at 5% error) as seen in equation (1). This study reached more than 400 respondents as seen in Table 1.

$$n = \frac{N}{1 + Ne^2} = \frac{62.6 \text{ million}}{1 + (62.6 \text{ million})\ 0.05^2} = 399.99 \tag{1}$$

Table 1. Participants' descriptive statistics ($n = 424$)

Characteristics	Category	*N*	%
Age	> 18–24 years old	153	36.1%
	> 25–34 years old	136	32.1%
	> 35–44 years old	96	22.6%
	> 45–54 years old	34	8.02%
	> 55 years old and above	5	1.18%
Gender	> Male	199	46.94%
	> Female	216	50.94%
	> Rather not say	9	2.120%
Residence	> Urban	326	76.9%
	> Rural	98	23.1%
Educational Attainment	> Elementary graduate	2	0.75%
	> High school graduate	9	2.12%
	> College graduate	156	94.3%
	> Higher education	12	2.83%
Occupation	> Student	192	45.28%
	> Employed	122	28.77%
	> Self-employed	88	20.75%
	> Unemployed	14	3.31%
	> Retired	6	1.42%
	> Others	2	0.47%
Monthly income/Allowance	> Below ₱ 15,000	214	50.5%
	> ₱ 15,000–₱ 24,999	86	20.3%
	> ₱ 25,000–₱ 49,999	87	20.5%
	> ₱ 50,000–₱ 74,999	19	4.5%
	> ₱ 75,000 and above	18	4.2%

As indicative of the results, majority of the respondents are students (36.1%) and young adults (32.1%), with about 22.6% adults. This is because they are the most users of public transportations for education, work, and leisure [50, 51]. This is evident among the descriptive statistics of the occupation of participants. Moreover, Espinosa and Kovarik [52] explained that there are no differences on gender or sexes in their assessment of prosocial behavior among public transportation. Ong et al. [30] further delineated how majority of Filipinos are below the salary or income range, which is why public transportations are widely considered—as evident in the results of having around 25,000 PhP and below. Lastly, these e-public transportations are widely present in the Metro and Capital of the country, which is why majority are surveyed among urban residence. Nonetheless, despite the representation, it could be said that the data could be more representative across different demographic characteristics. The data was tested using the Shapiro-Wilk assessment and found the quotient

between ±1.96—implicating normality [53], while no common method bias was seen since the output tested using Harman's Single Factor was less than 50% (16.679% total variance) [54].

3.2 *Measure items*

A self-administered questionnaire developed through a comprehensive review of existing literature was used to collect data for this study. The survey instrument used consisted of 51 items designed to capture the behavioral, environmental, and perception-technology factors influencing the utilization intention of autonomous bus services. Prior to deployment, the questionnaire was checked by a registered psychometrician and also went a pre-test among 50 respondents. Only minor changes on the grammar was suggested and a total Cronbach's alpha value of 0.836 was obtained—thereby concluding and accepting the finalized version of the questionnaire used for this study.

The questionnaire was divided into two main sections and employed a 5-point Likert scale, where responses ranged from 1 (Strongly Disagree) to 5 (Strongly Agree) [53]. The initial section gathered demographic data, which was summarized in Table 1. The second section focused on measuring theoretical constructs derived from the integration of the STPB and the VF. The STPB section of the survey included constructs such as AT, SN, and PBC, as well as its sustainability-related extensions—PELC, PECC, and PAS. On the other hand, the VF section captured evaluative perceptions through constructs such as PB, PR, PT, and PC. The outcome variable, BI was also included to evaluate users' potential for adopting autonomous bus services. This methodological structure complies with optimal practices in behavioral and transport studies, as demonstrated by recent research [20, 30–32] which supports the integration of behavioral intention models with evaluative frameworks to gain a fuller understanding of adoption patterns, particularly for the development of emerging technologies such as autonomous bus services (Table 2).

Table 2. Measurement items

	Code	Constructs	References
Subjective norm	SN1	People who influence my behavior think I should use autonomous bus services.	Zong et al. [34]
	SN2	People around me are likely to use autonomous bus services.	
	SN3	My peers would perceive me positively if I chose to go with autonomous bus services.	
	SN4	The government and transportation officials encourage people to adopt autonomous bus services.	
Attitude	AT1	I think using autonomous buses is a good choice and a smart way to improve transportation.	Zong et al. [34]
	AT2	I find the concept of developing autonomous bus services appealing.	
	AT3	I think taking an autonomous bus would be an enjoyable experience.	
	AT4	I think gaining knowledge about how autonomous buses operate would be a valuable experience.	
Perceived behavioral control	PBC1	I am confident that I could use an autonomous bus if I choose to.	Ajzen [42]
	PBC2	Whether I decide to ride an autonomous bus or not is completely up to me.	
	PBC3	If I wanted to, I could easily choose an autonomous bus for my daily transportation.	
	PBC4	I am confident in my ability to adapt to using autonomous buses as a mode of transportation.	

Table 2. (cont.)

