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Promoting Sustainable Transportation: Factors Influencing Battery Electric Vehicle Adoption Across Age Groups in Thailand

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Abstract: Battery Electric Vehicles (BEVs) are a crucial innovation for achieving sustainable transportation and reducing greenhouse gas emissions, which are major contributors to global warming and climate change. While previous studies have explored attitudes towards BEV technology acceptance, few have examined the interplay of external factors such as government measures and adoption barriers in promoting sustainable mobility. This study addresses this gap by investigating the roles of government policies, usage obstacles and innovation diffusion in stimulating BEV purchase intentions, while applying the Innovative Diffusion Theory (IDT). Data from 3632 respondents in Thailand were analyzed using structural equation modeling (SEM) to examine causal relationships between factors. The results indicate that government policies supporting BEV users enhance innovation diffusion in society, leading to increased adoption intentions. Furthermore, effective policies help mitigate barriers to BEV usage, further encouraging adoption. The study also reveals that causal relationships of BEV usage intentions vary across age groups, highlighting the need for targeted approaches in promoting sustainable transportation. These findings contribute to the development of evidence-based policy recommendations to accelerate BEV adoption, supporting Thailand's Carbon Neutrality goals and broader sustainable development objectives. By elucidating the complex dynamics of BEV adoption, this research provides valuable insights for policymakers and stakeholders working towards a more sustainable and environmentally friendly transportation sector.

Keywords: government support; innovation diffusion; adoption barriers; sustainable transportation; clean energy adoption; carbon emission reduction

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1. Introduction

Climate change is one of the greatest social and environmental challenges of the 21st century. The increase in the Earth's average temperature has led to rising sea levels and losses of biodiversity. Analyses of historical data on society and the environment indicate that climate change results from political impacts and economic structures that have led to various pollution problems. Maintaining global temperature levels requires urgent awareness of social changes in energy use, land utilization, national infrastructure, and industrial operating systems [1]. Industrial expansion has significantly increased the world population's energy demand. The fuel combustion process releases greenhouse gases such as methane, carbon dioxide, and nitrous oxide, which are major causes of climate change that will subsequently affect the health of the world's population [2].

The global community has been working to address climate change under the United Nations Framework Convention on Climate Change (UNFCCC), which aims to stabilize greenhouse gas concentrations. Developed countries are expected to lead the fight against climate change while considering the specific needs and situations of developing

countries [3]. One of the key missions is the policy to support the use of clean energy sources (renewable energy sources), which has gained attention from many organizations worldwide as a replacement for limited fossil fuels that impact the environment. However, there are still many obstacles, including government policies, technological limitations, and economic situations that hinder the full implementation of clean energy [4]. Many countries worldwide prioritize energy policies to increase economic competitiveness while reducing environmental impacts from the use of greenhouse gas-emitting fuels. This requires government policy drives and public support [5]. The main factors hindering the use of clean energy in European Union countries are four key barriers: administrative processes barriers, grid barriers, political barriers, and market and economic barriers [6].

Thailand has signed and ratified the United Nations Framework Convention on Climate Change, which came into effect on 28 March 1995. The country has set goals for Carbon Neutrality by 2050 and Net Zero Greenhouse Gas Emission by 2065 [7]. This has led to the development of a national energy plan framework that supports Thailand's transition towards clean energy use and aims to reduce carbon dioxide emissions. One of the key energy policies is the shift towards green energy in the transport sector through electric vehicle technology. The 2021–2035 plan includes government policies to promote personal electric vehicles and develop the country's electricity demand management system to stimulate the growth of Thailand's electric vehicle industry [8,9].

The transportation sector plays a significant role in Thailand's greenhouse gas emissions, contributing 29.50% of total emissions, second only to the energy industry at 39.63% [10]. Recent forecasting analysis suggests that without intervention, CO_2 emissions from transportation will reach 78,514.470 kTons by 2030. However, successful implementation of the 30@30 policy could reduce emissions to 63,517.583 kTons in the same period—a potential reduction of approximately 14,996.888 kTons [10]. This significant reduction in CO_2 emissions demonstrates the crucial role of BEV adoption in achieving Thailand's Carbon Neutrality goals. The forecasting models indicate that the transition to BEVs could contribute substantially to emission reductions, particularly in urban areas where vehicle density is highest.

The National Electric Vehicle Policy Committee has issued guidelines for promoting the use of Battery Electric Vehicles (BEVs), setting a target for Zero Emission Vehicle (ZEV) production to reach at least 30% of total vehicle production by 2030. The committee has set targets for promoting 440,000 electric passenger cars and pickup trucks, 650,000 motorcycles, and 33,000 buses and trucks. Additionally, it aims to promote 12,000 fast-charge public electric vehicle charging stations and 1450 battery swap stations for electric motorcycles [11]. In the past, Internal Combustion Engine (ICE) vehicles accounted for over 80% of all domestic passenger vehicle sales in Thailand. In 2023, sales of all types of electric vehicles are expected to increase from 20.52% to 41.39% of total passenger vehicle sales [12,13]. However, the BEV industry is new and initially driven more by international and national government policies than by market forces, which are not yet fully developed. Furthermore, since late 2023, the electric vehicle market has begun to slow down in many countries worldwide.

Previous research has extensively applied the Technology Acceptance Model (TAM) and Theory of Planned Behavior (TPB) to study factors affecting BEV purchase intentions [14–19]. Key factors studied include government policy and promotion [17,20,21], user attitudes and technological capabilities [14,18,22,23], and barriers causing user concerns such as costs, supporting infrastructure, technological readiness, travel behavior, and access to information [15,21,24,25]. As previous studies have not provided conclusive findings on factors affecting personal electric vehicle purchase intentions, this study applies the Innovative Diffusion Theory (IDT) to determine causal relationships, along with factors related to government support policies and barriers to electric vehicle technology use.

Demographic factors, particularly age, play a crucial role in shaping attitudes towards and intentions to purchase electric vehicles. Previous studies have shown that different age groups exhibit varying levels of interest and motivations when it comes to EV adoption. For instance, younger consumers (typically those under 35) often show greater environmental

consciousness and technological enthusiasm, which can positively influence their EV purchase intentions [26]. Middle-aged consumers (35–50) may be more influenced by practical considerations such as long-term cost savings and family needs [15]. Older consumers (over 50) sometimes display more resistance to change, but may also be motivated by environmental concerns and the desire for energy independence [27]. However, these age-related patterns can vary significantly across different cultural and economic contexts. Understanding these age-related differences is crucial for policymakers and marketers in tailoring their strategies to effectively promote EV adoption across diverse demographic segments. This study aims to contribute to this understanding by examining how age groups in Thailand differ in their responses to government support, innovation diffusion, and adoption barriers in relation to BEV purchase intentions.

While previous studies have explored various factors influencing BEV adoption, there remains a significant gap in understanding the complex interplay between government support, innovation diffusion, and adoption barriers, particularly in the context of emerging markets like Thailand. Additionally, the impact of age on these relationships has not been thoroughly investigated. This study addresses these gaps by integrating external factors (government support and adoption barriers) with internal factors (innovation diffusion) and examining how these relationships vary across different age groups. This study offers a more comprehensive and nuanced understanding of BEV adoption dynamics, which is crucial for developing effective policies and marketing strategies in emerging markets.

The primary objectives of this study are threefold: first, to investigate the causal relationships between government support, innovation diffusion, adoption barriers, and BEV purchase intentions in Thailand; second, to examine how these relationships differ across various age groups (25–34, 35–44, and over 44 years); and third, to assess the effectiveness of current government policies in promoting BEV adoption and identify areas for improvement to achieve Thailand's Carbon Neutrality goal by 2050.

This study makes several significant contributions. Theoretically, it extends the application of Innovation Diffusion Theory to the BEV context, integrating it with concepts of government support and adoption barriers. This provides a more comprehensive framework for understanding BEV adoption in emerging markets. Methodologically, by employing a multi-group analysis across age groups, this study offers a more nuanced understanding of how demographic factors influence BEV adoption, providing a methodological template for future research in this area. Practically, the findings of this study will provide valuable insights for policymakers in Thailand and similar emerging markets. By identifying which factors are most influential for different age groups, it will enable the development of more targeted and effective policies to promote BEV adoption, ultimately supporting the country's journey towards Carbon Neutrality.

2. Literature Review

2.1. Government Support

In an era where the world is focusing on climate change issues, which are macro-level problems requiring cooperation from all parties both domestically and internationally to solve, the government serves as a mediator that can coordinate cooperation from all sectors under a defined policy framework. Moreover, government support policies affect consumers' emotional responses and decision-making behaviors [28]. A key policy to address climate change is supporting the transport industry in transitioning from fuel-powered vehicles to electric vehicles. Governments can implement measures to stimulate consumers' emotions and behaviors, such as providing consumer education through public relations, offering tax discounts, and supporting electric vehicle manufacturers and distributors [17,19].

Effective government policies are highly influential factors in spreading the acceptance of electric vehicle technology among the country's population, especially monetary incentive policies [29]. Additionally, communication policies that shape the image of electric vehicle owners are crucial in establishing social norms for technology acceptance, leading to

increased intentions to purchase electric vehicles among society's members [30]. Moreover, the overall effective policymaking by the government needs to be appropriate for the level of innovation diffusion within that society. For example, a successful case is given by Liuzhou, a third-tier city in Southwest China. This highlights the importance of contextualizing local policies from the government as well as product design from carmakers to meet specific consumer needs and wants. Liuzhou was also very good at engaging consumers when developing its EV market. The city's government and local carmakers jointly initiated a 10-month new EV test drive campaign in 2017 to increase consumer awareness about EVs and collect users' recommendations on improving the vehicle [26]. As for measures to support the diffusion of BEV innovation in Thai society, these are still national-level measures that will lead to the spread of innovation in large urban societies.

H1. *Government support is positively related to Innovation diffusion.*

Ruoso and Ribeiro [24] analyzed solutions to reduce factors hindering the use of personal electric vehicles. The government of Brazil's policies and support, such as electric vehicle tax reduction policies, can alleviate cost concerns in purchase decisions. Public relations campaigns raising awareness about the climate change crisis and environmental issues can increase users' confidence in electric vehicle technology. Support for research and development to improve electric vehicle usage efficiency, such as batteries with higher capacity and longer lifespan, faster charging systems, and infrastructure for electric vehicle use, can address technological barriers [24]. Additionally, in the case of China, the obstacle of insufficient charging stations can be resolved if the government implements policies to support businesses and users in installing efficient residential charging systems [26]. The support measures of the Thai government are still in the early stages. The support measures that have already been implemented include subsidies for vehicle purchases, reductions in excise tax rates, and increasing public electric charging stations, with the hope of reducing cost barriers and addressing long-distance travel needs.

