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Exploring the Role of Tourist Pro-Environmental Behavior in Autonomous Vehicle Adoption: A TPB and PLS-SEM Approach

Qingyu Zhang [1], Muhammad Zada [2], Salman Khan [1,*], Hossam Haddad [3,4], Nidal Alramahi [5] and Waleed Ahmed Nureldeen [3,6]

[1] Research Institute of Business Analytics and Supply Chain Management, College of Management, Shenzhen University, Shenzhen 518060, China; q.yu.zhang@gmail.com
[2] Facultad de Administración y Negocios, Universidad Autónoma de Chile, Santiago 8320000, Chile; muhammed.zada@uautonoma.cl
[3] Business Faculty, Zarqa University, Zarqa 13110, Jordan; hhaddad@zu.edu.jo (H.H.); w.nureldeen@ubt.edu (W.A.N.)
[4] College of Business Administration, University of Business and Technology, Jeddah 21361, Saudi Arabia
[5] Accounting Department, Business Faculty, Zarqa University, Zarqa 13110, Jordan; ramahinedal@zu.edu.jo
[6] UBT Academy, University of Business and Technology, Jeddah 21361, Saudi Arabia
* Correspondence: salman_pide@outlook.com

Abstract: As businesses and governments increasingly explore innovative strategies to promote pro-environmental behavior, autonomous vehicles (AVs) have emerged as a key initiative for fostering sustainable communities. However, the specific norms—personal, descriptive, and subjective—that influence behavioral intentions regarding AV adoption remain underexplored. This research addresses this gap by integrating the extended theory of planned behavior (TPB) with pro-environmental variables to examine both direct and indirect influences on behavioral intentions. Using Partial Least Squares Structural Equation Modeling (PLS-SEM), the proposed model was validated with data from 516 domestic Chinese tourists. The findings highlight that subjective norms and trust significantly shape positive intentions toward adopting autonomous vehicles. Furthermore, environmental knowledge and concerns exert a significant indirect impact on these intentions, underscoring the complex interplay of factors that drive pro-environmental behavior. These results provide valuable insights for policymakers and practitioners aiming to enhance the acceptance of AVs in China and offer a foundation for future research on the role of norms in technology adoption.

Keywords: theory of planned behavior; autonomous vehicles; behavioral intention

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1. Introduction

The use of artificial intelligence (AI), combined with real-time data processing technologies, has become increasingly crucial in enabling vehicles to achieve higher levels of automation and autonomous decision-making [1]. An autonomous vehicle (AV) powered by AI represents one of the most disruptive and transformative advancements in the transportation industry [2,3]. They are generally fully or highly automated, requiring little to no human interaction [4]. The built-in AI in AVs facilitates all driving tasks without the need for human intervention or supervision, making them a significant component of future smart transportation ecosystems. Despite ongoing concerns about safety, liability, and data privacy related to autonomous vehicles, there is growing support for their adoption as solutions to contemporary urban mobility challenges [5,6]. Autonomous vehicles are believed to offer several benefits when widely adopted. For instance, they are expected to improve road safety by utilizing artificial intelligence to minimize traffic accidents caused by human error [7]. According to [8], autonomous vehicles (AVs) are believed to reduce traffic congestion and make transportation more accessible to the elderly and the disabled, all of which enhance the efficiency of the road network [9]. Ref. [10] argued autonomous

vehicles have the potential to be more fuel-efficient. The use of AVs represents a breakthrough for the automotive industry. Recent projections indicate that by 2030, AVs could account for up to 30% of all vehicle sales worldwide, driven by major automotive manufacturers such as BMW, Volkswagen, Toyota, Nissan, General Motors, and Ford, which are aggressively pursuing the commercialization of Level 5 automation—vehicles that operate entirely without human intervention [11]. Globally, nations have established objectives and strategies to implement autonomous vehicles (AVs), which are expected to constitute a significant portion of vehicle fleets in the future [12].

While extensive research has been conducted on the implications of autonomous vehicles (AVs) for environmental sustainability, energy consumption, and governance, these studies often predate the availability of more advanced AV technologies and overlook critical socio-behavioral factors [13]. Notably, most studies on autonomous vehicles have been conducted in developed countries, such as Spain [14], France [15], and the United States (US) [16], while research in developing nations has been relatively limited. Notably, this gap is evident in China, despite its rapid advancements in AV technology and its high adoption rates globally. Given China's unique regulatory environment and the fast-growing rate of AV technology adoption, it is crucial to understand the socio-behavioral factors influencing AV adoption among tourists. While most research has focused on environmental implications or governance issues, this study specifically addresses, for the first time, tourists' behavioral intentions regarding AVs in China, with an emphasis on the role of pro-environmental behavior. Drawing on a theoretical framework [17] related to pro-environmental behavior and behavioral intention, this study aims to fill the gap in tourism research. It integrates this framework with other constructs, such as trust and personal norms, to provide a comprehensive approach to understanding the dynamics of AV adoption among tourists—an area not yet explored in the literature. The motivation behind this study is to highlight the role of pro-environmental behavior in influencing tourists' adoption of AVs, as such concerns are increasingly shaping consumer choices in transportation. The present study, therefore, focuses on domestic tourists—the primary segment of the travel market in China—whose choices and behavior are vital for devising effective policies and strategies. This extension is methodologically sound and justified, providing comprehensive insights into the unique factors influencing AV adoption among tourists in China.

This study applies the extended theory of planned behavior (TPB) framework to investigate factors influencing the adoption of autonomous vehicles (AVs). The TPB provides a robust theoretical foundation for understanding behavioral intentions, focusing on individual attitudes, subjective norms, and perceived behavioral control. In this study, the TPB is expanded by incorporating pro-environmental elements, such as personal norms, environmental knowledge, environmental concerns, and trust, to predict domestic tourists' intentions to adopt AVs. This extension builds upon the work of [17], who demonstrated the relevance of TPB in examining pro-environmental behavior. However, our research offers novel insights by introducing tourism-specific behavioral components and contextual variables pertinent to the rapidly evolving AV market in China. As environmental concerns increasingly shape consumer choices in the automotive industry, this survey is both timely and relevant.

Existing research has primarily focused on non-public AVs at Level 2, or partial driving automation, which are becoming increasingly common in urban centers across China. In 2009, the Chinese government implemented a range of preferential policies aimed at promoting the development of autonomous vehicles [18]. By 2016, China accounted for 40% of global AV sales, making it the largest market in the world [19]. In 2018, China rolled out a comprehensive set of guidelines for testing autonomous vehicles (AVs) on public roads, which led to the widespread adoption of vehicles equipped with Level 2 (L2) driving automation [20]. According to the China Association for Automobile Inspection, the number of passenger cars equipped with L2 autonomous driving functions registered in China increased by 118.9% annually from January to November 2020, totaling 2.60 million

units. Among these installations, 15.9% were from Guangdong, representing a significant increase compared to other provinces [4]. As stated in Document No. 39 of 2020 issued by the General Office of the State Council, new energy vehicles are projected to account for approximately 20% of total vehicle sales by 2025, according to China's New Energy Vehicle Industry Development Plan (2021–2035). Between January and September 2022, 28.4% of domestic passenger cars were equipped with Level 2 (L2) automation. By 2025, the adoption rate of L2 and Level 2+ (L2+) vehicles is expected to surpass 50%, with L2+ potentially accounting for 15% of this figure. Cities such as Shenzhen, Shanghai, and Guangzhou are implementing advanced autonomous driving policies to facilitate this transition [21]. These statistics may be more representative of domestic trends than of international tourism, limiting the generalizability of the findings outside of China. Therefore, further research is needed regarding the adoption of AVs by international tourists across a variety of geographical contexts to gain a broader understanding of this rapidly evolving market.

