Investigating People's Intention to Use Electric Bike in Pakistan as an Extended Technology Acceptance

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DEDICATION

I humbly dedicate this thesis to the remarkable teachers who have profoundly influenced my thinking with their wisdom and inspiration. Their guidance has played a pivotal role in shaping my academic journey.

To my cherished parents and siblings, who have been unwavering pillars of strength and constant sources of encouragement throughout my academic career, I offer my deepest gratitude. Your unwavering support has been instrumental in my achievements.

I wholeheartedly commit my efforts to the pursuit of knowledge and the betterment of society. It is my sincere hope that this thesis serves as a catalyst, inspiring future scholars and researchers to venture into unexplored realms and make noteworthy contributions to their specialized fields.

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LIST OF SYMBOLS, ABBREVIATIONS AND ACRONYMS

AGFI	Adjusted Goodness of Fit Index
AVE	Average Variance Extract
BI	Behavioral intentions
CB	Cost Benefit
CFI	Comparative Fit Index
CPEC	China Pakistan Economic Corridor
CR	Composite reliability
CRAN	Comprehensive R Archive Network
EA	ELECTRICITY ACCESSIBILITY
ENV_CON	ENVIRONMENTAL CONCERNS
GFI	Goodness of Fit Index
ML	Maximum Likelihood
NFI	Normed Fit Index
PER_EU	PERCEIVED EASE OF USE
PER_USE	Perceived usefulness
PER_VAL	PERCEIVED VALUE
PGFI	Parsimony Goodness of Fit Index
PNFI	Parsimony Normed Fit Index
RMSEA	Root Mean Square Error of Approximation
SAARC	South Asian Association for Regional Cooperation
SEM	Structural equation modeling
SO_INF	SOCIAL INFLUENCE

SRMR	Standardized Root Mean Square Residual
TAM	Technology acceptance model
TST	Trust
UTAUT	Unified Theory of Acceptance and Use of Technology
WHO	World Health organization

ABSTRACT

The growing concern for environmental sustainability and the need of efficient transportation options have led policymakers to consider environmentally friendly modes of transportation, such as electric bikes. Considering Pakistan, a country facing significant environmental challenges, the introduction of e-mobility presents a potential remedy against environmental catastrophe. However, the socioeconomic factors affecting the perception and acceptance of electric bikes, given Pakistan's substantial dependence on the use of motorbikes, needs to be considered. This research evaluates the determinants impacting the acceptance of electric bikes in Pakistan using Electric Automobiles Acceptance Model, combined with Structural Equation Modeling (SEM). A survey questionnaire has been developed to collect data from participants. Data analysis has been conducted using R programming. The study explores demographic information and examines key concepts that includes perceived utility, ease of use, value, environmental concerns along with social impact, electricity accessibility, behavioral intentions, trust and cost-benefit to evaluate the intentions towards using electric bikes. This research aims to ascertain the determinants that drive the inclination to use electric bikes in the context of Pakistan. The study findings will help to understand key factors that can impact people’s intention to use electric bike and provide recommendations to transportation agencies and policy makers to enhance the acceptance of use of electric bikes in Pakistan. Ultimately, the results have the potential to contribute towards sustainable transportation promotion and the reduction of carbon emissions in urban settings.

Keywords: Electric bikes; Technology Acceptance Model (TAM); Sustainable transportation; Policies and incentives

CHAPTER 1. INTRODUCTION

1.1 Overview

The transportation industry is responsible for a significant global CO2 emission, contributing to climate change and environmental concerns worldwide. As a result, the sector has been singled out as a major contributor to the worsening state of the environment. To mitigate these issues, it is essential to seek technological advancements that can reduce the negative impact accompanying with the transportation industry such as air and noise pollution; and CO2 emissions. Electric vehicles are considered to be a promising alternative, and the adoption of transportation rules that encourage the use of electric vehicles has contributed to a meteoric rise in sales of electric vehicles worldwide. For instance, the use of electric mobility increased at a rapid rate in developed countries, such as 55.93%, 21.6%, 13.14% and 12.43% in Norway, Iceland, the Netherlands, and Sweden, respectively [1]. However, the penetration level of electric cars in underdeveloped countries is not much high. Despite the increase in sales of electric automobiles worldwide, there adoption in Pakistan is still quite limited. Through an exploration of individual intentions to use electric bikes, this thesis aims to contribute to an enhanced understanding of the factors that provide the driving force towards the adoption of electric bikes in Pakistan, ultimately providing insights that may be useful in promoting sustainable transportation practices in the country.

1.2 Electric mobility in Pakistan

Pakistan ranks sixth among the countries that are most vulnerable to changes in the environment. The combustion of fossil fuels releases carbon dioxide that can be detrimental to human health and can contribute to the circulation of contaminated floodwater, aiding in the propagation of disease [3]. Despite Pakistan's commitments made at the SAARC summit to cut greenhouse gas emissions by approximately 20 percent by the year 2030, very slight efforts has been made in Pakistan towards the deployment electric vehicles [4].

