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MODEL DEVELOPMENT TO EVALUATE CONSUMERS' INTENTION TO ADOPT ELECTRIC VEHICLES

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By

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DEDICATION

I dedicate this thesis to my beloved parents, grandparents, and uncle, who have been my source of inspiration and pillar of support.

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ABSTRACT

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The University of Texas at Arlington, 2023

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The ever-increasing concern over climate change is compelling global economies to employ alternative fuel technology to combat the vehicular emissions of greenhouse gases. Electric vehicles (EVs) offer a viable environmentally friendly alternative that has the potential to facilitate an effective shift towards a sustainable transportation system with low emissions while preserving the environment. However, well-intentioned policies and other incentives have not been able to transcend the factors that prevent their adoption. Therefore, this research aims to develop three models to determine the factors affecting consumers' willingness to adopt EVs.

A questionnaire survey was designed based on an extensive literature search to accomplish the study's aim. The survey was administered to a population of 10,000 students, faculty, and staff who held active parking permits at the University of Texas at Arlington (UTA). The survey was electronically disseminated through an online platform QuestionPro, and after two rounds of reminder emails, 743 valid and complete responses were received.

Based on the collected survey data, the first model identified the technological, infrastructure, financial, and environmental factors influencing the consumers' intention to adopt EVs. Model 1 results indicated that of the four categories of barriers, only the environmental barriers are not significant. The second model examined the consolidative framework of personality beliefs- the intention to understand consumers' intention to adopt EVs. The model

revealed that perceived ease of use, personal innovativeness, and perceived usefulness positively impact consumers' intention to adopt EVs, while perceived risk harms the perceived usefulness and adoption intention of EVs. Additionally, consumers' personal innovativeness positively influences perceived ease of use and perceived usefulness and negatively influences perceived risk. Furthermore, the findings also reveal that perceived ease of use, usefulness, and risk partly mediate the influence of personal innovativeness on the EV adoption intention. The third model utilized the theory of planned behavior (TPB), and incorporated additional factors such as price value, moral norms, and financial incentives to examine consumers' intention to adopt EVs. The results reveal that attitude, subjective norms, perceived behavior control, moral norms, and price value significantly affect consumers' intentions to adopt EVs. Nevertheless, the findings indicate that providing financial incentives does not statistically impact consumers' adoption intention.

The outcomes of this study may aid policymakers in developing effective transportation and energy policies and guide those responsible for designing EVs that fit the needs and demands of potential consumers.

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CHAPTER 1

INTRODUCTION

1.1 Background

The transportation sector contributes significantly to emissions and air contamination. In addition, it utilizes roughly one-fourth of the worldwide fossil fuel reserves, the majority of which is used for road transportation (Moeletsi, 2021; Patel et al., 2021; Khan et al., 2022a; Etminani-Ghasrodashti et al., 2023a). The 2020 International Energy Agency (IEA) report states that the transport sector causes 24% of direct CO_2 emissions from fuel combustion. According to projections, this number will increase by up to 70% by 2050, assuming business as usual (IEA, 2020). These statistics demonstrate the necessity of devising a technology to reduce automobile CO_2 emissions (Adnan et al., 2018; Patel et al., 2022a).

The automotive sector has experienced a substantial transformation in recent decades due to technological advancements (Etminani-Ghasrodashti 2021 a, b; Channamallu et al., 2023), with electric vehicles (EVs) emerging as a crucial and revolutionary innovation within this sector. These emerging technologies, including autonomous vehicles, demand-responsive transit, and on-demand mobility, are anticipated to have a vital role in shaping the future of transportation mobility (Khan et al., 2021a; Etminani-Ghasrodashti 2022a; Patel 2023a). Their impact is expected to be transformative, affecting various aspects of the transportation system, such as user experience, business models, and travel options. The primary means of transportation in the United States is using personal vehicles or light trucks, with a notable proportion of families, at least 24%, now owning three or more such vehicles (Khan et al., 2023 a, b). Between 2010 and 2020, there was a notable increase in registered vehicles, rising from around 250 million to 276 million. This surge in vehicle ownership has resulted in several adverse consequences, including heightened levels of traffic congestion, amplified emissions of greenhouse gases, and an escalation in deadly accidents (Patel et al., 2022b; Pamidimukkala et al., 2023a; Roya-Etminani et al., 2023b, c).

EVs have been recognized as having the potential to substantially reduce reliance on fossil fuels, CO_2 emissions and various environmental concerns. By replacing fossil fuels with grid-based electricity, EVs offer significant economic and environmental advantages over internal combustion engine vehicles (ICEVs). They lower greenhouse gases (GHGs) and other emissions, improve reliability of energy, and enhance renewable energy use (Zhou et al., 2020). EVs the potential to reduce carbon emissions by approximately 30-50% and enhance fuel efficiency by around 40-60% in comparison to conventional vehicles (Higueras-Castillo, Kalinic et al., 2020; Jaiswal et al., 2022). Consequently, in response to the escalating issues of energy scarcity and environmental degradation resulting from the increasing number of motor vehicles, many nations engaged in automobile production have formulated comprehensive policies to foster electric vehicle acceptance (Zhou et al., 2020).

Three categories of EVs are currently on the road: battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs) (Guerra, 2019). HEVs rely primarily on ICEs and an electric engine that cannot be charged externally. They have an electric range of about 40- 60 miles, then must be run on the ICE. PHEVs have outstanding battery capacity and may be charged externally; however, they can only be driven approximately 10 – 30 miles using only electric power, then they switch over to gasoline for up to 190 miles (Sanguesa et al., 2021; Shamshirband et al., 2018). BEVs are powered through an electric engine that derives its energy from a rechargeable battery that can be charged from an external source (Wang et al., 2020; Zhou et al., 2020).

Globally, electric vehicle sales raised by 14% in 2019, drawing the attention of the automotive sector. Europe's sales grew by 80%, Canada's by 43%, while sales in China and the United States remained constant. Other nations, such as Norway (39.5%) and the United Kingdom (1.94%), joined the trend and purchased more EVs. In 2020, the sales were disrupted due to COVID-19 (Pamidimukkala and Kermanshachi, 2021; Pamidimukkala et al., 2021). However, the sales of EVs have experienced a noteworthy increase, reaching a record high of 6.6 million in 2021, which represents a doubling of the previous year's figures (Rietmann & Lieven, 2019). The share of electrified auto sales in the global market witnessed a significant increase in 2021, reaching nearly 10%, which is fourfold larger than the market share recorded in 2019. According to Patyal et al. (2021), the global count of EVs reached approximately 16.5 million, indicating a threefold increase from 2018.

1.2 Problem Statement

Despite the recent surge in the share of EVs in the United States, the nation continues to encounter challenges in promoting widespread EV adoption. Several factors attribute the massive acceptance of EVs to consumers' perceptions, and the literature has mostly disregarded the EV market's diverse and heterogeneous Characteristics (She et al., 2017). While customer preferences for electric vehicles vary depending on a combination of many factors, there is a dearth of scholarly investigation pertaining to the extensive array of factors that have influence on the adoption of electric vehicles, such as customers' preferences varying on a combination of environmental, symbolic, and pro-social benefits (Kumar and Alok, 2020). These variables, however, vary among nations and cultures and reveal the need to consider cross-cultural differences and how they impact EV adoption (Vafaei-Zadeh; Wong et al., 2022). In addition, only limited studies have considered the impacts of socio-demographics on the EV adoption intention. Hence, it is important to conduct an in-depth study in order to obtain insight into the consumer perception of EVs and determine the potential factors that influence their adoption or hinder it. Hence, comprehending the consumer perception of EVs and identifying the barriers impeding their purchase is of utmost significance.

1.3 Research Objective

The purpose of this research is to develop models that analyzes the factors affecting the consumer adoption of EVs. Accordingly, the objectives of this research are as follows:

1. Identify and categorize the contextual, situational, psychological, and demographic factors affecting the adoption of electric vehicles.
2. Evaluate the influence of technological, environmental, financial, infrastructure, psychological, and demographic factors influencing consumers' adoption of electric vehicles.
3. Develop various policy measures for different stakeholders including policymakers, manufacturers, and marketers to foster EV adoption.

1.4 Proposal Organization

Chapter 1 consists of the research background, problem statement, and research objectives of this study. Chapter 2 presents a paper that describes an overview of the factors that influence consumers' intention to adopt electric vehicles. This paper also presents a list of policy implications for different stakeholders. Chapter 3 presents a paper that identifies the barriers that affects consumers' intention to adopt electric vehicles. This paper ranks barriers and subsequently compares the results with prior research; identifies homogenous groups of respondents through cluster analysis; and compares socio-economic groups of respondents using a chi-squared test. Chapter 4 presents a paper that examines technological, environmental, infrastructure, and financial barriers that significantly effect consumers' intention to adopt electric vehicles. The results of this paper revealed that technological, infrastructure, and financial barriers negatively influences consumers’ intention to adopt EVs. Chapter 5 presents a paper that explores the factors affecting the consumers adoption intention of electric vehicles based on extended technology acceptance model utilizing variables such as personal-innovativeness, perceived ease of use, perceived risk, and perceived usefulness. Chapter 6 presents a paper that explores the consumers intentions to adopt electric vehicles based on extended theory of planned behavior utilizing variables including attitudes, subjective norms, perceived behavioral control, moral norms, price value, and financial incentives. Chapter 7 presents the conclusion, limitations, and recommendations for this study.

CHAPTER 2

BARRIERS AND MOTIVATORS TO THE ADOPTION OF ELECTRIC VEHICLES: A GLOBAL REVIEW

2.1 Abstract

Electric vehicles (EVs) have the potential to mitigate the severity of significant concerns including environmental pollution and reliance on fossil fuels; however, despite strong governmental promotional efforts, their market penetration is still at the nascent stage. This paper empirically investigates the factors that affect the consumers' intention to adopt EVs by conducting an exhaustive literature review. The initial search resulted in 1,690 publications, but after a thorough exclusion process, 537 articles were deemed relevant and were sorted by source, publication year, country of origin, data collection method, and research domain. The results revealed the influential factors over individuals' desire to adopt an EV were categorized into four main types (contextual, situational, demographic, and psychological); situational factors, that can act as both barriers and motivators, had the most influencing components. The most cited barriers to adoption of EVs were found to be the lack of charging stations availability and their limited driving range. The most cited motivators to EV adoption were found to be reduction in air pollution and the availability of policy incentives. The findings of this study may guide policymakers in formulating effective transportation and energy policies, as well as provide guidance to those who are responsible for designing EVs that fit the needs and demands of potential consumers.

Keywords: Electric vehicles, sustainability, adoption, policies, barriers, motivators.

2.2 Introduction

Data for 2022 shows that the transportation sector's proportion of Carbon dioxide (CO_2) emissions has trended upwards to around 37% since the mobility restrictions relating to the coronavirus were lifted (Teter, September 2022). The transportation sector relies on fossil fuels more than any other industry, and most of their greenhouse gases (GHGs) are attributable to road transport (Khan et al., 2021b; Etminani-Ghasrodashti et al., 2022b; Patel et al., 2022c). Electric vehicles (EVs) possess the capacity to lower these CO2 emissions and are vital to achieving the climate change goals established for reducing CO_2 (Adnan et al., 2018; Jaiswal et al., 2022). Despite significant government backing, however, most EV adoption initiatives have not achieved their intended goals, making it crucial that the factors affecting consumers' attitudes about EV adoption be identified and categorized.

Four distinct classifications of EVs are currently on the road: battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and extended range EVs (EREVs) (Adnan et al., 2018; Guerra, 2019; Pamidimukkala et al., 2023b). HEVs rely primarily on ICEs and an electric motor that lacks the capability of external charging. They have an electric range of about 40- 60 miles, then must be run on the ICE. PHEVs have outstanding battery capacity and can be charged externally; however, they can only be driven approximately 10 – 30 miles using only electric power, then they switch over to gasoline for up to 190 miles (Sanguesa et al., 2021; Shamshirband et al., 2018). BEVs are powered through an electric motor that derives its energy from a rechargeable battery that can be charged from an external source (Wang et al., 2020; Zhou et al., 2020). E-REVs have an onboard generator and operate solely on electricity; their increased battery capacity gives them an advantage over HEVs in terms of driving range (Singh et al., 2020; Stockkamp et al., 2021).

The existing literature has thus far demonstrated that consumers' perceptions and individual characteristics exert a significant influence in the adoption of EVs (He et al., 2018). Coffman et al. (2017) studied the factors influencing the EV adoption but disregarded the marketing component and psychological characteristics. Adnan et al. 2018)) analyzed consumer behavior predictions for the adoption of PHEVs, but failed to account for other factors, such as socioeconomic. Singh et al. (2020) studied the comprehensive list of factors influencing customers' willingness to adopt EVs but failed to classify the barriers and motivators. Kumar & Alok (2020) studied the EV adoption by exploring the primary antecedents, mediators and moderators. Stockkamp et al. (2021) developed a framework to examine the factors related to consumer EV adoption.

The literature has mostly disregarded the EV market's diverse and heterogeneous characteristics, and few researchers have investigated the extensive range of factors associated with EV adoption that differ from nation-to-nation and across cultures (Kumar & Alok, 2020). The objective of this study is to address these deficiencies by conducting a comprehensive review and compiling the multicultural findings to determine a broader comprehension of the factors that affect EV adoption. To accomplish this, this study will (1) identify and categorize the broader categories of factors affecting EV adoption; (2) classify the identified factors to barriers and motivators, (3) determine the frequency of each identified factor; and (4) ascertain policy measures that would assist governments, manufacturers, policymakers, and marketers in fully comprehending the factors that influence EV adoption. The results of this study may help to foster EV adoption and guide policymakers in crafting effective energy and transportation policies, as well as provide guidance to those who are responsible for designing EVs that fit the needs and demands of potential consumers.

2.3 Method

Figure 2.1 illustrates the multi-step methodology that was developed for this research. The relevant literature from 2011 to 2022 was collected by utilizing various combinations of keywords in search engines and eliminating the articles whose titles were not relevant to the goal of the study. The abstracts of the retained publications were thoroughly reviewed, and the finalized data was evaluated based on journal name, publication year, geographical location, data collection method, and research domain. The full text of the documents associated to the adoption behaviors of EVs was reviewed, and four major categories of factors affecting consumers' adoption of EVs were identified (contextual, situational, psychological, and demographic). The frequency with which each factor was focused in the literature was determined, and the policy implications were investigated.

A comprehensive search was conducted across various digital databases such as Scopus, Google Scholar, Science Direct, ProQuest, and JSTOR. The search was focused on English-language publications and involved exploring different combinations and extensions of significant keywords such as electric vehicle, adoption behavior, barriers, motivators, consumers, HEVs, PHEVs, BEVs, etc. The timeframe was restricted to 2010 onwards because the prevalence of electric vehicles has increased five times during this period, with the most notable trend observed in 2022. The search revealed 1,690 documents, which were narrowed down to 939 after eliminating non-peer-reviewed sources. Next, 402 papers had been excluded whose titles and abstracts did not indicate the inclusion of adoption behaviors and the final database comprised 537 publications.

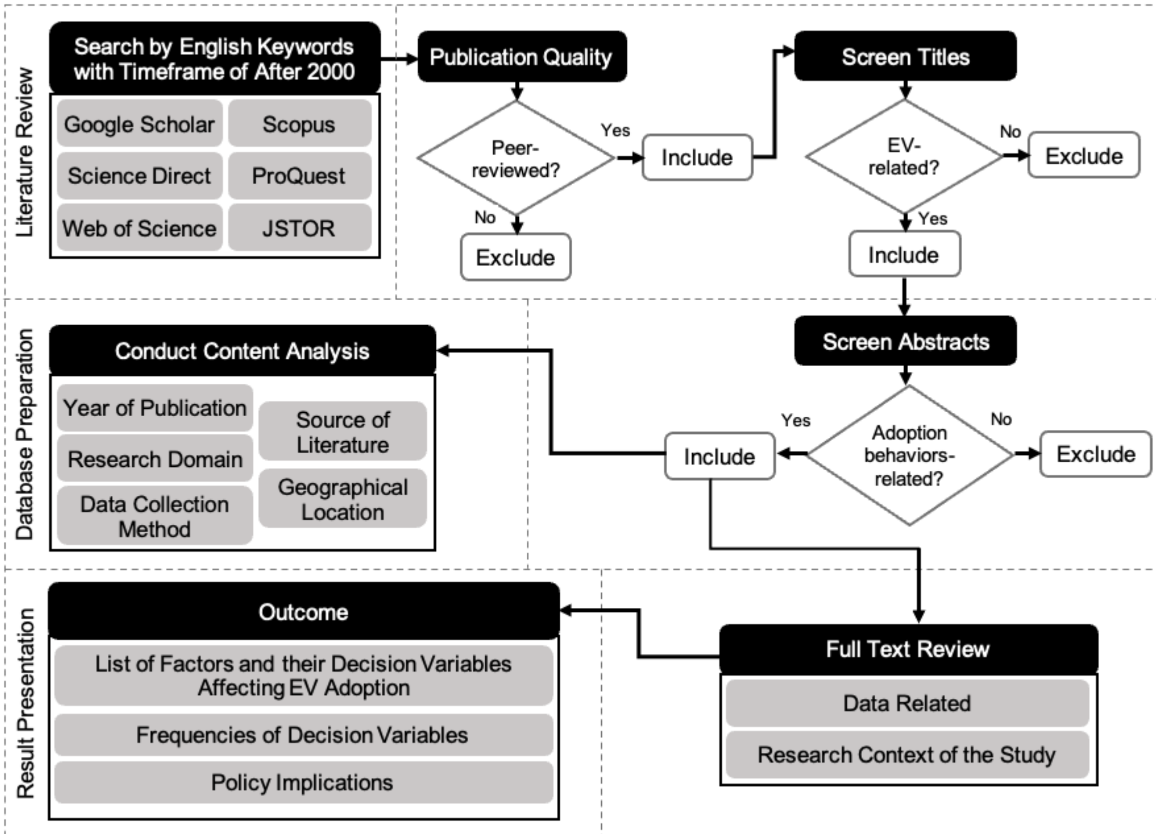

Figure 2.1 Research Framework

2.3.1 Database Content Analysis

2.3.1.1 Year of Publication

The 537 articles from the final database served as the basis for further evaluation. The annual publication trend of the selected articles is illustrated in Figure 2.2 and shows that the percentage of articles published annually has been increasing since 2011 when only two percent of researchers focused on EV adoption behaviors. From 2012 – 2017, approximately 4% - 7% addressed EV adoption behaviors, but about 70% of the publications on this topic were from the last five years (2018-2022), signifying the emerging importance of the research domain in recent years.

Figure 2.2 presents the number of publications related to EV adoption behaviors by year and highlights the increasing global interest in EVs as an alternative to vehicles dependent on fossil fuels. The increased interest is almost certainly related to concerns about climate change and consumers' interest towards alternative vehicles.

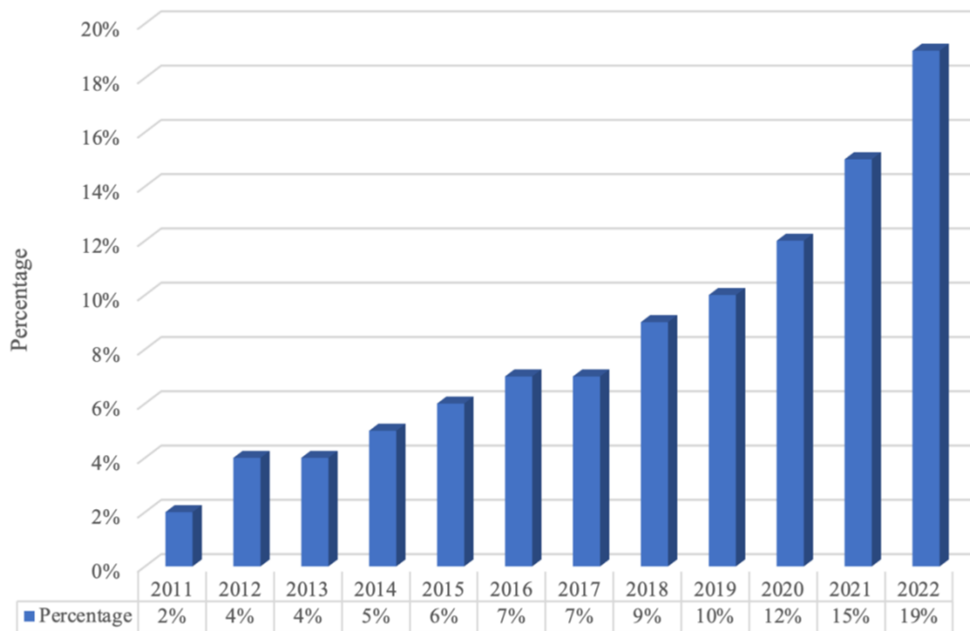

Figure 2.2 Distribution of Articles Based on Publication Year

2.3.1.2 Source of Literature

In analyzing the literature, special consideration was given to the source of the publication. Table 2.1 reveals that 64% of the articles were derived from five prominent research journals in the fields of business management, policy, transportation, and environment: Transportation Research Part D: Transport and Environment, Energy Policy, Journal of Cleaner Production, Energies, and Applied Energy.

Table 2.1 Frequency of Articles by Journal

#	Source	Percentage
1	Transportation Research Part D: Transport and Environment	23%

2	Energy Policy	18%
3	Journal of Cleaner Production	8%
4	Energies	8%
5	Applied Energy	7%
6	Renewable and Sustainable Energy Reviews	6%
7	Transportation Research Part A: Policy and Practice	6%
8	Sustainability	5%
9	Case Studies on Transport Policies	4%
10	Transport Policies	2%
11	Transportation Research Part F: Traffic Psychology and Behavior	2%
12	Sustainable Production and Consumption	1%
13	World Electric Vehicle Journal	1%
14	Others	9%

2.3.1.3 Based on Geographical Location

Studies related to EV adoption vary across countries owning to regional and cultural disparities, and many of them focus on nation-specific requirements and policy determinations that have the potential to expediate EV adoption. Figure 2.3. shows a breakdown of articles by the country in which the research was performed and reveals that researchers in nearly all the major countries focused on this topic. As can be observed, China leads in the EV research, followed by the USA, India, United Kingdom, and South Korea. Two percent of the articles lack a specific country attribution, and one percent, whose recorded frequencies were very low, are categorized as "others."

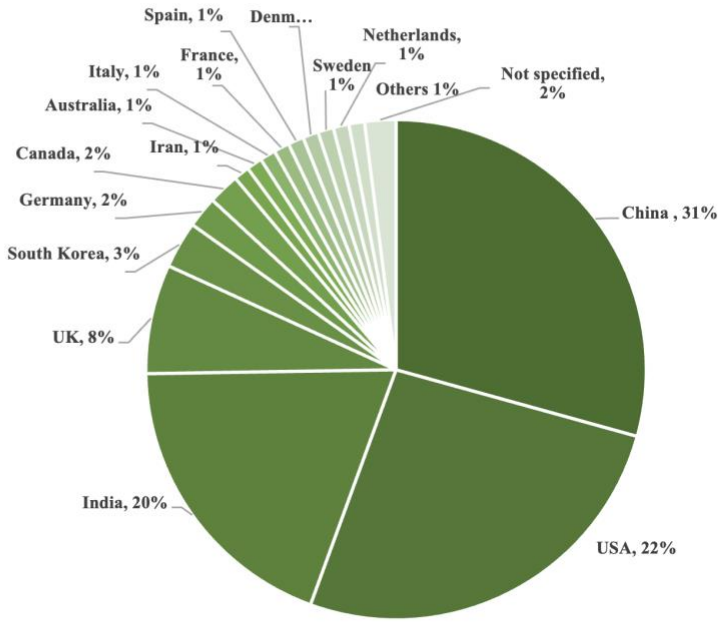

Figure 2.3 Distribution of Articles by Country of Origin

2.3.1.4 Based on Research Domain

The articles were categorized based on the research domain, as presented in Figure 2.4.

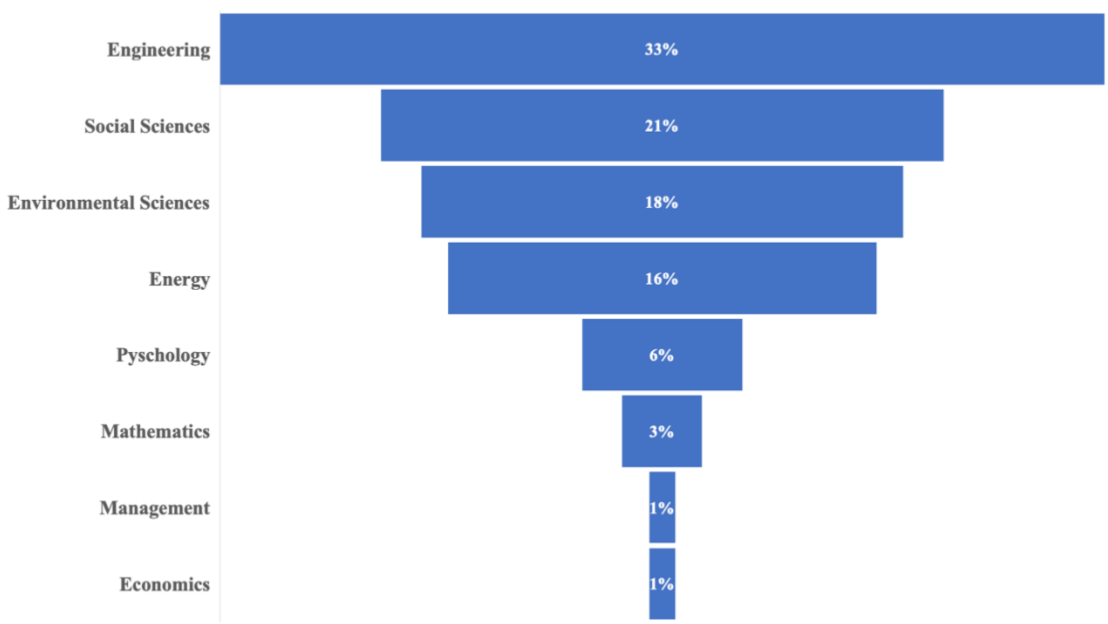

Figure 2.4 Distribution of Articles Based on Research Domain

Engineering has the highest percentage (33%), followed by the social sciences (21%), environmental sciences (18%), and energy (16%); the management and economics research domains recorded the lowest percentage (1%).

