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Understanding the Emergence and Social Acceptance of Electric Vehicles as Next-Generation Models for the Automobile Industry

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Abstract: This study explores potential factors of drivers' intentions to use electric vehicles and proposes an integrated adoption model. Results of a structural equation modeling analysis with 988 samples indicate that drivers' intentions are predicted by one negative factor (cost) and three positive ones (satisfaction, usefulness, and attitude). In addition, the total standardized effects of potential factors on the intention are computed. The current study also validates the original technology acceptance model. Based on the results of the current study, practical and academic implications with potential limitations are examined and presented.

Keywords: electric vehicles; social acceptance; technology acceptance model

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1. Introduction

With increased social interest in the environment, more attention is being paid to the transportation sector, which is considered a key contributor to greenhouse gas (GHG) emissions. The International Energy Agency (2017) indicated that about 14% of GHGs were generated globally by the transportation sector [1], and this rate is estimated to increase to half of all GHG emissions by 2030. Therefore, several nations are attempting to reduce GHG emissions and environmental pollution by the transportation sector by decreasing the use of fossil fuels. Among several alternatives, electric vehicles (EVs) are regarded as one of the most promising approaches in the transportation sector [2]. The U.S. National Resources Defense Council (2007) found that EVs can contribute toward handling several environmental problems [3]. With this positive effect in mind, the majority of vehicle manufacturing companies are developing, introducing, and selling EVs [4].

The energy demand of the world continues to grow [1], and currently, more than 25 billion tons of CO_2 arising from human activities are annually released worldwide into the atmosphere. Now, it is a world problem to reduce the emissions of greenhouse gases and air pollutants such as CO, HC, and NO_x by road transportations for city governance, as highlighted by previous studies (e.g., [5–7]). In the meantime, South Korea, which has ranked 11th worldwide in terms of gross domestic product (GDP) in 2017 and is the world's third fastest growing country in CO_2 emissions, has signed the Paris Agreement on 2016, and its Intended Nationally Determined Contribution (INDC) proposes an economy-wide target to reduce GHG emissions by 37% by 2030 relative to the business-as-usual level [8]. According to several prior studies [9], the level of GHG emissions in South Korea has been 0.69 billion tons of CO_2 in 2015, while a total of 49 billion tons of CO_2 has been emitted globally in 2015. Moreover, South Korea has established a GHG reduction target of 34.3% to transportation as energy consumption by nonindustrial sectors such as transportation is expected to continuously increase [10], and the South Korean Government is pushing the uptake of EVs with a goal of having 250,000 EVs on the road by 2020 [11].

Nations worldwide are vigorously developing and discovering alternative fuel sources and new technology to lessen the dependency on fossil fuels because of the increasing energy demand, the uncertainty of fuel prices, and severe air pollution restrictions in the road transport sector. Furthermore, attention has been recently drawn to developing cleaner alternative fuels from renewable sources and to improving hybrid vehicles so that the harmful emissions to air in city centers and the need for fossil fuels can be reduced [5,12].

In spite of this trend and its advantages, prior studies have identified notable barriers to the wide diffusion of EVs [2]. For instance, Axsen, Kurani, and Burke [13] found that the cost of a vehicle battery is a significant barrier to EV acceptance. Limitations in battery capacity and vehicle weight are further obstacles to commercializing EVs [14]. This context has directed the focus of engineers and researchers in the field to technical issues, which has yielded improvements in terms of the engineering-related agenda based on what prior studies highlighted as the major restrictions on the spread of EVs [15].

These improvements to the engineering and technical aspects of EVs have increased the importance of focusing on the users' perspectives on these vehicles [16]. EVs have been rapidly diffused in several developed countries, including Japan [17,18], the Netherlands, and the US, whereas in some nations, such as South Korea and China, they have propagated slowly [19,20].

Thus, the current study aims to explore drivers' perceptions of EVs by examining the vehicles' characteristics based on a model represented in user-oriented studies: the technology acceptance model (TAM) [21]. This study proposes a new adoption model that can be applied to renewable energy technologies and vehicle systems to elucidate drivers' acceptance of EVs in South Korea [19,22]. This study addresses two research questions: (A) what driver-oriented variables motivate intentions to use EVs? And (B) can the original TAM validly be applied to EVs?