In summary, this study proposes a novel theoretical framework based on the theory of planned behavior (TPB) [22] to comprehensively examine the factors that influence the adoption of AVs in China, a critical testbed for these technologies. The originality of this framework lies in its integration of pro-environmental components when addressing tourists' behavioral beliefs about AVs. Specifically, this study explores how personal norms, environmental knowledge, environmental concerns, environmental responsibility, and trust predict domestic tourists' intentions to adopt AVs, thus extending the application of TPB in this context.

Guided by [17], our framework integrates pro-environmental behavior and trust within the context of the Chinese tourism sector, offering new insights that enrich the existing body of literature. Despite thorough reviews, research on how personal norms, environmental knowledge, environmental concerns, environmental responsibility, and trust predict domestic tourists' intentions regarding autonomous vehicles (AVs) remains limited. We also candidly acknowledge that this, in part, extends the methodological contribution of the cited study. We have sought to distinguish our paper by incorporating additional variables and nuances specific to the Chinese market. In this regard, we acknowledge our methodological debt to the aforementioned study, while highlighting the unique value we add through the integration of these extra variables and context-specific details pertinent to the Chinese marketplace. This study focuses on domestic tourists due to their significant role in the Chinese AV market, while also acknowledging the need for broader research, including various segments, to generalize the findings. The inclusion of pro-environmental attributes into the expanded theory of planned behavior (TPB), along with the factor of trust, offers valuable insights for policymakers and industry leaders aiming to promote AV adoption in diverse contexts. By addressing this gap in the literature, our study aligns with recent research emphasizing the growing importance of environmental responsibility and pro-environmental behaviors in consumer decision-making, as supported by recent studies [23–25]. These additions provide a clear theoretical rationale for our focus. The specific research questions guiding this study are as follows:

RQ1: How do socio-psychological factors—personal norms, descriptive norms, and subjective norms—interact with pro-environmental attitudes to influence the behavioral intentions of tourists to adopt autonomous vehicles within China's rapidly growing AV market?

RQ2: To what extent do environmental responsibility, environmental concerns, and environmental knowledge mediate the relationship between socio-psychological norms and the behavioral intention to adopt autonomous vehicles among domestic tourists in China?

The paper is structured as follows: Section 2 provides a thorough literature review of previous studies related to the adoption of AVs and the TPB framework. Section 3 describes the methodological approach used in this study, including data collection and analysis techniques. Section 4 presents the research findings, while Section 5 discusses the implications. Finally, Section 6 concludes the paper by summarizing the key findings and offering suggestions for future research.

2. Literature Review and Hypotheses Generation

2.1. TBP for Forecasting Behavioral Intention Concerning Avs

Building upon the theory of reasoned action, the theory of planned behavior integrates perceived behavioral control, which influences both an individual's intention and their behavior [22,26–29]. The TPB is recognized as a robust framework for predicting various behaviors, particularly in the context of eco-friendly and sustainable actions. In fact, the foundational nature of the theory of planned behavior (TPB) is evident in its broad application across various disciplines, such as consumer behavior, environmental psychology, and transportation studies. Building on the well-established methodology of [17], who investigated pro-environmental behavior related to electric vehicles, this research extends that approach to explore autonomous vehicle (AV) adoption within the context of tourism. Consumers' intentions and behaviors are influenced by individual attributes and social pressures, which vary across contexts and can serve as useful predictors of behavior [22,30,31].

While conventional TPB models forecast behavioral intentions based on descriptive and subjective norms, recent studies have criticized their limited scope in complex and emerging contexts, such as autonomous vehicle (AV) adoption [32–35]. For instance, studies by authors such as [25,36] have expanded on the traditional TPB model by adding personal and descriptive norms, respectively, to better account for pro-environmental behavior. The study by [17] focused on incorporating pro-environmental components into the TPB model. However, in most cases, these modifications still fail to include critical factors such as trust in technology and perceived environmental responsibility, both of which are crucial for AV adoption. Therefore, this study builds on previous findings by proposing an extended TPB model that incorporates these previously overlooked factors to better explain consumer intentions toward AVs. Our research, drawing from the above-mentioned studies, proposes an extended TPB model contextualized for Chinese tourism. By incorporating trust and environmental responsibility as additional constructs, we provide a more nuanced understanding of the socio-behavioral determinants of AV adoption among domestic tourists. Recent applications of TPB have also ventured beyond traditional behaviorist approaches, exploring areas such as technology acceptance and the environmental consequences of AV development [32,35]. Several researchers have applied TPB to study environmentally friendly and sustainable behaviors by incorporating additional factors. For example, Refs. [25,36] added descriptive norms, while [37] introduced biospheric values, environmental self-identity, and personal norms. These modifications reflect a recent trend of adapting the theory of planned behavior (TPB) to better capture the complexities of pro-environmental behavior.

Although the TPB model has undergone subtle changes, introduced by [34,38,39], it still demonstrates considerable analytical strength regarding consumer intention, particularly in new contexts such as the acceptance of autonomous vehicles. Building on these developments, our research acknowledges the limitations identified in previous studies, including those cited, which were narrow in their focus on pro-environmental behavior and did not account for trust in AV technology. Recent research supports this by proposing hybrid versions of the theory of planned behavior (TPB), where the inclusion of context-specific factors serves as better predictors of behavioral intentions [40]. Moreover, recent advances in AV technology include magnetic sensor-based multi-vehicle data association and novel methods for vehicle speed estimation. Altogether, these contributions have significantly improved the reliability and efficiency of autonomous systems [41]. These technological advancements may influence public trust and perceived safety, both of which are key factors in the adoption of autonomous vehicles (AVs). Thus, this study proposes an extended theory of planned behavior (TPB) model in which perceived behavioral control is replaced by constructs such as environmental responsibility, environmental concern, and perceived environmental knowledge. These extensions are also in line with recent findings by [42]. Several studies have found that hybrid TPB models, incorporating context-specific factors, offer superior predictive power for behavioral intentions. This study, therefore,

bridges gaps in the literature by integrating new constructs into our framework, providing a more holistic understanding of AV adoption. While previous studies, such as [17], heavily relied on traditional TPB constructs, this research incorporates additional factors relevant to the context of Chinese tourism, namely perceived environmental knowledge and trust. This adjustment reflects the recognition of methodological requirements that accommodate regulatory, technological, and consumer dynamics unique to the Chinese market. The present research identifies the failure of previous studies to consider external factors affecting perceived behavioral control [42]. Using behavior as a proxy for actual control obscures the ability to identify the extent of control an individual can exercise over their actions [43]. Therefore, this research replaces perceived behavioral control with environmental responsibility, concern, and knowledge to develop a more accurate predictive model of individual behavior toward AVs. This aligns with current research trends, as noted by [44], highlighting the significant role of environmental knowledge in influencing consumer preferences for alternative sustainable technologies. This standpoint aligns with prevailing trends in contemporary research within this area, as highlighted by [45], who emphasized the significant role of technological advancements and consumer perceptions in shaping consumer adoption behavior.

Our framework builds on the work of [17] by including additional constructs, such as trust, which is considered critical, but was understudied in the original research. This approach offers a deeper understanding of AV adoption intentions, particularly in the dynamic Chinese market. In this paper, we present our extended TPB framework, incorporating trust and pro-environmental factors as additional elements that explain AV adoption intentions more comprehensively compared to previous studies. This work not only addresses the gaps identified in traditional TPB applications but also creates a holistic approach, reflecting recent findings on the role of perceived environmental benefits and trust in the adoption of sustainable technologies [46,47].