The transportation of people and goods by road in Pakistan heavily relies on non-renewable or fossil fuel energy sources and is responsible for 18% of the total CO2

emissions of the country. The country has been experiencing 310,000 deaths per year as a direct result of air pollution, which is an indication of the exceedingly bad environmental conditions for public living [5]. The government's attention has been drawn to electric vehicles as an environmentally friendly solution in response to the growing number of problems associated with air. Recent media reports indicate that the government of Pakistan is contemplating transitioning 90% of its vehicle fleet to electric-powered vehicles by the year 2040. Additionally, as part of the CPEC project, the government has formulated a policy framework to address the challenges associated with the acceptance of e-mobility. However, the elements that influence people's intentions to purchase electric bikes are not yet fully understood, especially in Pakistan where there is higher dependency on petroleum-fueled motorbikes. The public's renewed interest in electric mobility can be attributed to the government's recent decision to offer financial incentives to manufacturers, buyers, and importers of e-bikes. It is anticipated that there will be a surge in the production of electric vehicles, thanks to the support of the government. Given these policies, it is imperative to assess public acceptance of electric vehicles across various factors. Such evaluations can provide valuable insights for policymakers and electric vehicle manufacturers, aiding in the anticipation of public intentions regarding electric vehicle purchases[4].

As per the official sources, the main aim of the electric vehicle policy is to boost the automobile sector of Pakistan. The Pakistan government's Electric Vehicle Policy 2020-2025, a five-year plan, includes the introduction of electric bikes. The formulated electric vehicle policy is based on making the country clean and green.

Electric bikes are rapidly gaining popularity in Pakistan. They are energy-efficient and fully charged by electricity, allowing them to travel nearly 71 kilometers. It takes around five hours to fully charge the bike. The bikes are eco-friendly and use a battery instead of petrol, producing low sound and being free from nature pollution.

1.3 Motivation

Electric vehicles have been adopted around the world, but considering Pakistan this sector is neglected up till now. Currently, there are no sufficient electric powered two- or four-wheelers available for purchase in Pakistan's open market, and the country lacks the necessary infrastructure to support the adoption of electric vehicles, as there

is no system in place to levy fees on electric vehicles. Recent studies have found that hybrids make up less than one percent of Pakistan's light-duty passenger vehicles. However, the country has taken a significant step with the implementation of the National Electric Vehicle Policy in 2019 [6]. This policy provides a framework for electric vehicle importers and manufacturers in Pakistan to benefit from the increasing demand for electric vehicles. Under the policy, electric vehicles are expected to make up 30 percent of all new vehicle sales in Pakistan by 2030. If properly integrated into the country's existing transportation infrastructure, electric vehicles have the potential to create a new industry and generate a significant number of job opportunities, while also improving the economy. The importance of introducing electric vehicles in contemporary society cannot be overstated, and any delay could exacerbate the challenges faced by the country.

1.4 Problem Statement

Pakistan is a country facing numerous environmental challenges, including air pollution, deforestation, water scarcity, and poor waste management practices. Transportation is a major contributor to environmental issues in Pakistan, particularly in urban areas where traffic congestion and air pollution are prevalent. The country's heavy reliance on motorbikes as a primary mode of transportation is a significant factor contributing to these challenges. Because of this, Pakistan's air quality index has significantly worsened in recent years. Concentration of multiple environmental pollutants exceeds the WHO's upper limit by ten times. And it looks like things are just going to get worse as time goes on [3]. Motorbikes are often the most affordable and accessible mode of transportation for low-income individuals and families, and are widely used for daily commuting to work or school, as well as for carrying goods and transporting people. However, the widespread use of motorbikes has negative consequences for both the environment and public health. Motorbikes emit high levels of carbon monoxide, nitrogen oxides, and other harmful pollutants that results in poor air quality. This air pollution can lead to severe health repercussions, encompassing respiratory illnesses, cardiovascular diseases, and premature mortality. Furthermore, motorbikes also contribute to noise pollution, that can have adverse impacts on both human health and wildlife. If the current trajectory continues, the amount of emissions

could double by the year 2021, and then increase by more than twice the amount by the year 2030 [7].

To address these challenges, Pakistan can take steps to promote alternative modes of transportation, such as public transit, electric bikes, and walking. Electric bikes, in particular, have gained popularity as a cleaner and more efficient mode of transportation in many countries [8], and could provide a viable solution in Pakistan as well. Electric bikes produce significantly fewer emissions than conventional bikes, are cost-effective, and require minimal maintenance. However, the acceptance of electric bikes in Pakistan is still in its premature stages, and there is a dire need to comprehend the factors that power people's intentions to utilize them.

Therefore, this study intends to investigate the determinants effecting individuals' intentions to adopt electric bikes in Pakistan, taking into account environmental considerations and the high dependency on fuel bikes. By understanding the determinants of electric bike use, policymakers can design effective strategies to promote their adoption as an alternative mode of transportation, thereby reducing environmental pollution and improving public health in Pakistan

1.5 Aims and Objectives

The study seeks to explore the factors that power the intention to use electric bikes in Pakistan. The study will examine the potential barriers to the acceptance of electric bikes as a transportation mode. By evaluating the factors that powers the intention to use electric bikes, this study aims to provide insights into how electric bikes can be promoted as a viable and sustainable mode of transportation in the country.