The remainder of this paper is structured as follows. First, a literature review is presented. Second, the hypotheses and research model are introduced. Third, the study methods are elucidated, and the results are presented. Finally, a discussion, conclusions, and the limitations of the study are provided.

Electric Vehicles

Although automobiles based on the internal combustion engine are popular in our society, EVs has also been invented in the early stage of automobile history. However, vehicles installed with internal combustion engines have dominated the market, primarily against a background of widely available oil at low prices. Since the 1990s, with the increased interest in environmental issues, including GHG emissions, a number of nations and manufacturers have started paying more attention to EVs and hybrid EVs [23,24]. A hybrid EV has both an internal combustion engine powered by fossil fuels and an electric motor powered by a battery [25]. The battery is charged by the internal combustion engine when the vehicle is braked. Because the original energy of hybrids is supplied by fossil fuels, they are more economical and efficient than traditional vehicles [26].

Generally, EVs are referred to as battery-electric vehicles. Battery-electric vehicles are powered by large battery packs that are recharged via the electricity supply [27]. Although the widespread distribution of battery-electric vehicles may be the most promising solution for future transportation systems, the mass distribution of battery-electric vehicles is more difficult than that of other vehicles, including traditional ones, because of several limitations and technological differences [28].

Public attitudes toward EVs and public willingness to use them should be considered in promoting the use of these vehicles in the transportation sector. Not only should the technical limitations of EVs, including battery capacity and weight, be improved, but also drivers' individual and social issues should be investigated to enhance commercially successful distributions. Prior studies have reported that users' adoption and preferences are important factors for successful maintenance in the transportation sector [29]. Thus, this study investigates users' perceptions of EVs through the introduction of a new integrated model of EVs adoption.

2. Literature Review and Hypotheses

2.1. Modeling Social Acceptance of Electric Vehicles

Estimating users' responses to specific technologies and products has become a hot research area. Among the various academic studies that have attempted to develop theories for predicting user acceptance of specific technologies and products, the theory of planned behavior (TPB) proposed by Ajzen [30] and the TAM introduced by Davis [21] are well-regarded approaches for revealing how users shape their perceptions and opinions and adopt specific technologies and products. Related to the TPB, several studies have applied it to users' behavior in using environmentally friendly technologies and products. Chen (2016) note that the TPB can be a significant basic model for predicting users' intentions to employ environmentally friendly behavior [31]. Dezdar (2017) also employed the TPB in explaining users' intention to use green information technologies, and found that two constructs in the TPB, perceived behavioral control and subjective norms, were positively related to users' attitudes toward the technologies [32].

By applying these theoretical approaches to energy or vehicle technologies, prior studies have investigated users' perspectives toward the technologies. For instance, Kim and colleagues use the TPB to investigate users' adoption of solar energy, a well-known renewable energy technology [33]. Similarly, Huijts, Molin, and Steg (2012) found the TPB to be valid for explaining sustainable energy technology acceptance. In the field of vehicle-related systems [34], Park and Kim (2014) found the technology acceptance concept to be valid for investigating driver acceptance of automobile-related systems [35].

The original TAM is organized around four variables. Davis (1989) state that two cognitive beliefs, perceived ease of use and usefulness, are determinants of users' attitudes, and that attitude and usefulness are significantly related to users' intentions to use particular systems and products [21]. Moreover, the two cognitive beliefs act as mediators between specific characteristics of particular systems and products and two other variables: attitudes and intention. Several prior studies have found positive associations between ease of use and usefulness, ease of use and attitude, usefulness and attitude, usefulness and intention to use, and attitude and intention to use [21,36]. Related to the domain of transportation and innovative products, several prior studies have been conducted on the validity and significance of the TPB and TAM [37–39]. Moreover, although users can have positive attitudes toward EVs, there can be hindrances and real-world constraints in purchasing and using them. Because of this, this study separately formulates public attitude and intention to use, respectively. Therefore, based on the findings of previous technology acceptance studies, this study hypothesizes the following connections:

Hypothesis (H1): *Public attitudes toward using EVs are positively related to intention to use EVs.*

Hypothesis (H2): *The perceived usefulness of EVs is positively related to intention to use EVs.*

Hypothesis (H3): *The perceived usefulness of EVs is positively related to public attitudes toward using EVs.*

Hypothesis (H4): *The perceived ease of use of EVs is positively related to the perceived usefulness of EVs.*

Hypothesis (H5): *The perceived ease of use of EVs is positively related to public attitudes toward using EVs.*