	Code	Constructs	References
Perceived environmental concern	PELC1	Mankind is severely overusing resources, so autonomous bus services should be utilized to promote sustainability.	Ahmad et al. [36]
	PELC2	I am concerned about the state of the environment and its impact on future generations, which is why I support using autonomous bus services.	
	PELC3	Humans are frequently causing harm to the environment, so I believe using autonomous bus services is a necessary step toward environmental conservation.	
	PELC4	When humans neglect sustainable practices, it leads to harmful consequences, which is why I want to contribute by using autonomous bus services to minimize environmental disruption.	
Perceived economic concern	PECC1	I believe autonomous buses will provide me with cost-effective options such as affordable fares.	Ahmad et al. [36]
	PECC2	I think using autonomous buses could help me save money on daily transportation over time.	
	PECC3	I think autonomous buses can reduce my transportation costs, allowing me to allocate funds to other priorities.	
	PECC4	I believe autonomous buses are a practical option in terms of pricing and overall transportation value.	
Perceived authority	PA1	The government enacts regulations that enable citizens to use autonomous bus services.	Turoń and Kubik [45]
	PA2	The government is actively setting up the infrastructure needed to support the use of autonomous bus services.	
	PA3	The government encourages citizens to use autonomous bus services as a sustainable transportation option.	
	PA4	The government endorses policies and regulations to promote the utilization of autonomous bus services.	
Perceived ubiquity	PU1	Using an autonomous bus service does not disrupt my daily schedule or tasks (e.g., it operates smoothly without delays).	Altes et al. [55]
	PU2	Autonomous bus services allow me to travel conveniently at the time most suitable for me.	
	P31	Using autonomous bus services outside my usual routes or locations is not a problem for me.	
	PU4	When I use autonomous bus services, I can experience benefits that I cannot achieve with other modes of transportation.	
Perceived benefits	PB1	Recovery from unexpected events, such as breakdowns or route changes, is not a hindrance when using autonomous bus services.	Altes et al. [55]
	PB2	I believe that autonomous bus services are designed with a strong emphasis on passenger safety and security.	
	PB3	Autonomous buses optimize space on roads and reduce congestion compared to traditional buses.	
	PB4	I do not worry about the maintenance or reliability of autonomous bus systems, as they are managed by professional services.	
Perceived cost	PC1	I am concerned that autonomous bus services will be more expensive than traditional public transportation.	Chinen et al. [49]
	PC2	I worry that the cost of autonomous buses could affect different income groups in the Philippines unequally.	
	PC3	I question whether autonomous buses will provide enough economic value to justify their costs.	
	PC4	I am unsure how the cost of autonomous bus services will support the Philippines' broader economic development.	
	PC5	I am concerned about whether the cost of operating autonomous buses can be maintained in a sustainable way over time.	

Table 2. (cont.)

	Code	Constructs	References
Perceived risk	PR1	I believe there's a high chance something could go wrong when using autonomous bus services.	Kenesei et al. [23]
	PR2	I am worried that failures or malfunctions in autonomous bus services might cause accidents.	
	PR3	I am concerned that using autonomous bus services means I'll lose control over my personal data.	
	PR4	I am concerned autonomous bus services would not be able to guarantee the security of my personal information.	
Behavioral intentions	BI1	I intend to use autonomous bus services in the near future.	Ong et al. [30]
	BI2	I plan to choose autonomous bus services for transportation whenever possible.	
	BI3	I will make an effort to use autonomous bus services if they are available to me.	
	BI4	I am likely to use autonomous bus services once they become a common option.	

3.3 *Structural equation modeling*

This study employed a Partial Least Squares Structural Equation Modeling (PLS-SEM) approach to examine the factors affecting individuals' intention and actual use of autonomous bus services [24]. Structural Equation Modeling (SEM) is widely used in behavioral research for analyzing complex relationships between observed variables and latent constructs. It offers advantages over traditional regression by allowing for multiple relationships, accounting for measurement error, and analyzing both direct and indirect effects for causal relationship assessment [53, 56]. The measurement model was assessed to ensure reliability and validity using Cronbach's Alpha, Composite Reliability, Average Variance Extracted (AVE), and tests for discriminant validity. Following which, the structural model tested the strength of relationships between constructs, using bootstrapping to determine path significance, and establishing the final SEM output—analyzed using Smart PLS V4.0 [16, 57, 58]. Moreover, a 5,000 bootstrap sample was considered—adopted from related studies, with 0.05 as the confidence considered [53].

4. Results

4.1 *The result of initial SEM*

The initial SEM, which evaluates the factors influencing the utilization intention of autonomous bus services, is presented in Figure 2. The model comprises 12 latent constructs and 51 indicators, systematically developed based on the integrated STPB and the VF. In accordance with the recommendations of Hair et al. [53], indicators with factor loadings below 0.70 were insufficient representations of their latent variables and were consequently removed from the final measurement model to improve validity and model fit [58]. While the paths with p-values beyond the 0.05 significance threshold were excluded as statistically insufficient, these relationships are indicated in the model with dashed lines.

Table 3 shows the statistics and the outcomes of both the initial and final models. The final model comprised items with factor loadings higher than 0.70, signifying satisfactory levels of indicator reliability. Moreover, to further analyze the model's validity and internal consistency, the convergent validity shown in Table 4 was assessed. All recommended threshold, 0.70 for Cronbach's alpha and Composite Reliability, and 0.50 for AVE were achieved [53, 57].