2.3.1.5 Based on Methodological Approach

The methodological approach of the articles was examined, and the results are presented in Figure 2.5. Several quantitative and qualitative techniques were utilized, either individually or in conjunction, to elicit the adoption behaviors of EVs. The qualitative research methods included literature reviews, interviews, and case studies. Quantitative research designs comprise various methods such as surveys, optimization techniques, simulations, etc. A survey-based methodology was used in 57% of the articles, followed by secondary data analysis (13%), and simulation (10%).

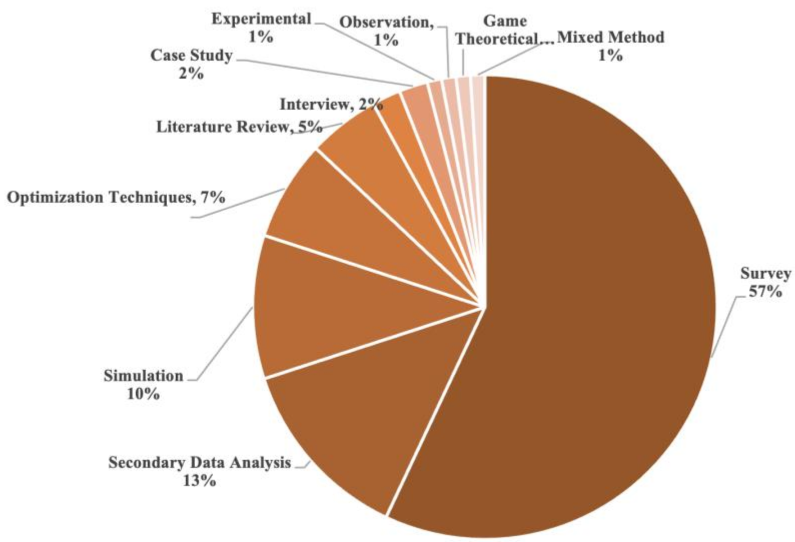

Figure 2.5 Distribution of Articles Based on Methodological Approach

2.4 Results

2.4.1 Factors Affecting the Consumers' Adoption of Electric Vehicles

The finalized database was carefully examined to identify the most influential factors on EV adoption. The factors were categorized, and the frequency of each variable was calculated based on their mention in the literature. The categories, factors, and frequency of being mentioned in the literature are discussed below.

2.4.1.1 Contextual Factors

Table 2. presents a list of the contextual factors. According to various studies conducted globally, an inadequate number of charging stations that reduce the users' flexibility and comfort is one of the primary barriers to consumers' electric vehicle adoption (Li et al., 2020; Ramesan et al., 2022; Ruoso & Ribeiro, 2022). This appears to be particularly true in China, India, and Norway (Li et al., 2020; Murugan & Marisamynathan, 2022a, 2022b). A few studies also found that the lack of sufficiently trained personnel at charging stations is an additional barrier in developing countries such as China (Goel et al., 2021; Ramesan et al., 2022; Stockkamp et al., 2021).

Table 2.2 List of contextual factors

Factor	#	Decision Variables	Classification	Frequency
Charging infrastructure	C1	Insufficient number of charging stations	Barrier	117
	C2	Lack of adequate staff at charging/service stations	Barrier	22
Policy incentives	C3	Purchase subsidies	Motivator	94
	C4	Tax exemptions for EV purchase and use	Motivator	77
	C5	Electricity subsidies	Motivator	53
	C6	Reduced costs for charging	Motivator	51
	C7	Free public parking lots	Motivator	38
	C8	Access to special lanes (bus/HOV lanes)	Motivator	23
	C9	License plate lottery policy	Motivator	19
	C10	Personal carbon trading policy	Motivator	12

According to research, most early adopters are in regions that offer attractive policy incentives (Haustein et al., 2021; She et al., 2017; Singh et al., 2020). As shown in Table 2.2, purchase subsidies are the most cited incentive in prior research, and in numerous countries, including the United States, China, Germany, Norway, Netherlands, and France, they are regarded as a highly influential factor in fostering consumer adoption (Ackaah et al., 2022; Hardman et al., 2017; Künle & Minke, 2022; Wang et al., 2018). Tax benefits (e.g., tax reduction for EV purchasers, road tax exemptions, exemptions from parking and toll fees, reduction in acquiring taxes and added-value taxes, and taxes on fossil fuels) appear to be the next most crucial factor in many countries for the widespread EV adoption (Habich-Sobiegalla et al., 2018; Jia & Chen, 2021; Kim et al., 2019; Lu et al., 2020; Xu et al., 2019). Xue et al., (2021) analyzed data on EVs' market share and policy incentives across 20 countries and found that tax exemption policies had a more significant influence on the consumer adoption of EVs than purchasing subsidies. EV adoption is also favorably correlated with the provision of electricity subsidies that reduce the operational costs of EVs (Anastasiadou & Gavanas, 2022; Mohammadzadeh et al., 2022; Ramesan et al., 2022).

Enhancing the advantages of using EVs was identified as an approach that might boost their appeal (Ma et al., 2017). Among these benefits are free and priority parking (Langbroek et al., 2016; Wolbertus et al., 2018), a decrease in the cost of charging (Rudolph, 2016; Shafiei et al., 2018), and entry to special lanes including bus and high occupancy vehicle lanes (Jenn et al., 2018; Melton et al., 2017; Mersky et al., 2016). A license plate lottery was shown to have a positive impact on the EV adoption (Peters et al., 2018; Zhuge et al., 2020), as it provides a specific number of vehicle purchase permits on yearly or monthly basis randomly or in accordance with a defined regulation to applicants who intend to acquire vehicles (Liu et al., 2020; Zhuge & Shao, 2019).

Lastly, although a personal carbon trading scheme, which levies a predetermined credit on carbon emissions and permits the exchange of unused credits, is referred to less frequently in the literature, it has been deemed effective (Li et al., 2018). Since EV adopters have a smaller carbon footprint, they spend fewer emission credits and can sell those they don't need (Li et al., 2019; Li et al., 2018).

2.4.1.2 Situational Factors

Multiple findings have uncovered the significance of environmental determinants in EV adoption (Biresselioglu et al., 2018; Xia et al., 2022). As shown in Table 2.3, a reduction in air pollution (e.g., greenhouse gases (GHG), CO_2, etc.) is the most frequently cited environmental factor that positively influences EV adoption (Lashari et al., 2021; Mandys, 2021; Tanwir & Hamzah, 2020; Xia et al., 2022). As EVs do not rely on fossil fuels for power and do not emit CO_2, they help reduce air pollution (Junquera et al., 2016). The next most frequently cited driver of EV adoption is a reduced energy consumption (Axsen & Sovacool, 2019; Degirmenci & Breitner, 2017; Globisch et al., 2018). Despite the significant number of researchers and articles that tout the environmental benefits of EVs, however, there are those who disparage their effectiveness (Liu et al., 2020; Ramesan et al., 2022) because of the pollution that is generated during electricity and battery production, and also due to the absence of recycling facilities for the discarded batteries (Ali & Naushad, 2022; Stockkamp et al., 2021).

Table 2.3 depicts the situational factors, including technological factors, that affect the EV adoption. The limited driving distance of EVs is one of the most frequently cited barriers to adoption by consumers (Krishnan & Koshy, 2021; Pradeep et al., 2021). Compared to conventional vehicles, most EVs have a shorter driving range, which can lead to concerns among consumers about the impact on their flexibility and the need to plan ahead for driving distances (Axsen et al., 2016; Barth et al., 2016; Coffman et al., 2017; Rezvani et al., 2015). The duration of the battery charging is the next most frequently cited barrier to adoption, as the process of charging an EV is more time-consuming compared to refueling a gasoline-powered vehicle (Dutta & Hwang, 2021; Hardman et al., 2016; Li et al., 2017). Two other consumer's concerns about EVs are their safety and reliability (Thananusak et al., 2017). She et al., (2017) conducted a study that revealed a considerable lack of trust in the reliability of EVs and concerns about their safety, most of which were related to the battery catching on fire in the event of an accident. In contrast, EVs' rapid initial acceleration is the most frequently cited motivating technological factor in the literature. According to findings of Burgess et al., (2013), the survey participants were overwhelmed by the fast acceleration of EVs. EVs exhibit higher acceleration at lower speeds and produce less noise compared to conventional vehicles, which was identified as a crucial factor in enhancing EV market share (Neves et al., 2019; Skippon, 2014). Moreover, Chen et al., (2020) espoused that ease of operation, low fuel economy, and smoother driving are the important factors enhancing EV adoption.

Table 2.3 List of situational factors

Factors	#	Decision Variables	Classification	Frequency
Environmental	S1	Reduced air pollution	Motivator	124
	S2	Reduced energy consumption	Motivator	81
	S3	Pollution from producing	Barrier	64
		batteries		39
	S4	Lack of battery recycling	Barrier	
		facilities		
Technological	S5	Limited driving range	Barrier	109
	S6	Longer charging time	Barrier	88
	S7	Fast initial acceleration	Motivator	54

	S8	High speed	Motivator	49
	S9	Less safety	Barrier	42
	S10	Low reliability	Barrier	42
	S11	Comfortable	Motivator	37
	S12	Less maintenance	Motivator	36
	S13	Low fuel economy	Motivator	32
	S14	Ease of operation	Motivator	25
	S15	Smoother to drive	Motivator	19
	S16	Low engine noise	Motivator	18
Economic	S17	High purchase cost	Barrier	83
	S18	Low fuel costs	Motivator	66
	S19	Low maintenance costs	Motivator	63
	S20	High battery replacement cost	Barrier	42
Marketing	S20	Informational campaigns	Motivator	39
	S21	Low quality of after-sales	Barrier	22
		service		19
	S22	Unavailability of EV models	Barrier	
		at dealerships		15
	S23	Consumers' lack of market	Barrier	
		knowledge		

Table 2.3 shows that the higher acquisition price of an EV is shown in various studies to be the strongest economic barrier to consumer adoption (Chhikara et al., 2021; Cui et al., 2021; Junquera et al., 2016; Rezvani et al., 2015; Sierzchula et al., 2014). While their lower fuel and maintenance costs (e.g., no oil change or air filter replacements) are drivers of adoption (Barth et al., 2016; Neves et al., 2019; Tamor et al., 2013), however, and render them potentially more cost competitive than traditional vehicles (Ystmark et al., 2016; (Biresselioglu et al., 2018). Lastly, the high battery replacement cost is a barrier to EV adoption, as many consumers fear that the expenses incurred in replacing batteries may surpass the benefits of lower operational costs and make the

purchase of an EV uneconomical (Kumar & Alok, 2020; Plötz et al., 2014; Stockkamp et al., 2021).

Marketing factors are illustrated in Table 2.3 as one of the situational factors that affect EV adoption. A considerable number of prospective purchasers exhibit inadequate knowledge regarding various models, their accessibility, and the ecological advantages of owning an electric vehicle. Lashari et al., (2021) highlighted the importance of informational campaigns as effective means of educating consumers about the EVs' benefits, which significantly fosters adoption. Broadbent et al., (2021) stressed the media's importance in disseminating relevant information. Recent studies have recognized the crucial influence of marketing agencies such as dealerships in promoting the purchase of environmentally friendly products (Krishnan & Koshy, 2021). Additionally, some research has indicated that dealers' lack of available EV models impacted their sales, as potential buyers were unable to view or test drive them, and the situation has been exacerbated by the waiting period of three to four months that is required to receive an EV after placing an order (Haustein et al., 2021; Huang & Ge, 2019).

2.4.1.3 Psychological Factors

Deciding whether to adopt an EV also depends on psychological factors (Barth et al., 2016; Schuitema et al., 2013), as they can either directly affect adoption intentions or mediate the objective factors (Lai et al., 2015). For instance, consumers' feelings about purchasing a vehicle usually take precedence over its cost. As presented in Table 2.4, numerous studies have shown that psychological characteristics are significant positive factors for EV adoption (Huang & Ge, 2019; Li et al., 2017).

Research on consumer adoption of EVs assumes that experience includes both knowledge and practical experience with EVs (Chu et al., 2019; Li et al., 2017; Singh et al., 2020); Table 2.4

shows that practical experience is the most frequently cited positive factor in the literature, as it improves consumers' comprehension and alter their stereotypical view of EVs. The perception of EVs among consumers tends to improve after experiencing them firsthand, particularly with regards to their acceleration, low noise emissions, and speed. Few studies employed an empirical approach to gather consumer data, assessing their practical experience by inquiring whether they had previously operated an electric vehicle. Singh et al., (2020) found that the accurate assessment and anticipation of buyers' intentions is contingent upon the appropriate consideration of their attitude.

Table 2.4 List of psychological factors

Factors	#	Decision Variables	Frequency
Experience	P1	Practical experience with driving EVs	54
	P2	EV-related knowledge	36
Attitudes	P3	Daily use of an EV	82
	P4	More environmental benefits	70
	P5	Less fuel consumption.	63
	P6	Necessary to society	29
	P7	Positive message to society	27
Perceived behavior control	P8	Affordability of EVs	35
	P9	Use of EVs in daily life	32
Social norms	P10	Influenced by family, co-workers, and neighbors	71
	P11	Peer pressure exerted by others	56
Personal moral norms	P12	Openness to new experience	59
	P13	Negative emotions	46
	P14	More efficient and self-disciplined	32
	P15	More outgoing and energetic	31
	P16	High motivation	24

Symbols	P17	Better self-image	52
	P18	Better social status	45
	P19	Pride	41
	P20	Feeling good about emission reduction contribution	27

Perceived behavior control (PBC) is defined as an individual's capacity to execute a behavior, determined by their internal and external resources. Xu et al., (2019) stated that PBC, not attitude, is the most robust predictor of adoption intention. A few studies demonstrated that customers are more likely to purchase an EV when they perceive them to be highly affordable and possess a sense of independence in the decision-making (Du et al., 2018; Liu et al., 2020; Pradeep et al., 2021).

Ackaah et al., (2022) defined "social norm" as the perceived social pressure that an individual experiences to involve in a specific behavior; other studies describe it as peer pressure and social influence (Adnan et al., 2018). Social influence is the most frequently cited factor, as illustrated in Table 4, as evidenced by car buyers showing pridefully off their purchases (Jansson, Pettersson, et al., 2017; Rezvani et al., 2015). Stockkamp et al., (2021) categorized societal influence into three distinct groups namely family, co-workers, and neighbors. Researchers have studied the variations among distinct groups and have found that the most significant impact on adoption behavior is wielded by neighbors, succeeded by family, and then colleagues. Many studies also revealed that peer groups' opinions have a significant impact on the adoption of EVs (Jansson, Nordlund, et al., 2017; Li et al., 2017).

Table 5 shows that an openness to new experiences is the most often mentioned factor in the literature. The findings of Rezvani et al., (2015) suggest that individuals who possess higher levels of personal moral norms exhibit a greater tendency to embrace electric vehicles. Irfan &

Ahmad, (2021) argue that openness (innovative, adventurous, and progressive); conscientiousness (self-disciplined, efficient); extraversion (outgoing, and energetic); and agreeableness (prosocial motivation, orientation) exhibit a positive influence on EV adoption, while neuroticism (negative emotions) has a negative influence. A higher degree of personal norms, with external costs positively influencing EV adoption (Adnan et al., 2018; Cui et al., 2021). The activation of personal norms pertaining to the environment leads to the development of personal moral responsibility, which in turn motivates individuals to involve in ecologically friendly actions (Li et al., 2020).

Many products have symbolic meanings that convey personal identity. The studies of Liu et al., (2021) and Rezvani et al., (2018) showed the influence of three categories of symbols on EV adoption: status symbols, environmental symbols, and innovation symbols. Status symbols such as self-image, social status, and pride represent the perceived social position conferred by the ownership of a luxury car. An environmental symbol, such as emission reduction, fosters a favorable perception of an individual as a protector of the environment, and an innovation symbol corresponds to being up to date (Hoang et al., 2022).

2.4.1.4 Demographic Factors

Extant literature considers demographic characteristics as distinguishing factors that can measure consumer adoption behavior. The demographic variables exhibit distinct characteristics contingent upon geographical location, cultural factors, and other country-specific circumstances. It is imperative to assess these variables to facilitate electric vehicle adoption in accordance with regional demands. Table 2.5 presents the demographic factors and the frequency with which they are cited.

Table 2.5 List of demographic factors

Factors	#	Decision Variables	Frequency
Individual	D1	Gender- predominantly male	168
	D2	Age – young and middle aged	161
	D3	Higher education	117
	D4	High-income group	110
Household	D5	Large household size	73
	D6	Live in multi-car households	56
	D7	Higher driving distances and frequencies	35
	D8	More years of having a driver's license	22
	D9	Home ownership	14
	D10	More household members with driving license	9

Table 2.5 shows that more literature focuses on individual factors such as age, gender, education, and occupation than on household factors. Gender differences get the largest share of attention, with the majority of the studies revealing that more males than females perceive the advantages of EVs (Ali & Naushad, 2022; Axsen et al., 2016; Axsen & Sovacool, 2019; Chen et al., 2020; Huang & Ge, 2019; Plötz et al., 2014; Sovacool et al., 2018; Zhang et al., 2011), which might be due to a higher propensity among men to exhibit interest in technological advancements (Axsen et al., 2016; Stockkamp et al., 2021). Very few studies revealed that women exhibit a greater inclination towards adopting EVs due to their heightened environmental consciousness (He et al., 2018; Shim et al., 2018). Age is the next most frequently cited factor in EV adoption, and according to the literature, young and middle-aged consumers exhibiting the significant intention to adopt such vehicles (Adnan et al., 2017; Anastasiadou & Gavanas, 2022; Axsen et al., 2016;

Chen et al., 2020; Huang & Ge, 2019; Kumar & Alok, 2020; Plötz et al., 2014; Sovacool et al., 2018); and Higgins et al., (2017) revealed that older consumers feel more comfort and familiarity with the conventional vehicles.

Table 2.5 also shows that income influences the adoption of EVs, as they are comparatively costlier than ICEs. Consequently, individuals with higher income levels have a greater intention to pay for EVs (He et al., 2018; Higgins et al., 2017; Plötz et al., 2014; Xue et al., 2021; Zhang et al., 2011). Education is another factor that was widely studied in relation to EV adoption, and the results of several studies have revealed a positive correlation between the level of education achieved and the EV adoption (Huang & Ge, 2019; Junquera et al., 2016). The literature shows that consumers with a higher education level exhibit a greater propensity to adopt electric vehicles (Alzahrani et al., 2019; Chu et al., 2019).

The most frequently cited household factor is the number of vehicles in a household, literature revealed that likelihood of adopting EVs is positively related to an increase in the household vehicles (Axsen et al., 2016; Chen et al., 2020; Cui et al., 2021). Family size is the next most frequently cited household factor in the literature, as the research revealed that the EV owners tend to reside in households with a greater number of occupants (Coffman et al., 2017; He et al., 2018; Rezvani et al., 2015). Possessing a driving license also has a positive influence on the inclination to acquire an EV (He et al., 2018; Sovacool et al., 2018), and Mukherjee & Ryan, (2020) espoused that homeowner, and medium- and long-distance commuters are likely to become early EV adopters.

2.5 Discussion and Policy Implications

An extensive literature review was performed to determine the factors affecting the adoption of electric vehicles, and the identified factors were classified into four categories. The frequency of each factor being cited in the literature was calculated within each category, and it was found that psychological and demographic factors have a positive influence on EV adoption, whereas the contextual and situational factors are contingent upon the consumers' inclination to modify their behavior, as well as the perceived usefulness and societal approval. Several policy implications were revealed regarding the adoption of EVs and are shown in Table 2.6.

Table 2.6 List of policy recommendations

Category	Stakeholders	Policy Recommendations
Contextual	Government, policymakers, and service providers	▪ Provide monetary and non-monetary incentives and implement government regulations ▪ Focus on new charging technologies like smart grid and vehicle-to-grid ▪ Diffuse rapid charging systems ▪ Improve investments in public charging infrastructure ▪ Facilitate domestic and workplace charging infrastructure options ▪ Standardize cost system at public charging stations
Situational	Government, energy providers, policymakers, Manufacturers, Marketers	▪ Switch electricity generation based on renewables ▪ Provide battery recycling facilities ▪ Concentrate on increasing functional characteristics like driving range and charging speed. ▪ Design EVs to enhance their safety and reliability. ▪ Focus on the reduction of total acquisition cost as perceived by prospective users ▪ Focus on improving battery technology and reducing associated costs ▪ Increase the number of EV models for viewing and test driving at dealerships ▪ Provide easy accessibility with no wait times for EV purchase

		▪ Focus on creating public awareness and imparting knowledge about EVs ▪ Focus on organizing events to showcase the environmental advantages of EVs
Psychological	Government, Manufacturers, Policymakers	▪ Focus on potential consumer's psychological attributes ▪ Initiate activities to enhance consumer's environmental consciousness and concern ▪ Consider consumer's diversity ▪ Eliminate potential risks associated with functionality, resale, maintenance, etc.
Demographic	Government, Manufacturers, Policymakers	▪ Focus on potential consumers with higher levels of income and education ▪ Target male young and middle-aged individuals as potential consumers ▪ Focus on homeowners, multi-car households, larger families, and medium and long-distance commuters

The most frequently cited factor in the literature's contextual category is the lack of an adequate charging infrastructure. Worldwide, the publicly available charging stations approached 1.8 million in 2021, and only one-third of them were fast chargers, which many recent studies have highlighted as important for highly populated and urban areas. As of 2021, China had the highest number of rapid charging stations, followed by Europe and the USA (IEA, 2020). Additionally, the presence of charging facilities at residence and workplace was also an important factor in enhancing charging infrastructure. Recent technological advancements such as smart grid and vehicle-to-grid have demonstrated the potential to enhance the charging infrastructure and subsequently augment the probability of EV adoption. In the same contextual category, policy incentives were found to be positively influencing EV adoption (Xia et al., 2022). Few countries including China, Europe, and the USA have experienced a significant increase in EV sales in recent times due to robust monetary and non-monetary incentives (Patyal et al., 2021). This sends an important message to governments and decision-makers that economics are important to consumers and that they need to develop policies that make purchasing EVs economically comparable or even better than traditional vehicles (Wolbertus et al., 2018).

In the situational category, the literature revealed that the environmental aspects of EVs act both as motivators and barriers to EV adoption and vary widely among countries. The greenhouse gas emissions of EVs vary between nations and is contingent on nature of energy used to fuel them. Industrialized nations like China and India utilize coal as their primary source of electricity production; therefore, growth in EV adoption may not result an overall reduction in GHG emissions (Lashari et al., 2021; Xue et al., 2021). The decarbonization of power generation sources is a crucial step for countries that rely primarily on coal-fired power plants to fully realize the advantages of electric vehicles. In addition, the incorporation of carbon labels has the potential to meet the demands of consumers, while the mitigation of battery pollution through battery recycling and the use of renewable energy sources could enhance the appeal of electric vehicles to prospective consumers (Irfan & Ahmad, 2021).

Technological factors exert the most significant impact on EV adoption, and major barriers in this category are their limited driving range and lengthy charging time. Recent literature has focused on the implementation of rapid charging stations to reduce the impact of charging time on adoption of EVs (Austmann, 2021). Thus, decision-makers should strive to reduce the anxiety issues related to these two barriers by offering options like rapid chargers, battery swapping stations, improving battery performance, etc. Manufacturers too must focus on improving the safety, reliability, and comfort of EVs (Brückmann et al., 2021).

The high acquisition price is a significant barrier to purchasing EVs, but their low operating and maintenance costs are assets. Therefore, government and policymakers should focus on reducing the total acquisition cost (Jaiswal et al., 2022). Lastly, marketing factors are the least studied factors in the situational category. For example, the lack of EV models at a dealership not only limits the chance for a potential customer to view and test drive the vehicle, but also establishes a knowledge gap. Thus, manufacturers should focus on increasing the range of EV models at dealerships, and marketers should focus on strategies to improve trust levels (Berkeley et al., 2018).

2.6 Conclusion

This study comprehensively reviewed the extant literature on the factors affecting consumers' adoption of EVs. A total of 63 factors influencing the adoption of electric vehicles were identified from the database. These factors were classified into four categories, which were further divided into 14 sub-categories. Reduction in air pollution is the most frequently cited motivator of EV adoption among all the identified factors. The consideration of environmental factors has a significant impact on the decision-making process regarding the acquisition of EVs, and it also has an indirect influence on the level of satisfaction experienced by buyers after the purchase. On the other hand, the high purchase price and limited driving range are significant barriers to EV adoption. Strategies must be promoted to reduce anxiety related to these two barriers by offering options like rapid chargers, battery swapping stations, and improving battery performance. It was also revealed that the consumer's socio-demographic and psychological characteristics positively impact buying or not buying an EV.

The widespread availability of EV technology and the development of charging infrastructure are expected to contribute to the growth of EV adoption. At present, the quantity of

EV charging stations is significantly limited. However, their availability is gradually increasing. Furthermore, facilitating transportation to and from these stations would offer an additional advantage. Professionals across multiple fields are currently exploring possible solutions for the inadequacies of battery packs while simultaneously seeking to enhance the driving range and reduce manufacturing costs. Such cost savings would subsequently be transferred to the end user. A substantial shift towards integrating EVs in personal and business transportation will likely occur upon achieving these objectives.

CHAPTER 3

BARRIERS TO THE ADOPTION OF ELECTRIC VEHICLES IN THE UNITED STATES

3.1 Abstract

Sustainable mobility options such as electric vehicles (EVs) have the potential to improve the quality of life for Americans as well as those in other countries, as they can enhance the quality of the air we breathe, while reducing greenhouse gases, fuel consumption, and the severe effects of global warming. Despite their many benefits, however, the demand for EVs remains low. This study purposes to determine the barriers that influence the EV adoption in the United States by conducting a literature search and developing and conducting an online questionnaire. Seventeen barriers were identified from the literature, and 733 responses were collected from participants in an online questionnaire. The responses were analyzed, and the findings revealed that the high acquisition price, high battery replacement cost, and the lack of public infrastructures for charging them were the primary concerns. The results also revealed that middle-aged men with high income and education are more enthusiastic about adopting EVs. The outcomes of this study may guide policymakers in crafting effective energy and transportation policies, as well as provide guidance to those who are responsible for designing EVs that fit the needs and demands of potential consumers.

Keywords: electric vehicle, consumer adoption, barriers, cluster analysis

3.2 Introduction

The transport sector contributes considerably to emissions and air pollution (Khan et al., 2021c). In addition, it utilizes roughly one-fourth of the global fossil fuel supply, the majority of which is used for road transportation (Gnann et al., 2018; Moeletsi, 2021; Etminani-Ghasrodashti et al., 2022c; Patel et al., 2023b). The 2020 International Energy Agency (IEA) report states that the transportation sector causes 24% of direct CO_2 emissions from fuel combustion. According to projections, this number will increase by up to 70% by 2050, assuming business as usual (IEA, 2020). These statistics demonstrate the necessity of devising a technology to reduce automobile CO_2 emissions (Adnan et al., 2018; Patel et al., 2022d; Khan et al., 2022b).