2.2. Satisfaction

Prior studies in the field of information science and communications have reported that the user's degree of satisfaction in interacting with particular systems and services is a key factor in the user's perception of the usability of the systems or services [40]. In addition, the user's satisfaction plays a notable role in elucidating the user's intention to employ renewable energy technologies or car-related systems [41]. For instance, Kim and colleagues found that users' satisfaction in economic and social aspects is a significant predictor of their acceptance of solar energy technologies [33]. Therefore, this study hypothesizes the following connections based on the results of prior studies:

Hypothesis (H6): *Satisfaction with using EVs is positively related to intention to use EVs.*

Hypothesis (H7): *Satisfaction with using EVs is positively related to public attitudes toward EVs.*

2.3. Perceived Enjoyment

Prior studies on user experience have shown that hedonic factors, including perceived enjoyment, are core determinants of users' perceptions [41]. Van der Heijden defined perceived enjoyment as "*the level to which the activity of using a particular system or service is perceived as being nice and enjoyable*" [42], and indicate that perceived enjoyment is a key determinant of users' attitudes and experiences in using a hedonic information service or system. In EVs, drivers' distinctive experiences from traditional vehicles can also be a source of driving enjoyment [43]. The relationships among users' satisfaction, enjoyment, and attitudes toward a particular product or service have generally been supported in the field of information science and communications [40]. Therefore, this study hypothesizes the following relationships:

Hypothesis (H8): *The perceived enjoyment of EVs is positively related to satisfaction with EVs.*

Hypothesis (H9): *The perceived enjoyment of EVs is positively related to public attitudes toward EVs.*

2.4. Perceived Cost

When users encounter newly introduced technologies and systems, the cost concept is a notable factor in determining their use of those technologies and systems [44]. In this process, users may consider the cost of the technology and its potential benefits at the same time. As presented in the findings and validations of prior studies on renewable energy technologies and facilities, the economic hindrance and subsidy which are provided by the central and local governments can be one of the most significant hindrances for the diffusion of the technologies and facilities [45]. The cost concept is a complex notion that encompasses the cost of maintenance, the purchase, and related processes [44]. In the case of EVs, although low running cost is one of the main benefits, the purchasing and infrastructure costs are greater than those of traditional vehicles.

In addition, several studies conducted in the field of transportation and automobiles have confirmed the cost concept as an important factor in the success of products and systems. For example, Jones (2002) found that the cost concept, including pricing strategy, could determine the success or failure of products and systems [46]. Therefore, this study hypothesizes the following connection based on the findings of the previous research:

Hypothesis (H10): *The perceived cost of EVs is negatively related to intention to use EVs.*

2.5. The Research Model

Based on the proposed hypotheses, the integrated research model is presented in Figure 1.

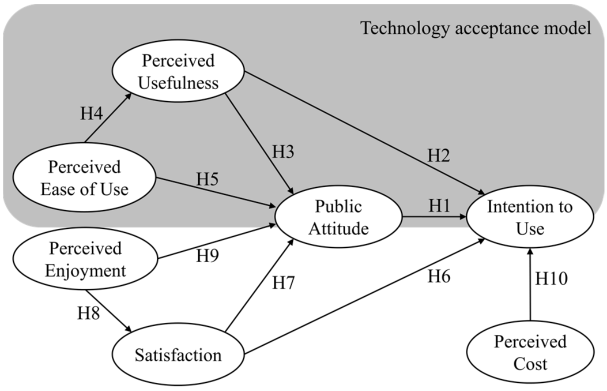

Figure 1. The integrated research model.

3. Method

3.1. Questionnaire Design

To administer the survey and obtain data, we followed the following five stages proposed by Shin and Shin [47]: (A) finding potential possible factors; (B) administering the factors; (C) exploring the reliability of the administered factors; (D) conducting a series of pilot surveys and review sessions; and (E) conducting the main survey. To find potential factors, ten-minute in-depth interview sessions were conducted with 15 car drivers with over five years of driving experience and who had driven EVs at least four times.