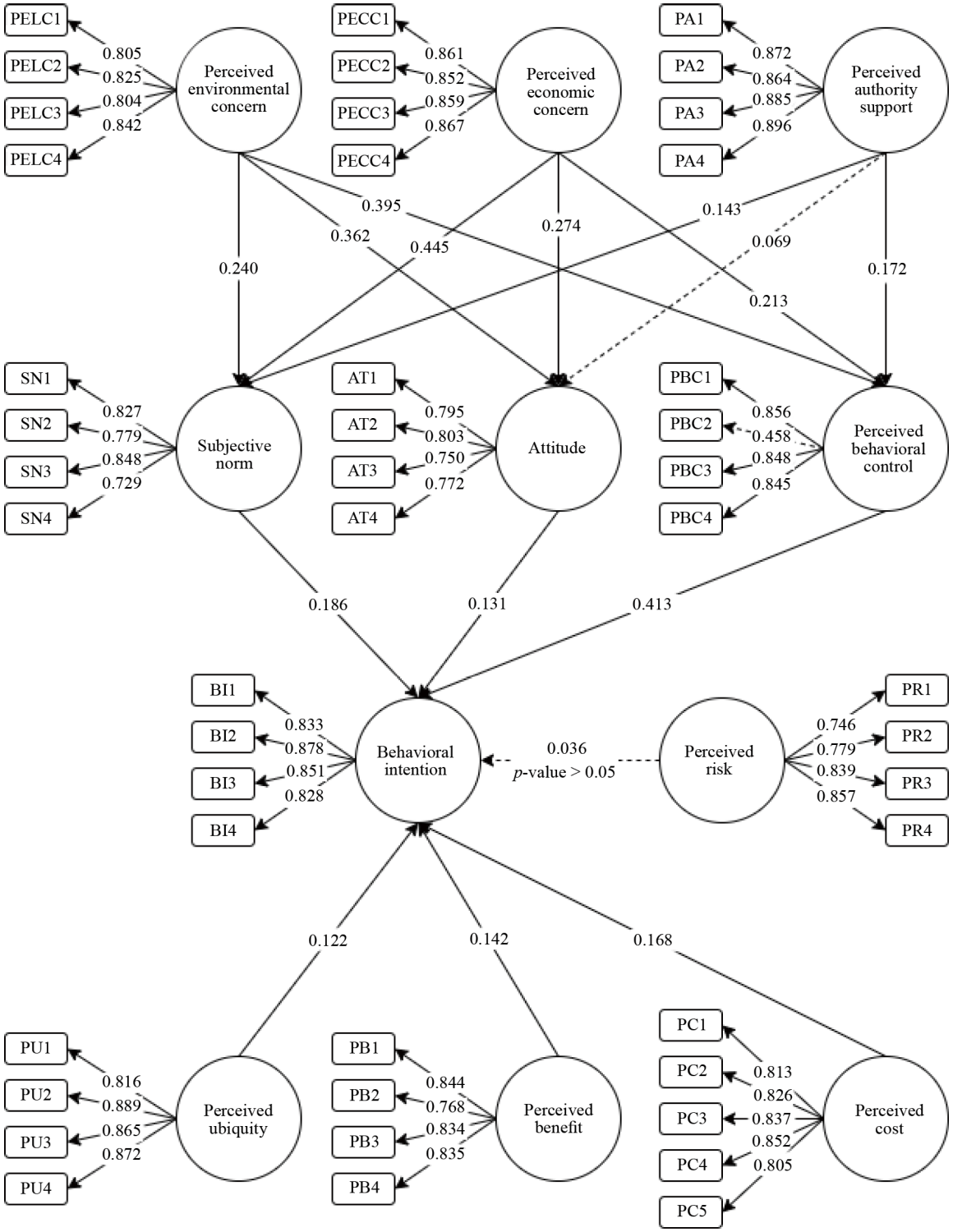

Figure 2. Initial SEM model

Table 3. Statistical analysis of indicators

Variables	Item	Mean	Standard deviation	Factor loading	
				Initial	Final
Subjective norm	SN1	3.682	0.962	0.827	0.827
	SN2	3.840	0.980	0.779	0.779
	SN3	3.703	0.907	0.848	0.848
	SN4	3.611	0.958	0.729	0.729
Attitude	AT1	4.066	0.759	0.795	0.795
	AT2	4.139	0.735	0.802	0.802
	AT3	4.153	0.779	0.752	0.752
	AT4	4.13	0.746	0.772	0.772
Perceived behavioral control	PBC1	3.844	0.981	0.856	0.868
	PBC2	4.191	0.800	0.458	-
	PBC3	3.800	1.088	0.848	0.865
	PBC4	3.941	0.865	0.845	0.850
Perceived environmental concern	PELC1	4.080	0.732	0.805	0.805
	PELC2	4.071	0.801	0.825	0.825
	PELC3	4.083	0.789	0.804	0.804
	PELC4	3.988	0.778	0.842	0.843
Perceived economic concern	PECC1	3.800	0.855	0.861	0.862
	PECC2	3.877	0.876	0.852	0.852
	PECC3	3.861	0.902	0.859	0.859
	PECC4	3.841	0.836	0.867	0.867
Perceived authority	PA1	3.304	0.951	0.870	0.871
	PA2	3.316	1.002	0.870	0.869
	PA3	3.328	0.931	0.882	0.882
	PA4	3.316	0.924	0.895	0.895
Perceived ubiquity	PU1	3.667	0.836	0.816	0.816
	PU2	3.745	0.909	0.889	0.889
	PU3	3.672	0.966	0.865	0.865
	PU4	3.717	0.877	0.872	0.872
Perceived benefits	PB1	3.653	0.966	0.844	0.844
	PB2	3.920	0.881	0.768	0.768
	PB3	3.837	0.900	0.834	0.834
	PB4	3.741	0.918	0.835	0.835
Perceived cost	PC1	3.792	0.876	0.813	0.813
	PC2	3.825	0.845	0.826	0.826
	PC3	3.788	0.805	0.837	0.837
	PC4	3.788	0.925	0.852	0.852
	PC5	3.868	0.763	0.805	0.805
Perceived risk	PR1	4.040	0.787	0.746	-
	PR2	4.052	0.811	0.779	-
	PR3	3.677	1.022	0.839	-
	PR4	3.708	1.004	0.857	-
Behavioral intentions	BI1	3.861	0.862	0.833	0.833
	BI2	3.774	0.959	0.878	0.878
	BI3	3.809	1.020	0.851	0.851
	BI4	3.929	0.879	0.828	0.828

