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Towards Sustainable Transport in the Moroccan Context: The Key Determinants of Electric Cars Adoption Intention

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Abstract: In recent years, many countries have actively promoted sustainable mobility as part of their efforts to decarbonize transportation through automotive electrification. Therefore, identifying the factors that influence individuals' interest in using electric cars (ECs) is crucial for guiding public opinion toward choosing this sustainable mode of transportation. Consequently, the present study mobilized the theory of planned behavior and the technology acceptance model to interpret the various factors influencing the intention to adopt ECs in a developing country. Following the developed model, data were collected from individuals using cars in Morocco through an online questionnaire. Data analysis using structural equation modeling revealed a positive influence of relative advantage on both the perceived ease of use and green perceived usefulness. Furthermore, the perceived ease of use, green perceived usefulness, environmental concern, and social influence positively affected attitudes toward using ECs. Similarly, these results confirmed that green perceived usefulness and individual attitudes positively enhance ECs adoption intention. These findings contribute to the literature related to ECs adoption and offer guidance to policymakers on promoting ECs adoption in developing countries.

Keywords: electric cars; Morocco; PLS-SEM; sustainable mobility; TAM; TPB

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1. Introduction

Over the last few years, the emerging players in the automotive manufacturing sector have expedited the shift toward a greener and low-carbon automobile industry. The advancement of electric vehicles is seen as a crucial strategy for countries to address decentralized carbon emissions, fulfill emission reduction commitments, and assist enterprises in cost reduction and efficiency enhancement [1].

The substantial consumption of fossil energy and carbon emissions, primarily driven by motor vehicles [2], underscores the significance of automotive electrification for transportation decarburization, prompting numerous countries in recent years to actively encourage the adoption of electric vehicles (EVs) [2,3]. In this context, Morocco is embracing sustainable mobility with the recent enforcement of the Euro6 emission standards from 1 January 2024, signaling a commitment to combat air pollution. Beyond pollution control measures, Morocco is working on a national sustainable mobility plan for 2030, which will reinforce public initiatives to encourage cleaner transportation, building upon earlier steps like waiving customs duties and annual special taxes on hybrid vehicles and EVs. Additionally, efforts to renew taxi and heavy vehicle fleets align with the new anti-pollution standards, and the development of a comprehensive sustainable mobility plan is expected to reshape existing public incentives.

As Morocco establishes itself as a significant player in the automotive industry, with plans to become a prominent exporter of vehicles to Europe, the launch of a 100% Moroccan-designed car and a EUR 50 million investment for a local production plant signal a notable growth trajectory. Furthermore, Morocco has already entered the electric vehicle market, exemplified by the production of an electric car with a range of 75 km and a three-hour charging time, demonstrating the country's commitment to environmentally friendly transportation solutions.

Consolidating the urban public transport service is among the strategic choices of the new development model adopted by Morocco [4]. This model advocates for an ecological transition and a strong commitment to carbon neutrality by proposing to steer the urban transport ecosystem toward green mobility, thereby supporting Morocco's positioning in the global value chain related to electric and hybrid mobility.

Emerging as a notable contender in the electric vehicle market, Morocco actively positions itself at the forefront of the industry, leveraging its existing dynamism in the automotive sector and various strengths that contribute to its success in the electric vehicle industry. According to the Ministry of Commerce and Industry, Morocco presently boasts a production capacity of around 40,000 electric cars per year and has set a target to elevate it to 100,000 by the year 2025. The Kingdom of Morocco also aspires to increase its production capacity to two million cars per year by 2030, enabling it to rank among the world's top ten automotive manufacturers.

With a significant increase of 25.28% in sales of electrified vehicles in Morocco in 2023 compared to 2022, a noticeable trend is unfolding in the Kingdom. However, despite this noteworthy percentage, electrified vehicles currently represent only 4.5% of the Moroccan automotive market, totaling 7165 units sold out of a total market of 161,504 vehicles in 2023. This shift toward electrification raises questions among Moroccan consumers, prompting them to ponder the optimal choice between hybrid and electric vehicles.

EVs constitute an innovative solution capable of reducing greenhouse gas emissions and contributing to the alleviation of factors causing climate change [5,6]. Despite its introduction to the Moroccan market in 2017, the electric car remains vastly underutilized. Within the realm of EVs, the utilization of electric cars (ECs) can play a role in addressing environmental concerns. Hence, the enhancement of the ECs attractiveness involves identifying and understanding factors that could increase the adoption rate of these vehicles. Consequently, our study aimed to identify various factors that can positively influence Moroccans' intention to adopt ECs, with a particular emphasis on the role of environmental concerns.

Numerous prior studies have examined the factors influencing the adoption of EVs in various countries, such as India [7], Saudi Arabia [8], Jordan [9], Spain [10], Pakistan [11], Malaysia [12], Norway [13], and China [14,15].

While previous studies predominantly addressed the broader category of EVs, our study focused on the determinants of the intention to adopt electric cars, providing a more detailed examination of this specific subset. Hence, there is still a lack of scholarly focus on the motivations behind the adoption and use of ECs in developing countries. Therefore, this study aimed to fill this gap by investigating the determinants of ECs adoption intention in the Moroccan context.

Our study delved into the following question: what are the key determinants that shape the adoption intention of ECs?

More specifically, the current study aimed to address the following derived questions:

- How does the relative advantage affect the PEU and GUS of ECs?
- What impact do the PEU, GUS, SIN, and ENC have on AEC?
- How do the PEU, GUS, and AEC collectively influence the intention to adopt ECs?

By delving into these research questions, this study makes a substantial contribution to the existing body of knowledge on utilizing the theory of planned behavior (TPB), and the technology acceptance model (TAM) to predict the intention to adopt ECs, taking into account environmental concerns. The rest of this paper is structured into five sections. The second section is dedicated to reviewing the current body of knowledge and proposing a research model. The third section outlines the methodology employed in this study. Subsequently, the fourth section presents the study findings. The final section is devoted to discussions, highlighting significant research implications, and suggesting directions for future studies.

2. Literature Review

As an extension of the theory of reasoned action (TRA), the TPB underscores that a positive influence on individual intention is achieved through attitude, subjective norms, and perceived behavioral control. This, in turn, enhances individual behavior [16]. Previous studies have extensively utilized the TPB for predicting behavioral intention toward EVs [17–19].

The TAM was initially introduced to comprehend the factors influencing behavioral intention and the use of a particular technology [20]. In accordance with this theory, the primary factor influencing an individual's behavioral intention is their attitude toward a particular technology, which is determined by the perceived usefulness and ease of use of this technology. This model is widely employed to evaluate the factors influencing individuals' intentions to adopt, accept, or purchase EVs [9,15,21].

Several previous research works have employed different theoretical approaches and models to investigate the determinants of electric vehicle adoption in various contexts (Table 1).

Table 1. Overview of the prior studies.