After the interviews, query analyses were conducted to obtain potential variables (Table 1). We selected five factors and conducted a pre-survey to test the reliability of the questionnaire items for the selected factors. First, we found 29 items that were validated by prior studies. Then, the items were revised by an expert group of three researchers and two professionals in the fields of communications, energy technology, and transportation. Next, three pilot surveys were conducted with 20 drivers who had more than ten years' driving experience. Respondents were asked to inform the experimenters if they had any problems understanding the questionnaire items. Cronbach's alpha was computed to test the validity of the responses. Consequently, 21 questionnaire items were selected, and eight items from the original questionnaire set were excluded from the final survey (Table 2).

Table 1. Results of the in-depth interviews.

	Potential Variables	*n* (%)
1	Functionality/Usability	39 (29.8%)
2	Cost (in maintenance and purchase)	30 (22.9%)
3	Satisfaction (including convenience)	22 (16.8%)
4	Easy to drive	12 (9.2%)
5	Enjoyment	7 (5.3%)
6	Etc.	21 (16.0%)
Total	From 15 drivers	131 queries

Table 2. Questionnaire items in the main survey.

Constructs	Descriptions
Perceived Ease of Use [21]	PEOU1: I find electric vehicles easy to drive. PEOU2: Driving electric vehicles does not require a lot of physical effort. PEOU3: Driving electric vehicles does not require a lot of mental effort.
Perceived Usefulness [21,36]	PU1: Driving electric vehicles may lead to better and new ways to significantly contribute to our environment. PU2: Driving electric vehicles can improve my work efficiency and performance. PU3: Using electric vehicles can increase my productivity.

Table 2. *Cont.*

Constructs	Descriptions
Perceived Enjoyment [41,42]	EN1: I enjoy driving electric vehicles. EN2: Driving electric vehicles is more enjoyable than driving traditional vehicles. EN3: I am happy to use electric vehicles.
Satisfaction [48,49]	ST1: Overall, I am satisfied with electric vehicles. ST2: I have positive feelings toward electric vehicles in general. ST3: I recommend electric vehicles to others who intend to purchase and use new vehicles.
Public Attitude [33,44]	ATT1: Driving electric vehicles is good for us. ATT2: Using electric vehicles is wise for us. ATT3: I agree with the use of electric vehicles.
Perceived Cost [44]	PC1: It takes a considerable amount of effort and cost to use electric vehicles. PC2: I think the purchasing cost of driving electric vehicles is expensive. PC3: I think the maintenance cost of driving electric vehicles is expensive.
Intention to Use [21,44]	IU1: I would rather drive electric vehicles than other vehicles. IU2: If possible, I intend to drive electric vehicles as much as possible. IU3: If possible, I would like to continually use electric vehicles.

A professional survey company was hired to conduct a pen-paper survey to test the proposed research model. The survey was conducted from July to August 2014 in Seoul, Republic of Korea. It was conducted using a convenience sampling method after a filtering process that investigated whether each participant had enough experience in using EVs. After this process, each participant was interviewed by the survey researcher face-to-face. All participants in the main survey were asked to respond to all items on a seven-point Likert scale (from 1 = absolutely disagree to 7 = absolutely agree). After the survey, all participants received 5000 KRW (about US $5). The company initially collected 1333 samples. After data filtering, 988 valid responses remained and were used as the dataset. The demographic data are presented in Table 3.

Table 3. Demographic data of the participants.

Age	*n* (%)	Driving Experience	*n* (%)
19–30	149 (15.1%)	0~5 years	128 (13.0%)
31–40	292 (29.6%)	5~10 years	198 (20.0%)
41–50	331 (33.5%)	10~15 years	351 (35.5%)
51–60	139 (14.1%)	15~20 years	205 (20.7%)
Over 60	77 (7.8%)	Over 20 years	106 (10.7%)
Driving experience of electric vehicles		Education	
3~5 times	97 (9.8%)	High school or below	677 (68.5%)
5~10 times	437 (44.2%)	College	272 (27.5%)
10~20 times	352 (35.6%)	Graduate or above	39 (3.9%)
Over 20 times	102 (10.3%)		
Gender			
Male	539 (54.6%)		
Female	449 (45.4%)		

3.2. Results

SPSS 18.0, a professional statistical software package, was used to compute the descriptive statistics of the selected constructs of the main survey. The descriptive statistics indicated that the respondents in the main survey had positive perceptions of EVs (Table 4).

Table 4. Descriptive statistics of the selected constructs.