H2. *Government support is negatively related to Barriers of electric vehicle usage.*

The conclusions of studies in China on the government support policy factors indicate that they can enhance public intention to purchase electric vehicles. Particularly, national policies that governments should consider include financial incentive policies (Financial incentive policy), which are monetary incentives such as tax reductions, discounts on electric vehicle prices, and fee reductions for using infrastructure services [20,22]. Information provision policies (Information provision policy) involve providing information on fee support, infrastructure support for electric vehicle use, building confidence in electric vehicle technology, and raising awareness about environmental friendliness [20,21]. Additionally, local policies that governments should consider include convenience support policies (Convenience policy), which involve allocating budgets to develop infrastructure supporting electric vehicle use [20], such as parking spaces, special lanes, and fast charging stations [22,31].

H3. *Government support is positively related to purchase intention of electric vehicles.*

2.2. Attitudes Toward Technology Base on Diffusion Innovation

Innovative Diffusion Theory (IDT), which was proposed by Rogers, refers to the spread of innovations or new things from one society to another and their acceptance in that society. Innovation here refers to knowledge, ideas, techniques, and new technologies [32]. IDT theory is widely used to explain the diffusion of individual behaviors in adopting new technologies [33] that lead to the intention to use that technology oneself [17]. Previous studies have examined the variables of innovation diffusion in relation to the acceptance of BEV usage in both developed countries and countries transitioning from developing to developed status. For individuals to accept an innovation, there are five key

characteristics: Relative Advantage, in the context of which studies in the UK, China, and Turkey have found that increased benefits are a crucial factor in individuals' intentions to use electric vehicles, such as reducing pollution, driving performance, and reducing fuel costs [14,18,19,25]. For other characteristics, the findings from studies in China are as follows: Compatibility with the culture of the receiving society, where creating characteristics of electric vehicles as an environmentally friendly technology aligns with current societal awareness of environmental issues, contributing to individuals' intentions to purchase electric vehicles [22]. Complexity of the innovation, whereby if electric vehicle technology is easy to use for everyone, it can increase individual purchase intentions [14,18]. Trialability can increase confidence in the decision to use, and observability of the benefits from using the innovation will further promote acceptance of that innovation [17]. The result of innovation diffusion leads to society's acceptance or rejection of that innovation, bringing about changes in the social system [34]. In the context of Thailand, after the COVID-19 pandemic, Thai society has become more accustomed to and adaptable in using technology to respond to lifestyle needs. Meanwhile, the business sector has also introduced technology to develop products and services. This indicates that Thai society has diffused innovations to be ready to accept new technologies that individuals can use or possess according to their own capabilities [35].

H4. *Innovation diffusion is positively related to purchase intention of electric vehicles.*

2.3. Barriers Against Electric Vehicle Use

Given the current climate change situation that impacts daily life, the population is becoming aware of the importance of solving problems to reduce these impacts. Research studying the intention to use electric vehicles has concluded that it is a technology that can reduce environmental impacts and is worth the price. However, there are still factors that act as barriers to individual decisions to use electric vehicles, which differ in each country's context, including the following. In studies from Turkey, which is not a country with an electric vehicle production base, people are concerned about the cost of acquiring the technology, such as the price of electric vehicles, battery prices, and maintenance costs [24]. For studies in countries with electric vehicle production bases like Germany and China, there are additional concerns regarding the adequacy of charging stations and long charging times [24,31,36]. Short driving ranges are also a concern [36], as is confidence in electric vehicle technology, the variety of models [24] and access to public information about electric vehicles [18,24]. This is because BEV technology is still in a continuous development phase, seeking to improve its efficiency.

In perceiving and accepting risks, which are barriers to the intention to use electric vehicles, past research has found an inverse relationship. If individuals are concerned about various obstacles, their intention to use electric vehicles decreases [18,24]. For example, concerns about maintenance costs [25], concerns about the difficulty of using the technology, concerns about range limitations [16,25], the variety of appealing designs [16], long charging times [31], and confidence in the safety of the technology [25] are barriers to users' long-distance travel behavior.

H5. *Barriers to electric vehicle usage are negatively related to purchase intention of an electric vehicle.*

2.4. Purchase Intention of Electric Vehicle with Different Age Groups

Demographic factors are another important factor used to explain differences in attitudes, expectations, and intentions to use electric vehicles, such as gender, education level, average monthly income, and age [18,23,31,37–40]. Individuals in different age groups have different thoughts and intentions regarding the use of electric vehicles [18,26]. A study by Singh et al. found that different age groups of Indians have different causal factors affecting their desire to own electric vehicles. People aged 21–35 years are influenced by social influence and personal norms, while those aged 45 and above are influenced by

hedonic motivation to own an electric vehicle [15]. Moreover, the cases in Canada and Ghana were that the intention to purchase electric vehicles is higher among younger age groups than older age groups, with those aged 41–50 years resisting the use of electric vehicles [37,41]. Conversely, in the UK and Japan, individuals over 50 years old have a higher environmental awareness that affects their intention to purchase electric vehicles more than younger people [25,27]. Therefore, there is still no clear conclusion to be found in studying the differences among people in different age groups, as past study results differ in the context of each country.

H6. *Antecedents of purchase intention are different between age groups.*

Figure 1 presents the conceptual framework of the study, illustrating the relationships between various factors influencing the intention to purchase electric vehicles. The model is composed of three main constructs: government support, diffusion of innovation, and barriers, all of which impact the intention to purchase. Government support is represented by five elements: information, policy, goal, tax, and communication. This construct is hypothesized to positively influence the diffusion of innovation (H1) and negatively affect barriers (H2). The diffusion of innovation construct is characterized by five attributes: relative advantage, compatibility, complexity, observability, and trialability. This construct is proposed to have a positive relationship with the intention to purchase (H4). Barriers are depicted by six factors: cost, station availability, long distance concerns, technology concerns, variety of car models, and public information. The model hypothesizes a negative relationship between barriers and intention to purchase (H5).

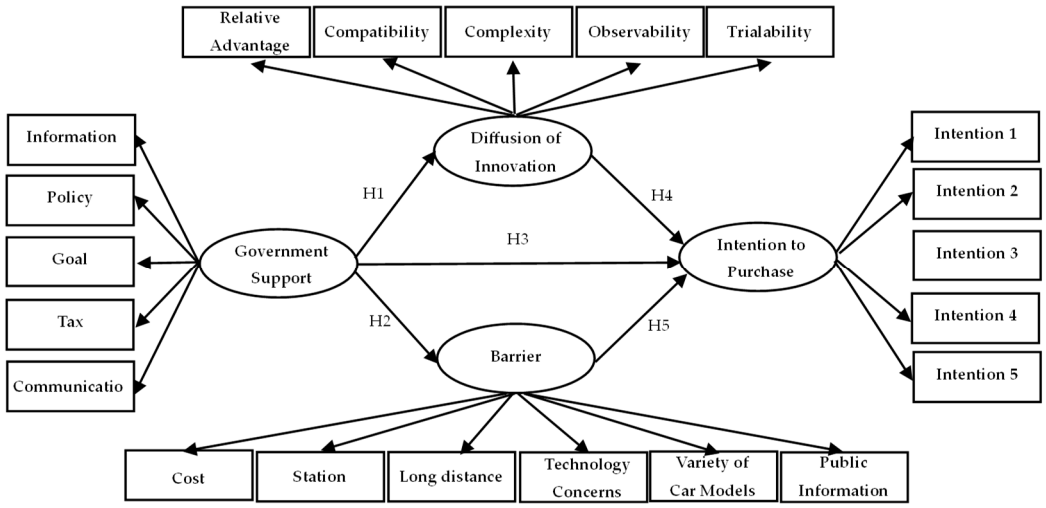


Figure 1. Conceptual framework.

The intention to purchase is measured by five indicators (Intention 1 to Intention 5). Additionally, the framework suggests a direct relationship between government support and intention to purchase (H3), although this hypothesis is not explicitly stated in the previous text. This comprehensive model aims to explain the complex interplay of factors affecting consumers' intentions to adopt electric vehicles, considering both encouraging elements (government support and innovation diffusion) and potential obstacles.

3. Materials and Methods

3.1. Questionnaire Design

The questionnaire used in this study was structured in two main parts: demographic information and attitude assessment. The demographic section gathered basic information about the respondents, including age, gender, residence area, driving status, and current vehicle type. The attitude assessment section comprised questions related to government

support, barriers to electric vehicle usage, innovation diffusion, and intention to purchase electric vehicles. The full list of questionnaire items is provided in Appendix A.

A seven-point Likert scale was employed for the attitude assessment section, ranging from 1 (strongly disagree) to 7 (strongly agree). This scale was chosen for several reasons. First, it offers a wider range of response options compared to five-point scales, allowing for more nuanced data collection and potentially increased reliability and validity. Second, the seven-point scale provides a midpoint (4), which can be crucial for respondents who have neutral opinions. Third, a comparison studies between a five-point Likert scale, seven-point Likert scale and ten-point Likert scale found that the higher the Likert point scale, the better it could control type I error, and the higher the power of the test in both parametric and nonparametric tests [42]. Awang et al. compared the performances of two categories of measurement scales— five- and ten-point Likert scales—using the same sample size and research subject. They confirmed that 10 points of a Likert scale offers a promising scale under parametric-based SEM. Both measurement and structural models can be assessed with 10 points of a Likert scale, which is expected to offer more success in determining the construct validity [43]. Siebert et al. [44] recommended that maximum information for the largest ability range was provided by a seven-point scale, which offers more stable information in measuring the spectrum of the latent construct of attitude scale. Thus, this scale is well-suited for the structural equation modeling (SEM) analysis planned for this study, as it provides sufficient variance in response to complex statistical analyses [45].

The questionnaire was designed to be comprehensive yet concise, aiming to capture all relevant factors influencing electric vehicle purchase intentions while minimizing respondent fatigue. Each construct (government support, barriers, innovation diffusion, and purchase intention) was measured using multiple items to ensure construct validity and reliability.

3.2. Data Collection

Data were collected from the population in five regions of Thailand: North, Central, Northeast, East, and South. To ensure representativeness and minimize sampling bias, a multi-stage stratified random sampling approach was employed. This method was chosen to align with our research objectives, particularly the need to understand BEV adoption across different geographical and demographic contexts.