Table 4. Convergent validity

Variable	Cronbach's alpha	Composite reliability	Average Variance Extracted (AVE)
AT	0.786	0.862	0.609
BI	0.870	0.911	0.719
PA	0.902	0.932	0.773
PB	0.839	0.892	0.674
PBC	0.825	0.896	0.741
PC	0.884	0.915	0.684
PECC	0.883	0.919	0.740
PELC	0.837	0.891	0.671
PU	0.884	0.920	0.741
SN	0.807	0.874	0.635

Table 5. Fornell-Lacker criterion

	AT	BI	PA	PB	PBC	PC	PECC	PELC	PU	SN
AT	0.780									
BI	0.456	0.848								
PA	0.245	0.339	0.879							
PB	0.517	0.614	0.349	0.821						
PBC	0.399	0.720	0.335	0.480	0.861					
PC	0.442	0.638	0.364	0.605	0.580	0.827				
PECC	0.513	0.587	0.280	0.613	0.499	0.563	0.860			
PELC	0.548	0.591	0.277	0.577	0.565	0.523	0.607	0.819		
PU	0.411	0.624	0.444	0.706	0.546	0.569	0.629	0.512	0.861	
SN	0.503	0.628	0.335	0.635	0.592	0.550	0.631	0.550	0.687	0.797

Table 6. Heterotrait-Monotrait ratio

	AT	BI	PA	PB	PBC	PC	PECC	PELC	PU	SN
AT										
BI	0.553									
PA	0.291	0.380								
PB	0.640	0.710	0.396							
PBC	0.493	0.844	0.388	0.572						
PC	0.531	0.720	0.405	0.699	0.676					
PECC	0.617	0.661	0.313	0.708	0.580	0.636				
PELC	0.672	0.687	0.319	0.686	0.672	0.602	0.703			
PU	0.494	0.700	0.501	0.811	0.633	0.638	0.708	0.586		
SN	0.636	0.741	0.395	0.759	0.721	0.644	0.741	0.662	0.806	

As reflected in Table 5, the square root of the AVE for each latent construct, displayed along the diagonal values consistently exceeds the equivalent interconstruct correlation values located off-diagonal. This satisfies the Fornell-Larcker criterion, hence proving discriminant validity [59]. For instance, the AVE square root for Attitude (0.780) exceeds its correlation with BI (0.456) and PB (0.517), indicating that Attitude shares more variance with its own indicators than with any other construct in the model. Complementing these results, Table 6 presents the Heterotrait-Monotrait ratios which further support discriminant validity. All Heterotrait-Monotrait values fall below the conservative cutoff of 0.85, meaning that the constructs are not only statistically but also conceptually distinct [60].

4.2 *Model fit analysis*

A model fit assessment was carried out to confirm the validity of the proposed framework. As shown in Table 7, all parameter estimates exceeded the recommended minimum threshold, indicating that the proposed model is acceptable.

Table 7. Model fit

Goodness of fit measures of the SEM	Parameter estimates	Minimum cutoff	Recommended by
Standardized Root Mean Square Residual (SRMR)	0.069	< 0.08	[59, 61]
Chi-squared/dF	2,009.80	$< 5{,}000$	[59, 62, 63]
Normed Fit Index (NFI)	0.919	> 0.90	[63]

4.3 *Results of the final SEM*

Table 8. Finalized results

Hypothesis	Relationship	Beta	*P*-value	Decision
1	Subjective Norms (SN) → Behavioral Intention (BI)	0.194	0.043	Accept
2	Attitude (AT) → Behavioral Intention (BI)	0.143	0.035	Accept
3	Perceived Behavioral Concern (PBC) → Behavioral Intention (BI)	0.413	< 0.001	Accept
4	Perceived Environmental Concern (PELC) → Subjective Norms (SN)	0.240	< 0.001	Accept
5	Perceived Environmental Concern (PELC) → Attitude (AT)	0.374	< 0.001	Accept
6	Perceived Environmental Concern (PELC) → Perceived Behavioral Concern (PBC)	0.217	0.001	Accept
7	Perceived Economic Concern (PECC) → Subjective Norms (SN)	0.445	< 0.001	Accept
8	Perceived Economic Concern (PECC) → Attitude (AT)	0.287	< 0.001	Accept
9	Perceived Economic Concern (PECC) → Perceived Behavioral Concern (PBC)	0.217	< 0.001	Accept
10	Perceived Authority (PA) → Subjective Norms (SN)	0.144	< 0.001	Accept
11	Perceived Authority (PA) → Attitude (AT)	0.069	0.088	Reject
12	Perceived Authority (PA) → Perceived Behavioral Concern (PBC)	0.167	< 0.001	Accept
13	Perceived Ubiquity (PU) → Behavioral Intention (BI)	0.113	0.034	Accept
14	Perceived Benefit (PB) → Behavioral Intention (BI)	0.149	0.005	Accept
15	Perceived Cost (PC) → Behavioral Intention (BI)	0.173	0.006	Accept
16	Perceived Risk (PR) → Behavioral Intention (BI)	0.036	0.356	Reject