Construct	Mean	Standard Deviation
Perceived Ease of Use	4.32	1.17
Perceived Usefulness	4.60	1.02
Perceived Enjoyment	4.09	1.25
Satisfaction	4.18	1.19
Public Attitude	4.54	1.01
Perceived Cost	3.95	1.38
Intention to Use	4.93	1.39

3.2.1. Analysis Methods

To test the proposed connections in the model, a structural equation modeling (SEM) method and confirmatory factor analysis were used. This study satisfied internal and convergent reliability tests according to the recommendations of prior studies that Cronbach's alpha values should be over 0.7, the sample size should be at least 200, factor loadings should be higher than 0.7, composite reliability values should be greater than 0.7, and average variance extracted (AVE) values should be over 0.5 (Table 5) [50,51]. Additionally, for a test of discriminant reliability, the correlation between two particular constructs should be less than the square root of AVE (Table 6). This study met all of these guidelines.

Table 5. Internal and convergent reliability of the constructs.

Construct	Item	Internal Reliability			Convergent Validity	
		Cronbach's Alpha	Item-Total Correlation	Factor Loadings	Composite Reliability	Average Variance Extracted
Perceived Ease of Use	PEOU1	0.860	0.799	0.883	0.911	0.772
	PEOU2		0.795	0.898		
	PEOU3		0.849	0.855		
Perceived Usefulness	PU1	0.838	0.813	0.856	0.919	0.791
	PU2		0.834	0.934		
	PU3		0.784	0.877		
Perceived Enjoyment	EN1	0.867	0.866	0.931	0.942	0.845
	EN2		0.828	0.924		
	EN3		0.835	0.902		
Satisfaction	ST1	0.908	0.846	0.925	0.942	0.844
	ST2		0.860	0.900		
	ST3		0.894	0.931		
Public Attitude	ATT1	0.910	0.861	0.830	0.857	0.667
	ATT2		0.899	0.851		
	ATT3		0.850	0.766		
Perceived Cost	PC1	0.859	0.819	0.924	0.931	0.819
	PC2		0.843	0.928		
	PC3		0.800	0.861		
Intention to Use	IU1	0.891	0.816	0.889	0.916	0.784
	IU2		0.904	0.890		
	IU3		0.885	0.878		

Table 6. Discriminant validity; the square roots of average variance extracted between the variables are presented in diagonal elements.

	1	2	3	4	5	6	7
1. Perceived Ease of Use	0.879						
2. Perceived Usefulness	0.221	0.889					
3. Perceived Enjoyment	0.198	0.151	0.919				
4. Satisfaction	0.098	0.327	0.293	0.919			
5. Public Attitude	0.176	0.550	0.425	0.396	0.817		
6. Perceived Cost	−0.112	−0.264	−0.098	−0.170	−0.309	0.905	
7. Intention to Use	0.383	0.402	0.187	0.141	0.284	−0.218	0.885

3.2.2. The Measurement Model

The fit indices of the measurement model showed that the collected data were well-represented by the model (Table 7). The fit indices met the satisfactory criteria presented in the previous studies [50–52].

Table 7. Fit indices of the measurement model and research model.

Index	Measurement Model	Research Model	Satisfactory Levels
χ^2	930.81	1031.91	-
Degree of freedom	198	214	-
χ^2/d.f.	4.701	4.822	<5.00
Comparative Fit Index	0.913	0.908	>0.900
Incremental fit index	0.916	0.923	>0.900
Goodness-of-fit index	0.901	0.902	>0.900
Adjusted goodness-of-fit index	0.903	0.903	>0.900
Normed fit index	0.910	0.908	>0.900
Non-normed fit index	0.908	0.911	>0.900
Standardized root mean square residual	0.059	0.058	<0.060
Root mean square of approximation	0.073	0.076	<0.080

3.2.3. Hypothesis Testing

The proposed connections were explored to investigate the structural relations. The fit indices of the research model were satisfactory (Table 7). As shown in Figure 2 and Table 8, the nine hypothesized connections were supported, but the connection between perceived enjoyment and public attitude toward EVs (H9, $p > 0.05$) was not supported. Public attitude was mainly determined by three positive variables: usefulness (H3, *beta* = 0.240, *CR* = 8.106, $p < 0.001$), ease of use (H5, *beta* = 0.130, *CR* = 4.376, $p < 0.001$), and satisfaction (H7, *beta* = 0.334, *CR* = 10.869, $p < 0.001$). In addition, perceived ease of use showed notable effects on perceived usefulness (H4, *beta* = 0.301, *CR* = 9.934, $p < 0.001$).