Electric vehicles (EVs) have been recognized as having the potential to substantially reduce reliance on fossil fuels, CO_2 emissions and various environmental concerns. There are a variety of EVs available, including hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), and battery electric vehicles (BEV) (Ghosh, 2020; Sanguesa et al., 2021; Stockkamp et al., 2021). By replacing fossil fuels with grid-based electricity, EVs offer significant economic and environmental advantages over traditional vehicles. They reduce greenhouse gas (GHG) and other emissions, improve reliability of energy, and enhance renewable energy use (Zhou et al., 2020).

Globally, electric vehicle sales raised by 14% in 2019, drawing the attention of the automotive sector. Europe's sales grew by 80%, Canada's by 43%, while sales in China and the United States remained constant. Other nations, such as Norway (39.5%) and the United Kingdom (1.94%), joined the trend and purchased more electric vehicles. The sales of EVs have experienced a substantial increase, reaching a record high of 6.6 million in 2021, which represents a doubling of the previous year's figures (Rietmann & Lieven, 2019). The market share of electrified auto sales in the global market witnessed a significant increase in 2021, reaching nearly 10%, which is four times higher than the market share recorded in 2019. According to (Patyal et al., 2021), the global count of electric vehicles reached approximately 16.5 million, indicating a threefold increase from 2018.

Despite the recent increase in the share of EVs in the United States, the nation continues to encounter challenges in promoting widespread EV adoption. Several studies attribute the massive adoption of electric vehicles to consumers' perceptions (Egbue & Long, 2012; She et al., 2017). Hence, comprehending the consumer perception of EVs and identifying the barriers impeding their purchase is of utmost significance. This study developed an online survey and distributed it to 10,000 active parking permit holders at the University of Texas at Arlington (UTA), asking them to indicate their level of importance with 17 identified barriers to EV adoption. The study involved a three-step process, which included: (1) the ranking of barriers and subsequent comparison of results with prior research; (2) the identification of homogenous groups of respondents through cluster analysis; and (3) the comparison of socio-economic groups of respondents through the use of a chi-squared test. The findings of this study can guide policymakers in crafting effective energy and transportation policies and guide those responsible for designing EVs that fit the needs and demands of potential consumers.

3.3 Background

The barriers to the acquisition of EVs were first investigated more than a decade ago when a few studies explored the opinions of manufacturers, investors, and public agencies to try to determine the barriers that hinder the adoption of sustainable transportation (Heidenreich & Kraemer, 2016; Nie et al., 2016). In addition, other studies have determined the barriers associated with consumers' EV adoption (Berkeley et al., 2018; Giansoldati et al., 2020; She et al., 2017). This study utilized the latter approach and focused on the consumer perspective to determine potential barriers to the adoption of EVs. Table 3.1 presents a list of the 17 barriers that were identified from the literature.

3.3.1 Technological Barrier

As demonstrated in Table 3.1. range limitation is one of the technological barriers to EV adoption. For an electric vehicle to operate, the batteries must be charged, and the battery's storage capacity determines the vehicle's range (Berkeley et al., 2018). Users whose daily activities require long-distance travel are less expected to adopt EVs (Quak et al., 2016).

Literature reveals that respondents in numerous studies are concerned about lengthy charging durations (Adhikari et al., 2020; Li et al., 2017). Charging was hampered by high charge times and a dearth of public charging stations, differences that were especially noticeable when comparing EVs and ICE vehicles (Noel et al., 2020).

Charged batteries power electric vehicles. The average warranty for an EV battery, which has been enhanced in recent years, now lasts between eight and ten years (Haddadian et al., 2015). After this period, the user is responsible for battery replacement. Additionally, the batteries are prone to overcharging, which is problematic for EV drivers (Noel et al., 2020).

EVs are recent technological advancements compared to traditional vehicles, and potential users often express apprehension regarding their safety and efficacy, increasing their reluctance to use EVs (She et al., 2017; Xue et al., 2014). Furthermore, users' perception of electric vehicles (EVs) is affected by their lack of reliability, while the expansion of EV deployment is significantly impeded by system instability. Thus, the insufficiency of evidence about reliability can be considered another technical barrier.

In addition, the fewer EV models pose a hindrance to widespread EV adoption. A wider range of vehicle models has the potential to attract a more diverse market segment (Linzenich et al., 2019). Thus, the limited availability of EV models presents an additional obstacle in restricting user options (Kongklaew et al., 2021). The electric vehicle manufacturing sector is accountable for conducting research, carrying out development activities, and producing electric vehicles. Nevertheless, EV production is typically limited (Xue et al., 2014).

Table 3.1 List of Barriers to EV Adoption

Category	Item	Possible Barrier	References
Technological barrier	B1	Limited driving range	(Berkeley et al., 2018; Singh et al., 2020)
	B2	Long charging times	(Adhikari et al., 2020; Li et al., 2017)
	B3	Limited battery life	(Noel et al., 2020)
	B4	Poor safety	(She et al., 2017)
	B5	Doubts about reliability	(Adhikari et al., 2020)
	B6	Fewer EV models	(Kongklaew et al., 2021)
Environmental barrier	B7	Problems of Battery disposal	(Berkeley et al., 2018)
	B8	Environmental impact of battery production	(Giansoldati et al., 2020)
Economic barrier	B9	High purchase price	(Noel et al., 2020)
	B10	High Battery replacement cost	(Kongklaew et al., 2021)
	B11	High electricity price for charging	(Kim et al., 2018)
	B12	Lower resale value	(Lim et al., 2015)
	B13	Adaptation cost of electrical system at home	(Patt et al., 2019)
Infrastructure barrier	B14	Insufficient public charging stations	(Kongklaew et al., 2021)
	B15	Charging problem in the absence of a garage	(Illmann & Kluge, 2020)
	B16	Insufficient maintenance and repair services	(Giansoldati et al., 2020)
	B17	Low Reliability of charging power grid	(Kumar & Alok, 2020)

3.3.2 Environmental Barrier

Despite the numerous environmental benefits that EVs provide, there exists a divergence of opinions regarding their environmental advantages, as evidenced by the studies conducted by (Liu et al., 2020; Ramesan et al., 2022). In addition, several studies have indicated that certain consumers harbor doubts regarding the capacity of electric vehicles to offer environmental protection. This phenomenon is attributed to the significant pollution generated during battery and electricity production and inadequate recycling infrastructure to dispose of old batteries (Ali & Naushad, 2022; Stockkamp et al., 2021).

3.3.3 Economic Barrier

Table 3.1. illustrates that the high purchase price of EVs is one of the economic barriers that hinder consumers from adopting them. The market price of EVs is high in comparison with traditional vehicles because of their higher production costs (Anastasiadou & Gavanas, 2022; Cherchi, 2017). According to (Noel et al., 2020), the increased cost of PHEVs can be attributed to their dual operational complexity. Additionally, the lower resale value of EVs poses a concern to individuals. The residual values of current EVs are comparatively lower than those of ICE alternatives due to lack of an established secondary resale or recycling market (Lim et al., 2015).

According to previous research, the battery cost accounts for a substantial portion of the total acquisition price of an EV (Berkeley et al., 2018; Stockkamp et al., 2021). As stated earlier, the lifespan of an EV battery is restricted to duration of eight to ten years, and the consumer is responsible for its replacement cost. Thus, it is a major barrier to EV adoption (Kongklaew et al., 2021).

EVs operate on electrical energy as opposed to conventional vehicles, which use gasoline or diesel. Considering that consumers are susceptible to the cost of fuel, an increase in the price of electricity decreases demand for EVs (Kim et al., 2018). The daily operational expenses of an EV are primarily influenced by the cost of electricity required for recharging. As a result, reduced electricity rates may serve as a motivating factor for prospective EV buyers to make a purchase.

As shown in Table 3.1, the cost of electrical system adaptation is the last barrier in this category. Literature indicates that people renting their homes or apartments must negotiate with the building owner to install a charging unit. This also necessitates an extensive electrical infrastructure upgrade, which incurs additional costs (Patt et al., 2019).

3.3.4 Infrastructure Barrier

The widespread adoption of EVs is contingent upon adequate charging stations. The limited number of charging infrastructure has been determined as a hindrance to consumers' acceptance of electric vehicles (Kongklaew et al., 2021; Singh et al., 2020). The reluctance of both private and public entities to allocate resources towards the establishment of charging stations can be attributed to the need to increase the number of EV drivers. Additionally, prospective EV drivers are hesitant to purchase the vehicle due to the inadequacy of charging infrastructure. Furthermore, the lack of a garage poses a challenge for individuals residing in apartments who wish to recharge their automobiles. (Illmann & Kluge, 2020).

The lack of support centers and facilities for EV repair and service compared to those available for conventional vehicles has caused dissatisfaction among existing EV owners. Furthermore, the procedures involved in repairing and maintaining electric vehicles can be intricate, and the availability of proficient mechanics to tackle such issues is limited. (Giansoldati et al., 2020).

3.4 Method

To determine the potential consumers' perceptions of EVs, a survey questionnaire was designed and conducted at the University of Texas at Arlington (UTA). The survey was distributed electronically in March 2023 to 10,000 students, faculty, and staff with active parking permits, using the online application QuestionPro. The survey consisted of 27 questions that were divided into two sections and required approximately 7 minutes to complete. Section 1 listed 17 barriers that were identified from the literature and asked the respondents to rate their importance, based on the five-point Likert scale. Section 2 asked questions about socio-demographics. Participants were also given an opportunity to express their concerns and preferences by responding to an open-ended question at the end of the survey. After sending two reminder emails, 1,219 responses were received, of which 776 were complete. The research team filtered the responses and removed those that were invalid based on two criteria: whether any values were missing and whether the questions were answered within a significantly larger- or smaller-than-average amount of time. The 733 valid responses that passed the criteria were used for the analysis.

Table 3.2 shows that 52.9% of the responses were from females, 44.3% from males, and 2.8% from those who identified as "Other." More than half (52.2%) of the respondents were above the age of 35 years, and approximately 62% held bachelor degrees, which made them better qualified to distinguish between the technological, financial, and environmental differences of EVs and ICEs (She et al., 2017). Only 17.6% of the participants were from households with an annual income of less than $35,000, 46.2% were from households with a median annual income between $35,000 to $99,999, and 36.2% were from households with an annual income of more than $100,000. More than half of the respondents had at least one vehicle, and 77% had more than five years of driving experience.

Table 3.2 Socio-Demographics of the Participants

Demographic	Item	Count	Percentage
Gender	Female	388	52.9%
	Male	325	44.3%
	Other	20	2.8%
Age	18-24	203	27.7%
	25-34	147	20.1%
	35-44	118	16.1%
	45-54	99	13.5%
	55-64	119	16.2%
	65+	47	6.4%
Education	High school/GED	53	7.2%
	Some college/technical school	137	18.7%
	Associate degree	94	12.8%
	Bachelor’s degree	153	20.9%
	Graduate degree	172	23.5%
	Ph.D. or other equivalent degree	124	16.9%
Household income	Less than $20,000	61	8.3%
	$20,000 - $34,999	68	9.3%
	$35,000 - $49,999	97	13.2%
	$50,000 - $74,999	118	16.1%
	$75,000 - $99,999	124	16.9%
	$100,000 or more	265	36.2%
Vehicle ownership	1vehicle	186	25.4%
	2 vehicles	314	42.8%
	3 or more vehicles	233	31.8%
Driving experience	0-3 years	80	10.9%
	3-5 years	89	12.1%
	Over 5 years	564	76.9%

3.5 Results and Discussion

3.5.1 Ranking of Barriers

Table 2.3 presents the rankings of the identified barriers and shows that the high purchase price (B10), insufficient public stations (B14), and high battery replacement cost (B11) were of most concern, resulting in a mean score of more than four. This demonstrates that most participants are worried about the EV price and charging facilities. The high purchase price ranked number one, which is consistent with most of the previous studies (Berkeley et al., 2018; Giansoldati et al., 2020; Noel et al., 2020). This underscores the significance of incentives and the need to minimize the ownership cost of EVs so that it is competitive with conventional equivalents on the US market (Liu et al., 2021; Parker et al., 2021). In our survey, the insufficient maintenance and repair service ranked higher than in those conducted by (Berkeley et al., 2018; Giansoldati et al., 2020), and adaption cost of setting up an electrical system at home ranked as another important barrier like the Switzerland case reported by (Patt et al., 2019).

Unlike many of the previous studies (Kongklaew et al., 2021; Noel et al., 2020; She et al., 2017), the respondents to our survey ranked the EV driving range and battery life quite low, which may be due to a proliferation in the battery's efficiency over a period of time. The barriers of charging problem due to lack of garage, and limited battery life are of less concern when compared to public charging infrastructure availability and battery replacement cost. To best of our knowledge, no study analyzed the barrier related to charging power grid reliability, which ranked 10 of 17 in our study. The responses about the environmental effect of battery manufacture and the difficulty of disposing of the battery revealed skepticism about the environmental benefits of EVs, which agreed with some of the literature. For instance, research by (Giansoldati et al., 2020; Zaunbrecher et al., 2015) ranked the environmental impact of manufacturing the battery and the difficulty of disposing of the battery 11th and 12th, respectively, out of the 17. Overall, however, our respondents appeared persuaded of the environmental advantages of swapping EVs for ICEs. The increasing proportion of renewable resources in electricity generation, as reported extensively in the digital networking platforms, and the technical advancements in battery reuse most certainly contributed to this outcome.

Table 3.3 Ranking of Barriers to EV Adoption

#	Barrier	Mean	Rank
B10	High purchase price	4.29	1
B14	Insufficient public charging stations	4.16	2
B11	High battery replacement cost	4.12	3
B16	Insufficient maintenance and repair services	3.99	4
B13	Adaptation cost of electrical system at home	3.93	5
B2	Long charging time	3.88	6
B1	Limited driving range	3.87	7
B15	Charging problem in the absence of a garage	3.87	8
B3	Limited battery life	3.85	9
B17	Low reliability of charging power grid	3.72	10
B8	Environmental impact of battery production	3.69	11
B7	Problems of battery disposal	3.50	12
B11	High electricity price for charging	3.45	13
B12	Lower Resale value	3.35	14
B6	Fewer EV models	3.23	15
B5	Doubts about reliability	2.83	16
B4	Poor safety	2.43	17

The two financial barriers including high electricity price for charging and lower resale value ranked almost similar to those of previous studies (Berkeley et al., 2018; Giansoldati et al., 2020).

The least scored barriers were poor safety and doubts about reliability which belong technological category. Majority of the respondents have not perceived these barriers as important, and their average score was below 3. This finding support previous results by (Berkeley et al., 2018) for UK, (Noel et al., 2020) for Denmark, and (Giansoldati et al., 2020) for Italy.

3.5.2 Identifying Homogenous Respondent Groups

Cluster analysis was adopted to identify the homogenous groups of respondents. A clustering technique was performed in two stages utilizing SPSS 29, with the 17 identified barriers as the clustering variables. The initial step involved the implementation of a hierarchical clustering methodology to generate viable clustering outcomes, utilizing Ward's linkage technique with agglomeration coefficient, as previously employed in a few scholarly investigations. (Jaiswal et al., 2022; Saleem et al., 2018). The outcome of the hierarchical analysis led to an assessment of the variance percentage in the heterogeneity-stopping rule, ultimately concluding that a 3-cluster solution was the most suitable. Subsequently, a K-means algorithm was employed to examine the membership of the clusters. Upon completion of the cluster analysis and attainment of an optimal cluster solution, an ANOVA was executed to ascertain the presence of statistically significant differences among the groups. The results indicate significant differences among the three groups for all the variables. Table 3.4 provides an overview of the three cluster memberships.

Table 3.4 Respondents Scores of Each Cluster

Barrier	**Cluster 1 (n_1=316)**	**Cluster 2 (n_2=93)**	**Cluster 3 (n_3=324)**	**Significance**
	Indifferents	Enthusiasts	Skeptics	
Limited driving range	3.79	2.14	4.45	<0.001
Long charging times	3.70	2.10	4.56	<0.001
Limited battery life	3.58	1.99	4.65	<0.001
Poor safety	2.10	1.57	2.99	<0.001

Doubts about reliability	2.35	1.74	3.60	<0.001
Fewer EV models	2.98	1.83	3.87	<0.001
Problems of Battery disposal	3.06	1.77	4.42	<0.001
Environmental impact of battery production	3.36	1.99	4.50	<0.001
High purchase price	4.21	2.99	4.74	<0.001
High Battery replacement cost	3.87	2.47	4.83	<0.001
High electricity price for charging	3.00	1.66	4.40	<0.001
Lower resale value	3.09	1.73	4.07	<0.001
Adaptation cost of electrical system at home	3.64	2.14	4.73	<0.001
Insufficient public charging stations	4.16	2.51	4.64	<0.001
Charging problem in the absence of a garage	3.68	2.12	4.56	<0.001
Insufficient maintenance and repair services	3.85	2.05	4.69	<0.001
Low Reliability of charging power grid	3.41	1.62	4.62	<0.001

Significant at $p<0.05$

Identifying the clusters based on demographic characteristics and using cross-tabulations of various demographic factors and segment memberships further enhanced our understanding of the clusters. The socio-demographic attributes of the respondents in each cluster are presented in Table 3.5. The cluster profiles are discussed below, based on the results from Table 3.4 and Table 3.5.

3.5.2.1 The Indifferents

The first cluster group, labeled the "Indifferents," was the second largest cluster, comprised of 316 respondents. Most of them indicated that they were neutral on all the barriers, except for poor safety (X= 2.10), doubts about reliability (X= 2.35), high purchase price (X=4.21), and insufficient public charging infrastructure (X= 4.16). Safety and reliability barriers were perceived to be less important in this cluster; the purchase price and lack of enough public charging stations were perceived to be more important.

Analysis of the demographic characteristics of this cluster showed that the proportion of male (49%) and female respondents (47.5%) was almost same, with most of them (53.8%) below the age of 34. The majority (23.7%) of them held a bachelor's degree; 23.4% held a graduate degree. Approximately 35.8% had an annual household income greater than $100,000, and 44.2% owned two vehicles. About 74.7% of them had more than five years of driving experience.

3.5.2.2 The Enthusiasts

The "Enthusiasts" were the smallest cluster, representing 12.7% of the respondents. This group has the lowest score on all the barriers as compared to other two groups. In addition, all these values are less than sample means, and they did not find any of the 17 barriers to be of importance. This indicates that the respondents in this cluster perceive EVs positively, and they tend to adopt EVs in future.

As shown in Table 3.5, the majority (58.1%) of the Enthusiasts were males, and 38.6% of them were between the ages of 45 and 64, which is higher than those in the other two clusters. Most of them held either a graduate or postgraduate degree (exceeding contribution of each of the other two clusters, and the total sample average) with the highest percentage (24.7%) holding a Ph.D. or other equivalent degree. Regarding income, the enthusiasts have the highest proportion of respondents in the highest income segment ($100,000 and more 46.2%). In addition, 45.2% of respondents own 2 vehicles, and 83.9% of them are experienced drivers

3.5.2.3 The Skeptics

The third cluster group labelled the “Skeptics.” was the largest group, representing 44.2% of the sample. They ranked all of the barriers high except poor safety, doubts about reliability, and fewer EV models. The mean values of this cluster were higher than those of the other two groups and higher than those of the sample means. This shows that the Skeptics considered almost all the identified barriers highly important and indicates their negative and unfavorable views towards adopting EVs.

Table 3.5 presents a sociodemographic profile of the Skeptics, which is primarily distinguished by the exceedingly larger percentage of females (62.6%) over males (35.8%) in comparison to other groups examined in the study. Based on income scale, the respondents in this cluster have relatively low income. In addition, in comparison with the other clusters, this group has lower proportion of graduates and post-graduates and has a greater number of beginners and intermediate drivers compared to other two clusters.

Table 3.5 Sociodemographic Characteristics Based on Individual Clusters

Demographic	**Item**	**Indifferents**	**Enthusiasts**	**Skeptics**
		n_1 = 43.1%	n_2 = 12.7%	n_3 = 44.2%
		%	**%**	**%**
Gender	Female	47.5%	37.6%	62.6%
	Male	49.0%	58.1%	35.8%
	Other	3.5%	4.3%	1.5%

Age	18-24	27.8%	21.6%	29.3%
	25-34	26.0%	21.6%	13.9%
	35-44	14.9%	13.9%	17.9%
	45-54	11.7%	19.3%	13.6%
	55-64	14.9%	19.3%	16.7%
	65+	4.7%	4.3%	8.6%
Education	High school/GED	8.6%	5.4%	6.5%
	Some college/technical school	15.6%	14.0%	23.1%
	Associate degree	10.7%	10.8%	15.4%
	Bachelor's degree	23.7%	14.0%	20.1%
	Graduate degree	23.4%	31.1%	21.3%
	Ph.D. or other equivalent degree	18.0%	24.7%	13.6%
Household income	Less than $20,000	10.4%	8.6%	6.2%
	$20,000 - $34,999	10.1%	4.3%	9.9%
	$35,000 - $49,999	13.0%	7.5%	15.1%
	$50,000 - $74,999	15.8%	15.1%	16.7%
	$75,000 - $99,999	14.9%	18.3%	18.5%
	$100,000 or more	35.8%	46.2%	33.7%
Vehicle ownership	1vehicle	30.1%	23.7%	21.3%
	2 vehicles	44.3%	45.2%	40.7%
	3 or more vehicles	25.6%	31.2%	38.0%
Driving experience	0-3 years	12.3%	7.5%	10.5%
	3-5 years	13.0%	8.6%	12.3%
	Over 5 years	74.7%	83.9%	77.2%

3.5.3 Barriers and Socio-economic Characteristics of Respondents

Respondents were classified by gender, age, education, income, vehicle ownership, and driving experience to determine whether individual characteristics substantially impact the public's views about purchasing an electric vehicle. Table 6 shows that each barrier was cross tabulated with each socio-economic characteristic to test the null hypothesis H_0 that the two variables X and Y are independent. This study employed a significance level of 5%.

As presented in Table 3.6, 10 of the 17 barriers exhibited statistically significant differences regarding gender. This demonstrates that females and males had distinctly different perspectives of most of the barriers, in line with literature (Giansoldati et al., 2020; Kongklaew et al., 2021). The data indicates that males exhibit a higher propensity to adopt electric vehicles, as compared to females, as the latter group expressed greater apprehension towards most of the barriers associated with EV adoption.

Statistically significant age group differences were observed for B3 (limited battery life), B5 (doubts about reliability), B6 (fewer EV models), and B15 (charging problem in the absence of garage). The age group of 18-24 years exhibited a greater level of concern towards the barriers. The findings indicate that individuals aged 45 and above exhibit comparatively lower mean scores, suggesting that middle-aged respondents are more inclined towards adopting electric vehicles.

The level of education attained by the respondents weighed heavily on the statistics pertaining to eight barriers: B3 (limited battery life), B7 (battery disposal problems), B8 (environmental impact of battery production), B9 (high purchase price), B11 (high electricity price for charging), B12 (resale value), B14 (insufficient public charging stations), B15 (charging problem in the absence of garage). Respondents possessing a higher level of education asserted that these barriers were not of great concern for EV adoption. This indicates that individuals with higher education levels showed the significant interest towards EV adoption.

The impact of household income was observed on 5 out of 17 barriers. Participants with an annual income exceeding $100,000 reported fewer concerns regarding economic factors, such as the high cost of purchase and battery replacement expenses. They also appeared less concerned with the charging problem in the absence of garage as majority of them might be homeowners.

As pertains to driving experience, Of the 17 barriers, only two, high charging time (B2) and poor safety (B4), were found to be statistically different among the three groups. The average score related to charging time, increased with the respondents' driving experience, which may be because it takes longer time to charge an EV than it takes to fill a conventional vehicle with gas. In addition, experienced drivers, were also more concerned about the safety of driving an EV.

Table 3.6 Summary of Respondents Personal Characteristics

Barrier	**Gender (df=8)**	**Age (df=20)**	**Education (df=20)**	**Income (df=20)**	**Vehicle Ownership (df=8)**	**Driving Experience (df=8)**
Limited driving range	**0.006***	0.685	0.483	0.134	**0.007***	0.075
Long charging times	**0.009***	0.114	0.051	0.209	0.053	**0.011***
Limited battery life	0.142	**0.040***	**0.002***	0.706	**0.022***	0.189
Poor safety	**<0.001***	0.102	0.164	**0.010***	0.406	**0.043***
Doubts about reliability	**<0.001***	**0.002***	0.320	**0.028***	0.213	0.213
Fewer EV models	0.291	**0.005***	0.723	0.338	**0.003***	0.682
Problems of Battery disposal	**0.045***	0.331	**<0.001***	0.495	**0.029***	0.304

Environmental impact of battery production	**0.002***	0.315	**0.017***	0.368	**0.019***	0.791
High purchase price	0.112	0.091	**0.023***	**0.028***	**0.020***	0.230
High Battery replacement cost	0.158	0.199	0.252	0.130	**0.007***	0.298
High electricity price for charging	<**0.001***	0.147	**0.011***	**0.023***	0.507	0.058
Lower resale value	0.020	0.108	**0.015***	0.277	0.391	0.553
Adaptation cost of electrical system at home	**<0.001***	0.086	0.189	0.106	0.273	0.113
Insufficient public charging stations	0.183	0.098	**0.026***	0.925	0.260	0.341
Charging problem in the absence of a garage	0.295	**<0.001***	**0.001***	**<0.001***	**0.020***	0.094
Insufficient maintenance and repair services	**0.004***	0.109	0.452	0.367	0.127	0.501
Low Reliability of charging power grid	**<0.001***	0.333	<0.001	0.131	**0.001***	0.721

*Refers to p value <0.05

3.6 Conclusion and Policy Implications

In this study, the barriers to EV adoption from the consumers' perspectives were explored by analyzing 733 responses to a survey conducted among students, faculty, and staff at the UTA. The results showed that of 17 identified barriers, 3 were considered the most critical: high purchase price, insufficient public charging stations, and the battery replacement cost. Unlike previously conducted studies, we found that the driving range facilitated by one charge was not of primary importance to our survey group. In addition, they felt that the adoption of EVs would lessen the environmental effects of conventional cars and appreciated the technological features that facilitate safety and reliability, which shows that few initial concerns regarding EVs have been alleviated. The respondents were, however, extremely sensitive to the availability of charging stations. Lastly, our study shows that the marketing of EVs should focus on male, middle-aged experienced drivers, as they show a strong interest and inclination to adopt one, and a concentrated effort should be made to increase the public's knowledge of the benefits of the EV technology.