Ref.	Country & Year	Model	Main Results
[15]	China, 2019	TAM	Individual intentions to use autonomous EVs depend on environmental concern, perceived ease of use, and green perceived usefulness.
[8]	Saudi Arabia, 2019	TRA	Subjective norms and attitudes positively influence intentions to adopt EVs.
[22]	India, 2020	IDT	Financial incentives and environmental advantages are significant drivers for EVs adoption.
[23]	Malaysia, 2021	UTAUT 2	Social influence, facilitating conditions, environmental concern, and perceived enjoyment all have positive effects on the adoption of EVs.
[24]	South Korea, 2021	TPB	Perceptions of environmental benefits and economic factors were the most influential predictors for purchasing EVs.
[25]	Malaysia, 2021	UTAUT	Social influence, technophilia, effort expectancy, and perceived environmental knowledge positively influence behavioral intentions.
[14]	China, 2022	TAM	Initial trust, social value, and social influence indirectly facilitated user acceptance, while perceived risk directly hindered it.
[17]	Indonesia, 2022	TPB-UTAUT2	Positive interest in using EVs is influenced by attitude toward use, subjective norms, and perceived behavior control.
[12]	Malaysia, 2022	TAM-TPB	Environmental self-image, price value, subjective norms, attitude, and perceived behavioral control positively influenced individual intention, while perceived risk exerted a negative influence.
[26]	Australia, 2022	TAM	Concerns about EVs safety exert a greater influence on the intention to adopt EVs compared to both purchase cost and perceived benefits.
[27]	China, 2022	TPB	Adoption intention is directly influenced by attitude, subjective norms, knowledge, perceived benefit, and perceived behavior control.
[9]	Jordan, 2023	TAM	The knowledge of EVs influences perceived usefulness and perceived ease of use, as well as the EVs acceptance.
[7]	India, 2023	UTAUT2-NAM	Performance expectancy, facilitating conditions, hedonic motivation, price value, and personal norms positively influence intentions to adopt EVs.
[28]	Iran, 2023	TAM-TPB-UTAUT	The TPB model demonstrated superior performance compared to other models in predicting behavioral intention toward accepting fully automated vehicles.
[11]	Pakistan, 2023	TAM	Environmental concern and perceived value have a considerable influence on behavioral intentions.
[29]	South Africa, 2024	TAM, TPB	The strongest predictors of EVs adoption intention are vehicle reliability and personal norms
[10]	Spain, 2024	TPB	Moral and subjective norms, attitude, and perceived behavioral control significantly influence the intention to adopt EVs.
[30]	Saudi Arabia, 2024	TTF- UTAUT	Combining the TTF and UTAUT models has a positive impact on the adoption of EVs.

Building upon the foundation laid by these earlier studies, our research extended the application of the TPB and the TAM, integrating factors such as relative advantage and environmental concerns. This approach was informed by the latest advancements in the field, providing a comprehensive understanding of the determinants influencing the intention to adopt ECs. By incorporating these factors, we aimed to provide valuable insights into the complex decision-making processes surrounding the adoption of EVs. This broader perspective is essential for policymakers, businesses, and researchers seeking to promote sustainable transportation solutions.

2.1. Relative Advantage

The relative advantage (RAD) is defined as "the degree to which an innovation is perceived as being better than the idea it supersedes" [31]. The RAD refers to the degree to which an innovation is perceived as being better to alternative options [32]. It is determined not by the innovation's objective advantage, but by the individual's subjective perception of its advantages [33].

In this study, the RAD signified the degree to which electric cars were perceived as a more advantageous and practical mode of transportation compared to alternative vehicle types, such as hybrid, petrol, or diesel cars, for a potential use. In other words, individuals evaluated ECs based on how much better they were perceived to be in comparison to conventional vehicles, influencing their decision-making process when considering adopting ECs transportation.

Research has shown that RAD positively influences perceived ease of use, and perceived usefulness of a particular technology [34–36]. For instance, [35] confirmed that the RAD positively affects perceived usefulness, perceived ease of use, and behavioral intention. Moreover, [34] empirically validated the positive influence of RAD on the perceived ease of use and perceived usefulness of the technology. More recently, [36] found that RAD serves as a predictor for the perceived usefulness of autonomous vehicles. From these studies, we can posit that the RAD associated with ECs may enhance the individual's perceived ease of use (PEU) and contribute to a positive perception of their green usefulness (GUS). Consequently, we formulated the following assumptions:

H1. *RAD is positively related to PEU.*

H2. *RAD is positively related to GUS.*

2.2. Determinants of Attitude toward Using ECs

The TAM places attitude toward technology as a pivotal factor that significantly influences behavioral intention. Likewise, individual attitude is shaped by the ease of use and perceived usefulness associated with the technology [20]. The perceived ease of use (PEU) is characterized by an individual's perception of how easy it would be to use a particular technology [20]. Additionally, the perceived usefulness explores the extent to which an individual perceives of the efficiency of electric cars functions. For the current study, green perceived usefulness (GUS) referred to the level to which an individual believed that their environmental sustainability efforts could be improved by utilizing ECs.

The positive impact of both the perceived ease of use and perceived usefulness of a specific technology on attitude toward that technology has been validated in various previous empirical studies [37–42]. In the context of EVs, [41] argued that individuals' attitudes toward behavior are significantly influenced by their perception of the usefulness and ease of use of EVs [41]. Furthermore, it is asserted in TAM 3 that the perceived ease of use plays a pivotal role in positively influencing the perceived usefulness of a specific technology [43,44]. The positive correlation between these variables was validated across various contexts, including electric motorcycles [11,40], fully automated vehicles [28], and EVs [39]. Based on the existing literature, we suggested the following assumptions:

H3. *PEU is positively related to GUS.*

H4. *PEU is positively related to AEC.*

H5. *GUS is positively related to AEC.*

Environmental concern (ENC) is related to the individual's recognition of environmental issues and their willingness to address and resolve them [45]. Previous studies confirmed the positive effect of ENC on individual attitude [46,47]. By adopting the TPB, [48] concluded that environmental concern is linked to attitude rather than behavioral intention directly. Ref. [49] confirmed the positive association between environmental concerns and attitudes toward electric scooters. In other words, individuals who demonstrate a heightened ENC are more likely to exhibit a positive attitude toward the use of environmentally friendly practices, including attitudes toward using ECs. Hence, we suggested that:

H6. *ENC is positively related to AEC.*

Social influence (SIN) is a measure of the extent to which society or peers believe in individuals' willingness to adopt new technology [50], such as ECs [51]. It encompasses the opinions of others regarding the importance of adopting EVs, including views from society, family, and close friends. As EVs represent the latest technology in the road transport sector, owning such a car is seen as a means of establishing identity and is perceived as a symbol of social status [23,52,53]. Studies indicate that opinions from society, family, friends, and colleagues can impact an individual's attitude toward adopting a technology [54–56]. For instance, the positive influence of SIN on attitude toward adopting technology innovations has been confirmed. Furthermore, [55] argued that SIN is a key determinant of attitudes toward mobile app technology. Hence we posited that:

H7. *SIN is positively related to AEC.*

2.3. ECs Adoption Intention

Behavioral intentions refer to an individual's expressed likelihood or willingness to engage in a specific behavior in the future. Individuals who have a predisposition to embrace new technology are the ones who have expressed an intention to adopt or acquire it in the future [17,23]. In multiple technology acceptance theories, the importance of either the intention to use or the intention to adopt has been consistently demonstrated [50]. In the current study, the adoption intention of ECs is considered as an individual's expressed likelihood or willingness to buy or to use ECs in the future.