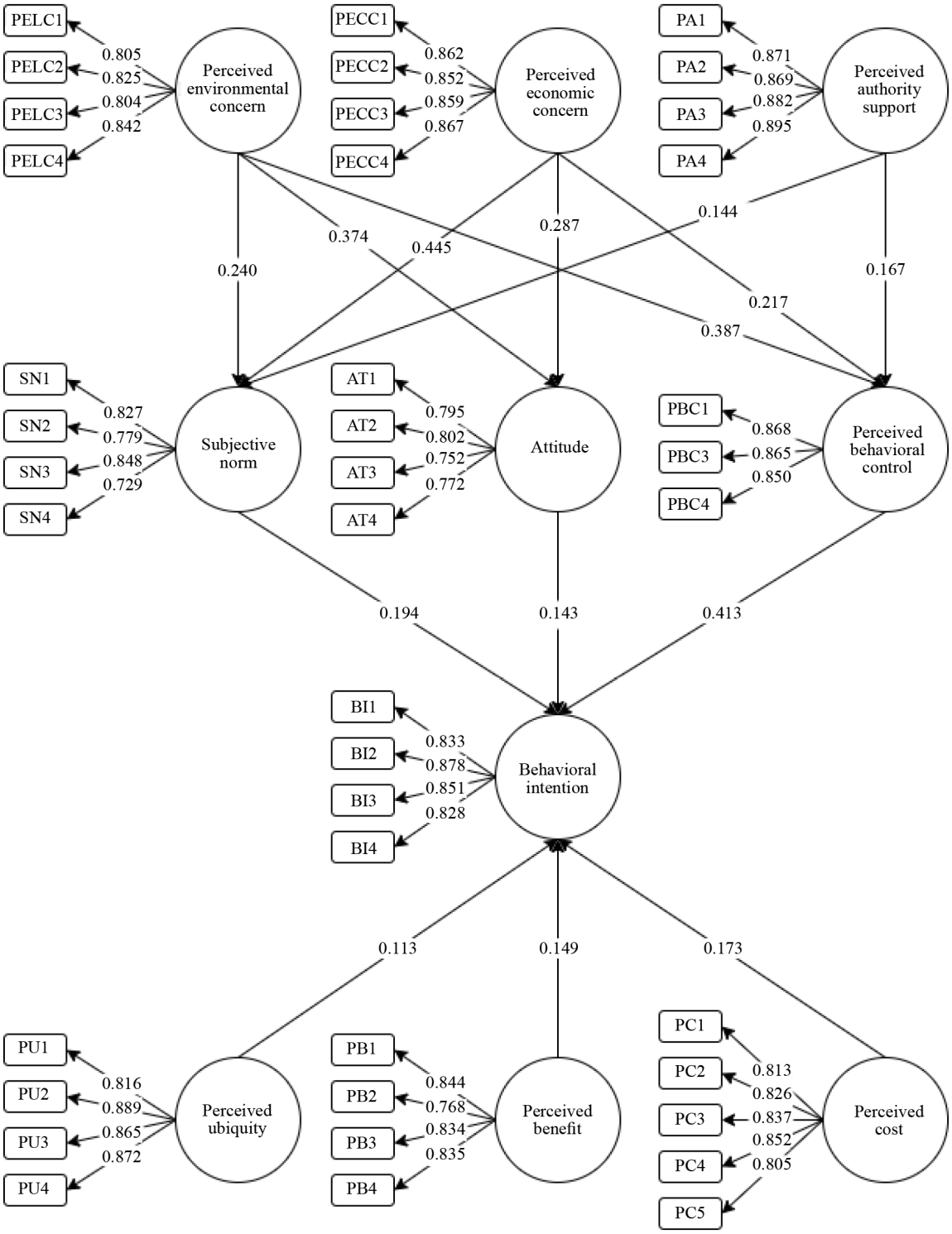

Figure 3. Final SEM model

The analysis of the structural model revealed that among the predictors of BI, Perceived Behavioral Control (PBC) had the strongest impact ($\beta = 0.413$, $p < 0.001$), followed by Subjective Norm (SN) ($\beta = 0.194$, $p = 0.043$), Perceived Cost (PC) ($\beta = 0.173$, $p = 0.006$), Perceived Benefit (PB) ($\beta = 0.149$, $p = 0.005$), Attitude (AT) ($\beta = 0.143$, $p = 0.043$),

and Perceived Ubiquity (PU) ($\beta = 0.113$, $p = 0.032$), all of which were statistically significant. In contrast, Perceived Risk (PR) ($\beta = 0.036$, $p = 0.356$) was not significant and thus rejected. Furthermore, Perceived Economic Concern (PECC) significantly influenced Attitude ($\beta = 0.287$, $p < 0.001$), PBC ($\beta = 0.217$, $p < 0.001$), and SN ($\beta = 0.445$, $p < 0.001$), while Perceived Environmental Concern (PELC) significantly influenced Attitude ($\beta = 0.374$, $p < 0.001$), PBC ($\beta = 0.217$, $p = 0.001$), and SN ($\beta = 0.445$, $p < 0.001$). Lastly, Perceived Authority (PA) significantly influenced PBC ($\beta = 0.167$, $p < 0.001$) and SN ($\beta = 0.144$, $p < 0.001$), but not Attitude ($\beta = 0.069$, $p = 0.088$), which was rejected. In total, 14 of the 16 hypothesized relationships were accepted as summarized in Table 8, emphasizing the crucial roles of control, motivation, and ease of use in driving behavioral intention and technology use. Following which is the final SEM utilized for the discussion of output in this study, presented in Figure 3.