The findings of this study can inform policymakers and transportation planners in Pakistan on how to promote electric bikes as a viable and sustainable transportation option. Moreover, this research can make a valuable contribution to the literature concerning electric bike adoption in developing nations. In these regions, electric bikes offer a promising solution for clean and cost-effective transportation.

To investigate whether people are willing to buy electric bikes, this study came up with a model called the Electric Vehicles Acceptance Model. This model includes aspects such as environmental concerns, value, and the availability of electric power.

TAM was selected as the primary theoretical framework due to the simplicity and efficiency with which it explains the technological acceptance of various information systems related to electric vehicles. Following are the key hypothesis considered for the study, further the explanation of these hypothesis is given in the literature review section.

H1: Per_Use has positive relationship with BI towards using electric bikes.

H2: Per_EU has positive relationship with BI towards using electric bikes.

H3: Per_EU has positive relationship with Per_Use.

H4: Env_Con positively linked with BI towards using electric bikes.

H5: So_Inf have effect on Per_Use.

H6: EA has positive effect on Per_Use.

H7: Per_Val has positive effect on Per_EU.

H8: CB have positive effect on Per_EU.

H9: TST has positive effect on Per_EU.

1.6 Scope

This study aims to investigate the factors effecting individuals' intentions to use electric bikes in Pakistan, utilizing TAM. It will also conduct a comprehensive literature review on the factors that provides a driving force towards the adoption of electric bikes in different countries. The study will offer valuable insights for automobile manufacturers to develop effective marketing strategies for electric bikes and policymakers to encourage the purchase of electric bikes.

To gather data, the study will design a questionnaire for individuals from various socioeconomic backgrounds, including students, working professionals, and low-income households. SEM will be used to evaluate the statistics and identify factors influencing individuals' intentions to use electric bikes. The study will also compare its findings with existing literature on electric bike adoption in other countries to identify similarities and differences in factors influencing adoption.

Furthermore, this study's methodology and findings will be valuable for other underdeveloped and developing countries seeking to promote sustainable transportation modes. The study's methodology can be applied to other countries to investigate factors influencing consumers' intentions to use electric bikes. The study's recommendations and implications can also be adopted to suit the specific context of other countries, contributing to the promotion of sustainable transportation globally.

1.7 Thesis Organization

This thesis consists of six main chapters. Chapter one provides a brief overview of the background, aims, objectives, and scope of the study. Chapter two provides an overview of electric vehicles acceptance, previous studies, and literature published on electric vehicle acceptance. In addition, this chapter also summarizes the methods used in previous studies. Chapter three discusses the details of TAM, data collection selection for the thesis models, and the results for selected latent factors from the Extended TAM. Chapter four provides a background on the results and discussion from the TAM. Chapter five explains the implications of the research. Chapter six explains the overall conclusion as well as the limitations and future studies.

CHAPTER 2. LITERATURE REVIEW

This chapter offers a thorough literature review on the consumption of electric bikes and their intended use, drawing on previous studies. Additionally, the use of the TAM in the context of electric bike acceptance, including the latent factors and their impact on electric bike acceptance, are also discussed.

2.1 Investigating the Factors Affecting Electric Bikes Adoption: A Critical Review of the Literature

The transportation sector, particularly vehicular emissions, has a detrimental impact on air quality and the environment, especially in urban areas. Past studies have focused on various aspects of electric bikes proliferation, such as charging infrastructure, legislation and incentives, and business models, among others [8], [9], [10]. However, despite numerous evidence existing on the determinants of electric bike acceptance and its advantages, the question of why electric bike adoption is so challenging remains largely unanswered [11]. Moreover, many crucial aspects, including the mediating and moderating factors of the relationship between these variables have only been investigated to a limited extent. In addition, most prior research has been based on survey studies, optimization approaches, or secondary data analysis and projections to understand electric bike adoption in specific countries or regions with limited policy implications. The multidimensional and fragmented aspects of the electric bikes market have not received much attention in the existing body of research, Although, consumer intentions for electric bikes vary, they are influenced by a combination of economic, environmental, and prosocial considerations. Furthermore, these factors vary not only across cultures but also from nation to nation. As such, it is necessary to gather these findings across cultures to better understand the spread of electric bikes [12].

2.2 Technology Acceptance Model

The Theory of Planned Behavior and the Theory of Reasoned Action both have contributed in the development of the TAM. Davis (1985) came up with the idea for the TAM, which aimed to not only explain but also forecast the behavioral intentions of an individual in relation to technical advancements. Davis has investigated a

“potential user’s overall attitude toward using a given system is hypothesized to be a major determinant of whether he uses it [13]. Attitude toward using, in turn, is a function of two major beliefs: perceived usefulness and perceived ease of use.” Design elements have major influence on both the perceived usefulness and the perceived simplicity of the technology with which it can be utilized under the TAM. Both perceived usefulness and perceived ease of use have a direct influence on one's attitude towards utilizing a certain product or service. In the end, one's mental approach to using a system will have an effect on how that system is utilized. Figure 2.1 presents an illustration of the relationships that exist between these variables.