Previous studies have demonstrated that perceived ease of use and perceived usefulness predict behavioral intention [34,42,57]. By examining the factors impacting the adoption of autonomous vehicles, [36] discovered that perceived usefulness and perceived ease of use have a positive impact on users' behavioral intention to utilize autonomous vehicles [36]. Ref. [15] also demonstrated that green perceived usefulness, perceived ease of use, and environmental concern positively influence on individuals' intentions to use EVs in China. Likewise, the positive association between these variables was also confirmed in Jordan [9]. Based on these studies, we supposed that:

H8. *PEU is positively related to AIN.*

H9. *GUS is positively related to AIN.*

According to the Ajzen's TPB, the individual's attitude constitutes one of three key factors influencing his or her behavioral intention [16]. Ref. [58] concluded from their meta-analysis that attitude stands out as the pivotal factor influencing behavioral intention [58]. The positive association between attitude–intention has been confirmed in prior literature [59], including studies related to EVs [17,60]. Based on the TAM, [14] verified that the attitude toward using EVs is the most crucial factor influencing behavioral intention [14]. The positive association between these two variables was also confirmed in Ghana [61] and Indonesia [17]. From these studies, we posited that:

H10. *AEC is positively related to AIN.*

3. Materials and Methods

Figure 1 illustrates the various steps followed for the development and testing of the research model using the PLS-SEM approach.

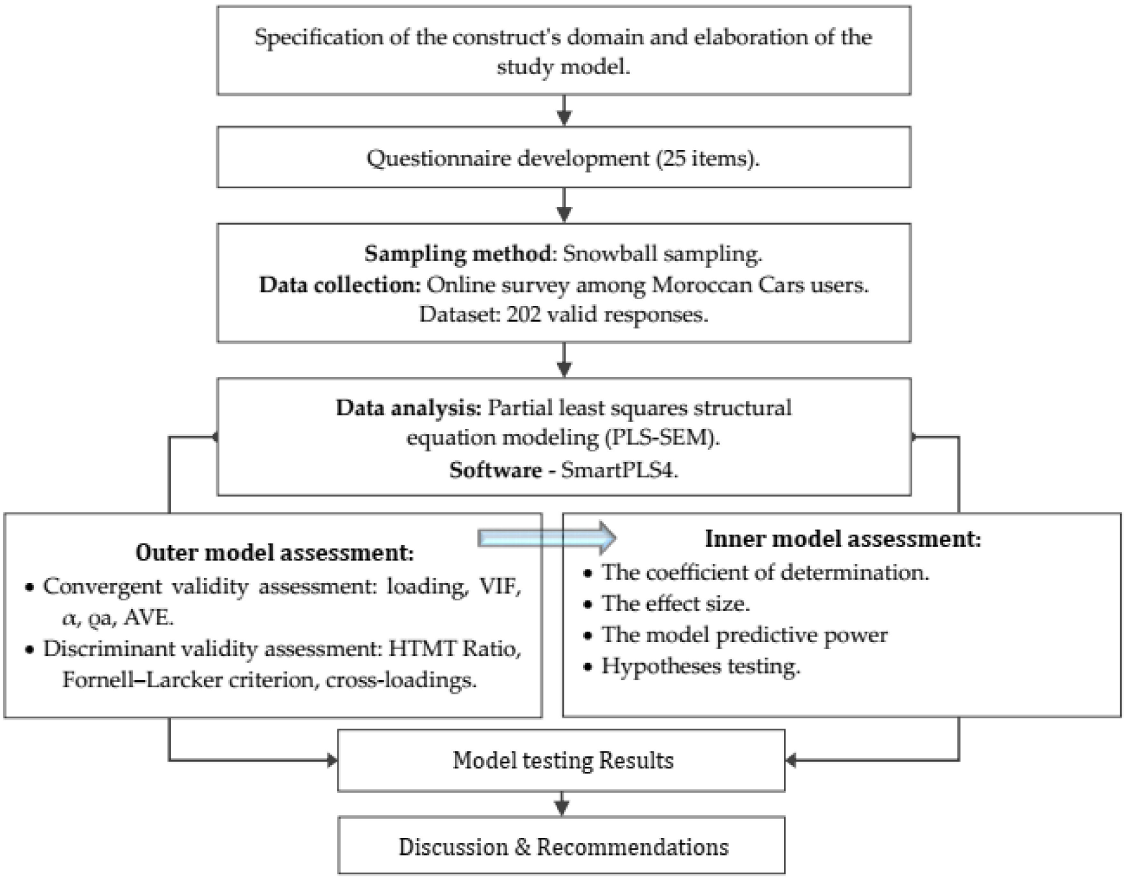

Figure 1. Study method steps.

3.1. Study Questionnaire

The various latent variables of our research model (Figure 2) were operationalized based on the measurement scales selected from previous empirical studies. Environmental concern was assessed using four items drawn from previous studies [62–64]. Social influence was gauged through four items [65]. Relative advantage was evaluated with three selected items [66]. Green perceived usefulness was measured using three items [20,67,68]. Perceived ease of use was assessed with four items selected from [20] and adjusted based on the study of [69]. Attitude toward using ECs was measured using three items from [70]. Finally, ECs adoption intention was assessed using four items [71,72]. These measurement scales were selected based on their utility and relevance to ensure the comprehensiveness and accuracy of our research findings (Appendix A).