The results of this study propose a series of enhancements that various stakeholders could implement to overcome some of the barriers to EV adoption. To avoid barriers related to high purchase price and battery replacement costs, possible incentive measures should include reducing the cost of ownership for EVs through purchase subsidies, specific battery subsidies, and subsidized battery replacement programs. Moreover, there exist significant infrastructure demands, including inadequate availability of charging stations on highways and unclear policies regarding parking charges at charging stations and residential complexes. To facilitate charging, policymakers must consider factors such as the quantity and placement of charging stations, as well as their distribution and accessibility. It is recommended that novel business models pertaining to charging infrastructure, such as public-private partnerships, be established and widely implemented to attract increased social funding.

The findings also suggest that the enthusiasts are more inclined to purchase EVs, as manufacturers could readily target them as early adopters using extrinsic incentive measures. In addition, this segment should be informed about the fundamental advantages of EVs, including savings on fuel cost and environmental conservation, through increased social persuasion and a positive attitude into using such vehicles. The findings also revealed that the indifferents are the second largest cluster, emerging with a neutral attitude of adopting EVs. This homogeneous cluster might be converted into potential EV adopters with convincing evidence demonstrating the significant benefits of EV use, including its affordability and environmental friendliness. Manufacturers should increasingly target young women as potential EV buyers considering this demographic.

The outcomes of this research will guide EV designers, manufacturers, marketers, and other stakeholders in their efforts to educate the public on the advantages of environmentally friendly mobility and influence their desire to own one.

A limitation of this study is that as EVs are a relatively new technology, it is possible that the respondents were familiar with them but lacked actual driving experience. After a test drive or gaining real-world experience, respondents may alter their opinions. A cross-country survey in major metropolitan cities is necessary to plan future EV adoption as a pilot area to foster EV adoption.

CHAPTER 4

EVALUATION OF THE BARRIERS TO ELECTRIC VEHICLE ADOPTION: A STUDY OF TECHNOLOGICAL, ENVIRONMENTAL, FINANCIAL, AND INFRASTRUCTURE FACTORS

Abstract

The ever-increasing concern over climate change is compelling global economies to employ alternative fuel technology to combat the vehicular emissions of greenhouse gases. Electric vehicles (EVs) offer a viable environmentally friendly alternative that has the potential to facilitate an effective shift towards a sustainable transportation system with low emissions while preserving environment; however, well-intentioned policies and other incentives have not been able to transcend the technological, infrastructure, and financial barriers that prevent their adoption. This study aims to develop a model that depicts the impact of the barriers on EV adoption. The model, developed and empirically validated with data collected from 733 respondents to a questionnaire survey, employed the structural equation modeling technique and revealed that of the four categories of barriers, only the environmental barriers are not significant. The outcomes of this study may aid policymakers in the development of effective transportation and energy policies and guide those responsible for designing EVs that fit the needs and demands of potential consumers.

Keywords: barriers, electric vehicle, adoption intention, confirmatory factor analysis, structural equation modeling

4.1 Introduction

The transportation sector is the second-largest carbon-emitting industry (Patel et al., 2023c). At present, it accounts for over 20% of the world's carbon emissions, and a recent study revealed that it will experience a 1.7% annual increase by the year 2030, due to the rising number of motor vehicles (Moeletsi, 2021). Most (74%) of these emissions are generated by vehicular traffic, which also seriously depletes energy resources and increases pollution (Ghosh, 2020; Stockkamp et al., 2021; Khan et al., 2022c, d).

Electric vehicles' (EVs') efficient operation and low environmental impact will make them a vital component of the automotive industry in the future, as they provide a way for economies to effectively address concerns related to energy, climate change, and the environment (Adnan et al., 2018). In addition, they offer a variety of models, such as hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs), that manufacturers are striving to make attractive to potential consumers (Gnann et al., 2018; Sanguesa et al., 2021).

Sales of electric vehicles increased globally by 14% in 2019, in Europe by 80%, in Canada by 43%, in Norway by 39.5%, and the United Kingdom by 1.94%, while in China and the United States, they remained constant (Rietmann and Lieven, 2019). In 2021, sales increased significantly, reaching a record high of 6.6 million, which was double the previous year's figures. The global market share also increased significantly in 2021, reaching nearly 10%, which is four times higher than the market share recorded in 2019. According to Patyal et al. (2021), the global count of EVs reached approximately 16.5 million, indicating a threefold increase from 2018.

Despite their advantages, however, consumers are still reluctant to transition from traditional automobiles to EVs (She et al., 2017). Hence, it is important to understand consumers' perceptions of EVs and identify the barriers to their purchasing them. This study aimed to accomplish both objectives by exploring the casual relationships among the barriers and investigating their impact. The outcomes of this study may aid policymakers in the development of effective transportation and energy policies and guide those responsible for designing EVs that fit the needs and demands of potential consumers.

4.2 Background

The barriers to the acquisition of EVs were first investigated more than a decade ago when a few studies explored the opinions of manufacturers, investors and public agencies to try to determine the barriers that impede the acquisition of sustainable transportation (Heidenreich, S., & Kraemer ; Nie et al., 2016). Moreover, few other studies were conducted on barriers associated with consumers' electric vehicle adoption (Berkeley et al. 2018; Giansoldati et al., 2020; Saleem et al., 2018). This study utilized the latter approach and focused on the consumer perspective to determine potential barriers to the adoption of EVs. Table 4.1 presents a list of the 17 barriers categorized into technological, environmental, financial, and infrastructure barriers that were identified from the literature and A hypothesis was formulated for each of the categories of barriers. Figure 1 illustrates the conceptual model developed for this study.

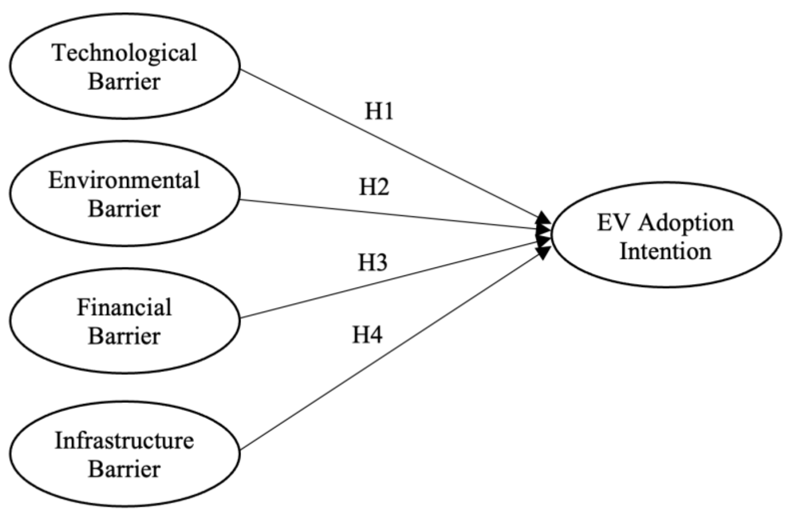

Figure 4.1 Conceptual Model for the Study

4.2.1 Technological Barriers

Table 4.1 demonstrates that one of the limitations of EVs is the distance that they can operate on a single battery charge (Berkeley et al., 2018), which means that those whose daily activities require long distance travel are less likely to adopt them. In addition, the average warranty for an

EV battery is only valid for eight to ten years (Haddadian et al., 2015), and as they are costly, the need for replacing them also constitutes a significant barrier. The literature reveals that potential consumers are also apprehensive about the duration of charging process for electric vehicles (Adhikari et al., 2020; Li et al., 2017), and the shortage of public charging stations (Noel et al., 2020).

Safety and reliability are also areas of concern for those who are considering purchasing an EV (She et al., 2017), and there is a lack of information on both. The limited number of models that are available is also an impediment to EV sales (Kongklaew et al., 2021), but while a wider variety of vehicles would attract a more diverse market segment (Ali and Naushad, 2021), EV production is typically limited. Therefore, this study assumed that

Hypothesis H1: Technological barriers have a significantly negative impact on adoption intention of EVs.

4.2.2 Environmental Barriers

The significant amount of pollution that is generated in producing the batteries and electricity necessary for EVs, as well as the lack of an adequate recycling infrastructure for the disposal of used batteries (Ali and Naushad, 2021). This have resulted in a divergence of opinions regarding their environmental advantages (Liu et al., 2020; Ramesan et al., 2022). Several studies have even demonstrated that consumers harbor doubts regarding the capacity of electric vehicles to offer any environmental protection. Therefore, this study hypothesized that:

Hypothesis H2: Environmental barriers have a significantly negative impact on adoption intention of EVs.

4.2.3 Financial Barriers

Table 4.1 illustrates that the cost and resale values of EV are major barriers to consumers purchasing them. The residual values of EVs are currently lower than conventional vehicles due to the lack of an established secondary resale or recycling market (Lim et al., 2015). It is also more costly to manufacture EVs (Anastasiadou and Gavans, 2022), and that additional cost is passed on to the consumers.

Previous research has found that the battery cost accounts for a substantial portion of the total acquisition price of an EV (Berkeley et al., 2018), and its lifespan is potentially eight to ten years. Thus, the battery cost is also a significant barrier to EV adoption (Kongklaew et al., 2021).

EVs operate on electrical energy; therefore, a hike in the price of electricity decreases the demand for EVs (Kim et al., 2018). It seems reasonable, therefore, to assume that reduced electricity rates could serve as a motivating factor for purchasing EVs.

The cost of converting an electrical system to one that provides a charging infrastructure for EVs is the last barrier in this category (Liu et al. 2021; Parker et al., 2021). The literature indicates that those who rent their homes have to negotiate with owners about this issue, and as it requires an extensive and costly electrical infrastructure upgrade (Patt et al., 2019), it can be a significant barrier to purchasing an EV. Therefore, this study hypothesized that

Hypothesis H3. The financial barriers have a significantly negative impact on adoption intention of EVs.

4.2.4 Infrastructure Barriers

The widespread adoption of EVs is contingent upon there being an adequate number of charging stations, and the limited number of them currently in existence is a hindrance to consumers' acceptance (Kongklaew et al., 2021). Both private and public entities are reluctant to allocate resources towards the establishment of charging stations, thus adding to the concern about the practicality of driving an EV. Furthermore, the lack of a garage poses a challenge for individuals residing in apartments who wish to recharge their automobiles (Illmann and Kluge, 2020).

The lack of support centers and facilities for EV maintenance and repairs as compared to those available for conventional vehicles causes dissatisfaction among existing EV owners. In addition, the procedures involved in repairing and maintaining electric vehicles can be intricate, and the availability of mechanics who are proficient in these skills is limited (Giansoldati et al., 2020). Therefore, this study assumed that

Hypothesis H4: Infrastructure barriers have a significantly negative impact on adoption intention of EVs.

Table 4.1 List of Identified Barriers

Category	**Item**	**Possible Barrier**	**References**
	B1	Limited driving range	(Singh et al., 2020)
	B2	Long charging times	(Adhikari et al., 2020)
	B3	Limited battery life	(Noel et al., 2020)
Technological barrier	B4	Poor safety	(She et al., 2017)
	B5	Doubts about reliability	(Adhikari et al., 2020)
	B6	Fewer EV models	(Kongklaew et al., 2021)
Environmental barrier	B7	Problems of Battery disposal	(Berkeley et al., 2018)
	B8	Environmental impact of battery production	(Giansoldati et al., 2020)
	B9	High purchase price	(Noel et al., 2020)
	B10	High Battery replacement cost	(Kongklaew et al., 2021)

Economic barrier	B11	High electricity price for charging	(Kim et al., 2018)
	B12	Lower resale value	(Lim et al., 2015)
	B13	Adaptation cost of electrical system at home	(Patt et al., 2019)
Infrastructure barrier	B14	Insufficient public charging stations	(Kongklaew et al., 2021)
	B15	Charging problem in the absence of a garage	(Illmann & Kluge, 2020)
	B16	Insufficient maintenance and repair services	(Giansoldati et al., 2020)
	B17	Low Reliability of charging power grid	(Kumar & Alok, 2020)

4.3 Method

An online survey questionnaire was developed and administered at the University of Texas at Arlington (UTA) to examine the hypothesis and evaluate the conceptual model. The electronic document distribution was subject to review and approval by UTA's Institutional Review Board (IRB). In March 2023, the document was disseminated to a population of 10,000 individuals consisting of students, faculty, and staff who were 18 or older and held active parking permits. The survey consisted of 27 questions that were divided into two sections and required approximately 7 minutes to complete. Section 1 listed 17 barriers that were identified from the literature and asked the survey participants to rate their importance, based on the five-point ordinal scale. Section 2 asked questions about socio-demographis. Participants were also given an opportunity to express their concerns and preferences by responding to an open-ended question at the end of the survey.

After sending two reminder emails, 780 responses were received. The research team filtered the responses and removed those that were invalid based on two criteria: whether any values were missing and whether the questions were answered within a significantly larger- or smaller-than-average amount of time. The 733 valid responses that passed the criteria were used for the analysis. The adequacy of the sample size, consisting of 733 participants, was determined based on the recommended criterion of having a minimum of 20 observations per item for conducting structural equation modeling (SEM) (Hair et al. 2015).

Table 4.2 shows that 52.9% of the responses were from females, 44.3% from males, and 2.8% from those who identified as "Other." More than half (52.2%) of the respondents were above the age of 35 years, and approximately 62% held bachelor's degrees, which made them better qualified to distinguish between the EVs and ICEs (She et al., 2017). Only 17.6% of the participants have an annual income below $35,000, 46.2% were from households with a median annual income between $35,000 to $99,999, and 36.2% have an annual household income greater than $100,000. More than half of the respondents had at least one vehicle, and 77% had more than five years of driving experience.

Table 4.2 Socio-Demographic Characteristics of the Survey Participants

Demographic	Item	Count	Percentage
Gender	Female	388	52.9%
	Male	325	44.3%
	Other	20	2.8%
Age	18-24	203	27.7%
	25-34	147	20.1%
	35-44	118	16.1%

	45-54	99	13.5%
	55-64	119	16.2%
	65+	47	6.4%
Education	High school/GED	53	7.2%
	Some college/technical school	137	18.7%
	Associate degree	94	12.8%
	Bachelor’s degree	153	20.9%
	Graduate degree	172	23.5%
	Ph.D. or other equivalent degree	124	16.9%
Household income	Less than $20,000	61	8.3%
	$20,000 - $34,999	68	9.3%
	$35,000 - $49,999	97	13.2%
	$50,000 - $74,999	118	16.1%
	$75,000 - $99,999	124	16.9%
	$100,000 or more	265	36.2%
Vehicle ownership	1vehicle	186	25.4%
	2 vehicles	314	42.8%
	3 or more vehicles	233	31.8%
Driving experience	0-3 years	80	10.9%
	3-5 years	89	12.1%
	Over 5 years	564	76.9%

4.3.1 Model Development

The model development process consists of a measurement model, and a structural model. The measurement model specifies the interrelationships among variables, whereas the structural model is used to examine the causal relationships between the factors (Safapour et al., 2019; Nipa and Kermanshachi 2022; Rouhanizadeh and Kermanshachi 2022a). Based on the survey responses, the confirmatory factor analysis (CFA) was developed and verified, and then the structural model was developed.

CFA is frequently employed in the initial phase of the SEM process to evaluate the interconnected nature of a group of factors and to assess the degree to which a given dataset conforms to a causal model (Rouhanizadeh and Kermanshachi 2021; Nipa et al., 2023). Researchers frequently utilize this method to authenticate their comprehension of the interconnections among diverse variables in a proposed framework (Fung et al., 2020). In the context of CFA, Asymptotically Distribution Free (ADF), and Maximum Likelihood (ML) are parameters that are commonly employed (Asun et al., 2016).

SEM is a statistical method that analyses latent factors and is recognized for its flexibility in examining the direct, indirect, and interactive relationships among complex, interrelated variables (Shaheen et al., 2017; Rouhanizadeh and Kermanshachi 2022b, c). The methodology above involves the integration of multivariate statistical models and algorithms to examine the structural relationships and evaluate latent constructs within a given dataset. In order to conduct SEM, it is necessary to specify the endogenous and exogenous variables (Bentler, 2006). Exogenous variables are identifiable and independent, whereas endogenous variables are latent and lack a self-contained metric. In this research, all the identified barriers to EV adoption are exogenous variables, based on the scores provided by survey respondents. While the four categories are regarded as endogenous variables due to their unobservable nature and reliance on the barriers. The subsequent section outlines the procedure for developing the model.

4.4 Results

4.4.1 Measurement Model

Before conducting the CFA, the researchers evaluated the possibility for common method bias. This was necessary because the data was collected from a single source and relied on survey questionnaire. The Harman's single-factor test was utilized, and all 20 items were loaded on one latent construct. The result revealed that multiple constructs were extracted with eigen values exceeding 1 which collectively accounted for 69.461% of the cumulative variance. The first factor constituted for only 33.237% of the variance, which fell short of the established value of 50% (Harman, 1976), indicating the absence of common method bias in the data (Podsakoff et al., 2003).

Next, CFA was conducted utilizing AMOS software to measure the validity and reliability of the construct for which the loadings of all factors were acquired. As per for the findings of Hair et al. (2006), items with loadings equal to or exceeding 0.5 are deemed significant and can be considered a reliable variable that accounts for a substantial percentage of the variance in the corresponding latent variable. When the loading is less than 0.5, they recommend that the item be dropped and Two items of the technological construct (TB5, and TB6) were dropped. Table 3 presents the results of measurement model.

The internal consistency of the items for each latent variable was assessed using Cronbach's α coefficient, while the reliability of the latent variables was evaluated using the measure of composite reliability (CR). As presented in Table 4.3, the alpha value of all the latent variables are above the acceptable value of 0.70, which suggests that the constructs are reliable (Nunnally and

Bernstein, 1978). Likewise, the composite reliability values of all the latent variables surpassed the acceptable value of 0.70, confirming their reliability (Hair et al., 2015).

Table 4.3 Results of Measurement Model

Latent Variable	Item	Loadings	Cronbach's alpha	AVE	CR
Technological	TB1	0.823	0.772	0.670	0.890
	TB2	0.880			
	TB3	0.800			
	TB4	0.767			
Environmental	EB1	0.905	0.880	0.788	0.882
	EB2	0.871			
Financial	FB1	0.709	0.823	0.578	0.873
	FB2	0.745			
	FB3	0.804			
	FB4	0.786			
	FB5	0.755			
Infrastructure	IB1	0.838	0.827	0.596	0.854
	IB2	0.797			
	IB3	0.647			
	IB4	0.794			
EV Adoption intention	INT1	0.825	0.903	0.797	0.922
	INT2	0.948			
	INT3	0.902			

The validity of the latent variables was scrutinized to verify if the measurement items accurately represented the latent variables. According to the guidelines established by Fornell and Larcker (1981), the convergent validity of all the latent variables was evaluated by using loadings and average variance (AVE). The resulting AVE values, which ranged from 0.578 to 0.797, exceeded the acceptable value of 0.50, which is deemed acceptable in the relevant literature.

4.4.2 SEM Model

An SEM model generated through AMOS, using the maximum likelihood estimate, was employed to test the relationships, and Table 4.4 shows that the model fit was found to be satisfactory. In addition, the squared multiple correlation (R^2) for EV adoption intention was found to be 0.413, which shows that the 41.3% variance in EV adoption intention is jointly accounted by all the predictor variables.

Table 4.4 Results of Goodness-of-Fit Statistics of Model

Fit Statistic	Observed Value	Recommended Value (Hair et al. 2015)	Fit
CMIN/DF	2.108	>1 and <5	Good fit
RMSEA	0.063	<0.08	Good fit
IFI	0.950	>0.90	Good fit
GFI	0.936	>0.90	Good fit
NFI	0.946	>0.90	Good fit
CFI	0.950	>0.90	Good fit
AGFI	0.904	>0.90	Good fit

After obtaining the satisfactory results of the structural model's fit, the hypothesis was examined to determine the variables' impact. As presented in Table 4.5, the results of the full structural model were assessed by utilizing the p-value and standard coefficient. The findings indicate that the financial barrier (H_3; β = -0.749, p =0.001) had the most significantly negative impact on EV adoption intention followed by infrastructure barrier (H_4; β = -0.401, p =0.021) and technological barrier (H_1; β = -0.360, p =0.030). On the other hand, the study revealed a positive yet statistically insignificant correlation between environmental barriers and the dependent variable. Consequently, the results demonstrated that all the hypotheses were supported ($H_{1,}$ $H_{3,}$ H_5), except the H_2 that was not supported.

Table 4.5 Results of Structural Model

Hypothesis	Path	Standard Coefficient (β)	p-value	Supported
H1	INT <---TB	-0.360	0.030*	Yes
H2	INT <--- EB	0.099	0.159	No
H3	INT <--- FB	-0.749	0.001*	Yes
H4	INT <--- IB	-0.401	0.021*	Yes

*p-value <0.05

4.5 Discussion

Table 4.5 shows that the model confirmed the first hypothesis that technological barriers have a significantly negative influence on consumers' willingness to adopt EVs. In other words, the survey respondents who consider technological barriers important are less likely to adopt EVs. Most of the population, exhibit a greater aversion to risk and are disinclined to acquire innovative products that deviate significantly from their accustomed choices. As per the outcomes of the measurement model, the limited driving range and long charging times obtained loadings of 0.823 and 0.880, respectively, making them important components of technological barriers. Thus, decision-makers should strive to reduce the anxiety issues related to these two barriers by offering options like rapid chargers, battery swapping stations, improving battery performance, etc.

The structural model does not confirm the hypothesis that environmental barriers significantly negatively impact the intention to adopt EVs. The results indicated no significant correlation between the environmental barrier and EV adoption intention. The survey participants exhibit a lack of apprehension towards environmental barriers, potentially due to their strong conviction regarding the ecological advantages of replacing conventional gasoline-powered vehicles with electric cars. The rise in the proportion of renewable resources in the electricity mix, as widely reported on social media, and advancements in battery reutilization technology are possible factors contributing to this outcome.

The model supports the hypothesis that financial barriers significantly negatively influence the intention to adopt EVs. Respondents who prioritize financial barriers tend to exhibit price sensitivity when considering the adoption of EVs. The cost of EVs typically exceeds that of traditional gasoline-powered vehicles, rendering price a crucial determinant for potential or recent customers in adopting novel fuel-efficient automobiles. Hence, the government and policymakers must prioritize the reduction of the overall acquisition cost.

The model supports the hypothesis that infrastructure barriers significantly negatively impact the intention to adopt EVs. The highest factor loading of 0.838 in the measurement model suggests that the insufficiency of public charging infrastructure could account for this issue. The aggregate quantity of charging stations within the United States is presently limited to 50,000. Insufficient charging infrastructure diminishes the adaptability and convenience for users, thereby diminishing the appeal of operating electric vehicles.

4.6 Conclusion

This study surveyed 733 potential consumers to investigate the EV adoption barriers from the perspective of consumers. Although most respondents would like to see more EVs on the road, their current enthusiasm for EVs is quite less, which is in line with literature. The results revealed that the survey participants were hesitant to purchase EVs for many reasons, and many of them had a wait-and-watch approach to EV adoption, with financial, technological, and infrastructure barriers providing significant impediments to EV adoption. On the other hand, the respondents are not concerned about environmental barriers potentially due to their strong conviction regarding the ecological advantages of replacing conventional gasoline-powered vehicles with electric cars. The outcomes of this study will guide EV designers, manufacturers, marketers, and other entities in their efforts to educate the public on the advantages of environmentally friendly mobility and influence their desire to own one.

The findings of this research led to an understanding that stakeholders could initiate changes to EVs that would help overcome some of the adoption barriers and increase their attractiveness to consumers. Incentives to reduce the cost of EV ownership could be made available through purchase subsidies for EVs and batteries, and subsidized battery replacement programs could be initiated. The infrastructure demands, including those for charging stations on highways, homes, and rental properties, could be met by well-designed policies that govern their quantity, distribution, placement, parking charges, and accessibility. It is recommended that novel business models pertaining to charging infrastructure, such as collaborations between the public and private sectors, be established and widely implemented to attract increased social funding.

There are a few limitations in this study. The variable examined in this research is the intention to adopt electric vehicles rather than their actual behavior. While behavioral intention may closely associate with actual behavior, the research outcomes are likely more satisfactory when the dependent variable is the actual behavior. Therefore, future studies could explore the adoption of electric vehicles by utilizing factual purchase behavior as the dependent variable in the research framework. Furthermore, our research encompasses all types of electric vehicles, implying that the outcomes may differ based on whether the automobile is fully electric or hybrid. Henceforth, future studies could distinguish between various types of electric vehicles and conduct comparative analyses of the outcomes. Finally, the findings of our study may have limited generalizability beyond the United States, given that the data were exclusively gathered within this geographical context. The potential for variation in research outcomes exists when applying findings to different nations due to inherent national differences.

CHAPTER 5

AN EMPIRICAL STUDY OF CONSUMERS' INTENTION TO ADOPT ELECTRIC VEHICLES: AN EXTENDED TECHNOLOGY ACCEPTANCE MODEL

Abstract

Electric vehicles (EVs) are widely recognized as a highly promising green technology for mitigating carbon dioxide emissions and reducing energy usage within the transportation industry. So, it is imperative to comprehend and investigate the factors that impact consumers' propensity to promote such vehicles. Therefore, this study aims to explore the integrative approach of personality-beliefs-intention using extended technology acceptance model to understand consumers' intention to adopt EVs. The structural equation modeling technique was employed based on the survey data collected from 743 potential consumers. The results revealed that perceived ease of use, personal innovativeness and perceived usefulness have a significant and positive correlation with consumers' adoption intention for EVs, while perceived risk have a negative impact on the perceived usefulness and adoption intention of EVs. Additionally, consumers' personal innovativeness positively influences perceived ease of use and usefulness, and negatively influences perceived risk. Furthermore, the results also reveal that perceived usefulness, perceived risk, and perceived ease of use, partially mediate the effect of personal innovativeness on the EV adoption intention. The outcomes of this study provide a more profound understanding for policymakers and marketers regarding the promotion of EVs within the realm of further research on sustainable mobility.