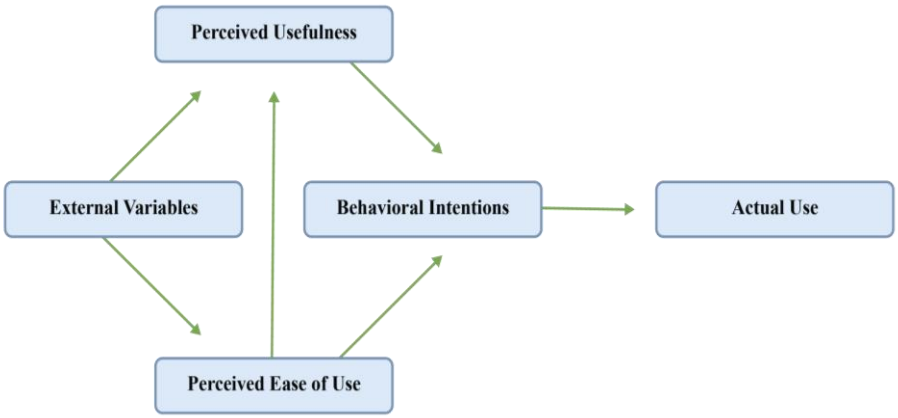

Figure 2.1: Actual TAM Model [13]

Davis (1985) has evaluated that “perceived usefulness indicates the extent to which individuals believe the use of particular systems would improve their job performance, whereas the factor perceived ease of use indicates to which extent individuals believe the use of particular systems would reduce physical or mental effort”. There is a wide range of possible contextual factors; it has been suggested that a helpful framework would include considerations of access, inspiration, ability, design, and training, among others. Beside Per_Use and Per_EU, researchers have analyzed the past half-century of research on how people react to advances in technology. They have developed a heuristic tool to help identify the factors that technology designers should keep in mind when developing new products. Perceptions about compatibility, complexity, enjoyment, self-image, freshness, privacy, facilitating conditions, and risk of harm were among the factors that were emphasized by these researchers. According to [14], separate models are required to account for the variables that influence

perceptions of how easy it is to learn and those that influence acceptance or rejection of technological advancements. A person's self-efficacy, the perceived difficulty of the task, and their attitudes are all elements that influence how easy it is to learn anything. Because of these characteristics, the TAM has gained widespread acceptance as a model that can both explain and forecast the attitude that humans have toward newly developed forms of technology. Due to these factors, TAM was an appropriate choice for the subject of this research.

2.3 Application of TAM for Investigating Factors Impacting Electric Bikes Adoption

One of the most popular theories of information systems, TAM was reformed from the theory of reasoned action by including new components. Users' acceptance and use of a novel technology are explained by TAM, it also identifies additional variables that contribute to acceptance. The usage of Per_Use and Per_EU is employed. The latter can be defined as the degree to which an individual believes that employing a particular approach would enhance their job performance. The ultimate factor is the Per_EU, which gauges an individual's perception of the simplicity of utilizing a specific technology [15].

TAM is a well-established framework used to understand and predict individuals' acceptance and usage of technology. When applied in the context of electric bikes, TAM can help in comprehending the factors that affect an individual's choice to adopt and utilize an electric bike. Several factors that can be examined through the lens of TAM in the context of electric bikes encompass:

- **Per_Use:** This refers to the degree to which an individual perceives that using an electric bike will enhance their performance and aid in achieving their objectives.
- **Per_EU:** This refers to the extent to which an individual perceives that using an electric bike is simple and requires minimal effort.
- **So-Inf:** This entails the influence of an individual's social circle, including friends, family, and colleagues, who use electric bikes, and how it affects the individual's own behavior regarding electric bike usage.

TAM has been utilized to examine the acceptance of electric bikes. According to TAM, the determinants affecting an individual's choice to adopt and utilize electric bikes encompass Per_Use, Per_EU and attitude towards the technology. By comprehending these factors, policymakers, manufacturers, and other stakeholders can formulate strategies to enhance the acceptance and adoption of electric bikes [16][17].

In one study conducted by Kroesen in 2017 [18], TAM was employed to forecast the acceptance of electric bikes. In this case, the study focused on examining how drivers intended to use electric bikes. Another study used TAM as the background to understand how Indian original equipment manufacturers (OEMs) and consumers perceive the use of battery charging infrastructure in electric bike adoption [19].

2.4 Purchase Intention

Purchase intention is a critical aspect of consumer behavior that describes the intention of a customer to complete a transaction with a vendor. The fundamental concept that drives consumer behavior is purchase intention. This term refers to situations where customers have a favorable mindset to complete a transaction with a vendor and is widely defined in academic research. Purchase intention considers the circumstances in which a consumer is driven to buy a product or service, and it is a useful tool for understanding customer behavior as it reveals their motivations. Studies have shown that purchase intention can shift based on factors such as price, perceived quality, or perceived value. To better understand the relationship between price, perceived quality, and perceived value, a conceptual model has been developed using evidence from previous research and an exploratory investigation. This model presents hypotheses on the concepts and their relationships, and evidence from existing research is used to support these claims. The discussion centers on the management of price, quality, and value, and potential directions for future research are identified [20].