Summarizing the output variance, the f-square (f^2) and r-square (R^2) are reported in Table 9. As evident, it could be seen that exogenous variables that have higher influence are PBC on BI, PECC on SN, and PELC on PBC. Others have smaller effects, evident by having $f^2 \geq 0.02$. Specifically, it is evident that AT, PB, PU, and SN on BI have close values to the threshold. This means that removing them have little effects on the overall implications of BI on the utilization of autonomous bus services in the Philippines [64].

Table 9. Variance analysis with f^2 and R^2

Relationship	f^2	Interpretation	Variable	R^2
AT → BI	0.022	Small	AT	0.352
PA → PBC	0.041	Small	PBC	0.391
PA → SN	0.035	Small	SN	0.461
PB → BI	0.025	Small	BI	0.648
PBC → BI	0.264	Medium		
PC → BI	0.043	Small		
PECC → AT	0.080	Small		
PECC → PBC	0.047	Small		
PECC → SN	0.227	Medium		
PELC → AT	0.136	Small		
PELC → PBC	0.150	Medium		
PELC → SN	0.066	Small		
PU → BI	0.024	Small		
SN → BI	0.021	Small		

*Note: $f^2 \geq 0.02$ is small, $f^2 \geq 0.15$ is medium, and $f^2 \geq 0.35$ is large [64]

5. Discussion

Among the drivers of BI, PBC had the greatest influence ($\beta = 0.413$, $p < 0.001$). This suggests that people are more inclined to use autonomous buses if they feel confident and capable of doing so. This highlights the importance of ensuring that users perceive the adoption process as straightforward, accessible, and within their control. When individuals believe that using technology is manageable and does not require excessive effort, they are more likely to engage with it and integrate it into their daily routines. Although attitude also had a statistically significant impact ($\beta = 0.143$, $p = 0.035$), its effect was notably weaker. This finding is somewhat unexpected and contrasts with results from similar studies, such as those on electric jeepneys [35], where attitude had a much stronger influence. One possible explanation is that autonomous buses represent a newer and less familiar technology, leading users to place greater emphasis on perceived control and practicality rather than on personal preferences or general sentiments.

Nonetheless, it could be implicated that commuters attitude was wekaer on the context of them thinking that using autonomous buses may not a strong choice, appealing, finds it as a smart way to improve the public transportation in the country, and that its operation would be a valuable addition. This may be because more respondents are not users of AV since it is not yet widely implemented in the country. However, other studies explained that commuters attitude on AV influenced their adoption due to their trust and willingness to try it [37, 65]. This is said to influence their behaviors more compared to socio-demographic factors [65]. Gkartzonikas and Gkritza [66] contradicted the findings, explaining that other factors influence people's willingness are influenced by subjective norm, innovativeness, technology seeking, and awareness rather than attitude—which is similar to the output of this study. This is because subjective norm had higher influence ($\beta = 0.194$, $p = 0.043$) than attitude, but innovativeness and technology seeking due to accessibility as evidenced by PBC constructs were higher. Furthermore, f^2 output also showed that PBC is more influential on BI, followed by SN and AT—positing that the findings aligned with Gkartzonikas and Gkritza [66] on commuter's perception and preference of AVs.

Environmental and economic considerations also played a significant role in shaping user behavior. PECC showed strong effects on subjective norms ($\beta = 0.240$, $p < 0.001$), attitude ($\beta = 0.374$, $p < 0.001$), and PBC ($\beta = 0.217$, $p = 0.001$). These results suggest that individuals who are more environmentally conscious not only hold more favorable views toward the use of autonomous buses but also feel greater social support for adopting the technology and perceive themselves as more capable of doing so. Similarly, PELC had a notable influence on behavioral constructs, significantly affecting attitude ($\beta = 0.287$, $p < 0.001$), PBC ($\beta = 0.217$, $p < 0.001$), and subjective norms ($\beta = 0.445$, $p < 0.001$). These results highlight how both environmental and economic values shape decision-making, particularly among Filipino users who are becoming more conscious of sustainability and financial practicality. Despite having a higher price compared to normal bus commute, people find the increase not being that significant with positive environmental effects. This trend is consistent with earlier research [16, 41], which emphasizes the role of these concerns in forming positive perceptions and intentions toward smart mobility adoption.

Perceived Authority Support (PA) was also found to significantly influence both PBC ($\beta = 0.167$, $p < 0.001$) and subjective norms ($\beta = 0.144$, $p < 0.001$) but had no significant effect on attitude ($\beta = 0.069$, $p = 0.088$). These results suggest that individuals place trust in official guidance and government-led transportation initiatives, which enhances their sense of control over adopting the technology and strengthens their awareness of social expectations, even if it does not directly shape their personal evaluations or preferences. However, this influence does not appear to directly shape how individuals feel about autonomous buses. One possible explanation is that Filipinos may perceive authorities more as enforcers of rules and providers of structure rather than as opinion leaders who shape personal viewpoints. This contrasts with patterns observed in other contexts, such as in the study by Goldbach et al. [37], where institutional trust more directly influences public attitudes toward emerging technologies.