The first stage involved selecting provinces within each region based on the number of electric vehicle charging stations. This criterion was chosen because charging infrastructure is a critical factor in BEV adoption, as demonstrated by previous studies [24,41,46]. These studies have concluded that higher charging station density, including both the number of available stations and their distribution, significantly increases BEV adoption rates by addressing user needs and reducing usage barriers. By focusing on areas with more developed charging infrastructure, we aimed to capture data from locations where BEV usage is more feasible and potentially more prevalent, thus providing more meaningful insights into adoption factors and barriers. The provinces with the highest number of charging stations in each region were selected: North—Chiang Mai (11 stations, 5.21%) and Lampang (7 stations, 3.32%); Central—Bangkok (61 stations, 28.91%) and Pathum Thani (7 stations, 3.32%); Northeast—Nakhon Ratchasima (30 stations, 14.22%), Khon Kaen (16 stations, 7.58%), Ubon Ratchathani (8 stations, 3.79%), and Udon Thani (8 stations, 3.79%); East—Chonburi (21 stations, 9.95%), Chanthaburi (10 stations, 4.74%), and Prachinburi (10 stations, 4.74%); South—Phuket (6 stations, 2.84%) and Nakhon Si Thammarat (5 stations, 2.37%). In the second stage, within each selected province, quota sampling was used to ensure a balanced representation of age groups (25–34 years, 35–44 years, and over 44 years) with similar proportions. This approach directly addresses our research objective of examining how factors influencing BEV adoption differ across age groups, allowing for meaningful comparisons and insights into age-specific adoption patterns.

To further minimize bias and capture a diverse range of respondents, the survey was conducted at gas stations (along highways and rural roads) and shopping malls

(including Neighborhood Centers, Community Centers, Regional Centers, and Super Regional Centers) that had electric vehicle (EV) charging stations. This strategic choice of locations ensured exposure to both conventional vehicle users and those familiar with or interested in electric vehicles, providing a more comprehensive perspective on attitudes towards BEVs. Random selection methods were employed within each quota to choose individual participants at these locations. Data collectors were trained to approach potential participants at various times of day to capture a diverse range of respondents. While this sampling strategy aimed to maximize representativeness and minimize bias, potential limitations such as self-selection bias among respondents willing to participate in the survey are acknowledged. To address this, sample demographics were compared with regional population statistics, and post-stratification weights were applied where necessary to align the sample more closely with the population distribution.

This study emphasizes the importance of generational differences by applying generational theory. The concept of generation as a homogeneous age group refers to individuals of similar age who share common cultural characteristics, have developed a sense of group identity, and are perceived by society as belonging to this group [47] (e.g., youth—aged 14–25 years old; adults—aged 25–40 years old; elders—aged 40–65 years old; aging—aged over 65 years old) [48]. This aligns closely with the age categorization based on birth year, which distinguishes Generation X or late-career workers (44–59 years in 2024), Generation Y or early to mid-career workers (25–44 years), and Generation Z or students, recent graduates, and young professionals (below 25 years). Generational theory posits that growing up under specific socio-economic, environmental, and cultural contexts unique to each era is a crucial factor in shaping the habits and thought processes of each generation. This also relates to work experience, which reflects income levels and financial stability [49]. While more granular age divisions could offer additional insights, this study deliberately focused on three generational cohorts (25–34 years, 35–44 years, and over 44 years) to capture key differences in life stages, values, and economic situations that are particularly relevant to EV adoption patterns. This approach allows for a focused analysis of generational differences while maintaining robust sample sizes for statistical analysis.

The demographic information from the sample of 3632 Thai respondents reveals several key characteristics. The majority of participants were male (62.3%), with a fairly balanced distribution across the three age groups—37.7% aged 25–34 years, 26.4% aged 35–44 years, and 35.9% above 44 years. Most respondents (64.6%) resided in urban areas. A significant majority (79.7%) were drivers rather than passengers. Regarding the type of vehicle engine, 47.5% owned internal combustion engine (ICE) vehicles, while 52.5% owned various types of electric vehicles (HEV, PEV, and BEV combined). Notably, 27.8% of respondents already owned Battery Electric Vehicles (BEVs). When asked about their likelihood of purchasing an electric vehicle in the future, responses varied, with 30.9% indicating a 100% certainty of purchase, while 17.5% expressed no intention to purchase. This distribution suggests a growing interest in electric vehicles among the Thai population, with a significant portion already adopting or strongly considering the technology (Table 1).

Table 1. Demographic characteristics.

Characteristics	Overall (N = 3632)		25–34 Years (n = 1369)		35–44 Years (n = 959)		Above 44 Years (n = 1304)	
	Number	Ratio (%)	Number	Ratio (%)	Number	Ratio (%)	Number	Ratio (%)
Gender								
Male	2260	62.3%	783	57.2%	580	60.5%	897	68.8%
Female	1372	37.7%	586	42.8%	379	39.5%	407	31.2%
Resident area								
Rural	1285	35.4%	562	41.1%	291	30.3%	432	33.1%
Urban	2347	64.6%	807	58.9%	668	69.7%	872	66.9%
Driving								
Passenger	737	20.3%	277	20.2%	184	19.2%	276	21.2%

Table 1. *Cont.*

Characteristics	Overall (N = 3632)		25–34 Years (n = 1369)		35–44 Years (n = 959)		Above 44 Years (n = 1304)	
	Number	Ratio (%)	Number	Ratio (%)	Number	Ratio (%)	Number	Ratio (%)
Driver	2895	79.7%	1092	79.8%	774	80.8%	1027	78.8%
Engine type								
ICE	1727	47.5%	719	52.5%	446	46.5%	562	43.1%
HEV	449	12.4%	120	8.8%	174	18.1%	155	11.9%
PEV	448	12.3%	172	12.5%	106	11.1%	170	13.0%
BEV	1008	27.8%	358	26.2%	233	24.3%	417	32.0%
Change to purchase								
0%	636	17.5%	259	18.9%	142	14.8%	235	18.0%
25%	868	23.9%	379	27.7%	279	29.1%	210	16.1%
50%	589	16.2%	258	18.8%	199	20.8%	132	10.1%
75%	417	11.5%	113	8.3%	127	13.2%	177	13.6%
100%	1122	30.9%	360	26.3%	212	22.1%	550	42.2%

Note: N = 3632.

3.3. Data Analysis

A structural equation model (SEM) was utilized to quantify the underlying relationships between the latent constructs. SEM is considered a robust research tool frequently implemented across both families of inductive and deductive research, particularly when there is an interest in measuring latent and unobserved variables [50]. The data analysis process involved several steps to ensure model selection and verification. Model specification: Based on the theoretical framework and literature review, an initial model was specified including the hypothesized relationships between government support, innovation diffusion, barriers, and purchase intention. Model identification: The model was assessed to ensure it was over-identified, with degrees of freedom greater than zero, allowing for model testing. Measurement model: Confirmatory Factor Analysis (CFA) was employed to validate the measurement model. Factor loadings, Composite Reliability (CR), and Average Variance Extracted (AVE) were examined to ensure construct validity and reliability. Items with factor loadings below 0.5 were considered for removal. Structural model: The structural model was developed using maximum likelihood estimation to test the hypothesized relationships between constructs. Model fit assessment: The model's goodness-of-fit was assessed through multiple indices to ensure robust evaluation. These include Chi-square/df (CMIN/df) < 5 [51], *p*-value > 0.05, Tucker and Lewis Index (TLI) > 0.90, Comparative Fit Index (CFI) > 0.90, Root Mean Square Residual (RMR) < 0.08 and Root Mean Square Error of Approximation (RMSEA) < 0.07 [50]. Model modification: If initial fit indices were unsatisfactory, the model was refined based on modification indices, ensuring that any changes were theoretically justified.

Multi-group analysis: To verify the model's applicability across different age groups, invariance analysis was conducted. This involved evaluating four nested models—Model 1, unconstrained model; model 2, measurement weights model; Model 3, structural weights model and Model 4, structural covariances model. Invariance was determined by examining the difference in ΔCMIN/df (not exceeding 3), and the differences in fit indices ΔCFI, ΔTLI, ΔRMSEA, and ΔRMR (not exceeding 0.01 for each model) [52]. Hypothesis testing: After confirming adequate model fit, path coefficients were examined to test the proposed hypotheses.

3.4. Construct Validity and Reliability Analysis

The construct validity of the measurement model for all four latent variables was checked for consistency with empirical data. This was assessed using the following criteria: CMIN/df less than 5 [51], *p*-value greater than 0.05, Tucker and Lewis index (TLI) and comparative fit index (CFI) greater than 0.90, Root Mean Square Residual (RMR) less than 0.08, and Root Mean Square Error of Approximation (RMSEA) less than 0.07. The factor loadings of observed variables in each set of latent variables should be no less than 0.6, with

construct reliability (CR) greater than 0.7 and Average Variance Extracted (AVE) greater than 0.5 [50], as shown in Table 2. The questionnaire items are shown in Appendix A.

Table 2. Descriptive statistics, construct validity and reliability analysis.

Factors	Items	Factor Loading	CR	AVE
Government Support			0.988	0.763
Information	3	0.797; 0.940; 0.916		
Policy	3	0.895; 0.923; 0.884		
Goal	3	0.883; 0.910; 0.907		
Tax	3	0.926; 0.919; 0.905		
Communication	3	0.770; 0.750; 0.742		
CMIN/df = 4.627; CFI = 0.992; TLI = 0.996; RMR = 0.028; RMSEA = 0.032				
Barrier			0.998	0.734
Cost	3	0.860; 0.888; 0.846		
Station	3	0.882; 0.861; 0.914		
Long Distance	5	0.876; 0.916; 0.853; 0.850; 0.998		
Technology Concerns	3	0.658; 0.662; 0.711		
Variety of Car Models	3	0.900; 0.906; 0.915		
Public Information	3	0.864; 0.868; 0.835		
CMIN/df = 4.661; CFI = 0.995; TLI = 0.990; RMR = 0.036; RMSEA = 0.032				
Innovation Diffusion			0.997	0.810
Relative Advantage	3	0.903; 0.945; 0.933		
Compatibility	3	0.806; 0.911; 0.925		
Complexity	3	0.904; 0.879; 0.913		
Observability	3	0.897; 0.888; 0.909		
Trialability	3	0.907; 0.889; 0.886		
CMIN/df = 4.759; CFI = 0.995; TLI = 0.993; RMR = 0.033; RMSEA = 0.032				
Intention			0.993	0.697
INT1	1	0.914		
INT2	1	0.963		
INT3	1	0.917		
INT4	1	0.685		
INT5	1	0.642		
CMIN/df = 1.161; CFI = 0.998; TLI = 0.997; RMR = 0.004; RMSEA = 0.007				

4. Results

A structural model was produced to examine the research hypotheses using path analysis. The results reveal the data fitted the model with the indices CMIN/df = 4.492 [51], CFI = 0.961, TLI = 0.956, RMR = 0.056, and RMSEA = 0.042 [50]. Furthermore, the predictive power of the model was evaluated using the R^2 indicator, and the intention to purchase BEV's 91.6% variance was predicted by government support, innovation diffusion, and barriers of electric vehicle usage.