2.2. Personal Norm

Psychological needs are significant determinants of motivation and play a crucial role in intrinsic motivation, which is characterized by the satisfaction of needs for competence, autonomy, and relatedness [48,49]. Intrinsic motivation often stems from personal norms or internalized moral obligations that guide specific actions [50,51]. Personal norms constitute an important motivational element of pro-environmental behavior, aligning with self-determination and ethical responsibility toward society [52]. Individuals who demonstrate strong environmental ethics possess a significant moral responsibility, which tends to drive pro-environmental intentions and behaviors [53]. In this context, the inclusion of personal norms in the theory of planned behavior (TPB) enhances its explanatory power, particularly in environmental settings, as discussed by various scholars [53,54]. These studies consistently find that personal norms play a crucial role in adopting green products, influenced by social and environmental factors [55,56]. Although previous studies have identified that personal norms significantly influence eco-friendly behavior, they have largely overlooked the interaction between personal norms and external factors, such as trust and environmental responsibility, in the context of technology adoption. The framework presented here aims to address this gap by investigating the effects of personal norms, along with perceived knowledge and perceived responsibility for environmental safety, on behavioral intentions to adopt autonomous vehicles (AVs) [55,56]. In light of the overwhelming influence of social norms on behavioral intentions, as advanced in both classical and contemporary literature, we propose the following hypotheses:

H1. *Personal norms positively impact behavioral intentions toward adopting AVs among Chinese tourists.*

2.3. Descriptive Norms

Descriptive norms, which are inherent to social norms, represent the actions and attitudes commonly observed among others within a social group [57,58]. These norms provide powerful behavioral cues that influence what is deemed appropriate in various situations. In marketing, descriptive norms leverage social proof to guide consumer decisions [59]. The reason descriptive norms have a greater influence is that they offer direct and powerful behavioral suggestions [60]. When integrated into the theory of planned behavior (TPB), descriptive norms exhibit the greatest predictive power regarding intentions toward behaviors, especially in pro-environmental contexts, as demonstrated in studies [61–63]. Empirical studies consistently show that descriptive norms significantly impact behavioral intentions, often providing social validation that consumers accept simply because these behaviors are deemed socially acceptable, without deeper consideration [64]. This study extends the TPB model by incorporating descriptive norms, along with trust and environmental constructs, to provide deeper insights into their roles in shaping intentions to adopt AVs. Unlike previous studies that emphasized social proof as a driver of pro-environmental behavior, our model situates descriptive norms within the context of environmental concerns and trust, highlighting the complex mechanisms through which social influence operates in technology adoption. Based on the preceding discussion, we propose the following hypothesis:

H2. *Descriptive norms positively impact behavioral intentions toward adopting AVs among Chinese tourists.*

2.4. Subjective Norms

Subjective norms constitute a fundamental component of the theory of planned behavior, relating to a person's perception of societal pressure to perform or refrain from a specific behavior. This perception is formed by the opinions and expectations of relevant individuals and significant others [65]. Empirical evidence supporting this conceptualization is derived from numerous studies that demonstrate its crucial role within the TPB framework. While [66] argue that it encompasses the entire spectrum of beliefs individuals consider when forming their understanding of behavior, subjective norms play a relevant role in influencing conformity to meet others' expectations, while other research partially focuses on the effects of subjective norms on behavior and attitudes [67]. As noted by [68], subjective norms can moderate and mediate the influence of other determinants. This is supported by past studies, which reiterated that subjective norms are among the most crucial predictors of behavioral intentions in situations with high social influence. Thus, drawing from [69,70] and findings of previous research, all these studies have concluded that subjective norms are a potent predictor of behavioral intentions when the social expectations regarding the performance of a behavior are widely accepted. Our extended TPB model, which incorporates these variables, provides a more comprehensive understanding of how subjective norms influence behavioral intentions toward AVs. Accordingly, the following hypothesis has been developed based on prior studies:

H3. *Subjective norms positively affect behavioral intentions toward adopting AVs among Chinese tourists.*

2.5. Environmental Knowledge

One the important factors that could influence stated preferences and actual behavior regarding the adoption of autonomous vehicles (AVs), particularly in the context of sustainability framing, is environmental knowledge. As [71] noted in previous studies, informed consumers may be better equipped to understand the ecological relevance of products and make eco-friendly decisions. Researchers have thoroughly documented that increased environmental knowledge can lead to pro-environmental behavior.

For example, several studies have found that environmental knowledge influences decision-making by fostering a broad understanding of ecological and sustainability issues [72–74]. This understanding not only shapes attitudes but also enhances intentions to engage in sustainable practices, including AV adoption [75]. Additionally, other research identifies environmental knowledge as a strong predictor of behavior, particularly concerning emerging technologies such as AVs [76]. Although general environmental knowledge has been used in previous studies, the perceived environmental knowledge scale employed in this study captures an individual's subjective understanding of sustainability issues [77,78]. This is especially important in the context of AV adoption, as perceived knowledge, rather than objective knowledge, drives behavioral intentions [79,80]. We are, therefore, proposing the following hypothesis:

H4. *Environmental knowledge positively influences behavioral intentions toward adopting AVs among Chinese tourists.*

Ref. [81] argued that personal norms, which promote eco-friendly behaviors, are shaped by internal psychological factors, reflecting an individual's internalized morality toward environmental preservation. Descriptive norms guide behavior by providing social proof, thereby simplifying decision-making in environmental contexts [82]. Subjective norms, which reflect peer group expectations, also critically influence the development of behaviors. Together, descriptive, personal, and subjective norms shape how individuals interpret events and form behavioral intentions. Ref. [83] noted that as people become more familiar with AV technologies and their environmental implications, these norms increasingly influence their behavioral intentions, emphasizing that people's perceptions and judgments are shaped by their environmental knowledge, which improves decision-making when balancing technological adoption with environmental sustainability. Studies have shown that greater environmental awareness leads to more pronounced pro-environmental action [84,85]. This has highlighted the strong need for environmental education and awareness in fostering eco-friendly behavior, especially in the adoption of new technologies such as AVs.

H4a. *Environmental knowledge mediates the relationship between personal norms and behavioral intentions toward adopting AVs.*

H4b. *Environmental knowledge mediates the relationship between descriptive norms and behavioral intentions toward adopting AVs.*

H4c. *Environmental knowledge mediates the relationship between subjective norms and behavioral intentions toward adopting AVs.*

2.6. Environmental Responsibility

With the increasing environmental problems, people and organizations are realizing the need to accept their responsibilities in an effort to combat ongoing environmental degradation. This sense of responsibility is often triggered by feelings of guilt or a moral obligation related to one's contribution to a sustainable environment [86]. Both individuals and organizations bear significant responsibilities toward environmental protection [75]. Businesses, acknowledging this responsibility, are incorporating environmental stewardship into their operations to enhance their competitive advantage and meet consumer demand for responsible practices [87]. As eco-friendly products gain popularity, consumers are becoming more informed and accountable for environmental sustainability [88]. Refs. [89,90] emphasized that environmental responsibility is one of the main determinants of purchase intent and the adoption of green products, which can encourage eco-sensitive behavior and acceptance of technologies such as autonomous vehicles (AVs). This study thus proposes the following hypothesis:

H5. *Environmental responsibility positively influences behavioral intentions toward adopting AVs among Chinese tourists.*

According to [79], environmental responsibility is an important human obligation to care for the Earth's ecosystem. This responsibility encompasses personal accountability and the collective contributions of others toward the restoration of the environment. Ref. [80] further states that certain facilitative constructs may influence perceptions and beliefs, even when there are constraints related to descriptive, personal, and subjective norms. Recent studies highlight the broader implications of environmental responsibility, particularly in corporate settings, where it can indirectly influence innovation and company value [91]. Likewise, Ref. [92] found that environmental responsibility can moderate the relationship between green purchasing intentions and actual conservation efforts. This suggests that a higher perceived level of environmental responsibility among consumers correlates with increased intentions to engage in eco-friendly behaviors, particularly concerning products and technologies such as autonomous vehicles (AVs). Our model integrates this construct with perceived environmental knowledge and trust, offering a comprehensive view of how responsibility influences intentions to adopt AVs. Based on such propositions, the following hypotheses can be formulated:

H5a. *Environmental responsibility mediates the relationship between personal norms and behavioral intentions toward adopting AVs.*

H5b. *Environmental responsibility mediates the relationship between descriptive norms and behavioral intentions toward adopting AVs.*

H5c. *Environmental responsibility mediates the relationship between subjective norms and behavioral intentions toward adopting AVs.*

2.7. Environmental Concern

Environmental concern reflects a consumer's awareness of environmental issues and their commitment to taking measures for improvement [93]. According to [32], environmental concerns influence attitudes and behavior; hence, they are crucial in eco-conscious decisions. Ref. [94] describe environmental concern as a commitment to reducing pollution and preserving natural resources. Ref. [56] found that environmental concerns drive consumers' intentions to adopt sustainable technologies such as autonomous vehicles (AVs), while [77] further confirmed that environmental concern strongly predicts purchase intentions, particularly for eco-friendly products. Other studies have shown that environmentally concerned consumers are more likely to purchase sustainable products that reflect their values. While previous studies have highlighted the role of environmental concern in shaping consumer behavior, they often overlook its interaction with other constructs, such as trust and perceived responsibility, in the context of AV adoption [79,89]. In this context, studies by [38,95], found that environmental concern mediates the relationship between psychological factors and behavioral intentions. These studies, however, generally focus on general pro-environmental behavior rather than the specific complexities associated with adopting new technologies, such as autonomous vehicles (AVs). Our research builds on this by incorporating environmental concern into an extended TPB model, highlighting its role alongside trust and perceived responsibility, both of which are significant in the adoption of new technologies. Considering its strong influence on consumer behavior, this justifies the rationale for using this variable within the framework. Based on this discussion, the hypothesis is as follows:

H6. *Environmental concerns positively affect behavioral intentions toward adopting AVs among Chinese tourists.*

Environmental concern refers to the awareness and intentional behavior aimed at addressing environmental issues [96]. Ref. [97] indicates that serious engagement with environmental concerns leads to environmentally responsible behavior and alters attitudes toward sustainability. Furthermore, environmental concern indirectly influences behavioral intentions regarding autonomous vehicles (AVs), similar to the purchasing of eco-friendly goods, as it reflects the environmental values of the consumer [22]. In this context, studies by [38,95] found that environmental concern mediates the relationship between psychological factors and behavioral intentions. These studies generally focus on pro-environmental behavior rather than the specific complexities associated with the adoption of new technologies, such as autonomous vehicles (AVs). Therefore, our research expands on this understanding by incorporating environmental concern into the extended TPB model, where its role operates alongside trust and perceived responsibility, both of which are significant in the adoption of new technologies. As put forward by [25] an environmentally aware consumer is inclined toward sustainable alternatives. At times, such a direct effect is weakened by variables of demographic nature. Environmental concern alone creates a convergence of personal norms and eco-friendly actions, significantly influencing behavioral intentions toward AVs. However, past studies have often viewed environmental concern in isolation, without considering its mediating role between social norms and technology adoption [80]. This research addresses these gaps by introducing environmental concern as a mediator in the extended TPB model, providing a deeper understanding of how this factor interacts with other constructs in shaping behavioral intentions toward AVs. Accordingly, environmental awareness indirectly affects behavioral intentions, since it tends to align social norms to environmentally friendly actions. The following hypotheses emerge:

H6a. *Environmental concerns mediate the relationship between personal norms and behavioral intentions toward adopting AVs.*

H6b. *Environmental concerns mediate the relationship between descriptive norms and behavioral intentions toward adopting AVs.*

H6c. *Environmental concerns mediate the relationship between subjective norms and behavioral intentions toward adopting AVs.*

2.8. Trust

Trust is a critical element in adopting novel technologies, as it helps individuals manage uncertainties. Ref. [98] asserts that trust is essential for the successful implementation and adoption of autonomous vehicles (AVs). Based on [99], trust is defined as "the capacity of an agent to contribute to the achievement of an individual's objectives within an uncertain and susceptible context," emphasizing its significance in uncertain situations. Trust in automation, particularly in safety-critical contexts such as AVs, is vital [100]. Overreliance on or neglect of technology can result from either too much or too little trust [98]. In the case of AVs, which perform complex tasks such as steering without human intervention, high levels of trust are crucial for adoption [101]. Users need to trust the system's reliability and controllability for broader acceptance. While trust has been extensively researched within various technology adoption frameworks, its specific role in conjunction with pro-environmental factors in the context of AV adoption has thus far garnered scant attention [102]. For instance, although studies such as [98] have presented reviews related to trust in the context of general technology adoption, our study integrates trust within an extended TPB model that incorporates pro-environmental constructs. Unlike traditional TPB models, which focus solely on determinants of behavioral intention, such as subjective and descriptive norms, our framework includes trust as a critical component. This approach aligns with recent research highlighting the significance of trust in adopting emerging technologies [94]. By incorporating trust into the extended TPB model, we

offer a more nuanced perspective on its influential role in shaping behavioral intentions toward AVs, particularly when combined with environmental concerns and a sense of responsibility. We, therefore, propose the following hypothesis:

H7. *Trust in AVs positively affects behavioral intentions toward adopting AVs among Chinese tourists.*

In this study, we extended the theory of planned behavior (TPB) model by incorporating pro-environmental factors such as environmental concern, knowledge, and responsibility, along with trust, to examine people's behavioral intentions towards autonomous vehicles (AVs). The proposed conceptual model offers a comprehensive framework for understanding AV adoption behavior, as it includes constructs commonly used to explain the adoption of eco-friendly products. This approach allows us to capture the interaction between trust and environmental factors, both of which are significant determinants of behavioral intentions towards AV adoption. See Figure 1.