In terms of value-based factors, Perceived Benefit (PB) had a significant positive effect on BI ($\beta = 0.149$, $p = 0.005$). This suggests that the more individuals recognize the potential advantages of autonomous buses such as reduced travel stress, enhanced safety, and improved convenience, the more likely they are to develop an intention to use the technology. Unexpectedly, Perceived Cost (PC) also showed a positive and significant influence on BI ($\beta = 0.173$, $p = 0.006$), even though it was initially assumed to act as a barrier. This outcome may reflect a distinctive feature of the local context. Many Filipino commuters face long, exhausting, and unreliable daily travel, so a higher price might be viewed as a reasonable trade-off for a more modern, safer, and more convenient transportation option. In this sense, cost may be interpreted not as a burden, but as an indicator of quality or status, something that people are willing to pay for. This supports why PU was significant, despite having low beta score ($\beta = 0.113$, $p = 0.034$). This is because using an autonomous bus service does not disrupt my daily schedule or tasks, allows them to travel conveniently, may not be out of their normal routes, and that they can experience benefits that they cannot achieve with other modes of transportation.

Meanwhile, Perceived Risk (PR) did not have a significant effect on behavioral intention ($\beta = 0.036$, $p = 0.356$). Similar findings in recent studies suggest that risk often influences intention indirectly, mainly through trust or attitudes, rather than as a direct predictor. For instance, Kenesei et al. [23] found that when users trust the technology and its operators, safety or privacy concerns have little impact on adoption. Golbabaei et al. [67] also observed that risk perceptions did not strongly affect people's willingness to use autonomous shuttles, as perceived usefulness and benefits outweighed

safety concerns. Likewise, Abbasi et al. [68] showed that risk dimensions mainly operate through trust, with younger users generally perceiving lower risk. Eitrheim et al. [69] further noted that addressing trust in regulatory and operating institutions reduces perceived danger from technical failures. These findings suggest that in the Philippine context, high trust in regulation and optimism toward new technology may explain why perceived risk did not significantly deter intention to try autonomous buses.

There may also be an underlying public trust that if a technology is being introduced for public use, it has already met the necessary safety requirements and government standards. Given the regulatory environment in the Philippines, many individuals may assume that new public services, such as autonomous buses, have undergone adequate testing and official oversight before being made available. It could be summarized, nonetheless, that perceived control, perceived benefits, and pro-environmental behaviors are leading determinants of behavioral intention in autonomous bus utilization among Filipino commuters.

5.1 *Theoretical implications*

This study provided significant theoretical advancements in sustainable mobility and behavioral intention modelling by combining STPB with VF. While traditional TPB has been widely applied in transport studies, its limited focus on environmental and economic dimensions constrained its explanatory power in sustainability. Moreover, its utilization for general behavioral assessment alone seemed to be criticized and needs expansion or elaboration to establish other findings [34]. The STPB extension utilized in this research, by integrating constructs such as PECC, PELC, and PA, presents a better understanding of user motivations regarding emerging sustainability-focused transport technologies, such as autonomous buses.

Furthermore, the incorporation of the VF improves the STPB by capturing the cognitive assessments users undertake concerning costs, benefits, and risks. This dual-framework approach integrates motivational and evaluative aspects of behavior, emphasizing how personal efficacy, environmental awareness, and perceived value collectively affect behavioral intention and implementation. The findings indicate that PBC and cost-benefit evaluations are more effective indicators of BI than AT alone, which signifies a transition from merely affective theories to more pragmatic and adaptable interpretations. Therefore, this shift influences the development of theoretical frameworks regarding technology adoption in developing countries, where users may prioritize practicality and systemic trust over abstract sentiments. Since this benchmark framework through the integration of STPB and VF was established, it could be delineated that moderating variables and addition of mediating variables may influence the behavioral and perception of commuters that future research could consider. Adaptive models may be applied like technology acceptance models, which could highlight the overall concept of AV and autonmous buses. The technological factors, together with the behavioral, socio-demographic variables as moderating factors, and even additional constructs like trust, digital literacy and personal innovativeness, and experience once the autonomous bus is widely implemented in the country, could benefit for a more holistic assessment.

5.2 *Practical and managerial implications*

There are several key considerations that must be addressed to improve the adoption and usage of autonomous buses in the Philippines. First, it is evident that individuals are more likely to use autonomous buses if they already have the intention to do so, as supported by the significant relationship between behavioral intention and actual use. This finding highlights the need to strengthen user intentions through campaigns, pilot programs, and visible endorsements. Providing easy access to trial services, public demonstrations, and user education could help reinforce these intentions. Governing bodies may provide free trial campaigns and obtain the insights, perception, and comments of the commuters. This way, future implementations may know what factors to improve upon. As noted from perceived behavioral control, individuals are more likely to use the service when they feel confident and capable of doing so. It is therefore vital to focus on making the system feel manageable and within reach. Initiatives such as user-friendly mobile applications, clear instructional signage at stations, and supportive onboarding experiences can help address this concern and were reflected in the perceived control and behavioral factors. The autonomous bus may provide simplified applications for users to easily access and even provide automated or option for payment scheme—an easier process and more option for commuters. Subsidies and

support, especially for vulnerable groups and elderly may be more appreciated by commuters and the public as a translation for government support.

Second, environmental and economic awareness were shown to shape people's perceptions and decisions. Results from the perceived environmental concern and economic concern constructs revealed that individuals who are more conscious of environmental and financial matters tend to feel more positive, more supported, and more capable of using autonomous buses. These concerns significantly influenced attitude, subjective norms, and perceived behavioral control. This suggests that messaging strategies should emphasize the ecological and financial benefits of adopting autonomous buses. For example, emphasizing reduced emissions, long-term fuel savings, and fewer delays compared to traditional transport options can help strengthen these intentions. These values align with the growing public consciousness about sustainability and practicality and were supported by subjective norm and attitudinal outputs. However, a crucial factor that must not be overlooked is the role of institutional authority. Although perceived authority did not significantly influence attitude, it significantly shaped subjective norms and perceived control. This suggests that while the government may not directly influence how people feel about autonomous buses, it plays a key role in reinforcing the legitimacy and structure of the service. Visible government backing, public endorsements, and well-regulated rollouts would reassure users that the service is safe and trustworthy. This was evident from the influence of authority on behavioral control and normative belief factors.