During the purchase process, customers are influenced by both internal and external motivations and impulses. Experts have identified six stages in the customer mindset that occur before they decide to purchase a product[21]. These stages include awareness, knowledge, curiosity, preference, the ability to be persuaded, and the ability to make a purchase. To make a purchase decision, customers consider and weigh various factors. Although the criteria evaluated and the weight they carry may vary

from customer to customer, customers as a whole consider a set of fundamental components, including cost, performance, lifestyle image, social impact, and environmental credentials.

In the transportation sector, the purchase intention of electric bikes has gained significant attention due to the potential for sustainable transportation options. Understanding the factors that influence consumer behavior and purchase intention for electric bikes can help promote their adoption and decrease dependence on conventional fossil fuel-based transportation.

2.5 Perceived Ease of Use

Per_EU plays a crucial role in shaping the intention to utilize a product or technology [16]. When it comes to electric bikes, it pertains to the user's perception of the ease or difficulty associated with operating and controlling the bike, encompassing its motor, battery, and other functionalities. Research has consistently revealed that Per_EU is the most reliable predictor of actual or anticipated usage of a technological tool [13]. In other words, if users perceive the bike as user-friendly, they are more inclined to use it.

Furthermore, Per_EU can be defined as the degree to which the electric bike is regarded as effective in meeting the transportation requirements of an individual's regular life. In this context, clients of electric bikes anticipate financial savings on the cost of fuel as a result of their participation in activities related to their jobs. A 2011 study by the Energy Industry Management Assistance Program found that executive-level personnel spend a significant portion of their income on pump fuel for their vehicles, highlighting the need to explore alternative fuel vehicles such as electric bikes [22].

2.6 Perceived Usefulness

In TAM, Per_Use refers to the extent to which a user believes that a specific technology or system will enhance their productivity, effectiveness, and/or efficiency in accomplishing tasks or attaining goals. Per_Use is recognized as one of the two main factors that influence an individual's intention to adopt and utilize a technology or system. The other factor is Per_EU, which pertains to the degree to which a user

believes that the technology or system will be straightforward to operate [1]. The Per_Use of a technology or system can be impacted by various factors, such as the user's previous encounters with similar technologies or systems, their perception of the potential advantages and risks associated with using the technology, and the extent to which the technology aligns with their personal and organizational objectives and values.

Gaining an understanding of the Per_Use and Per_EU of electric bikes are crucial for encouraging their adoption as a sustainable transportation alternative. Factors like ease of use, cost savings, and environmental impact can significantly impact consumers' intentions to purchase and utilize electric bikes. By taking these factors into account, researchers and policymakers can effectively promote the adoption of electric bikes and decrease dependence on conventional fossil-fuel-based transportation methods.

2.7 Cost Benefits

Electric bikes provide numerous benefits for individuals and companies, such as faster travel times, lower costs, and reduced environmental impact. For individuals, electric bikes allow them to keep pace with faster riders and make riding in a group more enjoyable. Delivery and courier services are increasingly embracing electric bikes due to their ability to reduce costs, shorten delivery times, and garner higher customer satisfaction ratings.

The concept of "cost-benefit" pertains to the perception of whether there exists adequate organizational and technical infrastructure to facilitate the utilization of a system. [23]. In the context of electric bikes, CB refers to the presence of organizations and infrastructure that will be necessary in the foreseeable future to ensure a smooth integration of electric bikes into regular travel activities. A study conducted in Germany discovered that the CB is used in relation to electric bikes, specifically referring to the availability of organizations and infrastructure that will be required in the future to facilitate the seamless utilization of electric bikes for daily travel activities [24]. Another study found that CB significantly influenced individuals' inclinations to use electric vehicles in Germany [25].

In summary, CB plays significant role in influencing individuals' intentions to use electric bikes, and the presence of organizational and technical infrastructure is crucial for the seamless integration of electric bikes into daily travel routines.

2.8 Trust

According to a study, trust can be defined as the level to which individuals perceive the reliability and importance of vehicles [26]. Furthermore, the positive correlation between TST and BI has been confirmed for the acceptance of automated road transport systems in European cities. Although this research was conducted in the context of adopting automated road transport systems, several studies conducted in China (regarding the acceptance of electric car-sharing systems) and Germany (exploring users' intentions to use electric vehicles) found limited evidence supporting the hypothesis that TST has a positive impact on individuals' intentions [27]. These findings emphasize the significance of trust in shaping intentions to use electric bikes, particularly in situations where the technology is relatively new or unfamiliar to potential users.

2.9 The role of Environmental Concern in Intentions to Use Electric Bikes

Env_Con have a significant impact on the public's willingness to contribute to solving environmental issues, which in turn affects their intentions to use electric bikes. A study conducted in Hong Kong revealed that public concerns about the environment, along with Per_Val, TST in electric bikes, responsive efficacy, and willingness to pay, all contribute to individuals' intentions to acquire electric bikes [28]. Similarly, a study explored consumers' intentions to embrace hybrid electric vehicles using the theory of reasoned action [29].When the SEM technique was utilized, Env_Con, subjective standards, and attitudes were significant predictors of behavioral intentions to use hybrid electric vehicles [30]. Anecdotal research conducted in Malaysia also supports these findings, demonstrating that environmental concerns significantly impact the public acceptability of electric vehicles [31]. According to the findings of the study, having a positive attitude toward the environment, as well as social standards and a perceived high level of behavioral control, positively influences the intentions to purchase a hybrid vehicle. According to the research that was discussed before, it is

abundantly evident that people's concerns about the environment are a significant element that influences their intent to acquire electric bikes [32].