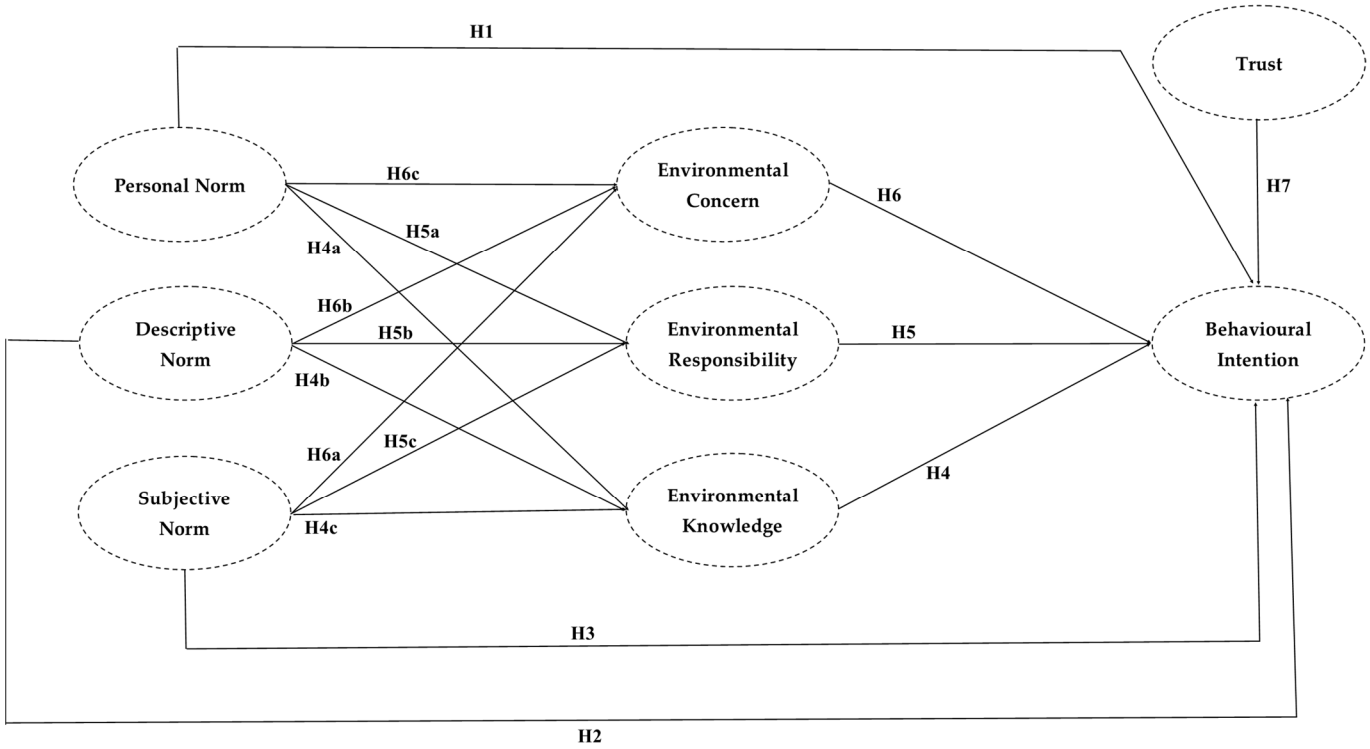


Figure 1. Proposed research model.

3. Research Methodology

3.1. Sample and Data Collection

Following [103]'s recommendations, we used a cross-sectional design to investigate our research questions and examine our hypotheses. This approach aligns with recent methodological practices in studying behavioral intentions related to technology adoption, as demonstrated in the study by [17]. We adapted their research methodology to suit our study on the adoption of AVs in the Chinese tourism market and made sure that the framework would meet the requirements of our particular research context. Additionally, study cases were selected using convenience sampling, a non-probability sampling method. A carefully designed closed-ended questionnaire was used to collect the data. The full questionnaire is provided in the Appendix A to ensure transparency and replicability (see Appendix A). It includes all items assessing pro-environmental behavior, trust, and AV adoption.

The representativeness of non-probability sampling has been questioned by some researchers [104]. However, we verified that our sample was representative by assessing participants' familiarity with AVs, which aligns with previous methodological approaches, including the methodological approach used in [105]. We are grateful to the reviewer for highlighting this ethical concern. In response, we explicitly acknowledged the methodological influence of [17] and adopted their approach in our research context. This adaptation respects the original while enhancing the reliability and validity of our findings in a new context. From 15 February 2024 to 25 March 2024, a snowball sampling technique was used to gather data from 516 Chinese tourists (310 men and 206 women). This demographic distribution allowed us to capture a broad spectrum of opinions, particularly those of key stakeholders in the process of adopting AVs. Careful attention was given to sampling and data collection, incorporating demographic variables such as gender, age, education, and income to provide a comprehensive understanding of the factors influencing AV adoption.

These efforts are further supported by the findings of [17], where demographic variables were adapted to factors relevant to the Chinese tourism market, making the analysis even more context-specific. This approach aligns with that of [17], which highlights that nuances cannot be generalized out of context, particularly with respect to the tourism market in China. Gender was also considered because previous studies suggest that men and women may differ in their attitudes toward and perceptions of new technologies. Men are generally more inclined to adopt innovative technologies, as they tend to perceive lower risk and exhibit greater technological confidence in such adoptions [106]. The age factor was considered crucial: young people are generally more accepting of emerging technologies compared to older individuals, who may have varying levels of risk perception and ability to adapt to innovations [107]. Educational level also influences attitudes and the acceptance of new technologies. Generally, the more educated people are, the more aware they become of sustainable practices and the more positive their attitudes are toward pro-environmental behavior [108]. Income was also considered an important determinant in both affordability and the potential adoption of new technologies, including AVs, as adoption behaviors are heavily influenced by income levels [109]. We believe that including these demographic variables in our research design, along with publishing the complete questionnaire in the Appendix A, would address the concerns expressed by the reviewer and enhance transparency and methodological rigor.

Overall, this study acknowledges its indebtedness to the methodological approach of [17] and extends it by applying it to the Chinese tourism context. This adaptation not only respects the original study but also offers a comprehensive, context-specific understanding of AV adoption dynamics among Chinese tourists (Table 1).

Table 1. Demographics profile.

		Frequency	Per Cent
Gender	Male	310	60.0
	Female	206	40.0
Age	18–24	97	18.8
	25–34	142	27.5
	35–44	167	32.4
	45–54	75	14.5
	56 or above	35	6.8
Education	Primary school	87	16.9
	High school	116	22.5
	Bachelor's degree	165	32.0
	Master's degree or higher	148	28.6

Table 1. *Cont.*

		Frequency	Per Cent
Income	4000 or less	85	16.5
	4001–7000	190	36.8
	7001–10,000	201	38.9
	more than 10,000	40	7.8
Awareness about autonomous vehicles	Yes	516	100

3.2. Instrument Development

The questionnaire was divided into two sections. The first section focused on the characteristics of the respondents, while the second section consisted of eight constructs with 30 items that examined behavioral intentions surrounding autonomous vehicles (AVs). The constructs in this study have been validated in previous research. Appendix A lists the constructs, items, and sources. Each item is rated on a seven-point scale, ranging from 7 ("very strongly agree") to 1 ("very strongly disagree"). Some modifications were made to the items to align them with the study's themes.

3.3. Data Analysis

The data analysis was performed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS software (version 4.1.0.8.), chosen for its effectiveness in handling complex models with multiple constructs, non-normal data, and a moderate sample size, as referenced in [110]. This method is particularly well suited for exploratory research and for testing mediation effects within the proposed theoretical framework [111]. The analysis consists of two parts: measurement model validation and structural model evaluation. First, the measurement model was validated by ensuring the reliability and validity of the constructs, with detailed results provided in the corresponding section below. Next, the structural model was evaluated by examining the path coefficients, R^2 values, and mediation effects, which illustrate the relationships among the constructs in relation to the hypotheses. The application of PLS-SEM allows for the assessment of both direct and indirect effects, emphasizing the role of key constructs, such as subjective norms, environmental concern, and trust in adoption intentions. Further discussions on these analyses are provided in their respective sections.

4. Results

4.1. Common Method Biasness (CMB)

Although the questionnaire was constructed based on self-reports, Common Method Bias (CMB) may have influenced the validity of the study. The Harman single-factor test was performed as described by [112]. Datasets with significant CMB levels were considered statistically significant if the significance level exceeded 40%. A total of 36.13 percent of the variance was accounted for in this investigation, with all items loaded on Factor 1 (below 40%). Consequently, the current dataset did not show CMB, allowing us to conclude that it was absent.