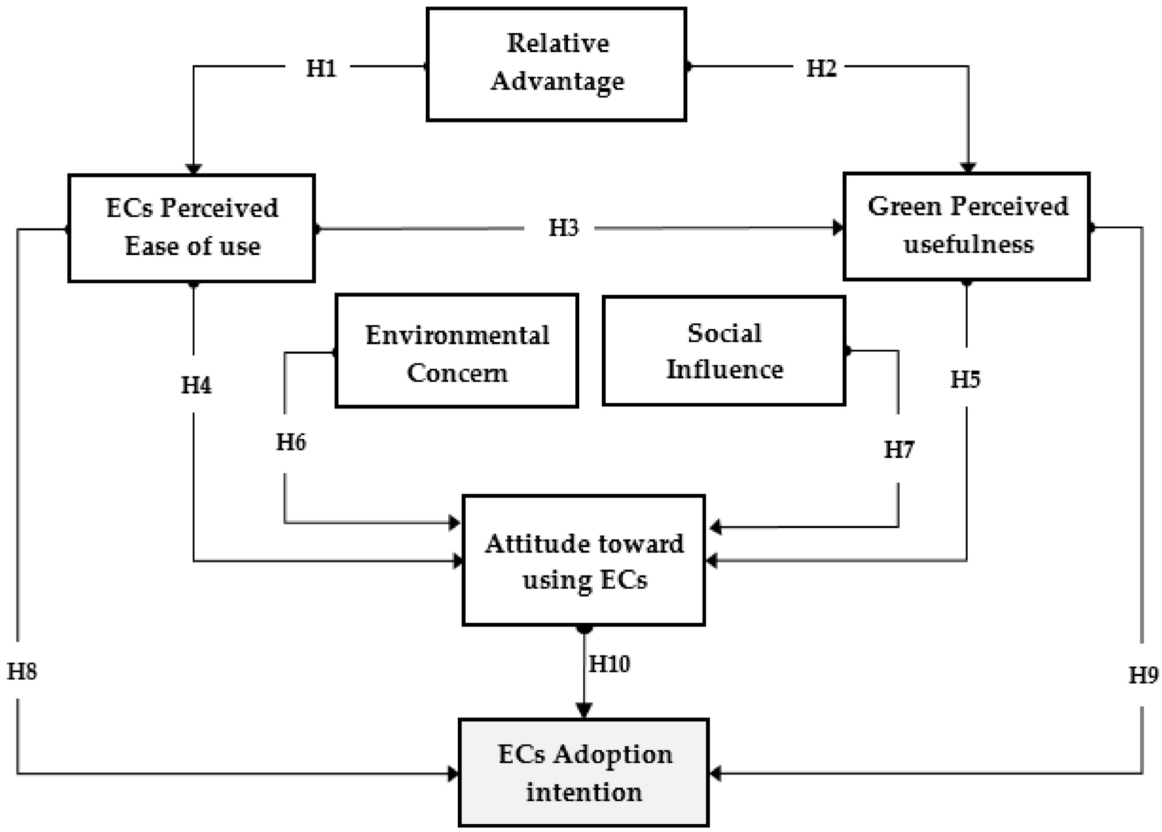

Figure 2. Study model.

All items were evaluated based on a Likert scale, ranging from (1) indicating strong disagreement to (5) signifying strong agreement.

3.2. Participants Selection and Sampling

The study population focused on individuals residing in Morocco who utilize a car. Because of the lack of a comprehensive population database, we opted for the snowball non-probability sampling method [73]. In practical terms, participants were invited to distribute the link of the study questionnaires to other individuals who use cars in Morocco.

The research unfolded in two distinct phases. Given the online nature of data collection, the initial stage focused on enhancing the survey's comprehensibility. This involved conducting a pretest among a subset of 10 individuals who use a car. The feedback from this pilot test led to refinements in the wording of specific questions. The second stage involved administering the questionnaire online.

The study's minimum sample size was calculated by multiplying the total number of indicators (25 questions) by a range of five to ten [74], resulting in a requirement for 125–250 respondents. During a 50-day data collection period, from 7 December 2023 to 25 January 2024, data was gathered using online methods by distributing questionnaire links to Moroccans through email and WhatsApp. The questionnaire was also administered in three languages: Arabic, French, and English. The decision to employ an online survey as the research method enhanced the objectivity of the study. This choice enabled participants to independently and impartially engage in the survey without being influenced by the researcher [75]. The adoption of an online survey provided participants a convenient and easily accessible channel to express their perspectives. Consequently, this initiative yielded 202 valid responses.

Table 2 provides a comprehensive overview of the study participants' characteristics. The majority of participants were male (78.71%), with diverse age distributions, predominantly falling within the 31–40 age group (35.15%). Education levels varied, with a significant percentage holding master's degrees (45.05%) and PhDs (31.19%). The majority of participants were married (65.35%), and government employees constituted a substantial portion of the occupational demographic (65.84%). These findings align with income distribution trends, with 30.20% earning between 5 and 10 KMAD, 34.16% earning between 10 and 15 KMAD, and 18.81% earning 15 KMAD and above.

Table 2. Characteristics of the study participants (N = 202).

Profile	Category	Frequency	Percentage (%)
Gender	Female	43	21.29%
	Male	159	78.71%
Age	18–25	21	10.40%
	26–30	17	8.42%
	31–40	71	35.15%
	41–50	54	26.73%
	51 and above	39	19.31%
Education	BAC Level	5	2.48%
	BAC	4	1.98%
	BAC+2	9	4.46%
	BAC+3	30	14.85%
	Master	91	45.05%
	PhD	63	31.19%
Marital status	Married	132	65.35%
	Single	67	33.17%
	Divorced	3	1.49%
Occupation	Government employee	133	65.84%
	Private Company employee	31	15.35%
	Student	24	11.88%
	Business owners	8	3.96%
	No occupation	6	2.97%
Monthly income	No response	3	1.49%
	Less than 5 KMAD	31	15.35%
	5–10 KMAD	61	30.20%
	10–15 KMAD	69	34.16%
	15 KMAD and above	38	18.81%

Figure 3 illustrates that the majority of the cars used in the study were diesel (71.29%), followed by petrol cars (25.74%), and hybrids (2.97%).

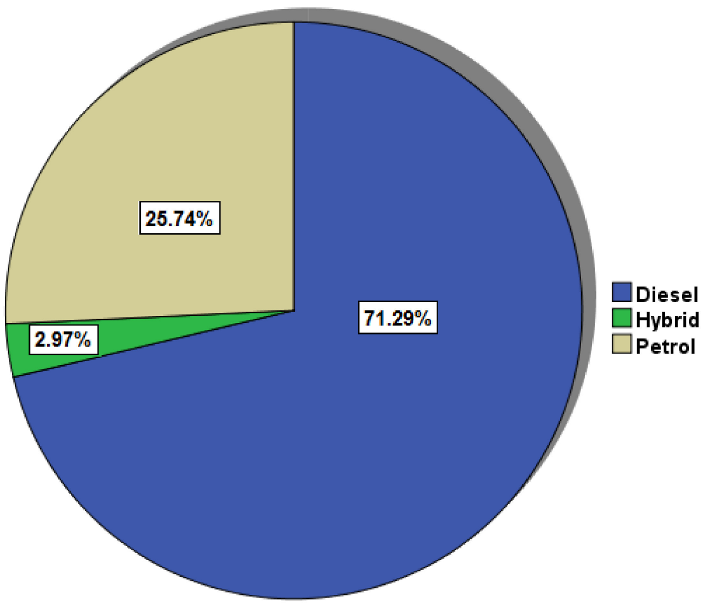

Figure 3. Participant distribution across types of used vehicles.

Additionally, the distribution of the cars used across different regions varied, with Laâyoune-Sakia El Hamra having the highest representation (29.21%), followed by Rabat-Salé-Kénitra (24.26%), and Fez-Meknes (10.40%), showcasing geographical differences in car ownership patterns within the study population (Figure 4).