Keywords: Electric vehicles; adoption intention; technology acceptance model; personal innovativeness; perceived ease of use; perceived risk; perceived usefulness

5.1 Introduction

Transport emissions experienced a notable increase at an average annual rate of 1.7% from 1990 to 2022, surpassing the growth rates observed in all other sectors of energy consumption (atel et al., 2023e). Currently, this sector constitutes to around 25% of worldwide carbon dioxide emissions, and it is estimated to rise to 50% by the year 2030 (IEA 2022). Electric vehicles (EVs), which are being recognized as an ecologically friendly advancement, are expected to serve as a viable and viable resolution for the worldwide predicaments of energy insufficiency and environmental pollution (Ali & Naushad, 2022; Feng et al., 2022). The utilization of advanced battery technology has been instrumental in the advancement of EVs, thereby positioning them as technology-driven products (Tu & Yang, 2019). Literature has indicated that EVs have the potential to reduce carbon emissions by approximately 30-50% and enhance fuel efficiency by around 40-60% in comparison to conventional vehicles (Higueras-Castillo et al., 2020; Jaiswal, Kant, et al., 2022).

Globally, electric vehicle sales increased by 14% in 2019, drawing the attention of the automotive sector. Europe's sales grew by 80%, Canada's by 43%, while sales in the United States and China remained constant. Other nations, such as Norway (39.5%) and the United Kingdom (1.94%), joined the trend and purchased more electric vehicles. The sales of electric vehicles (EVs) have experienced a significant increase, reaching a record high of 6.6 million in 2021, which represents a doubling of the previous year's figures. The share of electrified auto sales in the global market witnessed a significant increase in 2021, reaching nearly 10%, which is fourfold greater than the market share recorded in 2019. According to (Patyal et al., 2021), the global count of EVs reached approximately 16.5 million, indicating a threefold increase from 2018.

Since the use of EVs has persistently growing over the past few years, researchers have acknowledged the necessity of comprehensively addressing pertinent issues by utilizing the Technology Acceptance Model (TAM). Furthermore, to facilitate the widespread acceptance of EVs, it is crucial to ascertain the factors that impact consumer preferences regarding the acquisition of EVs (Jaiswal et al., 2021; Singh et al., 2020). According to existing literature, hardly any research has been identified that specifically investigates the TAM and its extension, which include measures of negative and positive beliefs, to comprehend the consumers' adoption intention of EVs within the context of the American mobility market. Currently, there is a dearth of research that explicitly examined the role of personality on EV adoption behavior. Therefore, considering the existing body of research on EV adoption intention, this research developed a framework that integrates consumer personality and beliefs to thoroughly understanding the factors that influence the EV adoption behavior. We aimed to answer (1) To what extent do consumer beliefs influence the intention to adopt EVs? (2) How does consumer disposition influence their perceived beliefs and intent to adopt EVs? This comprehensive theoretical framework has the potential to enhance the research on the EVs, specifically focusing on consumers' acceptance of technology.

5.2 Theoretical Background, Research Model, and Hypothesis

The TAM, which was initially formulated by Davis (1989), is a frequently employed theoretical framework in academic research. It serves as a tool for understanding the psychological determinants that impact individuals' inclination to embrace novel technologies or products. As a result, scholars have employed the core constructs of the extended TAM, including, perceived ease of use, perceived usefulness, and perceived risk, in combination with measures linked to the other theories (Haustein and Jensen, 2018; Eccarius and Lu, 2020). Furthermore, other researchers have included additional variables like ecological consciousness (Wu et al., 2019), knowledge regarding electric vehicles (Jaiswal et al., 2021), and policy incentives (Wang et al., 2018), among other things, to predict the intention to use EVs. The discourse offered centers on the conceptual framework that covers perceived usefulness, personal innovativeness, perceived ease of use, and perceived risk. These variables have been incorporated to examine the effects on customers' propensity to embrace EVs. Figure 1 illustrates the "personality-beliefs-intention" framework adopted in this research.

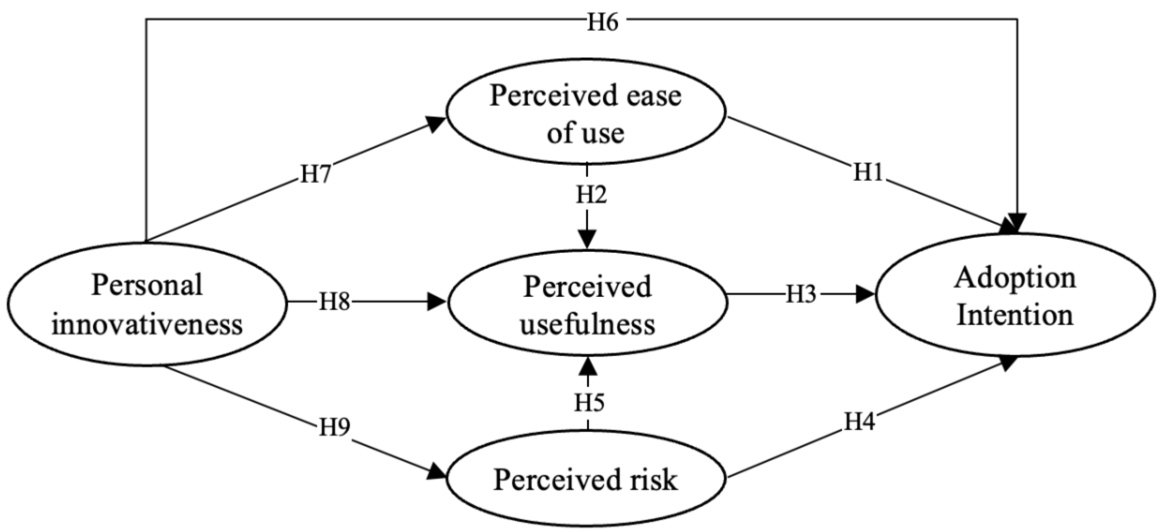

Figure 5.1 Conceptual Model

5.2.1 Perceived Ease of Use

The perceived ease of use denotes the arbitrary assessment of consumers' regarding the likelihood that utilizing a precise technology is likely to be effortless and free of both psychological and physical strain (Jaiswal et al., 2021). The better the perceived user-friendliness of a new product/technology, the higher the likelihood that consumers will demonstrate their inclination to adopt it. In the realm of EVs, the concept of perceived ease of use pertains to the extent that a consumer holds the belief that operating an EV is not excessively challenging. Furthermore, few scholars described that the perceived ease of use positively impact the perceived usefulness (Cheng et al., 2019; Wang et al., 2020). Consequently, new technologies are deemed beneficial solely if individuals perceive them to be user-friendly and convenient. This indicates that individuals demonstrate a willingness to embrace EVs when they perceive them easy to operate, and accompanied zero carbon emissions, fuel efficiency, and cost savings, etc. Accordingly, this study hypothesized that,

Hypothesis H1. Perceived ease of use has a significant and positive impact on consumers' adoption intention of EVs

Hypothesis H2. Perceived ease of use has a significant and positive impact on consumers' perceived usefulness

5.2.2 Perceived Usefulness

Perceived usefulness pertains to the degree to which the use of a specific technology may be advantageous and supportive in enhancing the performance of products. Consequently, it has an impact on users' favorable attitudes towards novel technology or innovative products, as well as their intention to utilize them (Kim et al., 2018; Wu et al., 2019). In light of the adoption of EVs as environmentally friendly modes of transportation, an interpersonal assessment of perceived usefulness encompasses few fundamental characteristics: The utilization of EVs has proven to be advantageous in mitigating carbon dioxide emissions and regulating the consumption of petrol. Additionally, EVs offer benefits such as reducing household expenses related to transportation and enhancing the overall quality of health, particularly in terms of respiratory well-being by safeguarding against air pollution. Thus, it is assumed that

Hypothesis H3. Perceived usefulness has a significant positive impact on consumers' intention to adopt EVs

5.2.3 Perceived Risk

Perceived risk pertains to the negative state of mind experienced by consumers when considering the adoption of innovative technologies (Featherman et al., 2021). It is characterized by users' subjective assessment of ambiguity or anxiety including concerns about the required financial investment, and feelings of inconvenience stemming from limitations in driving range, charging infrastructure, etc. Therefore, this can potentially influence their choice concerning the adoption of EVs. Additionally, the perceived risk can act as a deterrent to individuals' positive beliefs regarding the usefulness of EVs and their associated benefits, thereby reducing their trust in and preference for these vehicles. Hence, the concept of perceived risk holds significant importance as a variable that poses obstacles, thereby leading to a decrease in consumers' confidence when it comes to accepting EVs (Kumar and Alok, 2020). As a result, this could have a negative impact on consumers' confidence in the efficacy of EVs and their willingness to choose them in the immediate future (Cheng et al., 2019; Wang et al., 2018). Moreover, existing research provides evidence that individuals who lack comfort with technology may experience a detrimental impact on their perceived ease of use and usefulness of EVs (Jaiswal, Deshmukh, et al., 2022; Wang et al., 2020). Therefore, it is hypothesized that

Hypothesis H4. Perceived risk has a negative significant impact on consumers’ adoption intention of EVs

Hypothesis H5. Perceived risk has a negative significant impact on consumers’ perceived usefulness

5.2.4 Personal Innovativeness

Personal innovativeness can be conceptualized as an consumer’s disposition to adopt novel technologies/products at an earlier stage compared to their peers (Rogers Everett, 1995). The level of personal innovativeness has a crucial role in forecasting consumers' inclination to embrace novel technologies (He et al., 2018). Moreover, the incorporation of technological advancements, including wireless connectivity (Parveen & Sulaiman, 2008), mobile learning (Liu et al., 2010), and smartphone payments (Thakur & Srivastava, 2014), is positively influenced by an individual's level of personal innovativeness. Therefore, EVs as a novel form of transportation technology have the potential to captivate the interest of innovative individuals and fulfil their psychological need for exploration and inquisitiveness. According to He et al. (2018) study, individuals who choose to adopt EVs demonstrate a greater degree of innovativeness compared to those who do not adopt EVs.

Additionally, Wang et al. (2020) studied that personal innovativeness has a direct impact on a consumer's subjective perception of new technology, specifically focusing on perceived ease of use and perceived usefulness. In contrast, research has shown that individuals who possess a high level of personal innovativeness tend to exhibit a greater inclination towards risk-taking behavior (He et al., 2018). This suggests that they have a higher capacity to tolerate and embrace risks compared to individuals with lower levels of personal innovativeness. In context of EVs, individuals characterized with high innovativeness have the potential to mitigate the risks associated with adopting these vehicles, such as the phenomenon of range anxiety caused by the limited distance that can be travelled on a single charge and the insufficient availability of charging infrastructure. Therefore, it is assumed that

Hypothesis H6. Perceived innovativeness has a significant positive impact on consumers' adoption intention of EVs

Hypothesis H7. Perceived innovativeness has a significant positive impact on consumers' perceived ease of use

Hypothesis H8. Perceived innovativeness has a significant positive impact on consumers' perceived usefulness

Hypothesis H9. Perceived innovativeness has a significant negative impact on consumers' perceived risk

5.3 Methodology

5.3.1 Data

To determine the potential consumers' perceptions of EVs, a survey questionnaire was designed and conducted at the University of Texas at Arlington (UTA). The survey was distributed electronically in March 2023 to 10,000 students, faculty, and staff with active parking permits, using the online application QuestionPro. The questionnaire comprised of 27 questions that were categorized into two sections and required approximately 7 minutes to complete. Section 1 consists of pre-validated measurement items that were derived from the literature with the intention to accurately capture the fundamental constructs within the proposed model. Section 2 asked questions about socio-demographics of the participants. Participants were also given an opportunity to express their concerns and preferences by responding to an open-ended question at the end of the survey. After sending two reminder emails, 1,219 responses were received, of which 781 were complete. A sample size of 743 responses was used for the analysis after removing missing values and outliers.

Table 1 shows that 53.2% of the responses were from females, 44.1% from males, and 2.7% from those who identified as "Other." More than half (52.1%) of the participants were above the age of 35 years, and approximately 61% held bachelor's degrees. Only 17.5% of the respondents were from households with an annual income of less than $35,000, 46.3% were from households with a median annual income between $35,000 to $99,999, and 36.2% were from households with an annual income of more than $100,000. More than half of the respondents had at least one vehicle, and 77.1% had more than five years of driving experience.

Table 5.1 Demographics of the Survey Respondents

Demographic	Item	Count	Percentage
Gender	Female	395	53.2 %
	Male	328	44.1%
	Other	20	2.7%
Age	18-24	206	27.7%
	25-34	150	20.2%
	35-44	119	16.0%
	45-54	101	13.6%
	55-64	119	16.0%
	65+	48	6.5%
Education	High school/GED	54	7.4%
	Some college/technical school	138	18.6%
	Associate degree	95	12.8%
	Bachelor’s degree	156	21.0%
	Graduate degree	177	23.8%
	Ph.D. or other equivalent degree	123	16.6%
Household income	Less than $20,000	61	8.2%
	$20,000 - $34,999	69	9.3%
	$35,000 - $49,999	101	13.6%
	$50,000 - $74,999	119	16.0%
	$75,000 - $99,999	124	16.7%
	$100,000 or more	269	36.2%
Vehicle ownership	1vehicle	190	25.6%
	2 vehicles	316	42.5%
	3 or more vehicles	237	31.9%
Driving experience	0-3 years	80	10.8%

	3-5 years	90	12.1%
	Over 5 years	573	77.1%

5.3.2 Measures

The measurement items were established by performing an inclusive examination of the existing research pertaining to TAM, personal innovativeness, and perceived risk. Certain terminologies of the items were adjusted to better align with the electric vehicle context. The measurement of all items was conducted using a five-point Likert scale, which encompassed responses that ranged from "strongly disagree" to "strongly agree". The measures of personal innovativeness were taken from Wang et al. (2020) and He et al. (2018). The scale for perceived usefulness and ease of use was taken from studies Wang et al., (2018) and Wu et al., (2019). The three items of perceived risks were taken from He et al., (2018). Finally, the three components of "EV adoption intention" were taken from He et al. (2018).

5.4 Results

In order to evaluate the hypothesized model, this study utilized structural equation model (SEM) with AMOS 26.0, which allows the concurrent assessment of both the measurement and the structural model. First, the reliability and validity of the measurement model was tested, followed by evaluation of structural model to test the hypothesis.

5.4.1 Measurement Model

Confirmatory Factor Analysis (CFA) was conducted to evaluate the construct validity and reliability. The construct reliability was assessed using Cronbach's α and Composite reliability (CR). As presented in Table 2, the alpha values ranging from 0.840 to 0.921, surpassing the cut-off value of 0.7 which specifies that the scales are reliable. The CR values of the latent variables also exceeded 0.7 suggesting that scales exhibited strong internal reliability (Nunnally and

Bernstein, 1978). Next, the validity of construct was explored to verify the extent to which the measurement items accurately represent the latent variables. As recommended by Hair et al. (2015), convergent validity of latent variables was evaluated using average variance extracted (AVE), and loadings. As illustrated in Table 2, the AVE values were from 0.649 to 0.797 which were above the recommended value of 0.5, and loadings of all the items were observed to be more than suggested value of 0.6 (Hair et al. 2015).

Table 5.2 Construct Reliability and Validity

Construct	Item	Loadings	Cronbach's alpha	CR	AVE
Perceived usefulness (PU)	PU1	0.818	0.845	0.851	0.655
	PU2	0.812			
	PU3	0.799			
Personal innovativeness (PI)	PI1	0.844	0.840	0.847	0.649
	PI2	0.805			
	PI3	0.767			
Perceived ease of use (PE)	PE1	0.886	0.863	0.871	0.693
	PE2	0.824			
	PE3	0.785			
EV adoption intention (EVAI)	EVAI1	0.853	0.921	0.922	0.797
	EVAI2	0.934			
	EVAI3	0.891			
Perceived risk (PR)	PR1	0.848	0.859	0.865	0.680
	PR2	0.817			
	PR3	0.810			

Furthermore, discriminant validity was evaluated to determine the degree to which the constructs differ. As presented in Table 3, it was observed that the square root of average variance extracted for each construct exceeded the squared correlation between the constructs (Fornell and

Larcker 1981). Similarly, variance inflation factor (VIF) of the model was assessed and was found to be less than the acceptable value of 5, indicating no multicollinearity issues.

Table 5.3 Discriminant Validity

	PI	PR	PE	PU	EVAI
PI	**0.805**				
PR	-0.060	**0.832**			
PE	0.471	-0.344	**0.809**		
PU	0.394	-0.463	0.585	**0.825**	
EVAI	0. 426	-0.387	0.646	0.534	**0.893**

5.4.2 Structural Model

An SEM model generated through AMOS, using the maximum likelihood estimate, was employed to test the relationships. In addition, the squared multiple correlation (R^2) for EV adoption intention was found to be 0.483, which shows that the 48. 3% variance in EV adoption intention is jointly accounted by all the predictor variables. The model exhibited an acceptable level of fit. The ($\chi 2$/df) was found to be 2.85, which is below the critical threshold of 3.0 as established by Hair et al. (2015). The GFI, CFI, NFI, IFI, and AGFI values, which were 0.92, 0.96, 0.96, 0.91, and 0.93, respectively, met the minimum acceptable criteria of 0.90 as specified by Hair et al. (2015). Furthermore, the model fit indices, namely RMSEA=0.05 and SRMR=0.06, also exhibited values below the threshold of 0.08.

After obtaining the favorable results regarding the fit of structural model, the hypothesis was explored to determine the influence of direct paths in the model. Table 4 presents the results of full structural model. The results revealed that all the direct paths in the model were significant, and the path between PI →PE (H7; β = 0.426, $p<0.01$) had the most positive significant impact followed by the path PU →EVAI (H3; β = 0.388, $p<0.01$) and the path PI →AVEI (H6; β = 0.312, p<0.01). While the direct effect of perceived risk with EV adoption (H4; β = -0.123, p<0.05), and perceived usefulness (H5; β = -0.097, p<0.05) was also found to be significant with inverse direct relation. Consequently, the results revealed that all the hypotheses H1, H2, H3, H4, H5, H6, H7, H8, and H9 were supported.

Table 5.4 Results of Structural Model

Hypothesis	Path	Standard Coefficient (β)	Result
H1	PE →EVAI	0.257**	Supported
H2	PE →PU	0.203**	Supported
H3	PU →EVAI	0.388**	Supported
H4	PR →EVAI	-0.123*	Supported
H5	PR →PU	-0.097*	Supported
H6	PI →AVEI	0.312**	Supported
H7	PI →PE	0.426**	Supported
H8	PI →PU	0.278**	Supported
H9	PI →PR	-0.175**	Supported

Note: *p<0.05, **p<0.01

Finally, the mediating effects of the research model were investigated using methods proposed by Baron and Kenny (1986). In the first stage, it is imperative for the independent variable to exert a significant influence on the dependent variable. During the second step, it is expected that the independent variable will exert a significant influence on the mediator. In the last step, it was observed that both the independent variable and the mediator have a considerable impact on the dependent variable, suggesting the criterion of partial mediation (He et al., 2018). Based on the results displayed in Table 5, the results indicate that the model was partially arbitrated by perceived ease of use, perceived usefulness, and perceived risk.

Table 5.5 Results of Mediation Analysis

IV	M	DV	IV→DV	IV→M	IV + M →DV		
					IV	M	Mediating role
PI	PE	EVAI	0.376**	0.48**	0.228**	0.312**	Partial
PI	PU	EVAI	0.376**	0.481**	0.267**	0.293**	Partial
PI	PR	EVAI	0.376**	0.312**	0.235**	0.246**	Partial

5.5 Discussion

Given the prospective adoption of EVs as environmentally friendly and cost-effective vehicles, the present study aimed to investigate consumers' acceptance of EVs using an extended TAM. This study explored the direct and indirect effects of consumers' personal innovativeness on the EV adoption intention along with the key factors of TAM including perceived usefulness, perceived ease of use, and perceived risk.

The results reveal that there exists a positive correlation between customers' personal innovativeness and their propensity to embrace EVs. EVs are innovative and appealing to consumers that possess a high degree of personal innovativeness. Consistent with the outcomes of previous research conducted by He et al. (2018), it is observed that personal innovativeness has the potential to enhance consumer intention towards the adoption of EVs as shown by Hypothesis 6 (H6). It is worth noting that personal innovativeness has the potential to indirectly influence intention by either raising the perception of ease of use (H7) and usefulness (H8), or by reducing the perception of risk (H9). This observation may be attributed to the assumption that persons with a heightened level of personal innovativeness are more adept at envisioning the advantages associated with new ideas, hence diminishing their perception of associated risks.

The study revealed a positive correlation between the perceived usefulness of EVs and the intention to adopt them. This indicates that as consumers consider EVs to be more useful, their inclination to adopt these vehicles increases. This finding aligns with other research indicating that technologies that are seen as more useful tend to be more appealing and readily adopted by consumers (Wang et al., 2018; Jaiswal et al., 2021). Various strategies that are intended to emphasize the utility of electric vehicles (EVs) to consumers can be effective in enhancing their adoption of EVs.

Furthermore, perceived risk has a negative impact on perceived usefulness and consumers' adoption intention of EVs. Therefore, it is posited that the presence of uncertainty or negative impressions among customers significantly influences their decision-making process about the desire to use EVs. Hence, it is apparent that addressing and mitigating the perceived risks connected with EVs is crucial for augmenting customer desire towards their purchase.

5.6 Policy Implications

The findings of our study have significant practical implications. Firstly, the results reveal that personality traits have an important effect on customer inclination towards adopting EVs. The degree of personal innovativeness has a favorable effect on the intention to adopt novel products, both directly and indirectly. This influence is mediated by determinants like perceived ease of use, perceived usefulness, and perceived risk. Consequently, it is recommended that the automotive sector actively promote the adoption of novel technologies in EVs in order to capture the interest of innovative individuals.

Second, it is imperative to highlight the significance of perceived ease of use as a factor to EV adoption. The notion of EVs is novel to consumers, who lack familiarity with many aspects such as maintenance requirements, safety features, the battery's lifespan cycle, and charging procedures. Hence, the provision of information has the potential to enhance customers' trust in the perceived ease of use for EVs. This, in turn, can positively impact the perceived usefulness of EVs and foster the intention to adopt them.

Furthermore, considering the positive impact of perceived usefulness, it is essential to inform consumers about the practicality and effectiveness of EVs, as their purchase decisions are not solely driven by environmental considerations. In fact, the acquisition costs of EVs are higher compared to traditional vehicles. Hence, providing a comprehensive elucidation on the potential cost-saving benefits of EVs in the long term is expected to have a substantial impact on consumers' inclination towards adopting them. In relation to this matter, marketers may coordinate events and road shows with the purpose of highlighting the benefits associated with transitioning to a more environmentally friendly options such as electric vehicles.

Lastly, the findings indicate that there are notable adverse consequences associated with the perceived risk, which can hinder the consumers' willingness to embrace EVs. Consequently, it is imperative for both the government and the industry to take measures aimed at reducing the unfavorable perception that consumers have towards EVs. For example, it is recommended that the government allocate significant resources towards studying and improving the battery technology, as well as the construction of charging facilities. This strategic investment aims to address uncertainties and alleviate consumer concerns over the adoption and usage of electric vehicles.

5.7 Conclusion

This study devised a personality-beliefs-intention approach to comprehend the consumers' acceptance of EVs. A survey method was used to gather data from 743 students, faculty, and staff of University of Texas at Arlington (UTA). The model explored the influence of perceived usefulness, personal innovativeness, perceived ease of use, and perceived risk on consumers' adoption of EVs. The findings discovered the positive influence of personal innovativeness, perceived ease of use, and perceived usefulness, and negative effect of perceived risk on consumers' adoption intention of EVs. The findings enhance our comprehension of consumer adoption behavior regarding electric vehicles and have significant implications for practitioners seeking to incentivize customer acquisition of EVs. Furthermore, the present study aims to augment the current corpus of research pertaining to the adoption of electric vehicles and makes an important addition to the current research on the technological acceptance model by integrating insights on perceived risk and personal innovativeness.

There are a few limitations in this study. The variable examined in this research is the intention to adopt electric vehicles but not the actual behavior. While the two are closely associated, the research outcomes are more likely to be satisfactory when the dependent variable is the actual behavior. Therefore, future studies could explore the adoption of EVs by using factual adoption behavior as the dependent variable in the research. Furthermore, our research encompasses all types of electric vehicles, implying that the outcomes may differ based on whether the automobile is fully electric or hybrid. Future studies could distinguish between various types of electric vehicles and conduct comparative analyses of the outcomes. Finally, the findings of our study may have limited generalizability beyond the United States, given that the data were exclusively gathered within this geographical context and a potential for variations in research outcomes exists when applying findings to different nations due to inherent national differences.

CHAPTER 6

ELECTRIC VEHICLES AND CONSUMER ADOPTION INTENTION: AN EXTENDED THEORY OF PLANNED BEHAVIOR

Abstract

The ever-increasing concern over climate change is compelling global economies to employ alternative fuel technology to combat the vehicular emissions of greenhouse gases. Electric vehicles (EVs) offer a viable environmentally friendly alternative that has the potential to facilitate a shift towards a sustainable, low-emission transportation system while preserving the environment. This study utilized the theory of planned behavior (TPB) and incorporated factors such as price value, moral norms, and financial incentives to examine consumers' intention to adopt EVs. A survey was administered to prospective consumers at the University of Texas at Arlington in March 2023 and the 743 responses were analyzed, using a structural equation model (SEM), to determine which factors have the greatest impact on EV adoption. The results revealed that attitudes, subjective norms, perceived behavior control, moral norms, and price value positively and significantly influenced consumers' intentions to adopt EVs; however, it was also discovered that financial incentives do not have a statistically significant effect on consumers' propensity to adopt EVs.

Keywords: Electric vehicles, adoption intention, theory of planned behavior, structural equation modeling

6.1 Introduction

Transport emissions raised at an average yearly rate of 1.7% from 1990 to 2022, surpassing growth rates in energy consumption of all other sectors. It currently constitutes for about 25% of carbon dioxide global emissions, and that number is projected to raised to 50% by the year 2030 (Patel et al., 2022e; Patel et al., 2023d). Electric vehicles (EVs) are regarded as a viable and ecological solution for the worldwide predicaments of energy scarcity and environmental pollution (Ali and Naushad, 2022; Feng et al., 2022), as they have the possible to decrease carbon emissions by approximately 30-50% and enhance fuel efficiency by around 40-60% in comparison to conventional vehicles (Higueras-Castillo, Kalinic et al., 2020; Khan et al., 2023c,d,e; Patel et al., 2023e).