4.2. Measurement Model

The proposed model was assessed using Confirmatory Factor Analysis (CFA) [113]. Cronbach's alpha, composite reliability, and average variance extracted (AVE) were employed to evaluate the model. Utilizing the partial least squares (PLS) algorithm, we estimated the outer loading of each construct. The table shows that the composite reliability and Cronbach's alpha values are above 0.7 [114], and the AVE is above 0.5 [110]. The CFA results indicated that the loading of each item surpassed 0.7. Additionally, the CFA results met the cutoff values for Cronbach's alpha (CA), composite reliability (CR), and average convergent validity (AVE), which are above 0.7, 0.7, and 0.5, respectively [115]. In addition, RMSEA, SRMR, and NFI were used to assess model fit. The RMSEA value was 0.079 for the

saturated model and 0.107 for the estimated model, indicating borderline fit. An RMSEA value below 0.08 reflects adequate fit, while values below 0.05 reflect good fit, according to [116]. The SRMR values for the saturated and estimated models were 0.079 and 0.107, respectively, with values below 0.08 being acceptable, according to [117]. The NFI values were slightly below the threshold value of 0.9, suggesting there is still room for improvement in the model's fit. Moreover, since the Dijkstra and Henseler's rho_A index value was above 0.7, the model demonstrated consistent internal reliability, as per [118]. Taken together, these results indicate that while the measurement model meets most standard criteria for reliability and validity, certain issues related to model fit, particularly in the estimated model, require further refinement. This comprehensive assessment provides a solid foundation for subsequent structural model analysis and hypothesis testing (Table 2).

Table 2. Construct validity.

Constructs	Items	FL	α	rho_A	CR	AVE
Behavioral Intention	BI1	0.835	0.701	0.661	0.81	0.588
	BI2	0.711				
	BI3	0.75				
Descriptive Norm	DN1	0.763	0.752	0.694	0.829	0.618
	DN2	0.794				
	DN3	0.801				
Subjective Norm	SN1	0.82	0.862	0.865	0.906	0.707
	SN2	0.87				
	SN3	0.824				
	SN4	0.848				
Personal Norm	PN1	0.87	0.85	0.859	0.909	0.768
	PN2	0.878				
	PN3	0.881				
Environmental Concern	EC1	0.847	0.783	0.783	0.873	0.697
	EC2	0.834				
	EC3	0.823				
Environmental Responsibility	ER1	0.753	0.778	0.792	0.856	0.6
	ER2	0.855				
	ER3	0.701				
	ER4	0.782				
Environmental Knowledge	EK1	0.712	0.876	0.881	0.91	0.671
	EK2	0.861				
	EK3	0.853				
	EK4	0.829				
	EK5	0.832				
Trust	TR1	0.692	0.768	0.776	0.843	0.519
	TR2	0.7				
	TR3	0.697				
	TR4	0.716				
	TR5	0.794				

To demonstrate discriminant validity, we employed three methods to illustrate the differences between measurements of one variable and measurements of another [117]. The correlation between variables was examined to determine their relationship to the average variance extracted (AVE) for each hypothesis [115]. As shown in Table 3, each construct exhibited acceptable discriminant validity based on the square root of the AVE. Further validation was conducted using the Heterotrait–Monotrait Ratio of Correlations (HTMT) [117].

Table 3. Discriminant validity.

	BI	DN	EC	EK	ER	PN	SN	TR
BI	0.767							
DN	0.444	0.786						
EC	0.659	0.533	0.835					
EK	0.537	0.526	0.539	0.819				
ER	0.537	0.543	0.617	0.719	0.774			
PN	0.436	0.594	0.507	0.459	0.479	0.876		
SN	0.528	0.625	0.549	0.604	0.526	0.512	0.841	
TR	0.545	0.36	0.422	0.487	0.564	0.331	0.457	0.721
Heterotrait–Monotrait Ratio (HTMT)								
BI								
DN	0.659							
EC	0.821	0.72						
EK	0.707	0.674	0.646					
ER	0.754	0.717	0.767	0.864				
PN	0.572	0.76	0.617	0.52	0.564			
SN	0.703	0.812	0.666	0.695	0.628	0.591		
TR	0.777	0.481	0.535	0.588	0.742	0.396	0.545	

4.3. Structural Model

This research applied bootstrapping to test the mediating effects and analyze the hypothesized relationships between constructs [119]. Lastly, perceived norms significantly influenced environmental responsibility, with an R-value of 0.185 and a *p*-value of 0. Digital descriptive norms and social norms similarly produced significant effects on environmental responsibility, thereby confirming the hypotheses, each with *p*-values of 0. Descriptive norms, social norms, and perceived norms also significantly influenced environmental knowledge and environmental concerns, with *p*-values ranging from 0 to 0.001. Environmental knowledge significantly influenced behavioral intention ($\beta = 0.129$, $p = 0.02$). Environmental concerns also significantly influenced behavioral intention ($\beta = 0.43$, $p < 0.001$). Additionally, social norms significantly influenced behavioral intention ($\beta = 0.098$, $p = 0.047$), indicating that social influence plays an important role. The other significant predictor of behavioral intention was trust, which accounted for $\beta = 0.267$ and was significant at $p < 0.001$. In contrast, the paths from environmental responsibility, perceived norms, and descriptive norms to behavioral intention were insignificant, as all their *p*-values were above 0.05, indicating that these factors do not directly influence adoption intentions (Table 4). Overall, the results confirm that novelty constructs significantly affect environmental responsibility, knowledge, and concerns, which, along with trust and social norms, influence behavioral intentions toward adopting autonomous vehicles (Figure 2).

The product coefficient approach technique was employed to investigate the mediating roles of EC, ER, and EK. The significance of the indirect impact was determined using bias-corrected bootstrap confidence intervals (CIs) [120]. Table 5 illustrates the mediating roles of EC, ER, and EK in the relationship between PN, DN, SN, and BI. EC significantly mediated the relationships between PN and BI (ß = 0.098, t = 3.849, $p = 0.00$), SN and BI (ß = 0.13, t = 4.48, $p = 0.00$), and DN and BI (ß = 0.09, t = 3.472, $p = 0.001$). EK significantly mediated the relationship between SN and BI (ß = 0.054, t = 2.225, $p = 0.026$) and between DN and BI (ß = 0.024, t = 2.004, $p = 0.045$). However, ER did not significantly mediate the relationships between PN, DN, SN, and BI.

Table 4. Structural equation modelling (SEM).

Path	β-Value	SD	T-Statistics	*p* Values	Pass or Not
PN → ER	0.185	0.051	3.649	0	Pass
DN → ER	0.268	0.054	4.942	0	Pass
SN → ER	0.264	0.047	5.636	0	Pass
PN → EK	0.135	0.04	3.407	0.001	Pass
DN → EK	0.184	0.047	3.872	0	Pass
SN → EK	0.42	0.044	9.488	0	Pass
PN → EC	0.228	0.05	4.58	0	Pass
DN → EC	0.209	0.054	3.879	0	Pass
SN → EC	0.302	0.052	5.801	0	Pass
EK → BI	0.129	0.056	2.318	0.02	Pass
ER → BI	−0.036	0.057	0.631	0.528	Not
EC → BI	0.43	0.055	7.788	0	Pass
PN → BI	0.049	0.045	1.099	0.272	Not
DN → BI	−0.021	0.047	0.439	0.661	Not
SN → BI	0.098	0.049	1.986	0.047	Pass
TR → BI	0.267	0.042	6.332	0	Pass

Note: PN, personal norm (PN); ER, environmental responsibility (ER); DN, descriptive norm (DN); SN, subjective norm (SN); EK, environmental knowledge (EK); ER, environmental responsibility (ER); EC, environmental concern (EC); TR, trust (TR); BI, behavioral intention (BI).