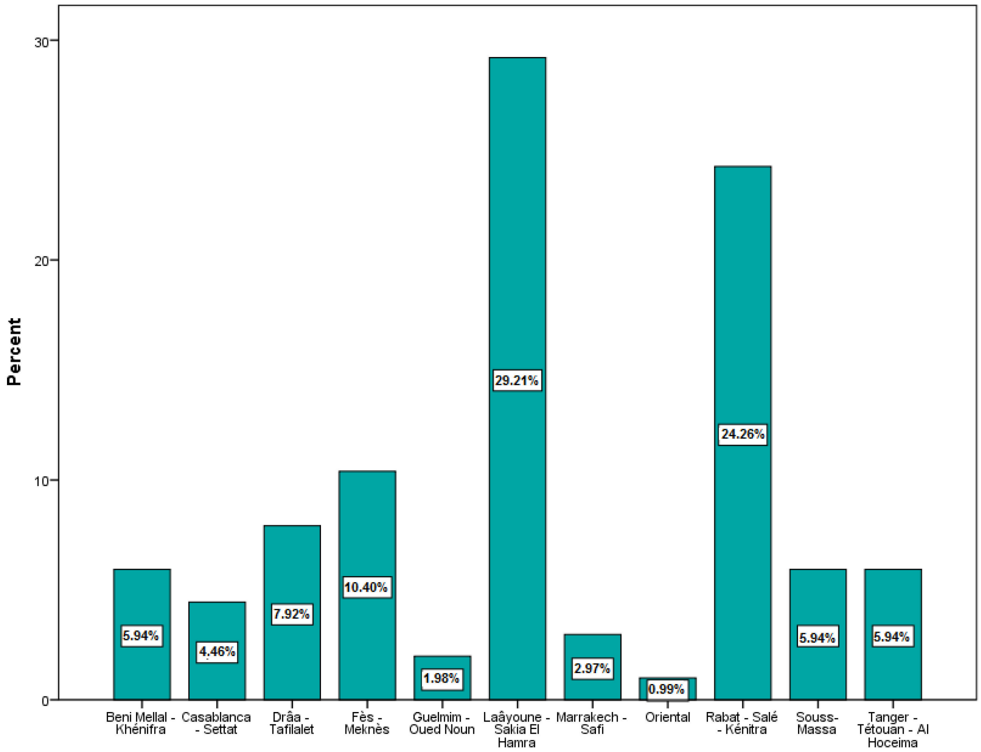

Figure 4. Geographic distribution of study participants.

3.3. Data Analysis

The collected data was entered into a Microsoft Excel spreadsheet (XLSX), facilitating the subsequent data analysis through SPSS Statistics 25 software for descriptive statistics and the application of Harman's single-factor test. Additionally, SmartPLS 4 software was employed for thorough data analysis [76]. These data were then analyzed using the partial least squares structural equation modeling (PLS-SEM) technique. This approach involves a two-stage evaluation process. In the initial stage, the outer model is assessed to ensure convergent and discriminant validity, examining factors such as loadings, Cronbach's alpha, composite reliability, and average variance extracted (AVE). In the subsequent stage, the inner model is scrutinized, evaluating coefficients of determination (R^2) for endogenous latent variables, effect size (f^2), and the predictive power (Q^2predict). Hypothesis verification, based on t-values and *p*-values, is also integrated.

Prior to initiating data analysis, we performed Harman's single-factor test to investigate the potential presence of common method variance (CMV). The results of the test indicated that a single factor explained 37.516% of the total variance, suggesting the absence of CMV in the collected dataset [77].

4. Results

4.1. Convergent and Discriminant Validity

4.1.1. Reliability and Convergent Validity Assessment

Table 3 illustrates the reliability and convergent validity assessment. All item loading values met scientific standards [78]. These values suggested strong associations between the items and their constructs, including the ENC (ranging from 0.845 to 0.894), RAD (ranging from 0.768 to 0.858), GUS (ranging from 0.751 to 0.882), PEU (ranging from 0.653 to 0.880), SIN (ranging from 0.659 to 0.875), AEC (ranging from 0.878 to 0.918), and AIN (ranging from 0.861 to 0.894). Furthermore, the reliability was examined based on Cronbach's alpha (α), whose values were between 0.737 and 0.901, indicating that all the measurement scales had good levels of reliability. Similarly, the composite reliability (ϱa) values, ranging from 0.745 to 0.903, all exceeded the threshold of 0.7. Likewise, the AVE values ranged between 0.591 and 0.801, indicating that the latent constructs were explained with a minimum of 59.1%. Moreover, the variance inflation factor (VIF) metrics did not reveal any signs of collinearity within the outer model.

Table 3. Reliability and convergent validity.

Construct	Item	Loading	VIF	α	ϱa	AVE
Environmental concern	ENC1 ENC2 ENC3 ENC4	0.845 0.894 0.850 0.845	2.512 3.007 2.106 1.961	0.882	0.888	0.737
Relative advantage	RAD1 RAD2 RAD3	0.801 0.858 0.768	1.421 1.665 1.425	0.737	0.745	0.656
Green perceived usefulness	GUS1 GUS2 GUS3	0.751 0.882 0.819	1.446 1.827 1.520	0.755	0.774	0.671
Perceived ease of use	PEU1 PEU2 PEU3 PEU4	0.837 0.653 0.880 0.680	2.008 1.309 2.249 1.316	0.766	0.803	0.591
Social Influence	SIN1 SIN2 SIN3 SIN4	0.875 0.828 0.869 0.659	3.301 3.039 2.041 1.345	0.823	0.837	0.660
Attitude toward using ECs	AEC1 AEC2 AEC3	0.889 0.918 0.878	2.403 2.831 2.158	0.876	0.877	0.801
ECs adoption intention	AIN1 AIN2 AIN3 AIN4	0.864 0.894 0.894 0.861	2.570 3.092 2.956 2.408	0.901	0.903	0.772

4.1.2. Discriminant Validity Assessment

Table 4 presents the outcomes of the assessment of the outer model discriminant validity according to the Fornell–Larcker criterion. This was demonstrated by the AVE diagonal values exceeding their correlations with the other constructs, thus confirming the distinctiveness of each construct.

Table 4. Fornell-Larcker criterion.

Construct	AEC	AIN	ENC	GUS	PEU	RAD	SIN
AEC	0.895						
AIN	0.699	0.878					
ENC	0.451	0.324	0.859				
GUS	0.704	0.588	0.353	0.819			
PEU	0.596	0.514	0.308	0.536	0.769		
RAD	0.589	0.503	0.536	0.658	0.435	0.810	
SIN	0.524	0.609	0.359	0.417	0.386	0.453	0.812

Table 5 offers an evaluation of the discriminant validity through the HTMT ratio, where the values below 0.9 indicate that the constructs within the measurement model were adequately distinguishable from one another [79].

Table 5. HTMT ratio.

Construct	AEC	AIN	ENC	GUS	PEU	RAD	SIN
AEC							
AIN	0.785						
ENC	0.507	0.353					
GUS	0.855	0.705	0.417				
PEU	0.718	0.610	0.361	0.680			
RAD	0.729	0.615	0.654	0.874	0.569		
SIN	0.613	0.703	0.412	0.515	0.466	0.587	

Furthermore, this illustrates that the loadings of all the indicators on their respective latent variables significantly exceeded their loadings on all the other variables, enabling us to affirm the discriminant validity of the outer models based on the cross-loading criterion (Appendix B). Figure 5 illustrates the model subsequent to confirming the reliability, convergent validity, and discriminant validity of the measurement scales pertaining to the seven latent constructs in the study model.