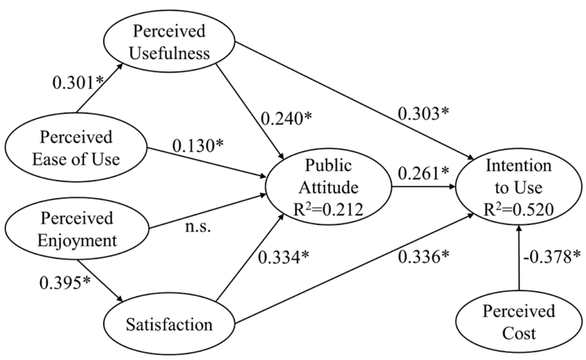

Figure 2. Results of the hypotheses tests; * $p < 0.001$, H1, H2, H3, H4, H5 (from the TAM), H6 (satisfaction—intention), H7 (satisfaction—attitude), H8 (enjoyment—satisfaction), and H10 (perceived cost—intention) were confirmed, while H9 (enjoyment—attitude) was not supported.

Table 8. Summary of the results; * $p < 0.001$; Attitude: Public attitude, Intention: Intention to use, PU: Perceived usefulness, PEOU: Perceived ease of use, Enjoyment: Perceived enjoyment, Cost: Perceived cost.

Hypotheses	Standard Coefficient	Standard Error	Critical Ratio	Results
H1. Attitude → Intention	0.261 *	0.039	10.600	Supported
H2. PU → Intention	0.303 *	0.036	13.117	Supported
H3. PU → Attitude	0.240 *	0.032	8.106	Supported
H4. PEOU → PU	0.301 *	0.028	9.934	Supported
H5. PEOU → Attitude	0.130 *	0.031	4.376	Supported
H6. Satisfaction → Intention	0.336 *	0.019	14.209	Supported
H7. Satisfaction → Attitude	0.334 *	0.030	10.869	Supported
H8. Enjoyment → Satisfaction	0.395 *	0.026	13.493	Supported
H9. Enjoyment → Attitude	0.023	0.026	0.750	Not supported
H10. Cost → Intention	−0.378 *	0.032	−17.158	Supported

Moreover, drivers' intention to use EVs was determined by four variables (three positive and one negative). Three significant antecedents, satisfaction (H6, *beta* = 0.336, *CR* = 14.209, $p < 0.001$), usefulness (H2, *beta* = 0.303, *CR* = 13.117, $p < 0.001$), and public attitude (H1, *beta* = 0.261, *CR* = 10.600, $p < 0.001$), showed positive significant effects on intention, but perceived cost had the most significant effect on intention (H10, *beta* = −0.378, *CR* = −17.158, $p < 0.001$).

Of the variance in public attitude, 21.2% was explained by perceived usefulness, ease of use, and satisfaction, whereas 52.0% of the variance in intention to use was explained by perceived cost, public attitude, satisfaction, and usefulness.

To present the most notable effects of the employed constructs in the proposed research model on the intention to use, the standardized total effects of the constructs on the intention to use were computed. As presented in Table 9, users' satisfaction had the most influence on intention (0.423).

Table 9. Total standardized effects on intention.

	Total Standardized Effects		Total Standardized Effects
Attitude	0.261	Enjoyment	0.173
PU	0.366	Satisfaction	0.423
PEOU	0.144	Cost	−0.378

4. Discussion & Conclusions

The purpose of this study was to explore drivers' motivations for using EVs. We conducted a structural investigation by examining and exploring a driver acceptance model. Based on one of the most widely employed user-oriented models, the statistical results indicated that the original TAM is valid for elucidating driver acceptance of EVs, and a sequential structural relationship of perceived enjoyment—satisfaction—attitude—intention is supported for explaining acceptance.

Building on the findings of prior studies that utility- and price-related factors are the key motivations for using renewable energy technologies and products [53], this study showed that users' satisfaction and enjoyment should also be considered in explaining their behavior and willingness to use such technologies and products.

This study introduced a new adoption framework for elucidating the user-decision process for EVs. Moreover, the integrated adoption framework was investigated by using SEM to explore the motivations for users' intention to use EVs and the systematic decision process. The results supported the validity of the proposed model, which thus improves our understanding of users' willingness to use and perceptions of EVs.