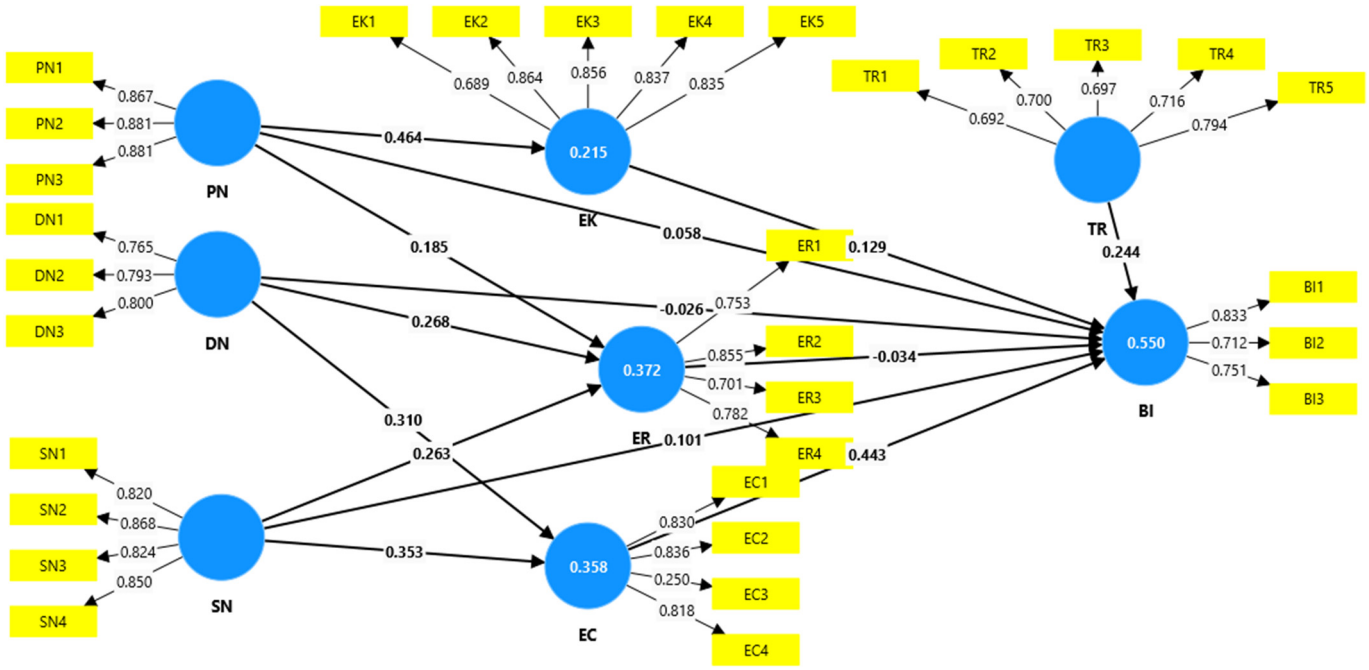


Figure 2. Research model with corresponding results.

Table 5. Mediation results.

Path	Original Sample	Standard Deviation	T Statistics	*p* Values	Pass or Not
PN → ER → BI	−0.007	0.011	0.588	0.556	Not
PN → EK → BI	0.017	0.009	1.856	0.064	Not
SN → ER → BI	−0.009	0.015	0.623	0.534	Not
PN → EC → BI	0.098	0.025	3.849	0	Pass
SN → EK → BI	0.054	0.024	2.225	0.026	Pass
SN → EC → BI	0.13	0.029	4.48	0	Pass
DN → ER → BI	−0.01	0.016	0.612	0.541	Not
DN → EK → BI	0.024	0.012	2.004	0.045	Pass
DN → EC → BI	0.09	0.026	3.472	0.001	Pass

5. Discussion

These findings suggest that subjective norms significantly affect environmental responsibility concerning the acceptance of autonomous vehicles (AVs), thereby supporting the results obtained by [17]. Descriptive norms also have a substantial influence on shaping individuals' acceptance of environmental responsibility, reinforcing the findings of [121]. This indicates that social factors exert a strong influence on encouraging people to consider their ecological responsibilities, while assessing new technologies such as AVs. Moreover, Ref. [122] emphasized that descriptive norms have a powerful impact on environmental consciousness, where behaviors deemed to be the norm within social groups significantly affect how citizens understand and act toward achieving environmental objectives. The current study corroborates the results of [123], which found that personal norms strongly correlate with environmental concern and that greater consideration of personal norms is associated with increased concern for environmental issues. Additionally, as suggested by [124], there is a significant relationship between descriptive norms and environmental concern, providing further evidence in the context of AV adoption. Similarly, subjective norms were also found to significantly influence environmental concerns.

These findings, based on the work of [125], indicate that stronger subjective norms are linked to higher levels of environmental concern. They highlight that the formation of pro-environmental attitudes relates to social expectations and personal values, which, in turn, shape the adoption of sustainable technologies such as autonomous vehicles (AVs). This aligns with the research of [17], which shows that environmental concern is a strong predictor of behavioral intentions to adopt AVs, suggesting that higher concerns for environmental issues increase the likelihood of embracing AV technology. Subjective norms play a significant role in determining domestic tourists' attitudes toward AVs and their willingness to adopt such technologies. Therefore, this forms the basis for understanding the social influence on consumer behavior regarding emerging technologies. Trust has emerged as a major factor underpinning the intention to use AVs, as supported by prior research, including studies [3,126]. This implies that trust in AV technology should enhance domestic acceptance and confidence, while negative perceptions of AV safety may erode trust and hinder further acceptance. In this context, trust is a critical factor for AV acceptance, as consumers navigate the uncertainties associated with the use of autonomous technology. Consequently, the present study establishes the importance of integrating and analyzing diverse constructs to understand behavioral tendencies toward the use of AVs. Pro-environmental factors are identified in this study as the most influential in shaping behavioral intentions toward the adoption of AVs. Given that most findings were statistically insignificant in demonstrating a direct influence of environmental responsibility on domestic tourists' intentions to adopt AVs, it suggests that other factors, such as safety, technological reliability, or perhaps the novelty of AV technology, may exert a greater influence. However, most findings regarding the direct influence of environmental responsibility on the intention of domestic tourists to adopt AVs proved insignificant. This suggests that environmental responsibility may not be the primary driver for adoption. Instead, factors such as safety, technological reliability, or the novelty of AV technology might play a more significant role. Unless the motivating factors are strong, environmental responsibility alone may not be sufficient to drive the adoption of autonomous vehicles (AVs). These results also indicate that the adoption of AVs is influenced by multiple mediators and moderators; therefore, there is a need to investigate other influences. The statistically insignificant mediating role of environmental responsibility between subjective norms and behavioral intentions can be explained by the variation in environmental awareness among individuals. This variation may weaken the impact of environmental responsibility on personal decision-making. In the context of AV adoption, it seems that environmental concerns are not strong enough to effectively mediate this relationship, especially since subjective norms already have a direct influence on behavioral intentions. The insignificant results regarding the mediating role of environmental responsibility between subjective norms and behavioral intentions (BIs) may be explained by variations in the

level of environmental awareness, which could dilute the effectiveness of environmental responsibility in decision-making. While subjective norms directly influence BIs, it appears that in the context of autonomous vehicle (AV) adoption, environmental concerns may not be substantial enough to effectively mediate this relationship. Similarly, environmental responsibility does not seem to mediate the relationship between descriptive norms and BIs for adopting AVs among Chinese domestic tourists. This suggests that perceptions of convenience, safety, and technological appeal may exert a greater influence on the adoption of AVs than environmental considerations. Alternatively, the weak mediating role of environmental knowledge between BIs and AV adoption could be attributed to the interplay between internalized values and a sense of moral obligation, which may overshadow the incremental impact of environmental knowledge. In any case, environmental knowledge alone may not necessarily translate into specific behavioral intentions if individuals do not perceive a direct and immediate benefit or relevance to their circumstances. Consequently, safety, convenience, and technological novelty could serve as significant motivators for AV adoption, particularly when viewed as immediate and tangible benefits.