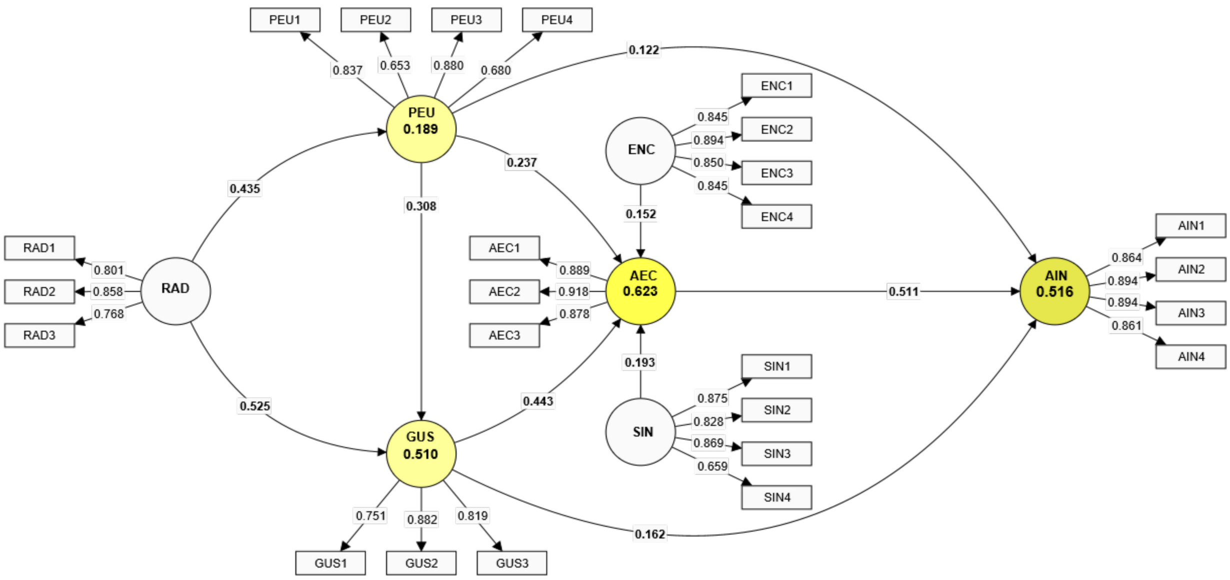

Figure 5. Results of outer models evaluation.

4.2. Inner Model Assessment

4.2.1. Coefficient of Determination and Model Predictive Power

As shown in Figure 6, the R^2 values for the four endogenous constructs, including the PEU, GUS, AEC, and AIN, were 19%, 51%, 62%, and 51% respectively, indicating a satisfactory level of explanatory power.

The Q^2predict of these constructs were 0.168, 0.423, 0.416, and 0.307, respectively, providing proof of an acceptable predictive power of the research model (Table 6).

4.2.2. Hypothesis Testing Results

Table 7 presents the results for the structural model evaluation. The VIF metrics, with all values below 0.33, did not provide indications of collinearity within the structural model [80]. The findings of the study validated the positive impact of the RAD on both the PEU (β = 0.435, t = 5.531, p = 0.000, f^2 = 0.233) and GUS (β = 0.525, t = 8.147, p = 0.000,

f^2 = 0.456), supporting the acceptance of hypotheses H1 and H2. Similarly, the positive association between the PEU and GUS was also confirmed (H3. β = 0.308, t = 3.911, p = 0.000, f^2 = 0.157).

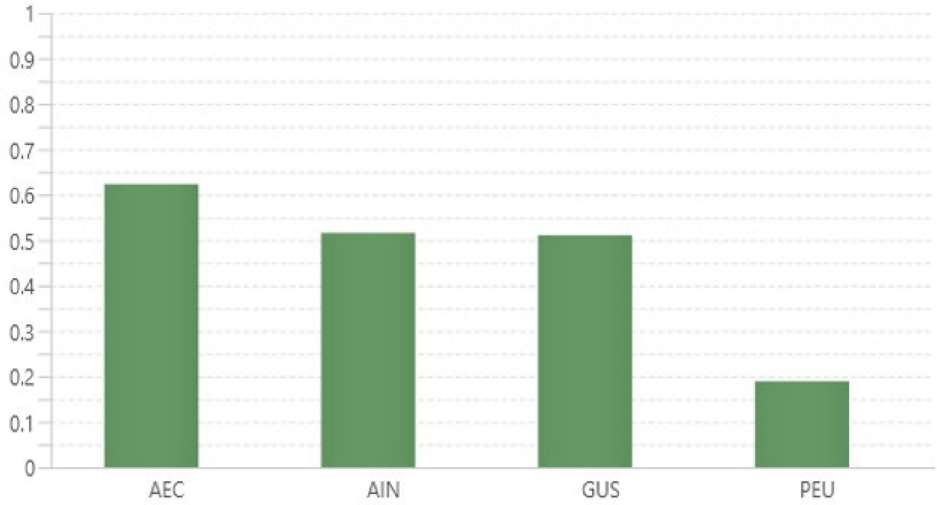

Figure 6. Coefficient of determination.

Table 6. R^2 and Q^2predict values.

Construct	R^2	R^2 Adjusted	Q^2predict
Perceived ease of use (PEU)	0.189	0.185	0.168
Green perceived usefulness (GUS)	0.510	0.506	0.423
Attitude toward using ECs (AEC)	0.623	0.615	0.416
ECs adoption intention (AIN)	0.516	0.508	0.307

Table 7. Hypotheses testing results.

Hypothesis				β	T Statistics	p Value	f^2	VIF	Decision
H1	RAD	→	PEU	0.435	5.531	0.000	0.233	1.000	Accepted
H2	RAD	→	GUS	0.525	8.147	0.000	0.456	1.233	Accepted
H3	PEU	→	GUS	0.308	3.911	0.000	0.157	1.233	Accepted
H4	PEU	→	AEC	0.237	3.152	0.002	0.100	1.485	Accepted
H5	GUS	→	AEC	0.443	6.070	0.000	0.334	1.560	Accepted
H6	ENC	→	AEC	0.152	3.021	0.003	0.050	1.231	Accepted
H7	SIN	→	AEC	0.193	3.657	0.000	0.074	1.335	Accepted
H8	PEU	→	AIN	0.122	1.807	0.071	0.019	1.618	Rejected
H9	GUS	→	AIN	0.162	2.077	0.038	0.026	2.072	Accepted
H10	AEC	→	AIN	0.511	7.006	0.000	0.236	2.289	Accepted

Furthermore, the findings revealed a significant and positive influence of the PEU (β = 0.237, t = 3.152, p = 0.002, f^2 = 0.100), GUS (β = 0.443, t = 6.070, p = 0.000, f^2 = 0.334), ENC (β = 0.152, t = 3.021, p = 0.003, f^2 = 0.050), and SIN (β = 0.193, t = 3.657, p = 0.000, f^2 = 0.074) on attitudes toward using ECs. Hence, we have provided empirical support for hypotheses H4, H5, H6, and H7.