Similar to prior TAM studies, this study confirmed the validity of the model in explaining users' perceptions of EVs. In addition, the integrated model and results mirrored the current status of EVs: (A) drivers consider their experiences with an overall feeling of enjoyment and satisfaction with the vehicles (0.173 and 0.423); (B) drivers' expectations of cost, including the cost of maintenance and purchase, can disturb their intention to use the vehicles (−0.378); and (C) drivers' perspectives toward the hedonic, utilitarian, and economic aspects of EVs should be considered in attempts to diffuse the vehicles. Thus, these factors should be considered when academic and industrial researchers and politicians want to promote EVs. The motivations of drivers, such as intention to use, perceived usefulness (0.366), and attitude (0.261) as positive determinants, and perceived cost (−0.378) as a negative one, were investigated as the key factors in encouraging drivers to purchase and use EVs and establishing support facilities.

The results of this study have several industrial and academic implications related to EVs for engineers, researchers, and government officers, including policymakers. From a practical perspective, practical engineers and researchers can apply our results to enhance EVs by improving their degree of utility and increasing users' hedonic perceptions of the vehicles. Moreover, government officers, including policymakers, should design financial and supportive policy plans minimizing the cost aspects of EVs for potential drivers. Moreover, automobile manufacturers should establish systematic and user-oriented plans to improve users' overall satisfaction in using EVs. With the increasing environmental concerns in our society, well-designed plans could encourage potential drivers to consider EVs for transportation. That is, future plans should be established with the considerations of not only economic aspects of EVs, but also users' experience of EVs. For example, the UK government operates the integrated supporting plans and provides the incentives of 35%-purchasing price (up to £4500) for low-emission vehicles based on seven categories [54]. The supporting plan in Norway mainly concentrates on tax benefit, including no purchase/import taxes, no charges on toll gates, half-company automobile tax, and so on [55]. However, in South Korea, there are two separated supporting plans for EVs which are operated by the central and local governments, respectively [56].

Academically and theoretically, this study improves our understanding of this conceptual structure, including utilitarian, hedonic, and economic factors and their connections. Considering the prior studies that explored drivers' perceptions of alternative transportation including EVs [57], the research model suggested and verified by this study can be applied to increase our overall understanding of drivers' adoption of EVs. Although this study examined users' adoption decisions related to EVs as a future transportation method, the following two research questions remain: (A) are other aspects of EVs significantly related to users' adoption of the vehicles? And (B) can the adoption model proposed by this study be used to explain future transportation methods and renewable energy products?

This study attempts to expand the findings of previous technology acceptance studies on users' adoption of particular technologies and products. Therefore, it contributes to the literature on EVs and renewable energy products by investigating the core roles of the variables examined and their significant connections in the integrated research model.

5. Limitations

This study has several limitations. First, other factors may be significantly associated with users' intention to use technology. For example, prior studies on user behavior have indicated that personal characteristics of users and the technological factors of particular products and technologies can be strongly related to users' perceptions of those technologies and products [58].

Second, some relationships may have been missed in the proposed research model. The correlation values among several of the investigated factors were high. This study has used a condensed model that excluded complicated connections.

Third, this study does not consider the unique characteristics of the individual driving experience. As previous studies have indicated, the driving patterns of EVs can be significantly affected by charging and parking systems [43]. Moreover, drivers' subjective needs and targeting behaviors can be related to their perceived usefulness [59]. Moreover, prior studies have showed that infrastructure availability for a particular service is strongly associated with users' perceived ease of use [60].

Fourth, although the functionality and usability of EVs have been extracted via the initial interview, perceived risks and problems in terms of the technical aspects of EVs have not been considered while prior studies have showed that the environmental aspects of EVs can be significantly related to users' attitudes toward them [59,61].

Fifth, there may be a common method bias. Several prior studies on SEM and information systems have shown that this bias can significantly influence the results of SEM and regression analysis [62,63]. Considering previous studies on how the perceived risks of renewable energy facilities and products affect their distribution [44], future studies should extend the research model by examining the potential risks and problems of EVs.

Sixth, perceived enjoyment of EVs has been one of the motivators for boosting driver attitudes and increasing their intention to use through perceived satisfaction. Therefore, future research should examine the relationships between perceived enjoyment of EVs and driver perspectives toward them.

Due to these limitations, future researchers should be careful in applying the results of this study to explaining other future transportation and renewable energy products.

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