The hypothesis testing results for the overall model show that (H1) government support had a positive effect on innovation diffusion ($\gamma = 0.168$, $p < 0.001$) (Table 3 and Figure 2); (H2) government support had a negative effect on barriers of electric vehicle usage ($\gamma = -0.360$, $p < 0.001$). The key components of government support in promoting innovation diffusion and reducing concerns about barriers to BEV usage are tax ($\lambda = 0.949$), policy ($\lambda = 0.927$), goal ($\lambda = 0.912$), information ($\lambda = 0.834$), and communication ($\lambda = 0.757$), respectively. On the other hand, government support had a negative effect on intention to purchase electric vehicle ($\gamma = -0.016$, $p < 0.05$), which rejects the research hypothesis. This shows that government support factors, which are external factors, have a direct effect in reducing the level of people's intention to purchase BEVs (H3). (H4) Innovation diffusion had a positive effect on intention to purchase electric vehicle ($\beta = 0.958$, $p < 0.001$). (H5) Barriers of electric vehicle usage had a negative effect on intention to purchase electric

vehicle (β = −0.028, $p < 0.001$) [50]. This demonstrates that internal personal attitude factors can increase the level of intention to purchase BEVs, including the innovation diffusion factor, with key components such as relative advantage (λ = 0.977), complexity (λ = 0.951), compatibility (λ = 0.818), observability (λ = 0.708), and trialability (λ = 0.673), and usage barrier factors can be reduced with key components including technology concern (λ = 0.996), cost (λ = 0.918), station (λ = 0.895), public information (λ = 0.874), variety of car model (λ = 0.866), and long distance (λ = 0.843), respectively.

Table 3. Results of the structural model.

Hypotheses	Path	Standardized Weights	*p*-Value	Results
H1	GS --> ID	0.168	***	Accept
H2	GS --> BA	−0.360	***	Accept
H3	GS --> IP	−0.016	0.030 *	Reject
H4	ID --> IP	0.958	***	Accept
H5	BA --> IP	−0.028	***	Accept
CMIN/df = 4.492; CFI = 0.961; TLI = 0.956; RMR = 0.056; RMSEA = 0.042				

Notes: GS (government support); ID (innovative of diffusion); BA (barriers); IP (intention to purchase). *** significant at p value < 0.001; * significant at p value < 0.05.

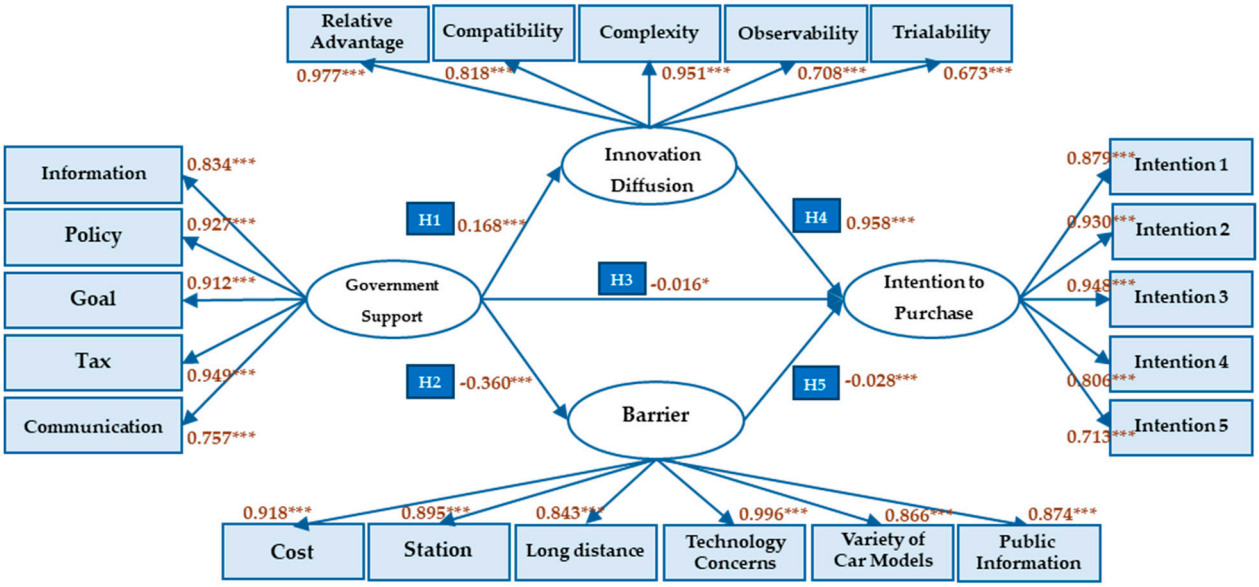


Figure 2. Structural model. *** significant at p value < 0.001; * significant at p value < 0.05.

As part of the research, hypothesis H6 was tested by invariance structural equation modeling analysis. The results comparing three age groups (25–34 years, 35–44 years, and above 44 years) show that the overall model is invariant across groups. This is determined by examining the difference in ΔCMIN/df not exceeding 3, and the differences in fit indices ΔCFI, ΔTLI, ΔRMSEA and ΔRMR for each model not exceeding 0.01 [52], as shown in Table 4. This model can be used in this study to interpret and compare the coefficients of causal relationships between latent variables across the three age groups. This allows for drawing conclusions about the similarities and differences in the relationships between variables affecting the intention to purchase personal electric vehicles.

Table 4. Invariance test.

Model	CMIN/df	CFI	TLI	RMR	RMSEA	Invariant
Unconstrained	3.521	0.954	0.948	0.056	0.026	
Measurement weights	3.563	0.953	0.947	0.058	0.027	
Structural weights	3.599	0.952	0.947	0.058	0.027	
Structural covariances	3.619	0.951	0.946	0.059	0.027	
Difference Δ	<3	<0.01	<0.01	<0.01	<0.01	No

Comparing the coefficients of causal relationships across all age groups shows similar causal relationships for purchase intention. Government support had a positive effect on innovation diffusion (25–34 years, $\gamma = 0.246$; 35–44 years, $\gamma = 0.379$; above 44 years, $\gamma = 0.107$, $p < 0.001$). Government support had a negative effect on barriers of electric vehicle usage (25–34 years, $\gamma = -0.326$; 35–44 years, $\gamma = -0.421$; above 44 years, $\gamma = -0.251$, $p < 0.001$). Innovation diffusion had a positive effect on intention to purchase electric vehicles (25–34 years, $\beta = 0.948$; 35–44 years, $\beta = 0.976$; above 44 years, $\beta = 0.955$, $p < 0.001$). Additionally, differences in causal relationships between factors were found among the three groups. Government support had a negative effect on intention to purchase electric vehicles ($\gamma = -0.054$, $p < 0.001$) only for the 35–44 years age group. Barriers of electric vehicle usage had a negative effect on intention to purchase electric vehicle ($\beta = -0.039$, $p < 0.01$) only for the 25–34 years age group. Therefore, H6 is accepted, as shown in Table 5 and Figure 3.

Table 5. Results of multi-group comparisons of all paths.

Hypotheses	Paths	25–34 Years (n = 1369)		35–44 Years (n = 959)		Above 44 Years (n = 1304)	
		Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value
H1	GS --> ID	0.246	***	0.379	***	0.107	***
H2	GS --> BA	−0.362	***	−0.421	***	−0.251	***
H3	GS --> IP	−0.010	0.468	−0.054	***	−0.007	0.527
H4	ID --> IP	0.948	***	0.976	***	0.955	***
H5	BA --> IP	−0.039	0.003 **	−0.024	0.073	−0.018	0.095

Notes: *** significant at *p* value < 0.001; ** significant at *p* value < 0.01.

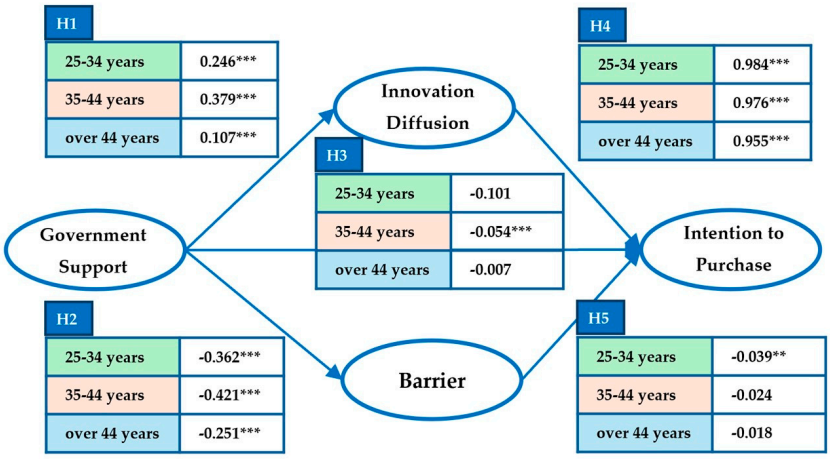


Figure 3. Multi-group comparisons. *** significant at *p* value < 0.001; ** significant at *p* value < 0.01.

5. Discussion and Implications

By utilizing the research framework, this study applies Innovation Diffusion Theory (IDT) to explain the diffusion and adoption of innovation use. This differs from many previous studies that widely used TAM, set out by Davis, to explain factors determining user

acceptance of technology, such as computers and the internet, which are only technological innovations [53]. Moreover, considering determinants like perceived usefulness (PU) and perceived ease of use (PEU) may not be sufficient to explain the intention to use innovations. In comparison, IDT, set out by Rogers, considers relative advantage, compatibility, complexity, trialability, and observability as determinants of innovation adoption that are not limited to technology alone, but also include products, processes, or business models [32].

The conclusion regarding causal factors of BEV purchase intention is influenced by several factors, especially the factor of innovation diffusion adapted from IDT, which is the most important factor reflecting purchase decision intention. The key dimensions that indicate innovation diffusion are users receiving more benefits than before, such as an option to save costs from refueling, reducing pollution emissions, etc. [40]; being a technology that is not complex to use [16]; and being an environmentally friendly technology accepted by society, which further supports people's desire to buy and use BEVs [22]. Additionally, indicators such as easily seeing the benefits of using BEVs and being able to test drive for decision-making information [17] are measures that can further increase the level of BEV purchase intention.

Regarding the barriers to BEV usage, this is another factor determining purchase intention. If users perceive there are obstacles, it will lead to avoidance of the decision to purchase a BEV. There are several barriers that cause concern for users, including the reliability of electric vehicle technology [24], high acquisition and future maintenance costs [25], the number of charging stations [31], insufficient public information about BEVs [18], the limited variety of desired models [16], as well as concerns about driving range [36]. If there are ways to address these concerns, it can increase the likelihood of BEV adoption in society.

The competitiveness of Thailand's BEV market significantly influences adoption patterns. While the global BEV market has shown signs of slowdown since late 2023, Thailand's unique market dynamics present both opportunities and challenges. As the world's 10th largest automotive manufacturing base, Thailand has a strong foundation for BEV production, but faces intense competition from established manufacturers in China and emerging players in Vietnam and Indonesia. This regional competition affects pricing strategies and model availability in the Thai market. Chinese manufacturers currently dominate Thailand's BEV market with competitive pricing and diverse model options, while established Japanese brands, which traditionally hold strong market share in Thailand's conventional auto market, are still developing their BEV offerings. The market competitiveness also influences consumer choices through several channels. First, the variety of available models and price points affects different consumer segments differently—while luxury BEV segments have multiple options, the middle-market segment faces limited choices. Second, competition between manufacturers has not yet led to significant price reductions in Thailand, unlike in more mature BEV markets. Third, the presence of multiple BEV technologies (BEV, PHEV, HEV) creates market fragmentation, potentially confusing consumers and diluting network effects that could accelerate adoption. These market dynamics interact with our findings about age-based adoption patterns, as different age groups show varying sensitivity to price competition and brand preferences.