Previous studies have primarily focused on the BI regarding the adoption of electric bikes, with a notable emphasis on electric cars over electric bikes, as evidenced by review studies.[10]. A study conducted in Taiwan with 233 participants shed light on the psychological factors that positively influence individuals' behavioral intentions to purchase hydrogen-electric motorcycles. These factors include Per_Val, product knowledge, perceptions of quality, and Per_Use [33]. However, it was investigated that perceived risk had a negative relationship with Per_Val in terms of individuals' purchase intentions for hydrogen-electric motorcycles. In a qualitative study conducted in Taiwan, consumer preferences regarding the adoption of electric bikes were examined using a stated preference survey. The study highlighted that individual demographics, electric bike pricing, speed, range, and charging were influential characteristics that impacted purchasing intentions. To validate these influencing factors, an extension of the TAM was employed, utilizing SEM to analyze the adoption of electric bikes. Another study conducted in Taiwan utilized TAM model to underscore the impact of Per_Val, perceived risk, and attitude on individuals' behavioral to purchase electric bikes. [34]. In South Asia, a study was conducted using a survey to examine the effects of range, speed, charging time, and price on the adoption of electric bikes. The study focused on individuals residing in an urban area of Indonesia and aimed to understand how these factors influenced their perceptions and intentions to purchase electric bikes [29]. In Macau, another study was conducted to examine the impact of environmental on the adoption of electric bikes. The study aimed to assess the correlation between the acceptance of electric bikes and individuals' perceptions of environmental policies, pollution reduction, energy conservation, and driving performance. Through this investigation, the study aimed to understand how environmental awareness and related factors impacted individuals' willingness to adopt electric bikes in Macau [35]. Consequently, studies have taken a comprehensive approach to investigate individuals' intentions to adopt electric bikes, considering a range of diverse perspectives. These include evaluating individuals' perceptions of environmental policies, examining the tangible characteristics of electric bikes, exploring how individuals perceive specific features of electric bikes, and taking into account relevant demographic factors. Considering these approaches, researchers have

aimed to gain a general understanding of the factors prompting individuals' decisions to embrace electric bikes as a mode of transportation.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Structural Equation Modeling

SEM is a statistical methodology widely employed to examine and validate theoretical models, such as TAM. SEM involves estimating a series of linear equations that describe the relationships among observed variables and latent variables (unobservable variables indirectly measured through their impacts on other variables). In the context of TAM, SEM can be utilized to assess the interconnections among the various constructs of the model, including Per_Use, Per_EU and BI.

In this research, SEM was employed to test the TAM model for electric bike acceptance in Pakistan. A survey was conducted to gather data from a sample of individuals regarding their perceptions of electric bikes, encompassing Per_Use, Per_EU, So_Inf, CB, EA and TST. Additionally, data on the intention to use electric bikes was collected. By employing SEM, a series of linear equations were estimated to illustrate the relationships among these variables.

For instance, the relationships between Per_Use, and intention to use, and Per_EU and intention to use were estimated. Furthermore, the relationship between Per_Use, Per_EU, along with the relationship between other extended variables and intention to use, were also examined. By simultaneously estimating relationships, SEM offers a comprehensive and nuanced understanding of the determinants impacting the adoption of electric bikes.

Moreover, SEM is a potent statistical method used to examine and assess complicated correlations between variables in the social sciences, economics, psychology, and other disciplines. By accounting for measurement error and determining the magnitude and direction of direct and indirect effects, it enables researchers to simultaneously analyze a number of dependent and independent variables[36]. To represent the links between observed (measured) variables and latent (unobserved or underlying) variables, SEM entails the creation of a system of linear equations. Understanding how variables are connected and how they help to explain certain phenomena is done using this modeling approach [37]. The measurement technique would involve employing various observable elements (for example, survey

questions) to gauge concepts like Per_Use and Per_EU in the context of electric bike uptake. More precise estimates of these constructs are provided by SEM, which also helps to adjust for measurement error.

3.2 Technology Acceptance Model

TAM is a widely recognized theoretical framework that explains the factors affecting the acceptance and adoption of new technologies. Developed by Fred Davis in the 1980s [13], TAM has been extensively utilized in information systems and technology adoption research.

TAM posits that an individual's intention to adopt a new technology hinge on two primary factors: Per_Use and Per_EU. Per_Use pertains to the extent to which an individual believes that a technology will enhance their performance or productivity. Per_EU, on the other hand, relates to the extent to which an individual perceives a technology as easy to use and learn.

In the context of electric bike acceptance, TAM can be applied to understand why some individuals may be more likely to adopt electric bikes than others. For example, an individual who perceives an electric bike as more useful than a traditional bike may be more likely to adopt the technology. Similarly, an individual who perceives an electric bike as easier to use than a traditional bike may also be more likely to adopt the technology.