Hypothesis H8, which assumed a positive impact of the PEU on the AIN, was rejected (β = 0.122, p = 0.071, f^2 = 0.019). Lastly, the results demonstrated a positive and significant influence of the GUS (β = 0.162, t = 2.077, p = 0.038, f^2 = 0.026) and AEC (β = 0.511, t = 7.006, p = 0.000, f^2 = 0.236) on the AIN (Figure 7).

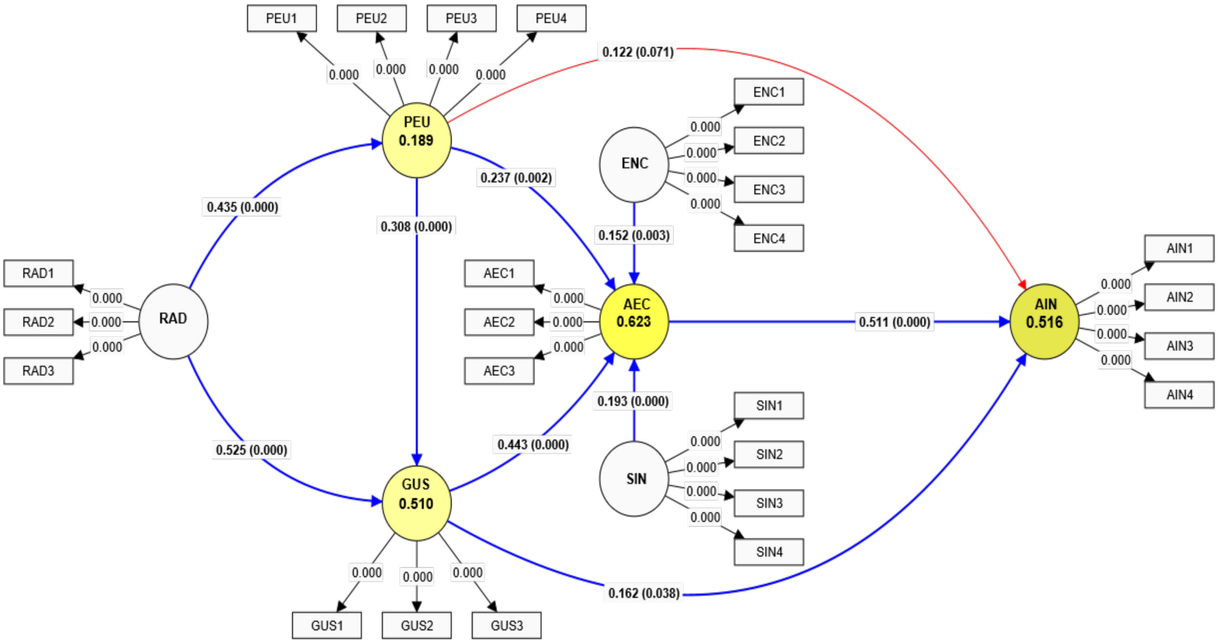

Figure 7. Results of model evaluation.

5. Discussion and Conclusions

The current study aimed to unveil the essential factors influencing the intention to adopt ECs in Morocco. To achieve this objective, we formulated a model based on Ajzen's TPB and the TAM, by incorporating elements such as relative advantage and environmental concerns.

The results of the PLS-SEM confirmed the positive influence of relative advantage on both the perceived ease of use and green perceived usefulness. In other words, when ECs are perceived as having a more advantageous and practical mode of transportation compared to alternative vehicle types, individuals are more likely to find it easy to use and consider it useful in terms of environmental friendliness. These findings are consistent with conclusions reported in previous research studies [34,35]. In their analysis of factors influencing the autonomous vehicle adoption in China, [36] argued that relative advantage plays a crucial role in enhancing the perceived usefulness at the individual level. Additionally, [34] provided empirical evidence supporting the pivotal role of the technology's relative advantage in enhancing both its ease of use and perceived usefulness.

The study results showed a positive association between ECs perceived ease of use and green perceived usefulness. In essence, the more individuals find ECs easy to operate, the higher their perception of the environmental usefulness of these vehicles. This finding aligns with previous studies [36,40,44], which also confirmed that an increased perception of technology ease of use plays a crucial role in enhancing the individual's perceived usefulness of that technology. Ref. [40] identified a positive correlation between the ease of use of electric motorcycles and individuals' perception of their utility. More recently, in the realm of fully automated vehicles, [28] revealed that perceived ease of use strongly predicts individual perceived usefulness.

Furthermore, the findings indicated a direct impact of perceived ease of use and green perceived usefulness on attitudes toward using ECs. These results are supported by earlier empirical studies [37–42]. Ref. [41] stated that people's attitudes toward behavior are notably shaped by their perceptions of the ease of use and usefulness of EVs.

The findings unveiled a positive influence of environmental concern, and social influence on attitudes toward using ECs. In other words, individuals with a heightened environmental concern are more inclined to show a positive attitude toward adopting environmentally friendly practices, such as using ECs. Likewise, the opinion of family and close friends regarding the importance of adopting ECs play a central role in shaping individual attitudes toward adopting ECs. These results are in line with prior empirical studies that pointed out the positive influence of environmental concern [46,47] and social influence [54–56] on individuals' attitudes.

Contrary to previous empirical studies emphasizing the importance of the technology perception of ease of use as a predictor of behavioral intention [36,42,57], the results of the current study attest to a lack of association between these two variables. This implies that individuals' perceptions of the ease of using electric cars does not influence their intention to adopt these vehicles. One potential explanation for this phenomenon might be connected to individuals' previous familiarity with similar technologies, the accessibility of charging infrastructure, or other external factors that shape their decision-making process regarding the adoption of ECs.

Finally, the findings revealed that green perceived usefulness and attitude toward using ECs positively enhanced ECs adoption intention, implying that better perception of green usefulness of ECs and better attitude toward using ECs significantly improves the individual adoption intention of ECs. These results are consistent with earlier studies, indicating that individuals with a higher level of green perceived usefulness [15], and positive attitudes toward using ECs [14,17,60], exhibit a heightened intention to adopt ECs. Likewise, [27] revealed that positive perceptions of technology usefulness and consumer attitudes significantly bolster EVs adoption intentions.

5.1. Study Implications

The current study aimed to unveil the determinants of individuals' intention to adopt ECs in Morocco. Therefore, the first implication for this theory was related to the developed model that integrates the TPB and the TAM, which are extensively employed to study behavioral intention [81]. Furthermore, the current study findings contribute to the existing literature regarding the determinants of technology adoption intention, particularly recent research on the determinants of EVs adoption intention [14]. More precisely, the findings confirmed the positive impact of perceived ease of use on green perceived usefulness. Similarly, perceived ease of use, green perceived usefulness, and social influence were found to have a direct influence on attitudes toward using ECs, which in turn enhances individual attitudes toward adopting ECs. Another theoretical implication involves incorporating relative advantage and environmental concerns into our research model. The results confirmed the role of relative advantage in enhancing the perception of ECs ease of use and usefulness. While [11] argued that environmental concerns directly influence behavioral intention, the current study findings offer a new perspective by conforming the role of environmental concerns in improving individuals' attitudes toward using ECs.