The important antecedent factor for this study is government support, which is a mechanism driving the country's attempt to achieve Carbon Neutrality goals. There are several important factors, especially policies that provide tax benefits, policies that align with social regulations, and welfare policies for BEV users. From the study results, although it was found that government policies towards BEV purchase intention have an inverse relationship, the value is very low [54]. Our findings regarding H3 show that government support is positively related to purchase intention of electric vehicle. This differs from previous studies that found government support enhances intention to use BEVs [29,38]. This is due to the low level of political stability in Thailand, from the public's perspective, caused by issues in forming a government during 2023–2024 in a coalition format where no single political party had an absolute majority, along with political parties not keeping

their campaign promises [55]. The finding contrasts with those of studies by Krishnan et al. [29], who found strong positive effects of government support on BEV adoption in India, and Jaiswal et al. [38], who demonstrated positive relationships between policy support and purchase intention in emerging markets. A recent study by Shetty et al. [54] can help explain this discrepancy, noting that government support may have limited direct effects on purchase intention when political stability is low, even if support measures exist.

The governance model of all Thai governments has lacked long-term planning for sustainable economic competitiveness. For instance, budgets are often allocated to distribute money to vulnerable groups for short-term economic stimulation, while lacking promotion of long-term technological investments and human resource development. This impacts the country's competitiveness, leading to low economic recovery [56]. This governance model has resulted in short-term satisfaction among low-income groups with government operations, while middle- and higher-income groups show low satisfaction levels. Citizens continue to face pressures from rising expenses, including living costs, utility bills, and loan interest rates [57]. Similarly, citizens' decisions to purchase BEVs, which would incur future debt, are influenced by the perception that the government lacks sustainable long-term planning in terms of support measures, legal frameworks, and infrastructure development to support the entire lifecycle of BEVs [58]. This governance approach affects different income groups differently. While low-income groups may show short-term satisfaction with immediate financial relief measures, middle- and higher-income groups—who are more likely to consider BEV purchases—express lower satisfaction levels. They are more concerned with long-term economic stability and policy consistency, which are crucial factors in making significant investments like BEV purchases. Moreover, the lack of comprehensive, long-term planning for BEV adoption—including support measures, legal frameworks, and infrastructure development—creates uncertainty among potential buyers. This uncertainty, combined with the financial pressures faced by many citizens, contributes to a hesitation in making long-term commitments such as BEV purchases, despite government incentives. In essence, the negative relationship between government support and BEV purchase intentions is not solely due to political instability, but rather a complex interplay of factors including inconsistent long-term planning, differing impacts on various income groups, and a lack of comprehensive support throughout the BEV lifecycle. These factors contribute to a sense of uncertainty and hesitation among potential BEV buyers, especially in the context of broader economic pressures.

However, this study provides important conclusions by introducing personal attitude-related factors as mediating variables to expand the study of causal relationships between government support factors and BEV purchase intention, including innovation diffusion factors by applying IDT and barriers to BEV usage factors. It was found that effective government policies can reduce concerns about barriers to BEV usage [24,26]. Moreover, they can support the diffusion and create an acceptance of BEV technology in society [26,29,30], which is an important direction in stimulating the demand for BEV purchases among people in the country. This shows that people do not immediately decide to buy BEVs based on government promotion measures. Instead, the study results indicate that people use government measure information to assess the situation of BEV innovation diffusion in Thai society and evaluate the risks of barriers to BEV usage. The diffusion of BEV technology in Thai society is uniquely influenced by several cultural factors. Thai society places a high value on social status symbols ("face"), with vehicle ownership being a significant indicator of success and social position [59]. This cultural dynamic creates both opportunities and challenges for BEV adoption. While BEVs can serve as symbols of environmental consciousness and technological sophistication for early adopters, the higher initial purchase price may conflict with Thai cultural preferences for demonstrating financial prudence, particularly among middle-income families. Additionally, Thai decision-making often involves extended family considerations (khrop khrua), with major purchases like vehicles typically being family decisions rather than individual choices [60]. This collective decision-making process means that BEV adoption must satisfy not just

individual preferences, but also family concerns about practicality, reliability, and long-term value. The Thai cultural trait of "kreng jai" (being considerate and avoiding inconvenience to others) may also influence adoption patterns, particularly regarding concerns about charging station availability and potential inconvenience to others when using public charging facilities. Furthermore, Thailand's Buddhist cultural heritage, which emphasizes harmony with nature and environmental stewardship, aligns well with BEVs' environmental benefits. However, this environmental consciousness often competes with practical economic considerations in a society where value-for-money is highly prioritized [61].

The environmental impact potential of successful BEV adoption is substantial. Current forecasting research projects that Thailand's transportation CO_2 emissions under business-as-usual conditions would reach 78,514.470 kTons by 2030. However, implementing the 30@30 policy effectively could reduce these emissions to 63,517.583 kTons [10]. This represents a reduction of 14,996.888 kTons of CO_2 emissions—approximately 19% lower than the baseline scenario. Such significant emission reductions underscore the importance of effective government measures to promote BEV adoption, particularly in urban areas where the impact would be most substantial. The projected emission reductions align with Thailand's broader environmental goals and demonstrate the critical role of transportation sector transformation in achieving Carbon Neutrality by 2050.

Furthermore, the study carries important policy implications for governments to encourage purchase intention of BEVs in Thailand. The study found that government support decreases BEV purchase intention due to Thailand's political instability, causing people to lack confidence in government operations. However, the significance of government support indirectly affects Thai people's BEV purchase intention levels through individual innovation diffusion perspectives and concerns about BEV usage barriers. The government can determine appropriate support measures for the Thai social context and effectively respond to people's needs in each age group, as follows.

First, they can establish policies and measures to support BEV usage to enhance innovation diffusion levels in Thai society, especially regarding the benefits of using BEVs over combustion engine vehicles. These include short-term measures that the government can immediately announce and enforce to stimulate innovation diffusion and quickly attract the mid-working age group (35–44 years) and above, which accounts for approximately 48% of Thailand's population and are relatively financially stable, with higher savings than the early working age group [49], encouraging them to intend to purchase BEVs. In 2024, the Thai government's electric vehicle support measures provided subsidies for BEV purchases between THB 70,000 and 150,000 based on battery size for models priced up to TBH 2 million, reduced excise tax to 2%, and reduced vehicle tax by 80% for 1 year. Meanwhile, measures in other countries such as Norway, Canada, Japan, and India have exempted excise tax on BEVs, and Germany's measures grant vehicle tax exemptions for 5–10 years to users from the date of registration [62]. Therefore, the Thai government can adjust existing measures to further stimulate BEV usage in the country, including subsidy measures for all BEV model buyers based on battery size and price, excise tax exemption measures, and measures to extend the period of vehicle tax exemption according to usage type, such as personal or commercial use.

Second, concerns about barriers to BEV usage are crucial issues for BEV purchase intention among the early working age group (25–34 years), which accounts for 14.4% of Thailand's population. This is because the early working age group is price-sensitive [63] and lacks financial stability [64], so they consider issues of value for money and maintenance costs more than older age groups [15]. To address price sensitivity, the government can implement middle-term measures such as supporting all BEV distributors in organizing campaigns to trade in old internal combustion vehicles (ICVs) for new BEVs. For instance, in China, such a campaign provided subsidies of up to TBH 100,000 per vehicle. Combined with the aforementioned tax reduction measures, this would further reduce BEV selling prices. The behavior of early-career workers shows similar proportions of car use in urban and rural areas due to their enjoyment of leisure travel. This leads to concerns about the

adequacy of charging stations. Currently, the ratio of BEV usage to charging outlets in Thailand is 54:1, while the global average is 10:1. Charging stations are densely distributed only in the central region, corresponding to the highest proportion of BEV registrations in the country [65]. The Thai government should implement local-level measures for budget allocation for charging station installation by government agencies like the Provincial Electricity Authority, increasing the number of fast-charging outlets to cover areas outside major cities. This responsibility should be distributed to agencies in each region to plan and allocate budgets for installing charging stations on each route, appropriate to the social and economic context of that region.

Regarding charging service rates in Thailand, they have increased in line with electricity rates, posing a barrier in terms of usage costs. Prices range from TBH 5.50 to 10 per unit, varying by service provider and time of day (peak/off-peak). In contrast, Norway, successful in stimulating EV use, provides public charging stations free of charge [66]. For Thailand, the government should support both public and private charging station operators to provide free charging during off-peak hours. However, electricity production in Thailand still relies on fossil fuels. Therefore, the government should support the development of solar-powered charging stations in residences, aligning with the current Solar Rooftop installation support measures. This should start in urban areas, as 80% of Thai BEV users in urban areas charge their vehicles at home [65]

The implementation should follow a three-phased approach:

- Focus on high-traffic corridors and urban centers—Initially prioritize installation along major highways and in areas with high BEV registration rates;
- Expand to secondary routes and developing areas—Based on usage data from phase one, extend coverage to connect regional centers and support growing BEV adoption areas;
- Comprehensive coverage—Fill remaining gaps in the charging network while upgrading existing stations based on demand patterns.

Each regional authority should:

- Identify optimal locations based on traffic flow data and grid capacity;
- Partner with shopping centers, hotels, and other businesses to integrate charging facilities;
- Implement standardized signage and real-time availability information systems;
- Develop maintenance schedules and emergency response protocols;
- Monitor usage patterns to guide future expansion.

Additional middle-term measures to achieve the government's goal of pushing Thailand towards a low-carbon society should include measures to support BEV use in the public transport sector, especially in major cities and tourist towns. In 2023, there were over 80,000 registered taxis in Thailand, emitting more than 500,000 tons of carbon dioxide per year. The government can establish incentive measures for public transport providers, such as free public charging stations for taxis, toll exemptions for routes with toll booths, and legal passenger pickup points to reduce fares to register taxis as BEVs to stimulate public transport usage. Increasing public relations channels through various media, especially social media channels, can allow people to access information about BEV technology to build trust in the technology. Also, to promote technical repair and maintenance, the government should implement measures to enhance training and develop technical skills, fostering user confidence.