The 14% global increase in sales of EVs in 2019 captured the interest of the automotive industry. Europe's sales grew by 80% and Canada's grew by 43%, while sales in China and the United States remained constant. Other nations, such as Norway (39.5%) and the United Kingdom (1.94%), joined the trend and also purchased more electric vehicles. In 2021, a record 6.6 million EVs were sold globally, double that of the previous year, and the market share reached nearly 10%, which was four times higher than that recorded in 2019. According to Patyal, Kumar et al. (2021), the global count of electric vehicles reached approximately 16.5 million, indicating a threefold increase from 2018.

The considerable body of empirical investigation on the advantages of EVs has not led to the expected rate of adoption. This may be attributed in part to the shortage of research on the variables that effect adoption, such as customers' preferences based on a combination of environmental, symbolic, and pro-social benefits (Kumar and Alok, 2020). These variables, however, vary among nations and cultures (Vafaei-Zadeh; Wong et al., 2022) and reveal the need to consider cross-cultural differences and how they impact EV adoption. The goal of this study is to determine the factors that influence a consumer's decision to purchase an EV by utilizing an extended theory of planned behavior model (TPB) and incorporating variables such as price value, moral norms, and financial incentives.

6.2 Background and Hypothesis Development

The TPB is an influential psychological work that is often used to examine consumers' behavioral characteristics, including those pertaining to purchasing (Abou-Zeid and Ben-Akiva, 2011). Several studies have employed the TPB model to examine the ecologically responsible behavior of consumers. The discourse presented herein focuses on the use of a conceptual model that encompasses attitudes, subjective norms, perceived behavioral control, moral norms, price values, and financial incentives to investigate their direct impact on consumers' inclinations to adopt EVs. Figure 1 illustrated the hypothesized model used in this study.

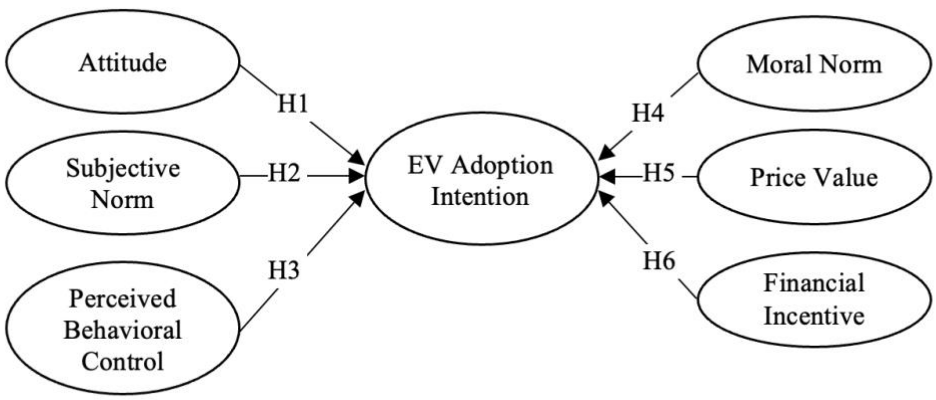

Figure 6.1 Proposed Research Model

6.2.1 Attitude

Attitude is a cognitive procedure that determines a consumer's positive or negative inclination towards a particular object or concept (Sreen, Purbey et al., 2018). According to the TPB, those who possess an optimistic disposition towards a particular task are more willing to involve in the corresponding behavior (Collins, Witkiewitz et al., 2011). In other words, individuals with a positive perception of owning an EV are more inclined to actually purchase one. Ajzen (2002) posits that the impact of attitude on behavioral intention is noteworthy, and recent studies have provided support for the assertion that a positive association subsists between attitude and behavioral intention (Yarimoglu and Gunay, 2020). From this, the following hypothesis was developed:

Hypothesis H1. Attitude has a significant and positive impact on consumers' intention to adopt EVs

6.2.2 Subjective Norms

Subjective norms pertain to a consumer's response to social pressure exerted on them to either engage in or abstain from a particular action (Collins, Witkiewitz et al., 2011). The notion of a social norm pertains to the endorsement and promotion of a specific behavior by a particular individual or group (Han, Chua et al., 2020; Shalender and Sharma, 2021). In essence, when a significant number of individuals who play a crucial role in an individual's life involve in a certain behavior, it becomes logical and emotionally compelling for that person to adopt similar actions (Cialdini, Reno et al., 1990). The behavior of individuals is greatly influenced by their perception of their belief in a particular behavior, particularly when that behavior is pro-environmental and aligns with their preferences (Li, Wang et al., 2020). In this setting of this paper, social norm is characterized as the consumers' perception that other esteemed individuals hold the belief that they should or should not acquire an electric vehicle. From this, the following hypothesis was developed:

Hypothesis H2. Subjective norms have a significant and positive impact on consumers' intention to adopt EVs

6.2.3 Perceived Behavioral Control

Perceived behavioral control pertains to an individual's subjective assessment of barriers they may encounter when they engage in a specific behavior. This is influenced by prior experiences or anticipated challenges, such as time limitations, convenience, and economic circumstances

(Collins, Witkiewitz et al., 2011). According to Ajzen and Fishbein (2005), an individual's ability to regulate their perceived behavioral control is strengthened when they focus more on opportunities and resources and less on potential challenges. Perceived behavioral control in the context of this paper pertains to the perceived level of difficulty or ease experienced by consumers in relation to their intention to adopt an EV (Huang and Ge, 2019). The findings of previous research indicate a positive correlation between perceived behavioral control regarding green products and consumer adoption intention (Sreen, Purbey et al., 2018; Xu, Zhang et al., 2019). From this, the following hypothesis was developed:

Hypothesis H3. Perceived behavioral control has a significant and positive impact on consumers' intention to adopt EVs

6.2.4 Moral Norm

The concept of moral norms pertains to an individual's sense of obligation in relation to engaging in specific types of behavior (Beck and Ajzen, 1991). The concept originates from the norm activation model and holds significant importance in the study of customers' psychological behavior (Schwartz, 1977). According to the National Academy of Medicine (NAM), two primary conditions must be met for an individual's norm to be activated. First, they must recognize that their behavior possesses both positive and negative implications in relation to society. This realization is evident in the level of consciousness an individual possesses regarding potential outcomes that may arise from their actions. Secondly, individuals should feel obligated to contribute positively to the matter under discussion.

According to Graham-Rowe (Graham-Rowe, Gardner et al., 2012), individuals who possess internal motivation and place importance on their societal responsibilities are more inclined to adopt EVs than those who do not exhibit these characteristics. According to the findings of Peters and Dütschke, (2014), when there is alignment between individuals' value systems and their environmental values, they are more likely to adopt EVs. The notion of moral norms is inherently intrinsic and distinct from subjective norms, as it lacks external influences and is solely guided by moral values and principles. Previous studies have found that individuals who possess a strong personal norm exhibit more favorable intentions towards the adoption of EVs compared to those who do not possess such a norm (Jansson, Nordlund et al., 2017; Shalender and Sharma, 2021). From this, the following hypothesis was derived:

Hypothesis H4. Moral norm has a significant and positive impact on consumers' intention to adopt EVs

6.2.5 Price Value

The concept of price value pertains to the extent to which consumers derive utility from their expectations regarding cost management (Sweeney and Soutar, 2001). The cost-benefit relationship, as elucidated by Venkatesh et al. 2012 plays a crucial role in influencing an individual's behavioral intention to adopt new technology and is contingent upon perceived benefits and the associated expenses incurred from its acquisition. Consumers form a perception of favorable value when the benefits derived from a particular product or service outweigh the associated costs. The current study ascribes significance to the advantages associated with the intention to acquire an EV. According to the US Department of Energy (2020), EVs cost less and are more efficient than gasoline-fueled vehicles, which results in their being more cost-effective in the long run. According to Zhang et al. (2020) there is a positive correlation between the expected decrease in long-term costs and the perceived present value. Consumers' knowledge of EVs' cost-saving benefits positively impacts their perceived value; therefore, the purchase is perceived as meaningful and suitable, and makes them inclined to purchase one. From this, the following hypothesis was derived:

Hypothesis H5. Price Value has a significant and positive impact on consumers' intention to adopt EVs

6.2.6 Financial Incentives

The higher costs of EVs are an obstacle to consumers purchasing them (Degirmenci and Breitner, 2017; Lin and Wu, 2018), and most consumers are apprehensive about the financial investment (Jaiswal, Kaushal et al., 2021). Financial incentives, including direct purchase subsidies and preferential tax policies, that have been initiated to reduce the cost of acquisition and stimulate greater consumer adoption of EVs have produced favorable outcomes, but several scholarly investigations have indicated that their impact may not be as potent as initially anticipated (Li, Long et al., 2018). The literature demonstrates that financial incentives can decrease the consumer's cost, as well as overall costs associated with the adoption of EVs, and have the potential to stimulate consumers' inclination to adopt EVs (Wang et al., 2018). Thus, it is plausible to hypothesize that the provision of additional financial incentives may lead to an increased propensity among consumers to adopt EVs. From this, the following hypothesis was derived:

Hypothesis H6. Financial Incentives have a significant and positive impact on consumers' intention to adopt EVs

6.3 Method

6.3.1 Data

A survey questionnaire was designed and distributed at the University of Texas at Arlington (UTA) to ascertain potential consumers' perceptions of EVs. It was reviewed and approved by UTA's Institutional Review Board (IRB) and distributed electronically in March 2023 to 10,000 students, faculty, and staff above 18 years of age with active parking permits, using the online application QuestionPro. The survey consisted of 27 questions that were divided into two sections and required approximately 7 minutes to complete. Section 1 consists of pre-validated measurement items derived from the literature to capture the fundamental constructs within the proposed model. Section 2 asks questions about socio-demographic characteristics. The participants were also given an opportunity to express their concerns and preferences by responding to an open-ended question at the end of the survey. After sending two reminder emails, 1,219 responses were received, of which 781 were complete. After removing outliers and missing values, 743 were used for the analysis.

Table 1 shows that 53.2% of the responses were from females, 44.1% from males, and 2.7% from those who identified as "Other." More than half (52.1%) of the respondents were above the age of 35, and approximately 61% held bachelor's degrees. Only 17.5% of the participants have annual income below $35,000, 46.3% have a median annual income between $35,000 to $99,999, and 36.2% were have an annual income of more than $100,000. More than half of the respondents had at least one vehicle, and 77.1% had more than five years of driving experience.

Table 6. 1 Demographics of the Survey Respondents

Demographic	Item	Count	Percentage
Gender	Female	395	53.2 %
	Male	328	44.1%
	Other	20	2.7%
Age	18-24	206	27.7%
	25-34	150	20.2%
	35-44	119	16.0%
	45-54	101	13.6%

	55-64	119	16.0%
	65+	48	6.5%
Education	High school/GED	54	7.4%
	Some college/technical school	138	18.6%
	Associate degree	95	12.8%
	Bachelor's degree	156	21.0%
	Graduate degree	177	23.8%
	Ph.D. or other equivalent degree	123	16.6%
Household income	Less than $20,000	61	8.2%
	$20,000 - $34,999	69	9.3%
	$35,000 - $49,999	101	13.6%
	$50,000 - $74,999	119	16.0%
	$75,000 - $99,999	124	16.7%
	$100,000 or more	269	36.2%
Race (More than one response)	Hispanic or Latino	144	19.3%
	American Indian or Alaskan native	17	2.3%
	Asian	98	13.1%
	Black or African American	83	11.1%
	Native Hawaiian or pacific Islander	2	0.2
	Caucasian or White	431	58.0%
	Other	20	2.6%
Vehicle ownership	1vehicle	190	25.6%
	2 vehicles	316	42.5%
	3 or more vehicles	237	31.9%
Driving experience	0-3 years	80	10.8%
	3-5 years	90	12.1%
	Over 5 years	573	77.1%

6.3.2 Measures

The measurement items were developed through a comprehensive review of the literature on TPB, moral norms, price value, and financial incentives, and terminologies of some of the items were adjusted to better align with the electric vehicle context. All of the items were measured by using a five-point Likert scale, which encompassed responses ranging from "strongly disagree" to "strongly agree." The scale for attitude was taken from the study by Cheng et al. (2019); the scale for subjective norms and perceived behavioral control was taken from a study by Han et al. (2020). The items for financial incentives were acquired from the study of Wang et al. (2018) and He et al. (2018). Finally, the three components of "EV adoption intention" were taken from the study of He et al. (2018).

6.4 Analysis and Results

6.4.1 Measurement Model

A confirmatory factor analysis (CFA) was conducted to evaluate the measurement model. As presented in Table 2, Cronbach's α values ranged from 0.806 to 0.931, surpassing the cut-off value of 0.7 indicating that scales are reliable. The CR values of the latent variables were also above 0.7, suggesting that the scales exhibited strong internal consistency (Nunnally and Bernstein, 1978). Next, the soundness of the construct was examined to verify the extent to which the measurement items accurately represent the constructs. As suggested by Hair et al. (2015), the convergent validity of the constructs was assessed by using average variance extracted (AVE) and factor loadings. As illustrated in Table 2, the AVE values ranged from 0.581 to 0.817, which were above the threshold of 0.5, and the factor loadings of all the items were observed to be higher than the suggested value of 0.6 (Hair et al., 2015).

Table 6.2 Construct Reliability and Validity

Construct	Item	Loadings	Cronbach's alpha	CR	AVE
Attitude (AT)	AT1	0.752	0.802	0.806	0.581
	AT2	0.823			
	AT3	0.708			
Subjective Norm (SN)	SN1	0.775	0.853	0.861	0.674
	SN2	0.860			
	SN3	0.826			
Perceived Behavioral Control (PBC)	PBC1	0.702	0.810	0.815	0.614
	PBC2	0.786			
	PBC3	0.822			
Moral Norms (MN)	MN1	0.867	0.874	0.876	0.702
	MN2	0.854			
	MN3	0.791			
Price Value (PV)	PV1	0.889	0.865	0.879	0.708
	PV2	0.838			
	PV3	0.795			
Financial Incentives (FI)	FI1	0.812	0.808	0.836	0.629
	FI2	0.798			
	FI3	0.769			
EV Adoption Intention (EVAI)	EVAI1	0.917	0.926	0.931	0.817
	EVAI2	0.902			
	EVAI3	0.894			

Discriminant validity was evaluated to determine the degree to which the latent variables differ. As presented in Table 3, the square root of the numbers on the diagonal was discovered to be greater than the squared correlation of numbers below the diagonal, thus confirming the satisfactory results of discriminant validity (Fornell and Larcker, 1981).

Table 6. 3 Discriminant Validity

	AT	SN	PBC	MN	PV	FI	EVAI
AT	**0.762**						
SN	0.348	**0.821**					
PBC	0.508	0.345	**0.784**				
MN	0.510	0.284	0.361	**0.837**			
PV	0. 232	0.321	0.299	0.320	**0.841**		
FI	0.173	0.209	0.470	0.191	0.513	**0.793**	
EVAI	0.487	0.402	0.293	0.262	0.335	0.399	**0.904**

6.4.2 Structural Model: Hypothesis Testing

After accomplishing acceptable results from the measurement model, the structural model was evaluated in AMOS v. 26.0. Before testing the hypothesis, the model fit was evaluated and was found to be acceptable. The ($\chi 2$/df) was found to be 2.32, which is below the critical threshold of 3.0 as established by Hair et al. (2015), and the GFI, CFI, NFI, which were 0.908, 0.926, 0.960, respectively, met the minimum acceptable criteria of 0.90 as specified by Hair et al. (2015). The model fit indices, namely RMSEA=0.042 and SRMR=0.055, also exhibited values below the threshold of 0.08. The total variance of EV adoption intention explained by the model was found to be 53.6%.

Table 6. 4 Results of Structural Model

Hypothesis	Path	Standard Coefficient (β)	Result
H1	AT →EVAI	0.426**	Supported
H2	SN →EVAI	0.164**	Supported
H3	PBC →EVAI	0.357**	Supported
H4	MN →EVAI	0.228**	Supported
H5	PV →EVAI	0.341**	Supported
H6	FI →EVAI	0.175	Not Supported

Note: * Coefficient is significant at 0.01

Table 4 illustrates the outcomes of the structural model. The hypothesis results revealed that attitude ($\beta = 0.426$, $p<0.01$), subjective norms ($\beta = 0.164$, $p<0.01$), perceived behavioral control ($\beta = 0.341$, $p<0.01$), moral norms ($\beta = 0.357$, $p<0.01$), and price value ($\beta = 0.228$, $p<0.01$) positively impact consumers' willingness to adopt EVs. In contrast, financial incentives ($\beta = 0.175$, $p>0.05$) do not have a noteworthy effect on consumers' EV adoption. Thus, hypotheses H1, H2, H3, H4, and H5 are supported, and H6 is rejected.

6.5 Discussion

As illustrated in Table 4, attitude, has the highest path coefficient, has the major impact on the intention to adopt an EV. These results align with the outcomes observed in most studies on the TPB (Alzahrani, Hall-Phillips et al., 2019; Jaiswal, Kaushal et al., 2021) and suggest that individuals who hold a favorable disposition towards the utilization and acquisition of EVs are also more inclined to embrace their adoption. The study also revealed a positive association between subjective norms and the intention to adopt EVs, indicating that individuals' decisions about whether or not to adopt electric vehicles are influenced by the opinions of those others that they hold in high esteem. This finding aligns with a limited number of studies that suggest that attitudes and perceived behavioral control are the primary determinants of consumers' intentions to purchase EVs, and subjective norms have a minimal impact.

Table 4 revealed that perceived behavioral control was the second most statistically significant positive impact on the intention to adopt electric vehicles, as consumers are more inclined to adopt EVs when they are self-confident in their purchasing decisions. The obtained outcome aligns with the initial TPB model, suggesting that perceived behavior control plays a significant role as a precursor to purchase intention. These findings align with previous research conducted in different contexts (Shalender and Sharma, 2021; Vafaei-Zadeh; Wong et al., 2022) that indicated that perceived behavior control significantly influences pro-environmental consumer behavioral intention. If consumers perceive EVs as being convenient to possess, repair, and maintain, it is probable that they will be more inclined to adopt them.

Price value was found to be the third most influential factor in the model. Venkatesh (Venkatesh, Thong et al., 2012) posits that the concept of price value pertains to the equilibrium between the perceived advantages of adopting novel technology and the monetary investment required to acquire it. This dynamic interplay between cost and benefit significantly influences an individual's inclination to engage with new technology, and any lack of sensitivity towards the cost can be attributed to a heightened awareness of the numerous benefits and intrinsic value associated with the technology.

Contrary to our initial expectations, the impact of financial incentives on consumers' inclination to adopt EVs was found to be statistically insignificant. Wang et al. (Wang, Wang et al., 2018) reported that a mere 25% of consumers indicated that a subsidy is a predominant factor, as the process for acquiring subsidies and tax benefits is excessively burdensome and requires consumers to complete a number of online and offline forms, furnish evidence of their identity, and submit other relevant documentation. Additionally, the approval process for these subsidies and tax benefits is often time-consuming and negatively impacts the consumers' level of enthusiasm towards adoption. Ultimately, consumers’ limited understanding of the financial incentives offered them prevents them from benefitting from them. Therefore, it can be concluded that financial incentives do not substantially impact individuals' intentions to adopt electric vehicles.

6.6 Policy Implications

The research results have significant implications for those seeking to inccrease consumer adoption of EVs. It is suggested that governments and automakers give greater priority to enhancing consumer awareness of the user-friendliness and essential attributes of electric vehicles, which has the potential to positively influence their attitudes towards the vehicles and thus increase the likelihood that they will purchase one. Educational initiatives and media promotions that emphasize the environmental advantages of EVs are proven effective methods for accomplishing this. Similarly, car manufacturers can employ experiential marketing strategies, such as offering test drives at auto shows, to provide consumers with an opportunity to personally experience the benefits of owning and driving an EV.

This study will also serve as valuable information for electric vehicle manufacturers as they refine their products and marketing strategies, as it presents an overview of the various elements that can impact consumers' intention to acquire an electric vehicle. The findings indicate that price value is the third most influencing factor in predicting an individual's intention to adopt an electric vehicle, as consumers compare the perceived value and benefits of owning an EV with the associated costs. As an example, automotive manufacturers have the capacity to improve the perceived pricing value for consumers by improving performance, ensuring reliability, enhancing fuel efficiency, and incorporating ecologically friendly features.

Lastly, given the lack of statistical significance on the impact of the financial incentives, additional steps can be implemented to enhance its efficacy. For instance, EV manufacturers, dealers, and retailers of EVs could provide in-depth and clear-cut explanations of the financial incentives, display information on specific subsidies and tax benefits, and assist with the application process.

6.7 Conclusion

This study utilized an extended TPB framework to examine the factors that influence consumer's intentions to adopt electric automobiles, with emphasis on their environmental advantages. Data from 743 potential consumers was collected and analyzed, and the results revealed that attitudes, subjective norms, perceived behavioral control, moral norms, and price value have a positive and significant impact. Conversely, financial incentives do not significantly influence the decision of whether or not to adopt an EV. The outcomes of this study will guide EV designers, manufacturers, marketers, and other entities in their efforts to educate the public on the advantages of environmentally friendly mobility and influence their desire to own an EV.

There are a few limitations in this study. The variable examined in this research is the *intention* to adopt electric vehicles rather than *actual behavior*. While the two are closely associated, the research outcomes are more likely to be satisfactory when the dependent variable is the actual behavior. Therefore, future studies could explore the adoption of electric vehicles by using factual adoption behavior as the dependent variable in the research framework. Furthermore, our research encompasses all types of electric vehicles, implying that the outcomes may differ based on whether the automobile is fully electric or hybrid. Future studies could distinguish between various types of electric vehicles and conduct comparative analyses of the outcomes. Finally, the findings of our study may have limited generalizability beyond the United States, given that the data were exclusively gathered within this geographical context and a potential for variations in research outcomes exists when applying findings to different nations due to inherent national differences.

CHAPTER 7

CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

7.1 Conclusion

This research aimed to identify the factors influencing consumers' willingness to adopt EVs. After comprehensively reviewing the extant literature on the factors affecting consumers' adoption of EVs, a total of 63 factors influencing the adoption of electric vehicles were determined from the database. These determinants were classified into four categories, which were further divided into 14 sub-categories. Reduction in air pollution is the most frequently cited motivator of EV adoption among all the identified factors. The consideration of environmental factors significantly influences the decision-making process about the acquisition of EVs, and it also has an indirect influence on the level of satisfaction experienced by buyers after the purchase. On the other hand, the high purchase price and limited driving range are significant barriers to EV adoption. Strategies must be promoted to reduce anxiety related to these two barriers by offering options like rapid chargers, battery swapping stations, and improving battery performance. It was also revealed that the consumer's socio-demographic and psychological characteristics positively impact buying or not buying an EV.

This study also aimed to explore the factors that are significant in affecting consumers' adoption intention of EVs. In this study, the barriers to EV adoption from the consumers' perspectives were explored by analyzing responses to a survey conducted among students, faculty, and staff at the UTA. The results showed that of 17 identified barriers, 3 were considered the most critical: high purchase price, insufficient public charging stations, and the battery replacement cost. Unlike previously conducted studies, we found that the driving range facilitated by one charge was not of primary importance to our survey group. In addition, they felt that the adoption of EVs would lessen the environmental effects of conventional cars and appreciated the technological features that facilitate safety and reliability, which shows that few initial concerns regarding EVs have been alleviated. The respondents were, however, extremely sensitive to the availability of charging stations. Lastly, our study shows that the marketing of EVs should focus on male, middle-aged experienced drivers, as they show a strong interest and inclination to adopt one, and a concentrated effort should be made to increase the public's knowledge of the benefits of the EV technology.

This study also developed a model to explore the EV adoption barriers from the perspective of consumers. The model results revealed that survey participants were hesitant to purchase EVs due to financial, technological, and infrastructure barriers providing significant impediments to EV adoption. On the other hand, the respondents are not concerned about environmental barriers potentially due to their strong conviction regarding the ecological advantages of replacing conventional gasoline-powered vehicles with electric cars

This study also developed a personality-beliefs-intention approach utilizing technology acceptance model and its extension to comprehend the consumers' adoption of EVs. The model explored the effects of perceived usefulness, personal innovativeness, perceived ease of use, and perceived risk on consumers' adoption of EVs. The findings discovered the positive impact of personal innovativeness, perceived ease of use, and perceived usefulness, and negative effect of perceived risk on consumers' adoption intention of EVs. The model's findings contribute to our comprehension of consumer adoption behavior regarding electric vehicles and have significant implications for practitioners seeking to incentivize customer acquisition of EVs. Furthermore, model augmented the current corpus of research pertaining to the adoption of electric vehicles and made a valuable contribution to the existing literature on the technological acceptance model by integrating insights on perceived risk and personal innovativeness. Lastly, this study utilized an extended theory of planned behavior framework to examine the factors that influence consumer's intentions to adopt electric automobiles, and the results revealed that attitudes, subjective norms, perceived behavioral control, moral norms, and price value have a positive and significant impact. Conversely, financial incentives do not significantly influence the decision of whether or not to adopt an EV.

7.2 Limitations and Future Research

This research has few limitations. Initially, an online platform was employed to distribute the survey. The utilization of this approach may potentially lead to sample bias as it fails to incorporate consumers who do not have access to or do not utilize the internet within our sample population. Therefore, it is possible for future research to extend the applicability of our findings to consumers who engage in offline activities. Furthermore, the variable we have chosen as the dependent variable in our research model is the intention to adopt electric vehicles, rather than the actual behavior of purchasing EVs. While there is a strong correlation between behavioral intention and actual behavior (Hung et al., 2003; Tan and Teo, 2000), conducting research with actual behavior as the dependent variable is likely to yield more satisfactory results. Therefore, future research endeavors may explore the adoption of electric vehicles by utilizing actual adoption behavior as the dependent variable within the research framework. In addition, our study encompasses all types of electric vehicles. It is possible that the findings may vary when comparing pure EVs to hybrid EVs, or when considering different EV brands. Therefore, future research endeavors may seek to differentiate between different types of electric vehicles and subsequently conduct comparative analyses based on these distinctions. Ultimately, the outcomes of our study may possess limited generalizability as they are contingent upon the potential consumers in United States, given that our sample was exclusively derived from United States. The application of the research model to different countries may yield varying results due to the inherent differences among nations. Therefore, it is possible to conduct similar research in other countries.

REFERENCES

Ackaah, W., Kanton, A. T., & Osei, K. K. (2022). Factors influencing consumers' intentions to purchase electric vehicles in Ghana. *Transportation Letters*, *14*(9), 1031-1042.

Adhikari, M., Ghimire, L. P., Kim, Y., Aryal, P., & Khadka, S. B. (2020). Identification and analysis of barriers against electric vehicle use. *Sustainability*, *12*(12), 4850.