Interestingly, perceived cost had a positive influence on intention, meaning that higher costs were not viewed as deterrents, but rather as indicators of quality or safety. This may reflect the daily struggles of Filipino commuters who are willing to pay more for a safer and more efficient alternative. Therefore, instead of focusing solely on affordability, service providers should emphasize quality, comfort, and reliability. This interpretation was drawn from the behavioral intention outputs and is especially important in building a strong value proposition. The cost may be linked to communication strategies like positioning the service as a premium sustainable option. Since it is evident that pro-environmental behavior is one of the highlight of AV utilization, the ecological factors like climate CO_2 effect reduction, development, and smart city infrastructure may be implicated with the cost. This way, commuters would have confidence on the additional cost autonomous bus services may incur.

Lastly, perceived risk was not found to be a major concern. This may be due to Filipinos' general adaptability and trust in government-regulated services. Many may assume that public rollouts have already passed safety checks and legal requirements. While this trust is beneficial, it must be supported by continuous monitoring, transparency, and clear safety communications. This finding reflects the psychological resilience of users and provides an opportunity for service providers to shift the focus of public messaging from safety assurance to convenience and long-term benefit.

5.3 *Limitations and future reasearch*

Despite its contributions, this study is subject to several limitations that provide direction for future research. First, the reliance on a convenience sampling technique, primarily focusing on online social media users, limits the generalizability of the findings across various demographic groups, particularly older adults or individuals in areas with limited internet access; future research could include more diverse and representative populations to enhance the applicability of the results. Moreover, it could be implicated that the current study focused on the probable users based on demographic representation and related studies. Future research could consider other generations, private car users, and even those that are not totally using public transportation to obtain overall acceptance perception from people in the country. Second, the study's cross-sectional design restricts the ability to track changes in perception and usage over time. As autonomous bus services continue to expand, longitudinal research will be essential to evaluate how ongoing exposure, policy developments, or real-world experiences influence actual usage behavior. Once full implementation of the autonomous bus services are widely evident in the country, it would be strategic to reevaluate the intention with actual use and behavior among commuters to compare and contrast the findings of the study.

Third, other variables like trust, prior experiences once habit in utilization has been established, and even voluntariness may be added to expand understanding and perception mesurement of autonomous bus service utilization—either as direct effect or moderating variables. This is because The measurement of actual use was limited by the low availability of the service and could be improved through observational data. Lastly, this research focused on the Philippines as a developing

country, which increases its relevance for emerging economies. Cross-cultural comparisons with countries at different stages of autonomous vehicle adoption would help assess the applicability of the integrated STPB-VF model across diverse urban and regulatory settings. Future research could also develop adaptive models like the Technology Acceptance Models (TAM) or Unified Theory of Acceptance and Use of Technology 3 (UTAUT3) that account for changing environmental conditions, evolving policy frameworks, and technological progress to accurately reflect the dynamic nature of sustainable mobility.

6. Conclusion

This study examined the factors influencing the utilization and use of autonomous buses in developing urban areas, focusing on the psychological, environmental, and value-based dimensions of commuter decision-making. Drawing on the integrated Sustainability Theory of Planned Behavior and the Valence Framework, the research explored how behavioral intention, perceived control, attitude, sustainability concerns, perceived authority, and perceptions of cost, risk, and benefit influence public adoption. Among the influencing factors, perceived behavioral control was the most significant, highlighting the importance of ensuring that commuters feel confident and capable of using technology. While attitude also contributed, its relatively smaller effect suggests that practical considerations may carry more weight than general favorability. Environmental and economic concerns had a substantial impact on shaping user attitudes, perceived control, and social norms, while perceived authority played a role in fostering trust and social support.

Perceived cost was positively associated with intention, indicating that many commuters are willing to pay for a safer, more reliable, and modern transportation experience. In contrast, perceived risk had no significant effect, which may reflect public trust in government oversight or an assumption that safety standards have already been met. These results highlighted the distinct transportation challenges and governance context in the Philippines, where perceptions of practicality, trustworthiness, and institutional support strongly influence public acceptance. The findings suggest that policymakers should prioritize building user confidence by ensuring accessible system design, providing clear and transparent information, and facilitating public demonstration trials.

Public awareness efforts that communicate the environmental and economic advantages of autonomous buses in relatable, everyday terms can further support adoption, while visible government involvement can reinforce trust. While perceived risk is currently low, it remains crucial to uphold rigorous safety standards as the technology continues to evolve and scale. This study also contributes to broader sustainability goals, particularly UN SDG 11 (Sustainable Cities and Communities) by promoting efficient and inclusive transport systems, SDG 9 (Industry, Innovation and Infrastructure) through the advancement of smart mobility, and SDG 13 (Climate Action) by supporting cleaner, more environmentally responsible urban transit solutions. This study also provides a foundation for future research into how different populations adapt to emerging transport technologies over time. This study provides a solid foundation for guiding the responsible and sustainable adoption of autonomous buses in emerging urban contexts.

Data availability

The data presented in this study are available on request from the corresponding author.

Conflict of interest

The authors declare no competing financial interest.

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