Finally, to enable Thailand to achieve its Carbon Neutrality goals, long-term measures should be established that support the entire BEV lifecycle in three phases (Figure 4): the production phase, utilization phase, and recycling phase. The study results support people's BEV usage in the utilization phase, as mentioned above. For the production phase, Thailand is currently the 10th largest automotive and auto parts production base in the world, but it is still primarily a production base for combustion engine vehicles. In the future, global market demand will change due to stimulating the BEV usage behavior of the world's population [67]. This shows that the government must take measures to provide incentives for existing businesses to adopt electric vehicle technologies, such as promoting

technical skills in electric vehicle parts technology for domestic entrepreneurs, like battery systems and electric motor systems, as well as soliciting foreign direct investment to establish manufacturing operations within the national borders [68]. This is to accommodate the changing demand for increased BEV production capacity in the global market. The final phase is managing the remnants of BEV usage, which have an average road life of 10–15 years, but the battery life is longer than that. As electric vehicle sales grow, policies for appropriate battery reuse and recycling must be established to make BEV lifecycle management as efficient as possible [69]. The main approaches to battery management, such as recycling, will help reduce the amount of metal ore used as a raw material in new battery production, using batteries with less than 60% efficiency; reuse reduces the production costs of any products that require batteries with 60–80% remaining efficiency, and repack involves using old battery cells that still have more than 80% efficiency [70]. However, Thailand does not yet have a policy for managing end-of-life BEVs. This shows that Thailand still lacks mechanisms to achieve Carbon Neutrality goals from stimulating BEV use throughout the lifecycle, which is a challenge for the government, suggesting it study and compare measures from many countries to determine appropriate measures for Thailand.

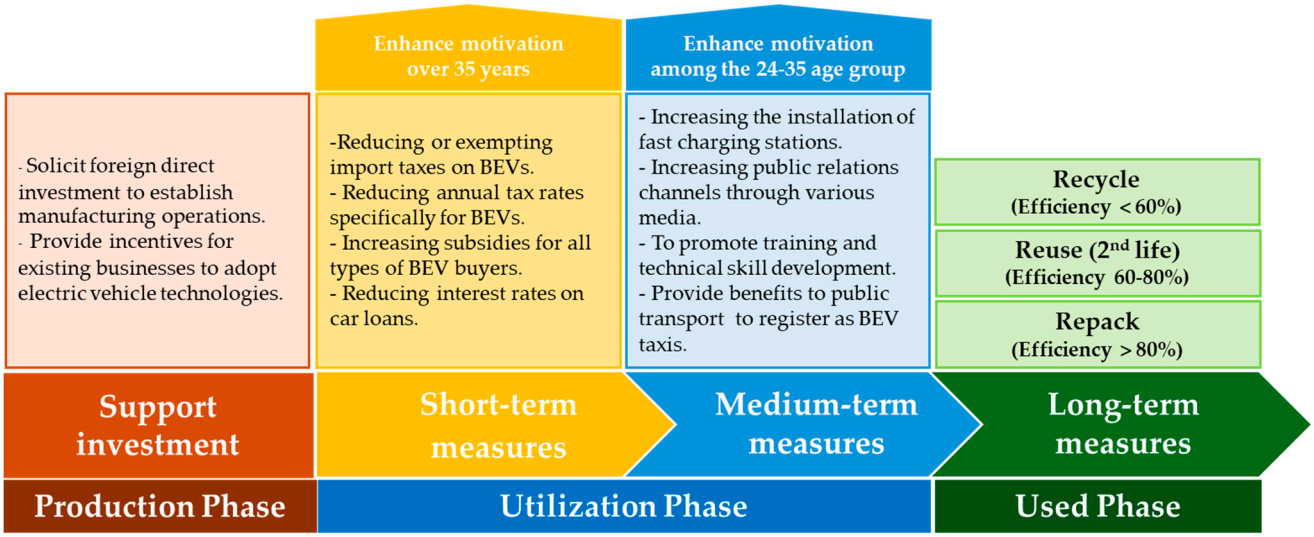


Figure 4. Lifecycle of the electric vehicle industry.

To establish effective long-term BEV lifecycle management beyond 2030, Thailand needs a comprehensive strategy encompassing several key areas. In terms of battery lifecycle management infrastructure, the country should establish dedicated battery testing and grading facilities in major industrial zones by 2031, develop regional collection and sorting centers, create a centralized database system for tracking battery lifecycle and performance, and implement standardized protocols for battery health assessment and classification. For battery recycling and repurposing, Thailand should focus on setting up specialized recycling facilities for recovering critical materials like lithium, cobalt, and nickel. This should be supported by incentive programs for manufacturers who use recycled materials in new battery production. The strategy should also include developing standards for repurposing batteries for energy storage applications and establishing partnerships with energy companies to utilize second-life batteries in renewable energy projects. The regulatory framework's development is equally crucial, requiring the institution of mandatory extended producer responsibility (EPR) programs by 2032. This should be accompanied by comprehensive safety and environmental standards for battery handling and recycling, along with clear certification systems for recycling facilities and processes, and established guidelines for battery disposal and recycling responsibilities. Industry development support must underpin these initiatives through targeted tax incentives for

companies investing in recycling technology, support for research and development in battery recycling efficiency, and the creation of training programs for specialized workforce development. Fostering collaboration between automotive manufacturers, recycling companies, and research institutions will be essential for building a sustainable ecosystem.

6. Conclusions

This study leads to conclusions regarding effective government policies to promote innovation diffusion in society and reduce concerns about barriers to BEV usage, in line with the electric vehicle (EV) promotion approach under the 30@30 policy, which aims to induce a level of at least 30% ZEV (Zero Emission Vehicle) out of total vehicle production. Considering the challenging goals of the country, the new EV registrations in 2024 show that HEVs are the most numerous (26,085 units), followed by BEVs (17,329 units) and PHEVs (1834 units). This indicates that the government's operational measures are not as effective as they should be [71]. This requires supportive measures to stimulate demand for BEV usage simultaneously. The conclusions of this study provide policy recommendations that the government can implement in the utilization phase to stimulate BEV purchase demand among the public, tailored to different age groups, especially those with financial stability such as middle-aged working adults and older (above 34 years). This group has purchasing power and represents a high proportion of Thailand's population. Stimulation can be achieved through short-term measures. National-level measures include providing subsidies for BEV buyers of all models, excise tax exemption measures, and vehicle tax exemption measures based on usage type. For medium-term national-level measures to stimulate BEV usage among early-career workers, there are campaigns supporting the trade-in of old vehicles for new BEVs, and measures supporting public charging station operators, both government and private agencies, by providing free charging services during off-peak hours. Furthermore, the government should plan and allocate budgets to regions for installing fast-charging stations to cover the context of each region. This includes supporting the technological development of solar-powered charging station installations in urban residential areas. Lastly, to expand cooperation in the transport service sector in reducing greenhouse gas emissions, the government can initiate measures in urban and tourist areas to promote taxi service providers. These measures could include special privileges for using charging stations, toll exemptions, and special parking spaces, to incentivize operators to switch to BEVs for increased service provision.

However, when considering the BEV lifecycle, it is found that the promotion of electric vehicles in Thailand is still in its early stages. The government has been promoting the production phase through measures such as investment promotion for electric vehicles, parts, and equipment, measures to support the use of domestic parts, and excise tax reduction measures. These aim to promote domestic electric vehicle production, allowing consumers to purchase electric vehicles at lower prices, and maintaining the export value of the country's automotive and auto parts industry. This leads to interesting issues for future studies, especially the adaptability potential of automotive and auto parts manufacturers to improve operational efficiency to meet global market demands. Although the demand for combustion engine auto parts is currently stable, in the future, it will be negatively impacted by the increasing demand for BEVs, particularly parts in the entire powertrain system, including exhaust system components and fuel tanks. Therefore, it is crucial to study the factors that auto parts manufacturers must accept for organizational change to support this transition, including production structure, organizational structure, technology, and employee skills [72]. There have been few studies on entrepreneurs and investors in the automotive and auto parts industry in Thailand.

A limitation of this study is that it has not concluded on measures for managing BEVs after their end of life. The process of disposing of vehicle waste, especially batteries, directly impacts the environment, and Thailand does not yet have clear supporting measures. This is because the laws related to car battery management are part of the hazardous waste management measures for communities. Legal measures have been specified only for

batteries used in hybrid electric vehicles, but there are no regulatory provisions for managing BEV batteries [73]. This will be a problem in achieving Carbon Neutrality goals in the future. To determine measures that will be beneficial in the use phase, there should be comparative studies of countries that have implemented measures for managing used batteries, analyzing them to derive measures appropriate for the Thai context. Another limitation is that the demographic factor analysis in this study compares differences between generations in explaining the causal relationships of electric vehicle purchase intention. From the literature review, we see that there are still demographic differences in other factors that have not been conclusively determined in each country's social context, such as gender [37,41], education level [38,40], household income [27,41], etc. Future studies could select demographic factors that are expected to show significant differences in the context of the country being studied. This study also faced methodological limitations. While SEM provided for the robust analysis of relationships between variables, it assumed linear relationships between constructs, which may not fully capture the complexity of adoption behaviors. Additionally, despite efforts to ensure regional representation through stratified sampling, the concentration of charging stations in urban areas may have created sampling bias toward urban perspectives. The study's focus on provinces with existing charging infrastructure potentially underrepresents views from areas without such infrastructure, particularly rural regions. This urban–rural disparity in sampling could affect the generalizability of findings to all regions of Thailand. Another limitation is that the demographic factor analysis in this study focused on three broad age groups to maintain statistical power and align with generational theory. While this approach provided robust findings about generational differences, a more granular analysis of age groups (such as subdividing the 25–34 group into early and late twenties) could potentially reveal additional nuanced patterns in BEV adoption attitudes and behaviors.

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Institutional Review Board Statement: This research was approved by the Ethics Committee for Research Involving Human Subjects, Rajamangala University of Technology Isan (Project Code: HEC-01-66-075), Data of approval: 21 December 2023.

Informed Consent Statement: Written informed consent has been obtained from the patient(s) to publish this paper.

Data Availability Statement: Data are available upon request due to restrictions (e.g., privacy, legal, or ethical reasons).