Adnan, N., Nordin, S. M., Amini, M. H., & Langove, N. (2018). What make consumer sign up to PHEVs? Predicting Malaysian consumer behavior in adoption of PHEVs. *Transportation Research Part A: Policy and Practice*, *113*, 259-278.

Adnan, N., Nordin, S. M., Rahman, I., & Rasli, A. M. (2017). A new era of sustainable transport: An experimental examination on forecasting adoption behavior of EVs among Malaysian consumer. *Transportation Research Part A: Policy and Practice*, *103*, 279-295.

Ajzen, I. (2002). Perceived behavioral control, self‐efficacy, locus of control, and the theory of planned behavior 1. *Journal of applied social psychology*, 32(4): 665-683.

Ajzen, I. and M. Fishbein. (2005). The influence of attitudes on behavior. The handbook of attitudes. Red. D. Albarracin, BT Johnson & MP Zanna. Mahwah: Erlbaum: 173-221.

Ali, I., & Naushad, M. (2022). A study to investigate what tempts consumers to adopt electric vehicles. *World Electric Vehicle Journal*, *13*(2), 26.

Bentler, P. M. (2006). EQS 6 structural equations program manual. Encino, CA: Multivariate Software.

Alzahrani, K., Hall-Phillips, A., & Zeng, A. Z. (2019). Applying the theory of reasoned action to understanding consumers' intention to adopt hybrid electric vehicles in Saudi Arabia. *Transportation*, *46*, 199-215.

Anastasiadou, K., & Gavanas, N. (2022). State-of-the-Art Review of the Key Factors Affecting Electric Vehicle Adoption by Consumers. *Energies*, *15*(24), 9409.

Asún, R. A., K. Rdz-Navarro, and J. M. Alvarado. (2016). Developing multidimensional Likert scales using item factor analysis: The case of four-point items. Sociological Methods Res. 45 (1): 109–133

Austmann, L. M. (2021). Drivers of the electric vehicle market: A systematic literature review of empirical studies. *Finance Research Letters*, *41*, 101846.

Axsen, J., Goldberg, S., & Bailey, J. (2016). How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners? *Transportation Research Part D: Transport and Environment*, *47*, 357-370.

Axsen, J., & Sovacool, B. K. (2019). The roles of users in electric, shared and automated mobility transitions. *Transportation Research Part D: Transport and Environment*, *71*, 1-21.

Barth, M., Jugert, P., & Fritsche, I. (2016). Still underdetected–Social norms and collective efficacy predict the acceptance of electric vehicles in Germany. *Transportation Research Part F: traffic psychology and behaviour*, *37*, 64-77.

Beck, L. and I. Ajzen. (1991). Predicting dishonest actions using the theory of planned behavior. *Journal of research in personality* 25(3): 285-301.

Berkeley, N., Jarvis, D., & Jones, A. (2018). Analysing the take up of battery electric vehicles: An investigation of barriers amongst drivers in the UK. *Transportation Research Part D: Transport and Environment*, *63*, 466-481.

Biresselioglu, M. E., Kaplan, M. D., & Yilmaz, B. K. (2018). Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes. *Transportation Research Part A: Policy and Practice*, *109*, 1-13.

Broadbent, G. H., Wiedmann, T. O., & Metternicht, G. I. (2021). Electric vehicle uptake: Understanding the print media's role in changing attitudes and perceptions. *World Electric Vehicle Journal*, *12*(4), 174.

Brückmann, G., Willibald, F., & Blanco, V. (2021). Battery Electric Vehicle adoption in regions without strong policies. *Transportation Research Part D: Transport and Environment*, *90*, 102615.

Burgess, M., King, N., Harris, M., & Lewis, E. (2013). Electric vehicle drivers' reported interactions with the public: Driving stereotype change? *Transportation research part F: traffic psychology and behaviour*, *17*, 33-44.

Bühler, F., Cocron, P., Neumann, I., Franke, T., & Krems, J. F. (2014). Is EV experience related to EV acceptance? Results from a German field study. *Transportation Research Part F: traffic psychology and behaviour*, *25*, 34-49.

Channamallu, S.S., Kermanshachi, S. and Pamidimukkala, A. (2023). Impact of Autonomous Vehicles on Traffic Crashes in Comparison with Conventional Vehicles. In International Conference on Transportation and Development 2023 (pp. 39-50).

Chen, C.-f., de Rubens, G. Z., Noel, L., Kester, J., & Sovacool, B. K. (2020). Assessing the socio-demographic, technical, economic and behavioral factors of Nordic electric vehicle adoption and the influence of vehicle-to-grid preferences. *Renewable and Sustainable Energy Reviews*, *121*, 109692.

Cheng, P., Z. OuYang and Y. Liu (2019). Understanding bike sharing use over time by employing extended technology continuance theory. *Transportation research part A: policy and practice*, 124: 433-443.

Cherchi, E. (2017). A stated choice experiment to measure the effect of informational and normative conformity in the preference for electric vehicles. *Transportation Research Part A: Policy and Practice*, *100,* 88-104.

Chhikara, R., Garg, R., Chhabra, S., Karnatak, U., & Agrawal, G. (2021). Factors affecting adoption of electric vehicles in India: An exploratory study. *Transportation Research Part D: Transport and Environment*, *100*, 103084.

Chu, W., Im, M., Song, M. R., & Park, J. (2019). Psychological and behavioral factors affecting electric vehicle adoption and satisfaction: A comparative study of early adopters in China and Korea. *Transportation Research Part D: Transport and Environment*, *76*, 1-18.

Cialdini, R. B., R. R. Reno and C. A. Kallgren. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of personality and social psychology*, 58(6): 1015.

Coffman, M., Bernstein, P., & Wee, S. (2017). Electric vehicles revisited: a review of factors that affect adoption. *Transport Reviews*, *37*(1), 79-93.

Collins, S. E., K. Witkiewitz and M. E. Larimer. (2011). The theory of planned behavior as a predictor of growth in risky college drinking. *Journal of studies on alcohol and drugs*, 72(2): 322-332.

Cui, L., Wang, Y., Chen, W., Wen, W., & Han, M. S. (2021). Predicting determinants of consumers' purchase motivation for electric vehicles: An application of Maslow's hierarchy of needs model. *Energy Policy*, *151*, 112167.

Degirmenci, K., & Breitner, M. H. (2017). Consumer purchase intentions for electric vehicles: Is green more important than price and range? *Transportation Research Part D: Transport and Environment*, *51*, 250-260.

Du, H., Liu, D., Sovacool, B. K., Wang, Y., Ma, S., & Li, R. Y. M. (2018). Who buys new energy vehicles in China? Assessing social-psychological predictors of purchasing awareness, intention, and policy. *Transportation Research Part F: Traffic Psychology and Behaviour*, *58*, 56-69.

Dutta, B., & Hwang, H.-G. (2021). Consumers purchase intentions of green electric vehicles: The influence of consumers technological and environmental considerations. *Sustainability*, *13*(21), 12025.

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy policy*, *48*, 717-729.

Etminani-Ghasrodashti, R., Patel, R., Kermanshachi, S., Rosenberger, J., Weinreich, D., and Foss, A. (2021a). Integration of Shared Autonomous Vehicles (AVs) into Existing Transportation Services: A Focus Group Study. *Elsevier Journal of Transportation Research Interdisciplinary Perspectives*, 12 (21), PP. 100481.

Etminani-Ghasrodashti, R., Ronik, P., Kermanshachi, S., Rosenberger, and Weinreich, D. (2021b). Exploring Concerns and Preferences Toward Using Autonomous Vehicles as a Public Transportation Option: Perspectives from a Public Focus Group Study. ASCE International Conference on Transportation & Development, Austin, TX, June 2021 (PP. 230-242).

Etminani-Ghasrodashti, R., Patel, R., Kermanshachi, S., Rosenberger, J., and Foss, A. (2022a). Modeling Users' Adoption of Shared Autonomous Vehicles Employing Actual Ridership

Experiences. Proceedings of Transportation Research Board 101st Annual Conference, (Paper 22-00825), Washington, DC, 2022.

Etminani-Ghasrodashti, R., Patel, R., Kermanshachi, S., Rosenberger, J., and Foss, A. (2022b). Exploring Factors Affecting Willingness to Ride Shared Autonomous Vehicles. Proceedings of Transportation Research Board 101st Annual Conference, (Paper 22-00841), Washington, DC, 2022.

Etminani-Ghasrodashti, R., Patel, R., Kermanshachi, S., Rosenberger, J., and Foss, A. (2022c). Modeling Users' Adoption of Shared Autonomous Vehicles Employing Actual Ridership Experiences. *Transportation Research Record*, 2676(11), pp.462-478.

Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J.M. and Foss, A. (2023a). Exploring motivating factors and constraints of using and adoption of shared autonomous vehicles (SAVs). *Transportation Research Interdisciplinary Perspectives*, 18, p.100794.

Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J.M. and Foss, A. (2023b). Capturing the Behavioral Determinant behind the Use and Adoption of Shared Autonomous Vehicles (SAVs). In Transportation Research Board 102 Annual Meeting (pp. 23-00181).

Etminani-Ghasrodashti, R., Hladik, G., Kermanshachi, S., Rosenberger, J.M., Arif Khan, M. and Foss, A. (2023c). Exploring shared travel behavior of university students. *Transportation planning and technology*, 46(1), pp.22-44.

Feng, L., K. Liu, J. Wang, K.-Y. Lin, K. Zhang and L. Zhang. (2022). Identifying Promising Technologies of Electric Vehicles from the Perspective of Market and Technical Attributes. *Energies* 15(20): 7617.

Fornell, C. and Larcker, D.F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, Vol. 18, pp. 39-50.

Franke, T., & Krems, J. F. (2013). What drives range preferences in electric vehicle users? *Transport Policy, 30*, 56-62.

Fung, S. F., E. O. W. Chow, and C. K. Cheung. (2020). Development and validation of a brief self-assessed wisdom scale. *BMC Geriatrics* 20 (1): 1–8.

Ghosh, A. (2020). Possibilities and challenges for the inclusion of the electric vehicle (EV) to reduce the carbon footprint in the transport sector: A review. *Energies*, *13*(10), 2602.

Giansoldati, M., Monte, A., & Scorrano, M. (2020). Barriers to the adoption of electric cars: Evidence from an Italian survey. *Energy Policy*, *146*, 111812

Globisch, J., Dütschke, E., & Wietschel, M. (2018). Adoption of electric vehicles in commercial fleets: Why do car pool managers campaign for BEV procurement? *Transportation Research Part D: Transport and Environment*, *64*, 122-133.

Gnann, T., Stephens, T. S., Lin, Z., Plötz, P., Liu, C., & Brokate, J. (2018). What drives the market for plug-in electric vehicles?-A review of international PEV market diffusion models. *Renewable and Sustainable Energy Reviews*, *93*, 158-164.

Goel, P., Sharma, N., Mathiyazhagan, K., & Vimal, K. (2021). Government is trying but consumers are not buying: A barrier analysis for electric vehicle sales in India. *Sustainable Production and Consumption*, *28*, 71-90.

Graham-Rowe, E., B. Gardner, C. Abraham, S. Skippon, H. Dittmar, R. Hutchins and J. Stannard. (2012). Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. *Transportation Research Part A: Policy and Practice*, 46(1): 140-153.

Guerra, E. (2019). Electric vehicles, air pollution, and the motorcycle city: A stated preference survey of consumers' willingness to adopt electric motorcycles in Solo, Indonesia. *Transportation Research Part D: Transport and Environment*, *68*, 52-64.

Habich-Sobiegalla, S., Kostka, G., & Anzinger, N. (2018). Electric vehicle purchase intentions of Chinese, Russian and Brazilian citizens: An international comparative study. *Journal of cleaner production*, *205*, 188-200.

Haddadian, G., Khodayar, M., & Shahidehpour, M. (2015). Accelerating the global adoption of electric vehicles: barriers and drivers. *The Electricity Journal*, *28*(10), 53-68.

Hair, J. F., W. C. Black, B. J. Babin, R. E. Anderson, and R. L. Tatham. (2006). Multivariate data analysis. 6th ed. Upper Saddle River, NJ: Pearson Prentice-Hall.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., Tatham, R.L. (2015). Multivariate data analysis (7th Edition). Pearson Education, New Delhi.

Han, H., B.-L. Chua and S. S. Hyun. (2020). Consumers’ intention to adopt eco-friendly electric airplanes: The moderating role of perceived uncertainty of outcomes and attachment to eco-friendly products. *International Journal of Sustainable Transportation*, 14(9): 671-685.

Hardman, S., Chandan, A., Tal, G., & Turrentine, T. (2017). The effectiveness of financial purchase incentives for battery electric vehicles–A review of the evidence. *Renewable and Sustainable Energy Reviews*, *80*, 1100-1111.

Hardman, S., Shiu, E., & Steinberger-Wilckens, R. (2016). Comparing high-end and low-end early adopters of battery electric vehicles. *Transportation Research Part A: Policy and Practice*, *88*, 40-57.

Harman, H.H. (1976). Modern Factor Analysis. University of Chicago Press, Chicago IL

Haustein, S., Jensen, A. F., & Cherchi, E. (2021). Battery electric vehicle adoption in Denmark and Sweden: Recent changes, related factors and policy implications. *Energy Policy*, *149*, 112096.

He, X., Zhan, W., & Hu, Y. (2018). Consumer purchase intention of electric vehicles in China: The roles of perception and personality. *Journal of Cleaner Production*, *204*, 1060-1069.

Heidenreich, S., & Kraemer, T. (2016). Innovations—doomed to fail? Investigating strategies to overcome passive innovation resistance. *Journal of Product Innovation Management*, *33*(3), 277-297.

Higgins, C. D., Mohamed, M., & Ferguson, M. R. (2017). Size matters: How vehicle body type affects consumer preferences for electric vehicles. *Transportation Research Part A: Policy and Practice*, *100*, 182-201.

Higueras-Castillo, E., Z. Kalinic, V. Marinkovic and F. J. Liébana-Cabanillas. (2020). A mixed analysis of perceptions of electric and hybrid vehicles. *Energy Policy*, 136: 111076.

Hoang, T. T., Pham, H. T., & Vu, H. M. T. (2022). From Intention to Actual Behavior to Adopt Battery Electric Vehicles: A Systematic Literature Review. *The Open Transportation Journal*, *16*(1).

Huang, X., & Ge, J. (2019). Electric vehicle development in Beijing: An analysis of consumer purchase intention. *Journal of cleaner production*, *216*, 361-372.

IEA. (2020). Electric Vehicles. In. Paris, France: IEA.

llmann, U., & Kluge, J. (2020). Public charging infrastructure and the market diffusion of electric vehicles. *Transportation Research Part D: Transport and Environment*, *86*, 102413.

Irfan, M., & Ahmad, M. (2021). Relating consumers' information and willingness to buy electric vehicles: Does personality matter? *Transportation Research Part D: Transport and Environment*, *100*, 103049.

Jaiswal, D., V. Kaushal, R. Kant and P. K. Singh. (2021). Consumer adoption intention for electric vehicles: Insights and evidence from Indian sustainable transportation. *Technological Forecasting and Social Change*, 173: 121089.

Jaiswal, D., Deshmukh, A. K., & Thaichon, P. (2022). Who will adopt electric vehicles? Segmenting and exemplifying potential buyer heterogeneity and forthcoming research. *Journal of Retailing and Consumer Services*, *67*, 102969.

Jansson, J., Nordlund, A., & Westin, K. (2017). Examining drivers of sustainable consumption: The influence of norms and opinion leadership on electric vehicle adoption in Sweden. *Journal of Cleaner Production*, *154*, 176-187.

Jansson, J., Pettersson, T., Mannberg, A., Brännlund, R., & Lindgren, U. (2017). Adoption of alternative fuel vehicles: Influence from neighbors, family and coworkers. *Transportation Research Part D: Transport and Environment*, *54*, 61-73.

Jenn, A., Springel, K., & Gopal, A. R. (2018). Effectiveness of electric vehicle incentives in the United States. *Energy policy*, *119*, 349-356.

Jensen, A. F., Cherchi, E., & de Dios Ortúzar, J. (2014). A long panel survey to elicit variation in preferences and attitudes in the choice of electric vehicles. *Transportation*, *41*, 973-993.

Jensen, A. F., Cherchi, E., & Mabit, S. L. (2013). On the stability of preferences and attitudes before and after experiencing an electric vehicle. *Transportation Research Part D: Transport and Environment*, *25*, 24-32.

Jia, W., & Chen, T. D. (2021). Are Individuals' stated preferences for electric vehicles (EVs) consistent with real-world EV ownership patterns? *Transportation Research Part D: Transport and Environment*, *93*, 102728.

Junquera, B., Moreno, B., & Álvarez, R. (2016). Analyzing consumer attitudes towards electric vehicle purchasing intentions in Spain: Technological limitations and vehicle confidence. *Technological Forecasting and Social Change*, *109*, 6-14.

Khan, M., Etminani, R., Shahmoradi, A., Kermanshachi, S., and Rosenberger. (2021a). Travel Behaviors of the Transportation-Disabled Population and Impacts of Alternate Transit Choices: A Trip Data Analysis of the Handitran Paratransit Service in Arlington, TX. ASCE International Conference on Transportation & Development, Austin, TX, June 2021 (PP. 502-512).

Khan, M., Etminani, R., Shahmoradi, A., Kermanshachi, S., and Rosenberger. (2021b). A Geographically Weighted Regression Approach to Modeling the Determinants of On-demand Ride Services for Elderly and Disabled. ASCE International Conference on Transportation & Development, Austin, TX, June 2021 (PP. 385-396).

Khan, M., Etminani, R., Kermanshachi, S., Rosenberger, J., and Foss, A. (2021c). Integrating Shared Autonomous Vehicles into Existing Transportation Services: Evidence from a Paratransit Service in Arlington, Texas. *International Journal of Civil Engineering*, 20, 601-618.

Khan, M., Etminani, R., Kermanshachi, S., Rosenberger, J., Foss, A., Hladik, G. (2022a). Demand-Responsive Transit (DRT) Services Vs. Fixed Route Transit: An Exploratory Study of University Students. ASCE International Conference on Transportation & Development, Seattle, WA, 2022 (PP. 77-87).

Khan, M., Etminani, R., Kermanshachi, S., Rosenberger, J., Qisheng, P., and Foss, A. (2022b). Do Ridesharing Transportation Services Alleviate Traffic Crashes? A Time Series Analysis. *Traffic Injury Prevention*, 23 (6), PP. 333-338.

Khan, M., Etminani, R., Kermanshachi, S., Rosenberger, J., and Foss, A. (2022c). Usage Patterns and Perceptions of Shared Autonomous Vehicles (SAVs): Empirical Findings from a Self-driving Service. ASCE International Conference on Transportation & Development, Seattle, WA, 2022 (pp. 94-104).

Khan, M., Etminani, R., Patel, R., Kermanshachi, S., Rosenberger, J., and Foss, A. (2022d). Identifying Usage of Shared Autonomous Vehicles (SAVs): Early Findings from a Pilot Project. Proceedings of Transportation Research Board 101st Annual Conference, (Paper 22-01325), Washington, DC, 2022.

Khan, M.A., Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J.M. and Foss, A. (2023a). A User and Ridership Evaluation of Shared Autonomous Vehicles. *Journal of Urban Planning and Development*, 149(1), p.05022048.

Khan, M., Patel, R.K., Pamidimukkala, A., Kermanshachi, S., Rosenberger, J.M., Hladik, G. and Foss, A. (2023b). Factors that determine a university community's satisfaction levels with public transit services. *Frontiers in Built Environment*, 9, p.1125149.

Khan, M., Patel, R.K., Kermanshachi, S., Rosenberger, J.M., Hladik, G., Etminani-Ghasrodashti, R., Pamidimukkala, A. and Foss, A. (2023c). Understanding Students' Satisfaction with University Transportation. In International Conference on Transportation and Development 2023 (pp. 522-532).

Khan, M., Etminani-Ghasrodashti, R., Kermanshachi, S., Michael Rosenberger, J. and Pan, Q. (2023d). Do Ridesharing Services Reduce Traffic Crashes and Injuries? A Case Study. In International Conference on Transportation and Development 2023 (pp. 171-179).

Kim, M.-K., Oh, J., Park, J.-H., & Joo, C. (2018). Perceived value and adoption intention for electric vehicles in Korea: Moderating effects of environmental traits and government supports. *Energy*, *159*, 799-809.

Kim, J. H., Lee, G., Park, J. Y., Hong, J., & Park, J. (2019). Consumer intentions to purchase battery electric vehicles in Korea. *Energy Policy*, *132*, 736-743.

Krishnan, V. V., & Koshy, B. I. (2021). Evaluating the factors influencing purchase intention of electric vehicles in households owning conventional vehicles. *Case Studies on Transport Policy*, *9*(3), 1122-1129.

Kongklaew, C., Phoungthong, K., Prabpayak, C., Chowdhury, M. S., Khan, I., Yuangyai, N., . . . Techato, K. (2021). Barriers to electric vehicle adoption in Thailand. *Sustainability*, *13*(22), 12839.

Kumar, R. R., & Alok, K. (2020). Adoption of electric vehicle: A literature review and prospects for sustainability. *Journal of Cleaner Production*, *253*, 119911.

Künle, E., & Minke, C. (2022). Macro-environmental comparative analysis of e-mobility adoption pathways in France, Germany and Norway. *Transport Policy*, *124*, 160-174.

Lai, I. K., Liu, Y., Sun, X., Zhang, H., & Xu, W. (2015). Factors influencing the behavioural intention towards full electric vehicles: An empirical study in Macau. *Sustainability*, *7*(9), 12564-12585.

Langbroek, J. H., Franklin, J. P., & Susilo, Y. O. (2016). The effect of policy incentives on electric vehicle adoption. *Energy Policy*, *94*, 94-103.

Lashari, Z. A., Ko, J., & Jang, J. (2021). Consumers' intention to purchase electric vehicles: Influences of user attitude and perception. *Sustainability*, *13*(12), 6778.

Li, J., Jiao, J., & Tang, Y. (2020). Analysis of the impact of policies intervention on electric vehicles adoption considering information transmission—based on consumer network model. *Energy Policy*, *144*, 111560.

Li, W., Long, R., Chen, H., & Geng, J. (2017). A review of factors influencing consumer intentions to adopt battery electric vehicles. *Renewable and Sustainable Energy Reviews*, *78*, 318-328.

Li, W., Long, R., Chen, H., Yang, M., Chen, F., Zheng, X., & Li, C. (2019). Would personal carbon trading enhance individual adopting intention of battery electric vehicles more effectively than a carbon tax? *Resources, Conservation and Recycling*, *149*, 638-645.

Li, W., Long, R., Chen, H., Yang, T., Geng, J., & Yang, M. (2018). Effects of personal carbon trading on the decision to adopt battery electric vehicles: Analysis based on a choice experiment in Jiangsu, China. *Applied Energy*, *209*, 478-488.

Lim, M. K., Mak, H.-Y., & Rong, Y. (2015). Toward mass adoption of electric vehicles: Impact of the range and resale anxieties. *Manufacturing & Service Operations Management*, *17*(1), 101-119.

Lin, B. and W. Wu. (2018). Why people want to buy electric vehicle: An empirical study in first-tier cities of China. *Energy Policy*, 112: 233-241

Linzenich, A., Arning, K., Bongartz, D., Mitsos, A., & Ziefle, M. (2019). What fuels the adoption of alternative fuels? Examining preferences of German car drivers for fuel innovations. *Applied energy*, *249*, 222-236.

Liu, R., Ding, Z., Jiang, X., Sun, J., Jiang, Y., & Qiang, W. (2020). How does experience impact the adoption willingness of battery electric vehicles? The role of psychological factors. *Environmental Science and Pollution Research*, *27*, 25230-25247.

Liu, R., Ding, Z., Wang, Y., Jiang, X., Jiang, X., Sun, W., . . . Liu, M. (2021). The relationship between symbolic meanings and adoption intention of electric vehicles in China: The moderating effects of consumer self-identity and face consciousness. *Journal of Cleaner Production*, *288*, 125116.

Lu, T., Yao, E., Jin, F., & Pan, L. (2020). Alternative incentive policies against purchase subsidy decrease for battery electric vehicle (BEV) adoption. *Energies*, *13*(7), 1645.

Ma, S.-C., Fan, Y., & Feng, L. (2017). An evaluation of government incentives for new energy vehicles in China focusing on vehicle purchasing restrictions. *Energy Policy*, *110*, 609-618.

Mandys, F. (2021). Electric vehicles and consumer choices. *Renewable and Sustainable Energy Reviews*, *142*, 110874.

Melton, N., Axsen, J., & Goldberg, S. (2017). Evaluating plug-in electric vehicle policies in the context of long-term greenhouse gas reduction goals: Comparing 10 Canadian provinces using the "PEV policy report card". *Energy Policy*, *107*, 381-393.

Mersky, A. C., Sprei, F., Samaras, C., & Qian, Z. S. (2016). Effectiveness of incentives on electric vehicle adoption in Norway. *Transportation Research Part D: Transport and Environment*, *46*, 56-68.

Mohammadzadeh, N., Zegordi, S. H., Kashan, A. H., & Nikbakhsh, E. (2022). Optimal government policy-making for the electric vehicle adoption using the total cost of ownership under the budget constraint. *Sustainable Production and Consumption*, *33*, 477-507.

Moeletsi, M. E. (2021). Socio-economic barriers to adoption of electric vehicles in South Africa: Case study of the gauteng province. *World Electric Vehicle Journal*, *12*(4), 167.

Mukherjee, S. C., & Ryan, L. (2020). Factors influencing early battery electric vehicle adoption in Ireland. *Renewable and Sustainable Energy Reviews*, *118*, 109504.

Murugan, M., & Marisamynathan, S. (2022a). Analysis of barriers to adopt electric vehicles in India using fuzzy DEMATEL and Relative importance Index approaches. *Case Studies on Transport Policy*, *10*(2), 795-810.

Murugan, M., & Marisamynathan, S. (2022b). Elucidating the Indian customers requirements for electric vehicle adoption: An integrated analytical hierarchy process–Quality function deployment approach. *Case Studies on Transport Policy*, *10*(2), 1045-1057.

Neves, S. A., Marques, A. C., & Fuinhas, J. A. (2019). Technological progress and other factors behind the adoption of electric vehicles: Empirical evidence for EU countries. *Research in Transportation Economics*, *74*, 28-39.