5.1. Theoretical Implications

This study provides important insights into the factors influencing domestic tourists' adoption of autonomous vehicles. It highlights significant relationships between personal, descriptive, and subjective norms with environmental responsibility, knowledge, and concerns, emphasizing the role of normative beliefs in shaping environmental attitudes. Subjective norms are particularly influential, strongly enhancing tourists' environmental awareness and concerns. Both environmental knowledge and concerns predict intentions to adopt autonomous vehicles, with environmental concerns serving as the stronger motivator. This suggests that while knowledge is essential, concerns about the environment drive adoption intentions more effectively. The impact of subjective norms on behavioral intentions underscores the importance of social influence in the adoption of autonomous vehicles. However, environmental responsibility and other normative beliefs do not directly translate into adoption intentions without the mediation of environmental concerns and knowledge. Trust in autonomous vehicle technology also plays a critical role, significantly influencing adoption intentions. To boost adoption among domestic tourists, strategies should focus on strengthening social norms, building trust, and increasing environmental knowledge and concerns. Policymakers and marketers can use these findings to promote sustainable tourism practices through autonomous vehicles, aligning technology adoption with environmental objectives.

5.2. Practical Implications

This study provides key insights into encouraging the adoption of autonomous vehicle among domestic tourists. Social influences, particularly subjective norms, significantly shape tourists' environmental attitudes, highlighting the importance of leveraging social norms in promotional strategies. Environmental concerns strongly influence adoption intentions, emphasizing the need for campaigns that raise awareness of the environmental benefits of autonomous vehicles. While environmental knowledge positively impacts adoption intentions, environmental responsibility alone does not. Therefore, educational efforts should focus on linking environmental awareness to the benefits and responsibilities associated with using autonomous vehicles. Personal and descriptive norms do not directly drive adoption behavior unless they translate into environmental consciousness and knowledge. Trust in autonomous vehicles is crucial, reinforcing the need for transparent communication regarding their safety, reliability, and benefits. Building trust through clear, reliable information and endorsements from influential groups can significantly boost adoption. In summary, strategies to promote autonomous vehicles should focus on enhancing social influences, improving environmental awareness, and building trust in the technology. Campaigns should highlight the environmental advantages and responsible use of autonomous vehicles, supported by credible information and social endorsements.

5.3. Limitations and Future Research Directions

This study has limitations, including the fact that it relies on self-reported data, which could introduce social desirability bias, as respondents may answer in ways they believe will be viewed favorably, leading to potentially inflated or skewed results. Additionally, it focuses on domestic tourists in China, limiting its generalizability to international tourists or other cultural and geographical contexts. The cross-sectional design also restricts the ability to examine changes in behavior over time and establish causality. Specifically, this design limits the research to a snapshot of behaviors at a single point in time, preventing an examination of how these behaviors might evolve in individuals over time. Additionally, other potentially moderating variables, such as familiarity with the technology, perceived ease of use, and perceived safety—factors critical to understanding the dynamics of technology adoption—were not considered in the study. Future research should broaden its scope to include international tourists and diversify the regions examined in order to validate the findings across different tourist segments. Using a longitudinal design would enable the tracking of tourists' behavioral and intentional changes over time, providing a more dynamic perspective on the adoption process. More importantly, comparative studies of domestic and international tourists would offer valuable insights into the various socio-cultural factors influencing AV adoption. Furthermore, a mixed-method approach that combines quantitative and qualitative methods could deepen understanding of both the motivations behind and the barriers to AV adoption. For example, in-depth qualitative interviews could reveal nuanced perceptions and concerns that might not be captured through surveys alone. Additionally, future studies should explore variables such as technology familiarity, perceived ease of use, and perceived safety, which may significantly impact behavioral intentions toward autonomous vehicles. More specifically, understanding how tourists' familiarity with technology and their trust in AV systems evolve over time can provide critical insights for developing effective marketing and educational campaigns. Addressing these areas could enhance understanding of the factors driving autonomous vehicle adoption among tourists.

6. Conclusions

The aim of this research was to investigate the factors influencing the adoption of AVs by domestic tourists, using an extended version of the theory of planned behavior (TPB) that incorporates pro-environmental constructs and trust. The results indicate that subjective norms play a significant role in shaping environmental responsibility, knowledge, and concern—all of which significantly affect tourists' intentions to adopt AVs. While environmental knowledge fosters the intention to adopt, environmental concern emerges as a stronger driver. This suggests that awareness is crucial, but emotional engagement with environmental issues has a more profound impact on the adoption of AVs. The role of social norms and trust, driven by both social and psychological factors, encompasses relevant dimensions for adoption. Although personal and descriptive normative variables are strongly associated with environmental constructs, they do not directly influence adoption intentions without being mediated by environmental concern and knowledge.

The key practical implications of these findings suggest that, to enhance the adoption of AVs among domestic tourists, strategies should focus on improving social norms, building trust in AV technology, and raising environmental awareness. This can be achieved through targeted campaigns that highlight the environmental benefits and safety of AVs, supported by endorsements from credible sources. This study is limited to domestic tourists in China and follows a cross-sectional design. Future research should explore these dynamics with international tourists and adopt a longitudinal approach to capture changes in behavior over time. Incorporating additional factors, such as perceived ease of use and safety, can further enrich the understanding of the AV adoption process. Overall, this paper contributes to the research on the adoption of sustainable technologies by developing an integrated framework that combines environmental and social factors, offering both detailed insights and nuance into the motivations behind AV adoption.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Shenzhen University (protocol code H15REA156 10 September 2024).

Informed Consent Statement: This study obtained informed consent from all participants.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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

Appendix A. Constructs, Indicators, and Sources

Construct	Items	Sources
Personal norm	I hold a personal obligation of using environmental-friendly products that reduces greenhouse gases. My guilty consciousness would thwart me using non-environmental-friendly products. I feel a sense of utmost satisfaction in following environmental-friendly footprint.	[127]
Descriptive norm	I suppose that the people whom I know would think of choosing A-vehicles when they use a new vehicle. I suppose that the people whom I know would think of choosing A-vehicles when they use a new vehicle. I suppose that the number of people whom I know have chosen A-vehicles as they reduce greenhouse gases.	[63]
Subjective norm	People who are important to me think that I should adopt A-vehicle. I wish to buy A-vehicle as the people who are important to me want me to adopt it. People who are important to me want me to adopt A-vehicles. People who are important to me would opine that I would prefer accepting A-vehicle in the near future.	[128]
Environmental knowledge	I have a good knowledge about environmental issues. Comparing other citizens, I am very much conversant with the issues related to environment. I am knowledgeable to differentiate vehicles based on greenhouse gas emission. I know the relationship between the use of vehicles and environmental pollution. I am confident that the use of A-vehicles enhances sustainable environment.	[129]
Environmental Responsibility	I consider environmental issue as one of the parameters when purchasing vehicles. I made a principle to buy eco-friendly products, hence e vehicles. I involve with a great sense of emotion in environmental protection issues. With a notion to protect the environment restrain unsustainable consumption.	[44]
Environmental Concern	I understand the serious issues of environmental problems in the recent period. I presume that if everyone lives in accord with nature, we can achieve sustainable development. I suppose that we do not take efforts to safeguard the natural resources that are scarcely available.	[44]

Construct	Items	Sources
Trust	I trust that autonomous vehicles can drive without assistance from me. I trust autonomous vehicles to be safe and reliable in severe weather conditions. I would trust the driving skills of autonomous vehicles more than my own driving skills. Autonomous vehicles can be trusted to carry out journeys effectively. My trust in autonomous vehicles will be based on the car manufacturer's reputation for safety and reliability.	[3]
Behavioral Intention	Assuming I have access to an autonomous vehicle, I would intend to use it. Given I have access to an autonomous vehicle, I predict I would use it. In the future, I would not hesitate to use an autonomous vehicle.	[130]

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