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

Appendix A. Questionnaire Items and Descriptive Statistics

Factors	Mean	S.D.
Government Support		
Information		
I am aware of the welfare or financial assistance from the government available for purchasing or using electric vehicles.	3.85	1.553
Knowledge about financial welfare from the government affects my consideration of electric vehicles.	3.99	1.471
The availability of government support encourages me to consider electric vehicles as a suitable option.	4.01	1.462

Factors	Mean	S.D.
Policy		
Government policies promoting electric vehicle use have a positive effect on my worldview.	4.07	1.472
I believe that supportive government policies are a crucial factor in adopting electric vehicles.	4.11	1.477
Adapting to government regulations inspires me to consider electric vehicles.	4.05	1.456
Goal		
I believe the government is committed to promoting sustainable travel through electric vehicles.	4.08	1.530
The level of commitment shown by the government affects my confidence in adopting electric vehicles.	4.04	1.565
I feel confident in the government's long-term commitment to supporting electric vehicles.	4.04	1.568
Tax		
The tax benefits provided by the government positively influence my decision to choose an electric vehicle.	4.10	1.523
I consider tax benefits for electric vehicle owners as a significant advantage.	4.16	1.518
Tax reductions for electric vehicle users encourage me to adopt this technology.	4.17	1.536
Communication		
Government communications and campaigns about electric vehicles influence my perspective.	4.55	1.525
I am more satisfied with the information provided by the government to make decisions about electric vehicles.	4.45	1.634
The clarity and transparency of government communications affect my confidence in adopting electric vehicles.	4.53	1.549
Barrier		
Cost		
The initial price of electric vehicles is too high for my budget.	5.16	1.468
I am concerned about the long-term maintenance costs of electric vehicles.	5.13	1.469
The cost of installing charging infrastructure is an obstacle for me.	4.94	1.604
Station		
The availability of charging stations in my area is low.	5.10	1.491
I am concerned about the time it takes to charge an electric vehicle compared to refueling a combustion engine vehicle.	5.23	1.479
The inconvenience of finding charging stations is an obstacle for me	5.12	1.531
Long distance		
I am concerned about the limited driving range of electric vehicles on a single charge.	5.20	1.519
Concerns about finding charging stations during long-distance travel deter me from choosing an electric vehicle.	5.23	1.521
Range anxiety (concern about battery depletion) is a significant obstacle.	5.27	1.575
I am concerned about the adequacy of parking spaces for charging.	4.86	1.461
I have heard news and am concerned about combustion engine vehicles occupying charging spots.	4.87	1.734
Technology Concerns		
I feel uncertain about the reliability of electric vehicle technology.	4.25	1.588
The technological complexity of electric vehicles is an obstacle for me.	4.27	1.571
I am concerned about the lifespan and efficiency of electric vehicle batteries.	4.99	1.553
Variety of Car Models		
The limited number of electric vehicle models available in the market is an obstacle.	4.80	1.658
I cannot find an electric vehicle that meets my needs.	4.72	1.693
The lack of variety in electric vehicles with different features and sizes is an obstacle	4.79	1.704
Public Information		
I feel there is a lack of public awareness and understanding about electric vehicles.	4.80	1.568
Insufficient information about the benefits of electric vehicles is an obstacle for me.	4.83	1.608
Public misunderstanding about electric vehicle technology is a problem for me.	4.72	1.496
Innovation Diffusion		
Relative Advantage		
I find BEVs would be helpful in my daily life	4.93	1.661
Using BEVs would help me move efficiently	5.04	1.721
Using BEVs would make my life easier	4.99	1.766
Compatibility		
I would be proud if people saw me using the BEV with advanced technological features	5.14	1.375
People in my social circle would be using a car withadvanced technological feature	4.97	1.528
People in my social circle would want that I use an environmentally friendly EV instead of a conventional vehicle	4.99	1.550

Factors	Mean	S.D.
Complexity		
I expect it would be easy for me to become skillful at driving BEVs	5.02	1.669
I expect my interaction with the functions of a BEV would be clear and understandable	4.89	1.796
I expect BEVs would be easy to use	4.93	1.647
Observability		
The lack of engine noise of BEV increases the driving pleasure	4.89	1.497
Driving BEV reduces pollution level and consumption of natural resources	4.95	1.462
I will save on fuel expenses, as running cost should be lower in case of BEV	4.93	1.508
Trialability		
I get excited about a new BEV model in the market	5.12	1.387
I feel confident in my ability to drive BEV	5.12	1.402
BEV test drive solidified my belief that electric vehicles are superior to conventional cars	5.10	1.422
Intention		
Next time I buy a vehicle, I would consider buying an Electric Vehicle	4.83	1.977
I expect to drive an Electric Vehicle in the near future	4.80	1.854
I have the intention to drive an Electric Vehicle in the near future	4.87	1.812
I would prefer to drive an Electric Car as compared to conventional car.	4.89	1.677
I intend to adopt Electric Vehicle because it is environmentally friendly	5.21	1.370

References

1. Dietz, T.; Shwom, R.L.; Whitley, C.T. Climate Change and Society. *Annu. Rev. Sociol.* **2020**, *46*, 135–158. [CrossRef]
2. Olabi, A.; Obaideen, K.; Elsaid, K.; Wilberforce, T.; Sayed, E.T.; Maghrabie, H.M.; Abdelkareem, M.A. Assessment of the pre-combustion carbon capture contribution into sustainable development goals SDGs using novel indicators. *Renew. Sustain. Energy Rev.* **2022**, *153*, 111710. [CrossRef]
3. UNFCCC. *United Nations Framework Convention on Climate Change: Handbook*; Climate Change Secretariat: Bonn, Germany, 2006. Available online: https://unfccc.int/resource/docs/publications/handbook.pdf (accessed on 25 July 2024).
4. Olabi, A.; Abdelkareem, M.A. Renewable energy and climate change. *Renew. Sustain. Energy Rev.* **2022**, *158*, 112111. [CrossRef]
5. Werner, D.; Lazaro, L.L.B. The policy dimension of energy transition: The Brazilian case in promoting renewable energies (2000–2022). *Energy Policy* **2023**, *175*, 113480. [CrossRef]
6. Gajdzik, B.; Wolniak, R.; Nagaj, R.; Grebski, W.W.; Romanyshyn, T. Barriers to renewable energy source (RES) installations as determinants of energy consumption in EU countries. *Energies* **2023**, *16*, 7364. [CrossRef]
7. Division of Foreign Affairs. United Nations Framework Convention on Climate Change. Available online: https://fad.mnre.go.th/th/mph/content/206 (accessed on 8 August 2024).
8. Working Group on Study and Preparation of Electricity Infrastructure Development Plan to Support Electric Vehicles in Thailand. Report on the Development Plan for Electrical Infrastructure to Support Electric Vehicles in Thailand. Available online: https://www.oic.go.th/FILEWEB/CABINFOCENTER8/DRAWER077/GENERAL/DATA0000/00000763.PDF (accessed on 8 August 2024).
9. Energy Policy and Planning Office. The Development Plan for Electric Vehicles' Charging Stations to Support the Goal of Promoting Electric Vehicles. Available online: https://www.eppo.go.th/images/energy-conservation/EV/EV_summary_manager.pdf (accessed on 10 July 2024).
10. Janhuaton, T.; Ratanavaraha, V.; Jomnonkwao, S. Forecasting Thailand's Transportation CO_2 Emissions: A Comparison among Artificial Intelligent Models. *Forecasting* **2024**, *6*, 462–484. [CrossRef]
11. Energy Policy and Planning Office. Guidelines to Promote Electric Vehicles in Thailand. Available online: https://www.eppo.go.th/index.php/en/component/k2/item/17415-ev-charging-221064-04 (accessed on 2 August 2024).
12. Deloitte. Global Automotive Consumer Study Southeast Asia Perspectives. Available online: https://www2.deloitte.com/content/dam/Deloitte/sg/Documents/consumer-business/sea-cb-2023-global-automotive-consumer-study-southeast-asia-perspectives.pdf (accessed on 30 May 2024).
13. International Energy Agency. Global EV Outlook 2024 Moving Towards Increased Affordability. Available online: https://iea.blob.core.windows.net/assets/a9e3544b-0b12-4e15-b407-65f5c8ce1b5f/GlobalEVOutlook2024.pdf (accessed on 30 May 2024).
14. Huang, X.; Lin, Y.; Lim, M.K.; Tseng, M.-L.; Zhou, F. The influence of knowledge management on adoption intention of electric vehicles: Perspective on technological knowledge. *Ind. Manag. Data Syst.* **2021**, *121*, 1481–1495. [CrossRef]
15. Singh, H.; Singh, V.; Singh, T.; Higueras-Castillo, E. Electric vehicle adoption intention in the Himalayan region using UTAUT2—NAM model. *Case Stud. Transp. Policy* **2023**, *11*, 100946. [CrossRef]