Moreover, TAM acknowledges that several additional factors can influence an individual's behavior to use a technology, including So_Inf, Per_Val, and Per_Use, Per_EU reflects the impact of an individual's peers or social networks on their technology adoption decisions. Considering these factors within the TAM framework provides a comprehensive understanding of the dynamics influencing the adoption of new technologies, such as electric bikes.

By incorporating factors such as Per_Use, Per_EU, Env_Con, Per_Val and So_Inf, researchers and practitioners can develop effective strategies to promote the adoption of electric bikes and other sustainable transportation technologies.

3.3 Theoretical Framework of the Study: Extending the Technology Acceptance Model

TAM framework was used to propose the relationships among the predictors of intentions to adopt electric bikes [38], consistent with previous studies [39]. Agreeing to traditional TAM [13], Per_EU positively influences Per_Use, and both Per_Use, and Per_EU positively impact consumer attitudes towards the technology.

The current study employed a streamlined version of the TAM, which posited a positive association between Per_Use, and Per_EU Furthermore, the study hypothesized positive relationships between Per_Use, Per_EU, and individuals' behavioral intentions to adopt electric bikes. By utilizing this simplified TAM model, the study aimed to identify and examine the essential factors that influence individuals' intentions to adopt electric bikes, with a particular emphasis on the Per_Use, and Per_EU of the technology as crucial determinants.

Furthermore, the study augmented the TAM by incorporating additional factors such as Env_Con, Per_Val, So_Inf, EA, CB and TST, proposing that they positively influence behavioral intentions to purchase electric bikes. In accordance with the TAM specifications, the behavioral intentions to adopt electric bikes were indicative of the participants' inclination to utilize the electric bikes. [38]. Consistent with previous studies, the present study posited hypothetical relationships among these predictors to examine their influence on intentions to adopt electric bikes, the study formulated the following hypothesis as depicted in Figure 3.1.

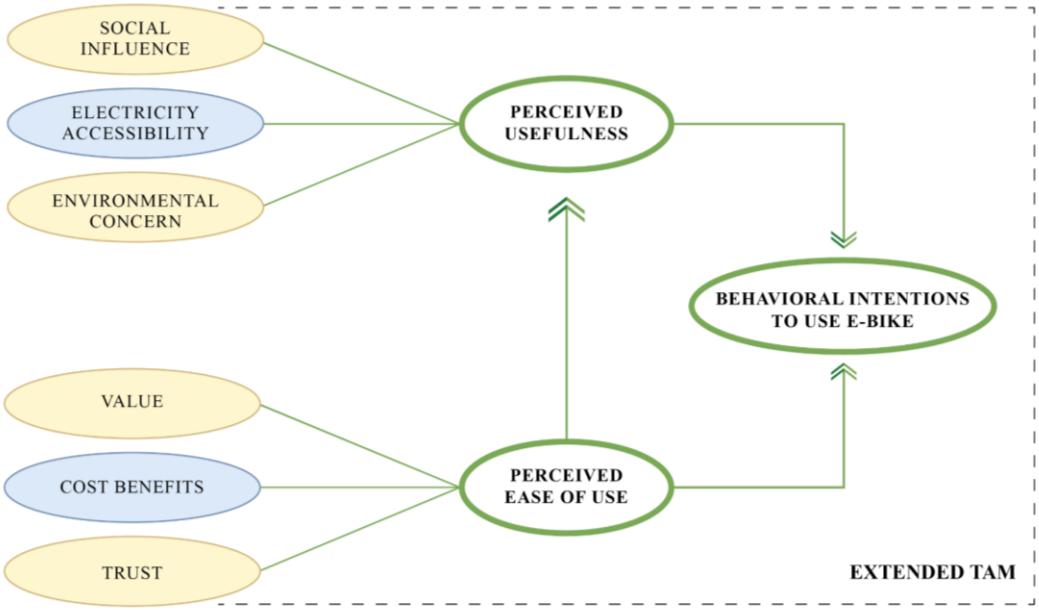

Figure 3.1: Conceptual Model

The hypotheses in this study propose various relationships among factors influencing the adoption of electric bikes.

- H1: Per_Use has positive relationship with BI towards using electric bikes.
- H2: Per_EU has positive relationship with BI towards using electric bikes.
- H3: Per_EU has positive relationship with Per_Use.
- H4: Env_Con positively linked with BI towards using electric bikes.
- H5: So_Inf have effect on Per_Use.
- H6: EA has positive effect on Per_Use.
- H7: Per_Val has positive effect on Per_EU.
- H8: CB have positive effect on Per_EU.
- H9: TST has positive effect on Per_EU.

3.3.1 Methodological Techniques

3.3.1.1 R Programing

R programming is an open-source programming language for statistical computing and graphics. It is widely used by statisticians, data analysts, and data scientists for data manipulation, visualization, and statistical analysis. R has a wide

variety of built-in functions and packages that can be used for data analysis and visualization. R's syntax is designed to be intuitive and readable, making it easy to write and understand code. It also has excellent support for data manipulation and handling, including support for data frames, which are like tables in a relational database. R is also highly extensible, with thousands of packages available for download through CRAN. These packages allow users to perform a wide array of tasks, ranging from text mining and machine learning to data visualization and web scraping.