In addition to the theoretical implications, the study findings offer significant practical implications for public policymakers and manufacturers seeking to promote the adoption of electric vehicles in Morocco. Initially, the results confirmed the positive impact of the relative advantage in improving the perceived ease of use and the green perceived usefulness of ECs. Hence, manufacturers and policymakers can raise awareness about the advantages and benefits of ECs to enhance their adoption among individuals. Additionally, given the positive impact of green perceived usefulness and perceived ease of use on attitudes toward using ECs adoption, Moroccan policymakers are urged to prioritize investments in charging infrastructure and provide financial incentives to encourage citizens to adopt ECs.

Another practical direction involves implementing public awareness campaigns through radio, television, and the most widely used social networks in Morocco. The goal is to provide concrete information about the environmental benefits of electric cars, aiming to encourage environmentally conscious citizens to adopt and promote the adoption of this type of transport within their social circles.

5.2. Limitations and Areas for Future Research

Like any empirical research on technology adoption, including the adoption of electric cars, our study entails certain limitations that should be considered in forthcoming studies to delve deeper into the reasons behind the intention to adopt ECs. The first limitation of this study lies in its exclusive focus on a quantitative approach. To address this limitation, the incorporation of a qualitative approach alongside quantitative methods (mixed methods approach) could provide a more holistic perspective on the determinants of ECs adoption intention in Morocco.

The second limitation is associated with the study population, which solely targeted car users. Thus, to further delve into the analysis of determinants affecting ECs adoption, broadening the study to encompass experts and professionals engaged in the ECs production process could enhance the developed model and foster a better understanding of the role of ECs characteristics in their adoption process by individuals.

Moreover, the current study only considered six variables to explore the determinants of ECs adoption intention. Hence, future research could expand this model by analyzing the role of other factors such as ECs characteristics, social status, technophilia, trust, and individual characteristics.

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Abbreviations

AEC	Attitude toward using ECs
AIN	Adoption Intention
AVE	Average Variance Extracted
CMV	Common Method Variance
ECs	Electric Cars
EVs	Electric Vehicles
ENC	Environmental Concern
GUS	Green Perceived Usefulness
HTMT	Heterotrait–Monotrait
IDT	Innovation Diffusion Theory
NAM	Norm Activation Model
PLS	Partial Least Squares
PEU	Perceived Ease of use
RAD	Relative Advantage
SEM	Structural Equation Modeling
SIN	Social Influence
TAM	Technology Acceptance Model
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
TTF	Task Technology Fit
UTAUT	Unified Theory of Acceptance and Use of Technology
VIF	Variance Inflation Factor

Appendix A

Table A1. Construct Measurement.

Variable	Code	Items
Environmental concern	ENC1	I worry about the environmental conditions we will live under in the future.
	ENC2	I am very concerned about current environmental pollution in Morocco and its impact on health.
	ENC3	Automobile exhaust emission is one of the primary sources of air pollution.
	ENC4	I have the responsibility to adopt a low-carbon travel mode.
Social Influence	SIN1	People who are important to me think that I should use ECs.
	SIN2	People who influence my behavior think that I should use ECs.
	SIN3	People whose opinions I value would like me to use ECs.
	SIN4	In general, the authority would support the use of ECs.
Relative advantage	RAD1	Using ECs would reduce greenhouse gas emissions and energy consumption.
	RAD2	Using ECs would eliminate my fuel costs.
	RAD3	Using ECs would reduce repair and maintenance costs.
Green perceived usefulness	GUS1	I believe that the use of ECs can improve the traffic quality.
	GUS2	I believe that the use of ECs can make me healthier.
	GUS3	I believe that the use of ECs can improve environmental quality.
Perceived ease of use	PEU1	It is easy for me to learn how to use electric cars.
	PEU2	The operation of an EC is no different to me from that of a conventional vehicle.
	PEU3	I find it easy to drive an EC.
	PEU4	I find it easy to charge an EC.
Attitude toward using ECs	AEC1	I think that using an EC is valuable.
	AEC2	I think that using an EC is right.
	AEC3	I think that using an EC is necessary.
Adoption intention	AIN1	I plan to adopt an EC in the near future.
	AIN2	If I need to buy a new car in the near future, I would prefer an EC.
	AIN3	If my friends want to buy a new car, I would suggest to them that they buy an EC.
	AIN4	I am willing to buy an EC in the future.

Appendix B

Table A2. Cross-loadings.

	AEC	AIN	ENC	GUS	PEU	RAD	SIN
AEC1	0.889	0.581	0.376	0.646	0.570	0.505	0.446
AEC2	0.918	0.635	0.453	0.662	0.546	0.560	0.446
AEC3	0.878	0.659	0.379	0.583	0.485	0.514	0.515
AIN1	0.577	0.864	0.270	0.464	0.443	0.417	0.511
AIN2	0.625	0.894	0.269	0.521	0.464	0.451	0.519
AIN3	0.634	0.894	0.302	0.562	0.474	0.480	0.560
AIN4	0.617	0.861	0.296	0.515	0.423	0.415	0.548
ENC1	0.323	0.162	0.845	0.247	0.246	0.397	0.219
ENC2	0.389	0.257	0.894	0.279	0.262	0.459	0.308
ENC3	0.391	0.279	0.850	0.318	0.234	0.463	0.314
ENC4	0.430	0.383	0.845	0.352	0.308	0.507	0.372
GUS1	0.456	0.399	0.179	0.751	0.369	0.451	0.263
GUS2	0.660	0.540	0.299	0.882	0.485	0.574	0.401
GUS3	0.594	0.493	0.369	0.819	0.453	0.581	0.346

Table A2. *Cont.*

	AEC	AIN	ENC	GUS	PEU	RAD	SIN
PEU1	0.500	0.473	0.309	0.470	0.837	0.367	0.373
PEU2	0.376	0.328	0.168	0.260	0.653	0.201	0.147
PEU3	0.562	0.451	0.279	0.513	0.880	0.372	0.352
PEU4	0.364	0.302	0.159	0.357	0.680	0.377	0.268
RAD1	0.531	0.359	0.544	0.544	0.368	0.801	0.314
RAD2	0.491	0.468	0.425	0.570	0.378	0.858	0.366
RAD3	0.401	0.391	0.323	0.481	0.306	0.768	0.430
SIN1	0.422	0.502	0.278	0.332	0.308	0.363	0.875
SIN2	0.376	0.447	0.269	0.283	0.315	0.349	0.828
SIN3	0.497	0.570	0.337	0.427	0.353	0.395	0.869
SIN4	0.388	0.438	0.272	0.287	0.267	0.356	0.659

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