Nie, Y. M., Ghamami, M., Zockaie, A., & Xiao, F. (2016). Optimization of incentive polices for plug-in electric vehicles. *Transportation Research Part B: Methodological*, *84*, 103-123.

Nipa, T.J. and Kermanshachi, S. (2022). Development of SEM Model to Measure Resilience in Horizontal Transportation Infrastructure. In *International Conference on Transportation and Development 2022* (pp. 83-95).

Nipa, T.J., Kermanshachi, S. and Pamidimukkala, A. (2023). Evaluation of Resilience Dimensions on Reconstruction of Highway Infrastructure Projects. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *15*(2), p.04522057.

Noel, L., de Rubens, G. Z., Kester, J., & Sovacool, B. K. (2020). Understanding the socio-technical nexus of Nordic electric vehicle (EV) barriers: A qualitative discussion of range, price, charging and knowledge. *Energy Policy*, *138*, 111292.

Nunnally, J., Bernstein, I. (1978). Psychometric Theory. McGraw-Hill, New York.

Pamidimukkala, A. and Kermanshachi, S. (2021). Impact of Covid-19 on field and office workforce in construction industry. *Project Leadership and Society*, *2*, p.100018.

Pamidimukkala, A., Kermanshachi, S. and Jahan Nipa, T. (2021). Impacts of COVID-19 on health and safety of workforce in construction industry. In International Conference on Transportation and Development 2021 (pp. 418-430).

Pamidimukkala, A., Kermanshachi, S. and Patel, R. (2023a). An Exploratory Analysis of Crashes Involving Autonomous Vehicles. In International Conference on Transportation and Development 2023 (pp. 343-350).

Pamidimukkala, A., Patel, R.K., Kermanshachi, S., Rosenberger, J.M. and Tanvir, S. (2023b). A Review on Shared Mobility and Electric Vehicles. In International Conference on Transportation and Development 2023 (pp. 333-342).

Parker, N., Breetz, H. L., Salon, D., Conway, M. W., Williams, J., & Patterson, M. (2021). Who saves money buying electric vehicles? Heterogeneity in total cost of ownership. *Transportation Research Part D: Transport and Environment*, *96*, 102893.

Patel, R.K., Etminani, R., Kermanshachi, S., Rosenberger, and Weinreich, D. (2021). Exploring Preferences towards Integrating the Autonomous Vehicles with the Current Microtransit Services: A Disability Focus Group Study. ASCE International Conference on Transportation & Development, Austin, TX, June 2021 (PP. 355-366).

Patel, R., Etminani, R., Kermanshachi, S., Rosenberger, J., and Foss, A. (2022a). Exploring Willingness to Use Shared Autonomous Vehicles. *Elsevier International Journal of Transportation Science and Technology,* 12(2023), 765-778.

Patel, R., Etminani, R., Kermanshachi, S., Rosenberger, J., and Foss, A. (2022b). Mobility-on-Demand (MOD) Projects: A study of the Best Practices Adopted in United States. *Elsevier Journal of Transportation Research Interdisciplinary Perspectives*, 14 (22), PP. 100601.

Patel, R., Etminani-Ghasrodashti, R., Kermanshachi, S., and Tafazzoli, M. (2022c). Exploring Disaster Preparedness and Awareness due to Natural Hazards Using Structural Equation Modelling (SEM). Proceedings of ASCE Construction Research Congress (CRC), Arlington, VA, March 2022 (PP. 160-171).

Patel, R.K., Etminani-Ghasrodashti, R., Kermanshachi, S., Michael Rosenberger, J. and Foss, A. (2022d). Impacts of Shared Autonomous Vehicles (SAVs) on Individuals' Travel Behavior: Evidence from a Pilot Project. In Automated People Movers and Automated Transit Systems 2022 (pp. 71-80).

Patel, R.K., Etminani-Ghasrodashti, R., Kermanshachi, S., Michael Rosenberger, J. and Foss, A., (2022e). How Riders Use Shared Autonomous Vehicles. In Automated People Movers and Automated Transit Systems 2022 (pp. 81-93).

Patel, R.K., Pamidimukkala, A., Kermanshachi, S. and Etminani-Ghasrodashti, R. (2023a). Disaster preparedness and awareness among university students: a structural equation analysis. *International journal of environmental research and public health*, *20*(5), p.4447.

Patel, R.K., Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J.M., Pamidimukkala, A. and Foss, A. (2023b). Identifying individuals' perceptions, attitudes, preferences, and concerns of shared autonomous vehicles: During-and post-implementation evidence. *Transportation Research Interdisciplinary Perspectives*, *18*, p.100785.

Patel RK, Etminani-Ghasrodashti R, Kermanshachi S, Rosenberger JM, Foss A. (2023c). Exploring Factors Affecting Shared Autonomous Vehicle Adoption: A Structural Equation Modeling Analysis. In Transportation Research Board 102 Annual Meeting 2023 (pp. 23-00216).

Patel, R.K., Etminani-Ghasrodashti, R., Kermanshachi, S., Michael Rosenberger, J. and Foss, A. (2023d). Exploring People's Attitudes and Perceptions of Using Shared Autonomous Vehicles: A Focus Group Study. In International Conference on Transportation and Development 2023 (pp. 231-240).

Patel, R.K., Etminani-Ghasrodashti, R., Kermanshachi, S., Michael Rosenberger, J. and Foss, A. (2023e). Users' and Nonusers' Attitudes and Perceptions of Shared Autonomous Vehicles: A Case Study in Arlington, Texas. In International Conference on Transportation and Development 2023 (pp. 241-252).

Patt, A., Aplyn, D., Weyrich, P., & van Vliet, O. (2019). Availability of private charging infrastructure influences readiness to buy electric cars. *Transportation Research Part A: Policy and Practice*, *125*, 1-7.

Patyal, V. S., Kumar, R., & Kushwah, S. (2021). Modeling barriers to the adoption of electric vehicles: An Indian perspective. *Energy*, *237*, 121554.

Peters, A. and E. Dütschke (2014). How do consumers perceive electric vehicles? A comparison of German consumer groups. *Journal of Environmental Policy & Planning*, 16(3): 359-377.

Peters, A. M., van der Werff, E., & Steg, L. (2018). Beyond purchasing: Electric vehicle adoption motivation and consistent sustainable energy behaviour in The Netherlands. *Energy Research & Social Science*, *39*, 234-247.

Plötz, P., Schneider, U., Globisch, J., & Dütschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. *Transportation Research Part A: Policy and Practice*, *67*, 96-109.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y., Podsakoff, N.P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology* 885 (879), 10–1037.

Pradeep, V. H., Amshala, V. T., & Kadali, B. R. (2021). Does perceived technology and knowledge of maintenance influence purchase intention of BEVs. *Transportation Research Part D: Transport and Environment*, *93*, 102759.

Quak, H., Nesterova, N., & van Rooijen, T. (2016). Possibilities and barriers for using electric-powered vehicles in city logistics practice. *Transportation Research Procedia*, *12*, 157-169.

Ramesan, S., Kumar, P., & Garg, S. K. (2022). Analyzing the enablers to overcome the challenges in the adoption of electric vehicles in Delhi NCR. *Case Studies on Transport Policy*, *10*(3), 1640-1650.

Rietmann, N., & Lieven, T. (2019). How policy measures succeeded to promote electric mobility–Worldwide review and outlook. *Journal of cleaner production*, *206*, 66-75.

Rezvani, Z., Jansson, J., & Bengtsson, M. (2018). Consumer motivations for sustainable consumption: The interaction of gain, normative and hedonic motivations on electric vehicle adoption. *Business Strategy and the Environment*, *27*(8), 1272-1283.

Rezvani, Z., Jansson, J., & Bodin, J. (2015). Advances in consumer electric vehicle adoption research: A review and research agenda. *Transportation research part D: transport and environment*, *34*, 122-136.

Rouhanizadeh, B. and Kermanshachi, S. (2021). Development of a Model Determining the Relationships of the Factors Delaying Reconstruction Projects. In International Conference on Transportation and Development 2021 (pp. 330-340).

Rouhanizadeh, B. and Kermanshachi, S. (2022a). Investigation of the Causal Relationships among Different Barrier Categories to Timely Post hurricane Recovery. *Natural Hazards Review*, *23*(3), p.04022013.

Rouhanizadeh, B. and Kermanshachi, S. (2022b). Post-Hurricane Recovery Process: Analysis of the Public and Subject Matter Experts' Perspectives Using Structural Equation Modeling (SEM). In Construction Research Congress 2022 (pp. 57-68).

Rouhanizadeh, B. and Kermanshachi, S. (2022c). Post-Hurricane Recovery Process: Analysis of the Public and Subject Matter Experts' Perspectives Using Structural Equation Modeling (SEM). In Construction Research Congress 2022 (pp. 57-68).

Rudolph, C. (2016). How may incentives for electric cars affect purchase decisions? *Transport Policy*, *52*, 113-120.

Ruoso, A. C., & Ribeiro, J. L. D. (2022). An assessment of barriers and solutions for the deployment of electric vehicles in the Brazilian market. *Transport Policy*, *127*, 218-229.

Safapour, E., Kermanshachi, S. and Kamalirad, S. (2019). Development of effective communication network in construction projects using structural equation modeling technique. In ASCE International Conference on Computing in Civil Engineering 2019 (pp. 513-521). Reston, VA: American Society of Civil Engineers.

Saleem, M. A., Eagle, L., & Low, D. (2018). Market segmentation based on eco-socially conscious consumers' behavioral intentions: Evidence from an emerging economy. *Journal of cleaner production*, *193*, 14-27.

Sanguesa, J. A., Torres-Sanz, V., Garrido, P., Martinez, F. J., & Marquez-Barja, J. M. (2021). A review on electric vehicles: Technologies and challenges. *Smart Cities*, *4*(1), 372-404.

Schuitema, G., Anable, J., Skippon, S., & Kinnear, N. (2013). The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. *Transportation Research Part A: Policy and Practice, 48*, 39-49.

Schwartz, S. H. (1977). Normative influences on altruism. Advances in experimental social psychology, Elsevier. 10: 221-279.

Shafiei, E., Davidsdottir, B., Fazeli, R., Leaver, J., Stefansson, H., & Asgeirsson, E. I. (2018). Macroeconomic effects of fiscal incentives to promote electric vehicles in Iceland: Implications for government and consumer costs. *Energy Policy*, *114*, 431-443.

Shamshirband, M., Salehi, J., & Gazijahani, F. S. (2018). Decentralized trading of plug-in electric vehicle aggregation agents for optimal energy management of smart renewable penetrated microgrids with the aim of CO2 emission reduction. *Journal of Cleaner Production*, *200*, 622-640.

Shaheen, F., N. Ahmad, M. Waqas, A. Waheed, and O. Farooq. (2017). Structural equation modeling (SEM) in social sciences & medical research: A guide for improved analysis." *Int. J. Acad. Res. Bus. Social Sci.* 7 (5): 132–143.

Shalender, K. and N. Sharma. (2021). Using extended theory of planned behaviour (TPB) to predict adoption intention of electric vehicles in India. *Environment, Development and Sustainability*, 23(1): 665-681

She, Z.-Y., Sun, Q., Ma, J.-J., & Xie, B.-C. (2017). What are the barriers to widespread adoption of battery electric vehicles? A survey of public perception in Tianjin, China. *Transport Policy, 56*, 29-40.

Shim, D., Shin, J., & Kwak, S. Y. (2018). Modelling the consumer decision-making process to identify key drivers and bottlenecks in the adoption of environmentally friendly products. *Business Strategy and the Environment*, *27*(8), 1409-1421.

Sierzchula, W., Bakker, S., Maat, K., & Van Wee, B. (2014). The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy policy, 68*, 183-194.

Singh, V., Singh, V., & Vaibhav, S. (2020). A review and simple meta-analysis of factors influencing adoption of electric vehicles. *Transportation Research Part D: Transport and Environment*, *86*, 102436.

Skippon, S. M. (2014). How consumer drivers construe vehicle performance: Implications for electric vehicles. *Transportation Research Part F: Traffic Psychology and Behaviour*, *23*, 15-31.

Sovacool, B. K., Kester, J., Noel, L., & de Rubens, G. Z. (2018). The demographics of decarbonizing transport: The influence of gender, education, occupation, age, and household size on electric mobility preferences in the Nordic region. *Global Environmental Change*, *52*, 86-100.

Sreen, N., S. Purbey and P. Sadarangani. (2018). Impact of culture, behavior and gender on green purchase intention. *Journal of retailing and consumer services*, 41: 177-189.

Stockkamp, C., Schäfer, J., Millemann, J. A., & Heidenreich, S. (2021). Identifying factors associated with consumers' adoption of e-mobility—A systematic literature review. *Sustainability*, *13*(19), 10975.

Sweeney, J. C. and G. N. Soutar. (2001). Consumer perceived value: The development of a multiple item scale. *Journal of retailing*, 77(2): 203-220.

Tamor, M. A., Gearhart, C., & Soto, C. (2013). A statistical approach to estimating acceptance of electric vehicles and electrification of personal transportation. *Transportation Research Part C: Emerging Technologies*, *26*, 125-134.

Tanwir, N. S., & Hamzah, M. I. (2020). Predicting purchase intention of hybrid electric vehicles: Evidence from an emerging economy. *World Electric Vehicle Journal*, *11*(2), 35.

Teter, J. (September 2022). *Transport Tracking Report- September 2022*. International Environment Agency (IEA). Retrieved January 5 from *https://www.iea.org/reports/transport*

Thananusak, T., Rakthin, S., Tavewatanaphan, T., & Punnakitikashem, P. (2017). Factors affecting the intention to buy electric vehicles: Empirical evidence from Thailand. *International Journal of Electric and Hybrid Vehicles*, *9*(4), 361-381.

Tu, J.-C. and C. Yang. (2019). Key factors influencing consumers' purchase of electric vehicles. *Sustainability*, 11(14): 3863

United States Department of Energy. (2020). Saving on Fuel and vehicle Costs. Office of Energy Efficiency and Renewable Energy.

Vafaei-Zadeh, A., T.-K. Wong, H. Hanifah, A. P. Teoh and K. Nawaser. (2022). Modelling electric vehicle purchase intention among generation Y consumers in Malaysia. *Research in Transportation Business & Management*, 43: 100784

Venkatesh, V., J. Y. Thong and X. Xu. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. MIS quarterly: 157-178.

Wang, F., Deng, Y., & Yuan, C. (2020). Life cycle assessment of lithium oxygen battery for electric vehicles. *Journal of Cleaner Production*, *264*, 121339.

Wang, S., Wang, J., Li, J., Wang, J., & Liang, L. (2018). Policy implications for promoting the adoption of electric vehicles: do consumer's knowledge, perceived risk and financial incentive policy matter? *Transportation Research Part A: Policy and Practice*, *117*, 58-69.

Wolbertus, R., Kroesen, M., van den Hoed, R., & Chorus, C. G. (2018). Policy effects on charging behaviour of electric vehicle owners and on purchase intentions of prospective owners: Natural and stated choice experiments. *Transportation Research Part D: Transport and Environment*, *62*, 283-297.

Xia, Z., Wu, D., & Zhang, L. (2022). Economic, functional, and social factors influencing electric vehicles' adoption: An empirical study based on the diffusion of innovation theory. *Sustainability*, *14*(10), 6283.

Xu, Y., Zhang, W., Bao, H., Zhang, S., & Xiang, Y. (2019). A SEM–neural network approach to predict customers' intention to purchase battery electric vehicles in china's Zhejiang province. *Sustainability*, *11*(11), 3164.

Xue, C., Zhou, H., Wu, Q., Wu, X., & Xu, X. (2021). Impact of incentive policies and other socio-economic factors on electric vehicle market share: A panel data analysis from the 20 countries. *Sustainability*, *13*(5), 2928.

Yarimoglu, E. and T. Gunay. (2020). The extended theory of planned behavior in Turkish customers' intentions to visit green hotels. *Business Strategy and the Environment*, 29(3): 1097-1108.

Zhang, Y., Yu, Y., & Zou, B. (2011). Analyzing public awareness and acceptance of alternative fuel vehicles in China: The case of EV. *Energy Policy*, *39*(11), 7015-7024.

Zhang, Y., C. Xiao and G. Zhou. (2020). Willingness to pay a price premium for energy-saving appliances: Role of perceived value and energy efficiency labeling. *Journal of Cleaner Production*, 242: 118555.

Zaunbrecher, B. S., Beul-Leusmann, S., & Ziefle, M. (2015). Laypeople's perspectives on electromobility: a focus group study. Internet of Things. IoT Infrastructures: First International Summit, IoT360 2014, Rome, Italy, October 27-28, 2014, Revised Selected Papers, Part II 1,

Zhou, Y., Wen, R., Wang, H., & Cai, H. (2020). Optimal battery electric vehicles range: A study considering heterogeneous travel patterns, charging behaviors, and access to charging infrastructure. *Energy*, *197*, 116945.

Zhuge, C., & Shao, C. (2019). Investigating the factors influencing the uptake of electric vehicles in Beijing, China: Statistical and spatial perspectives. *Journal of cleaner production*, *213*, 199-216.

Zhuge, C., Wei, B., Shao, C., Shan, Y., & Dong, C. (2020). The role of the license plate lottery policy in the adoption of Electric Vehicles: A case study of Beijing. *Energy Policy*, *139*, 111328.

APPENDIX A

Survey

EVs for Personal Use

1. How would you rate your interest towards using Electric Vehicles (EVs)?
   1. Not at all interested
   2. Slightly interested
   3. Neutral
   4. Fairly interested
   5. Strongly interested

2. How important are the following barriers in your decision-making to purchase an EV?

	Not at all important	Slightly important	Neutral	Fairly important	Strongly important
Limited driving range of EVs	❑	❑	❑	❑	❑
Long charging time	❑	❑	❑	❑	❑
Poor acceleration	❑	❑	❑	❑	❑
Risk of battery degradation	❑	❑	❑	❑	❑
Lack of choice and availability of EVs in the market (size and style)	❑	❑	❑	❑	❑
High purchase price of EVs	❑	❑	❑	❑	❑
Lower resale value	❑	❑	❑	❑	❑
Electricity cost of charging EVs	❑	❑	❑	❑	❑
Battery replacement cost when it reaches end of life	❑	❑	❑	❑	❑
Cost for installation of EV charging infrastructure at home	❑	❑	❑	❑	❑
Insufficient number of public charging stations	❑	❑	❑	❑	❑
Insufficient maintenance and repair services	❑	❑	❑	❑	❑
Charging problem in the absence of residential garage	❑	❑	❑	❑	❑
Problems of battery disposal	❑	❑	❑	❑	❑
Environmental impact of battery production	❑	❑	❑	❑	❑
Low reliability of charging power grid	❑	❑	❑	❑	❑

3. Please rate your agreement with the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I am familiar with the performance of EVs (such as charging time, acceleration, driving comfort, and driving range)	❑	❑	❑	❑	❑

I am familiar with the usage cost of EVs	❑	❑	❑	❑	❑
I am familiar with the advantages of EVs over the traditional gasoline vehicles	❑	❑	❑	❑	❑
An EV is useful to reduce my household expenditures on transportation	❑	❑	❑	❑	❑
An EV can improve my travel efficiency and improve my living quality	❑	❑	❑	❑	❑
I believe it would be simple to use an EV (eg., charging, maintenance)	❑	❑	❑	❑	❑
I believe it would be easy for me to drive EV to anywhere I want	❑	❑	❑	❑	❑
I believe it would be easy for me to handle EVs skillfully	❑	❑	❑	❑	❑
I am afraid of suffering financial losses when using electric vehicles	❑	❑	❑	❑	❑
I would not feel totally safe when I drive an EV on the road	❑	❑	❑	❑	❑
I worry about whether EVs will really perform like traditional vehicles	❑	❑	❑	❑	❑
I worry about inconveniences when using EVs (such as limited driving range, charging infrastructure and recharging time)	❑	❑	❑	❑	❑

4. Please rate your agreement with the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I think the development of EVs is good for the environment	❑	❑	❑	❑	❑
I support the country to introduce more policies to encourage individuals to purchase EVs	❑	❑	❑	❑	❑
I think buying an EV is a good choice	❑	❑	❑	❑	❑
I believe having subsidies will encourage the purchase of EVs	❑	❑	❑	❑	❑
I believe relaxation in tax policies will be helpful to purchase EVs	❑	❑	❑	❑	❑
EVs are reasonably priced	❑	❑	❑	❑	❑
EVs offer value for the money	❑	❑	❑	❑	❑
EVs are economical in the long run	❑	❑	❑	❑	❑
The opinion of my family members is an important factor in my decision to buy an EV	❑	❑	❑	❑	❑
If someone around me buys an EV, their	❑	❑	❑	❑	❑

behavior will motivate me to buy an EV					
The media's positive coverage of EVs will motivate me to buy an EV	❏	❏	❏	❏	❏
It is completely up to me whether or not I purchase an EV	❏	❏	❏	❏	❏

5. Please rate your agreement with the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I am confident that in the future I will be able to travel in an EV	❏	❏	❏	❏	❏
If I heard about a new product, I would look for ways to experiment with it	❏	❏	❏	❏	❏
I like to experiment with new products	❏	❏	❏	❏	❏
Among my peers, I am usually the first to explore new products	❏	❏	❏	❏	❏
I believe it is my moral responsibility to reduce environmental pollution and greenhouse gases emissions	❏	❏	❏	❏	❏
I feel morally obliged to adopt EV irrespective of what others think of me.	❏	❏	❏	❏	❏
I take into account environment consequences while I adopt a vehicle.	❏	❏	❏	❏	❏
I am willing to purchase an EV when choosing a vehicle in the next 5 years	❏	❏	❏	❏	❏
I am planning to purchase an EV when choosing a vehicle in the next 5 years	❏	❏	❏	❏	❏
I will definitely purchase an EV when choosing a vehicle in the next 5 years	❏	❏	❏	❏	❏

6. Do you own or have access to an EV for your daily use?
   - o Yes
   - o No

7. When do you anticipate owning or having access to an EV for your daily use?
   - o Within 1 year
   - o In 2-3 years
   - o In more than 3 years
   - o Never
   - o Do not know

8. How frequently do you drive your EV to campus?
   - o 1-2 days per week
   - o 3-4 days per week
   - o 5+; days per week
   - o Never

9. How often do you charge your electric vehicle on campus?
   - o 1-2 days per week
   - o 3-4 days per week
   - o 5+; days per week
   - o Never

10. What role should the university play in providing the public with available charging stations?
   - o It is the university's responsibility to provide EV charging
   - o It is not the university's role to provide EV chargers

11. How much is a reasonable amount to pay to fully charge an EV?
   - o $0- It should be free
   - o $1-$10
   - o $11-$20
   - o $21-$30
   - o $31-$40
   - o $41-$50
   - o $51+

12. Please rate the level of importance with the following statements.

	Not at all important	Slightly important	Neutral	Fairly important	Strongly important
It is important to have public Level 2 charging stations (25 miles of range per hour charged) on campus to charge EVs	❑	❑	❑	❑	❑
It is important to have public FAST charging stations (100 miles of range per hour charged) on campus to charge EVs	❑	❑	❑	❑	❑
It is important to have designated parking lots for EVs on campus when not actively charging	❑	❑	❑	❑	❑
It is important that the university convert the public shared vehicles (e.g., buses and vans) to electric	❑	❑	❑	❑	❑

13. How likely would you use the following type of shared services based on their fuel type?

	Very unlikely	Somewhat unlikely	Neutral	Somewhat likely	Very likely
Gasoline/Diesel car-sharing services (e.g., Zipcar, Car2Go)	❏	❏	❏	❏	❏
Electric car-sharing services (e.g., Zipcar, Car2Go)	❏	❏	❏	❏	❏
Gasoline/Diesel ride-hailing (e.g., Uber and Lyft)	❏	❏	❏	❏	❏
Electric ride-hailing (e.g., Uber and Lyft)	❏	❏	❏	❏	❏
Gasoline/Diesel ridesharing (e.g., Via, Late-Night Security Escort)	❏	❏	❏	❏	❏
Electric ridesharing (e.g., Via, Late-Night Security Escort)	❏	❏	❏	❏	❏
Gasoline/Diesel fixed-route service (e.g., Mavmover)	❏	❏	❏	❏	❏
Electric fixed-route service (e.g., Mavmover)	❏	❏	❏	❏	❏

14. If public transportation (e.g., buses, trains, DART, Trinity Metro) was available near your home, what is the likelihood that you would use it regularly to commute to campus instead of driving yourself if the fuel types were the following?

	Very unlikely	Somewhat unlikely	Neutral	Somewhat likely	Very likely
Gasoline/disel	❏	❏	❏	❏	❏
Electric	❏	❏	❏	❏	❏

15. Your role on campus is best described as:
- o Faculty
- o Staff
- o Student
- o Other ___________

16. What gender do you identify with?
- o Female
- o Male
- o Other

17. Please specify how you identify yourself?
- Hispanic or Latino
- American Indian or Alaska Native
- Asian
- Black or African American
- Native Hawaiian or Pacific Islander
- Caucasian or White
- Other __________

18. What is your educational background? Please check the highest level attained
- Some grade/high school
- High school/GED
- Some college/technical school
- Associate degree
- Bachelor’s degree
- Graduate degree
- Ph.D. or other equivalent degree

19. In which of the following schools or divisions do you currently study/work?
- College of Architecture, Planning, and Public Affairs
- College of Business
- College of Education
- College of Engineering
- College of Liberal Arts
- College of Nursing and Health Innovation
- College of Science
- School of Social Work
- Division of Academic Affairs
- Division of Business and Finance
- Division of Research and Innovation
- Division of Administration and Economic Development
- Division of Development and Alumni Relations
- Division of Marketing, Messaging, and Engagement
- Division of Government Relations
- Division of Planning/Chief of Staff
- Division of Talent, Culture, and Inclusion
- Division of Athletics
- Other __________

20. Please indicate your age group from the below list.
- 18-24
- 25-34

- 35-44
- 45-54
- 55-64
- 65+

21. What is your five-digit zip code for your current residence?

22. What was your household income last year?
    - Less than $20,000
    - $20,000-$34,999
    - $35,000-$49,999
    - $50,000-$74,999
    - $75,000-$99,999
    - $100,000 or more

23. Do you have a valid driver's license?
    - Yes
    - No

24. How many vehicles are available to you and members of your household for daily travel?
    - None
    - 1
    - 2
    - 3 or more

25. How much driving experience do you have?
    - No experience
    - 0-3 years
    - 3-5 years
    - Over 5 years

26. Please specify if you have any comments regarding EVs?

27. If you are interested in a short interview to discuss the factors affecting the purchase of EVs, please provide your email address below.