16. Sun, K.K.; He, S.Y.; Thøgersen, J. The purchase intention of electric vehicles in Hong Kong, a high-density Asian context, and main differences from a Nordic context. *Transp. Policy* **2022**, *128*, 98–112. [CrossRef]
17. Chang, T.-W. An indispensable role in promoting the electric vehicle Industry: An empirical test to explore the integration framework of electric vehicle charger and electric vehicle purchase behavior. *Transp. Res. Part A* **2023**, *176*, 103824. [CrossRef]
18. Nguyen-Phuoc, D.Q.; Truong, T.M.; Nguyen, M.H.; Pham, H.-G.; Li, Z.-C.; Oviedo-Trespalacios, O. What factors influence the intention to use electric motorcycles in motorcycle-dominated countries? An empirical study in Vietnam. *Transp. Policy* **2024**, *146*, 193–204. [CrossRef]
19. Toraman, Y.; Bayirli, M.; Ramadani, V. New technologies in small business models: Use of electric vehicles in last-mile delivery for fast-moving consumer goods. *J. Small Bus. Enterp. Dev.* **2023**, *31*, 515–531. [CrossRef]
20. Xue, Y.; Zhang, Y.; Wang, Z.; Tian, S.; Xiong, Q.; Li, L.Q. Effects of incentive policies on the purchase intention of electric vehicles in China: Psychosocial value and family ownership. *Energy Policy* **2023**, *181*, 113732. [CrossRef]
21. Wang, F.; Zhang, Z.; Lin, S. Purchase intention of Autonomous vehicles and industrial Policies: Evidence from a national survey in China. *Transp. Res. Part A* **2023**, *173*, 103719. [CrossRef]
22. Han, L.; Wang, S.; Zhao, D.; Li, J. The intention to adopt electric vehicles: Driven by functional and non-functional values. *Transp. Res. Part A* **2017**, *103*, 185–197. [CrossRef]
23. Simsekoglu, Ö.; Nayum, A. Predictors of intention to buy a battery electric vehicle among conventional car drivers. *Transp. Res. Part F* **2019**, *60*, 1–10. [CrossRef]
24. Ruoso, A.C.; Ribeiro, J.L.D. An assessment of barriers and solutions for the deployment of electric vehicles in the Brazilian market. *Transp. Policy* **2022**, *127*, 218–229. [CrossRef]
25. Salari, N. Electric vehicles adoption behaviour: Synthesising the technology readiness index with environmentalism values and instrumental attributes. *Transp. Res. Part A* **2022**, *164*, 60–81. [CrossRef]
26. Qian, L.; Huang, Y.; Tyfield, D.; Soopramanien, D. Dynamic consumer preferences for electric vehicles in China: A longitudinal approach. *Transp. Res. Part A* **2023**, *176*, 103797. [CrossRef]
27. Okada, T.; Tamaki, T.; Managi, S. Effect of environmental awareness on purchase intention and satisfaction pertaining to electric vehicles in Japan. *Transp. Res. Part D* **2019**, *67*, 503–513. [CrossRef]
28. Chang, T.-W.; Chen, Y.-S.; Huang, S.Y. How to weigh in on sustainability trends? Sustainable consumption by electric scooter customers and its implications for green marketing. *Corpor. Manag. Rev.* **2021**, *41*, 39–79.
29. Krishnan, V.V.; Sreekumar, M. An integrated behavioral approach to analyze the adoption of electric vehicles in the context of a developing country. *Transp. Policy* **2023**, *142*, 162–172. [CrossRef]
30. Deka, C.; Dutta, M.K.; Yazdanpanah, M.; Komendantova, N. Can gain motivation induce Indians to adopt electric vehicles? Application of an extended theory of Planned Behavior to map EV adoption intention. *Energy Policy* **2023**, *182*, 113724. [CrossRef]
31. Zhuge, C.; Dong, C.; Wei, B.; Shao, C. Exploring the role of technology innovations in the diffusion of electric vehicle with an agent-based spatial integrated model. *Resourc. Conver. Recyc.* **2021**, *174*, 105806. [CrossRef]
32. Rogers, E.M. *Diffusion of Innovations*, 5th ed.; Free Press: New York, NY, USA, 2003.
33. Jaiswal, M.; Zane, L. National culture and attitudes' impact on diffusion of sustainable new technology-based products. *N. Engl. J. Entrep.* **2022**, *25*, 5–25. [CrossRef]
34. Ahmad Wani, T.; Wajid Ali, S. Innovation Diffusion Theory Review & Scope in the Study of Adoption of Smartphones in India. *J. Gen. Manag. Res.* **2015**, *3*, 101–118.
35. National Statistical Office Ministry of Digital Economy and Society. The 2023 Household Survey on the Use of Information and Communication Technology (QUARTER 1). Available online: https://www.nso.go.th/nsoweb/storage/survey_detail/2023/20230913093840_23932.pdf (accessed on 1 October 2024).
36. Degirmenci, K.; Breitner, M.H. Consumer purchase intentions for electric vehicles: Is green more important than price and range? *Transp. Res. Part D* **2017**, *51*, 250–260. [CrossRef]
37. Mohamed, M.; Higgins, C.D.; Ferguson, M.; Réquia, W.J. The influence of vehicle body type in shaping behavioural intention to acquire electric vehicles: A multi-group structural equation approach. *Transp. Res. Part A* **2018**, *116*, 54–72. [CrossRef]
38. Jaiswal, D.; Kaushal, V.; Deshmukh, A.K.; Kant, R.; Kautish, P. What drives electric vehicles in an emerging market? *Mark. Intell. Plan.* **2022**, *40*, 738–754. [CrossRef]
39. Bösehans, G.; Bell, M.; Thorpe, N.; Dissanayake, D. Something for every one?—An investigation of people's intention to use different types of shared electric vehicle. *Travel Behav. Soc.* **2023**, *30*, 178–191. [CrossRef]
40. Bhat, F.A.; Verma, M.; Verma, A. Who will buy electric vehicles? Segmenting the young Indian buyers using cluster analysis. *Case Stud. Transp. Policy* **2024**, *15*, 101147. [CrossRef]
41. Atombo, C.; Pappoe, G.; Akple, M.S.; Adzah, D. Evaluating the adoption of electric vehicles: Insights from Ghana. *Afr. Transp. Stud.* **2024**, *2*, 100007. [CrossRef]
42. Sangthong, M. The Effect of the Likert Point Scale and Sample Size on the Efficiency of Parametric and Nonparametric Tests. *Thail. Stat.* **2020**, *18*, 55–64.
43. Awang, Z.; Afthanorhan, A.; Mamat, M. The Likert scale analysis using parametric based Structural Equation Modeling (SEM). *Comput. Methods Soc. Sci.* **2016**, *4*, 13–21.

44. Siebert, D.C.; Chonody, J.; Siebert, C.F.; Rutledge, S.E. The Importance of Confirmatory Validation: Short Version of the Attitudes Toward Lesbians and Gay Men Scale. *J. Soc. Soc. Work Res.* **2014**, *5*, 189–210. [CrossRef]
45. Dangbut, A.; Watcharamaisakul, F.; Champahom, T.; Jomnonkwao, S.; Wisutwattanasak, P.; Phojaem, T.; Ratanavaraha, V. The Impact of Attitude on High-Speed Rail Technology Acceptance among Elderly Passengers in Urban and Rural Areas: A Multigroup SEM Analysis. *Infrastructures* **2024**, *9*, 174. [CrossRef]
46. White, L.V.; Carrel, A.L.; Shi, W.; Sintov, N.D. Why are charging stations associated with electric vehicle adoption? Untangling effects in three United States metropolitan areas. *Energy Res. Soc. Sci.* **2022**, *89*, 102663. [CrossRef]
47. Popescu, A. The brief history of generation—Defining the concept of generation. An analysis of literature review. *J. Comp. Res. Anthropol. Sociol.* **2019**, *10*, 15–30.
48. Troll, L.E. Issues in the study of generations. *Aging Hum. Dev.* **1970**, *1*, 199–218. [CrossRef]
49. Daenghem, S.; Charoenphan, N. Factors Affecting Thai Household Savings in the Digital Economy. *J. Demogr.* **2021**, *37*, 49–68.
50. Hair, J.; Black, W.; Babin, B.; Anderson, R.; Tatham, R. *Multivariate Data Analysis*, 7th ed.; Pearson Educational International: Hoboken, NJ, USA, 2010.
51. Schumacker, R.E.; Lomax, R.G. *A Beginner's Guide to Structural Equation Modeling*; Psychology Press: Hillsdale, NJ, USA, 2004.
52. Byrne, B.M. Testing for multigroup equivalence of a measuring instrument: A walk through the process. *Psicothema* **2008**, *20*, 872–882. [PubMed]
53. Davis, F.D. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q.* **1989**, *13*, 319–340. [CrossRef]
54. Shetty, A.; Rizwana, M. Sustainable mobility perspectives: Exploring the impact of UTAUT2 model on fostering electric vehicle adoption in India. *Manag. Environ. Qual. Int. J.* 2024, *in press*. [CrossRef]
55. Kongkirati, P. A Political Analysis of Electoral Laws in Thailand. King Prajadhipok's Institute the Government Complex Commemorating 2023. Available online: https://www.kpi.ac.th/uploads/pdf/QHxbwy0NmmwU8inPrRF6fNXW8NyNlL43DuliGdVR.pdf (accessed on 1 October 2024).
56. Kanchanakhet, P.W.; Sompanyo, P.S. Economic Darkness: The Impact of Politics. *J. Leg. Entity Manag. Local Innov.* **2022**, *8*, 429–434.
57. World Bank Group. Regular Economic Report of Thailand. Available online: https://documents1.worldbank.org/curated/en/099062924130039174/pdf/P5010091789eca0181b4891ebcbf06e30f3.pdf (accessed on 16 October 2024).
58. Vasantiaupapokagorn, N.; Chitwattanakorn, T.; Bunyapo, K. The Trend and Legal of Electric Vehicle Conversion Business in Thailand. *J. Soc. Sci. Cult.* **2023**, *7*, 199–210.
59. Tangsupwattana, W.; Liu, X. Symbolic consumption and Generation Y consumers: Evidence from Thailand. *Asia Pac. J. Mark. Logist.* **2017**, *29*, 917–932. [CrossRef]
60. Pattrawiwat, K.; Nilrungratana, P.; Deewai, A.; Tuntivivat, S. The Measurement Model of Family Strengths for Generation Alpha in the Thai Context. *Behav. Sci.* **2024**, *14*, 921. [CrossRef]
61. Ahmad, S.; Chaveeesuk, S.; Chaiyasoonthorn, W. The adoption of electric vehicle in Thailand with the moderating role of charging infrastructure: An extension of a UTAUT. *Int. J. Sustain. Energy* **2024**, *43*, 2387908. [CrossRef]
62. The Revenue Department. Government Incentives and Policies Promoting the Production of Electric Vehicles in Thailand. Available online: https://www.rd.go.th/region/04/fileadmin/063_saraburi/HotArticle/2560/Jan16_electriccar.pdf (accessed on 15 October 2024).
63. She, Z.-Y.; Sun, Q.; Ma, J.-J.; Xie, B.-C. What are the barriers to widespread adoption of battery electric vehicles? A survey of public perception in Tianjin, China. *Transp. Policy* **2017**, *56*, 29–40. [CrossRef]
64. Haseeb, A.; Mitra, R. Travel behaviour changes among young adults and associated implications for social sustainability. *Transp. Res. Part A* **2024**, *187*, 104189. [CrossRef]
65. Energy Regulatory Commission. Update on the Global and Thai Electric Vehicle Market in 2024. Available online: https://www.erc.or.th/th/energy-articles/3094 (accessed on 15 October 2024).
66. Chaisrisawatsuk, S.; Chintayarangsan, R. A Transition to Electric Vehicle Industry in Thailand. *Dev. Econ. Rev.* **2022**, *16*, 98–113.
67. Tongsuar, V. The Future of Thailand's Automotive Parts Industry 2023–2024. Available online: https://krungthai.com/Download/economyresources/EconomyResourcesDownload_1918Research_Note_Auto_Part_20_03_66.pdf (accessed on 4 October 2024).
68. Figenbaum, E.; Wangsness, P.B.; Amundsen, A.H.; Milch, V. Empirical Analysis of the User Needs and the Business Models in the Norwegian Charging Infrastructure Ecosystem. *World Electr. Veh. J.* **2022**, *13*, 185. [CrossRef]
69. Pamidimukkala, A.; Kermanshachi, S.; Rosenberger, J.M.; Hladik, G. Evaluation of barriers to electric vehicle adoption: A study of technological, environmental, financial, and infrastructure factors. *Transp. Res. Interd. Perspect.* **2023**, *22*, 100962. [CrossRef]
70. Industrial Research Division Thailand Automotive Institute. Used Battery Management. Available online: https://thaiauto.or.th/2012/th/services/ev/pdf/research/2018/01_04.pdf (accessed on 4 October 2024).
71. Electric Vehicle Association of Thailand. Thailand Electric Vehicle Current Status. Available online: https://www.ev-roads.com (accessed on 15 October 2024).

72. Suntornsut, K. The Aaptation of Automotive Parts Manufacturing Enterprise to the Transformation from Interrnal Combustion Engines to Electric Vehicles. Master's Thesis, Thammasat University, Bangkok, Thailand, 2020. Available online: https://digital.library.tu.ac.th/tu_dc/frontend/Info/item/dc:187754# (accessed on 15 October 2024).
73. Bupphaklin, S. Legal Measures to Control Expired Electric Vehicle Batteries. Master's Thesis, Thammasat University, Bangkok, Thailand, 2022. Available online: https://ethesisarchive.library.tu.ac.th/thesis/2022/TU_2022_6201034623_15888_22407.pdf (accessed on 15 October 2024).

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