For the purpose of computing TAM in this study, the popular package "Lavaan" will be employed. Lavaan provides comprehensive functionality for SEM and facilitates the estimation and analysis of complex relationships between latent variables and observed variables.

3.3.1.2 Analytical Approach

The analytical approach for this study involves using the lavaan package in R to perform SEM using the ML estimation method. Prior to conducting SEM, the data will be checked for normal distribution using Skewness and Kurtosis indexes. This step ensures that the assumption for ML-based SEM is met.

Confirmatory factor analysis will be conducted initially, and subsequently, structural models will be developed to examine the proposed hypotheses elucidating the relationships between latent and observed variables. To assess the performance and validity of the SEM model, multiple indicators were used. These indicators include Absolute fit measures, RMSEA, GFI, AGFI and SRMR. Incremental fit indices; NFI and CFI. Parsimony fit indices; PGFI, PNFI.

3.4 Questionnaire and Measures

To gather data for this study, a questionnaire survey is being designed. The questionnaire began with a short introduction explaining the characteristics of electric bikes, along with an ethical statement ensuring the respondents that their information would be used solely for academic research purposes. The subsequent sections of the questionnaire focused on gathering demographic details of the respondents and measuring the latent factors relevant to the study.

The demographic information included age, occupation, education, vehicle ownership, income, and gender. The measurement of the latent factors involved the use of a five-point Likert scale, ranging from strongly disagree to strongly agree. These factors included Per_Use, Per_EU, Per_Val, Env_Con, So_Inf, EA, CB, TST, and BI.

To ensure consistency with previous research, the scale utilized to access the latent constructs in this study was developed with inputs from experts. A wisely selected list of elements, as outlined in Table 3.1, is offered to the general audience to gather survey responses.

Table 3.1: Questionnaire with its construct and its items

Construct with Items	
Behavioral intentions to use (BIU)	
BIU-1	Overall, I intent E-bikes are reliable mode of transport.
BIU-2	I would intend to use it, if I have access to E-bikes.
Perceived usefulness (Per-Use)	
Per-Use-1	E-Bikes prove to be more effective for work than conventional fuel bikes.
Per-Use-2	E-Bikes are found to be useful for riding compared to conventional fuel bikes.
Per-Use-3	I think I will use an E-Bike despite low fuel prices.
Perceived ease of use (Per-EU)	
Per-EU-1	I am confident that learning to operate E-Bike would be easy for me.

Per-EU-2	Using E-Bike for daily activities would increase my work productivity.
Per-EU-3	I anticipate that it would not be difficult for me to become skillful and proficient at using E-Bike.
Per-EU-4	E-bike will be better than a fuel bike.
	Perceived value (Per-Val)
Per-Val -1	The Price will be affordable and reasonable.
Per-Val -2	I'll be attracted to use an e-bike if the price is affordable.
Per-Val -3	I will feel comfortable using E-Bike.
	Environment Concern (Env-Con)
Env-Con-1	I am responsible for adopting a low-carbon mode of transportation in my daily life.
Env-Con-2	I want to safeguard the environmental ecosystem.
Env-Con-3	I intend to purchase an E-Bike to minimize the impact of the air pollution crisis in Pakistan.
Env-Con-4	E-Bikes contribute to preserving the environment for future generations.
	Social Influence (So-Inf)
So-Inf-1	People who hold significance in my life believe I should use E-Bike.
So-Inf -2	People who influence my behavior suggest that I should use E-Bike.

So-Inf-3	People whose opinions I consistently value encourage me to use E-Bike.
	Electricity Availability (EA)
EA-1	It would be easy to recharge the electric bike while away from home.
EA2	I could wait for the electric bike batteries to be charged even if the charging time were long.
EA3	Riding an electric bike would not make me unsure about the maximum mileage it can travel with a single charge.
	Cost benefit (CB)
CB-1	My budget is enough to buy an electric bike.
CB-2	E-Bike would lead to a financial loss for me.
CB-3	Do you think the Government organizations would be able to bear the cost of infrastructure related to e-bikes in Pakistan?
	Trust (TST)
TST-1	E-Bike might not perform well and create problems.
TST-2	Do you believe maintenance Workers (Mechanics) can understand, maintain, and repair e-bikes, like how they work with conventional fuel bikes?
TST-3	E-Bike is dependable.

3.5 Data collection

To gather data for this study, a questionnaire survey is being conducted across different areas of Pakistan using Google Forms. Conducting the survey online was chosen as it allowed for broader reach and convenience, considering that a significant number of early adopters of Internet facilities in Pakistan are educated and familiar with online surveys. Emphasis was placed on online distribution, and the questionnaire was shared through platforms such as Facebook and WhatsApp groups of colleges and universities, as well as via email. Additionally, to ensure a diverse sample, efforts were made to reach out to individuals through various channels.

Furthermore, to ensure a diverse and representative sample, an offline or physical survey was also conducted. This involved directly approaching individuals in various settings, including government departments and private organizations. By incorporating both online and offline survey methods, a more comprehensive range of participants was reached.

In total, 500 respondents voluntarily participate in the survey, after that data underwent a screening process to remove incomplete and invalid questionnaires. This data cleaning process results in 472 valid responses that are deemed suitable for further analysis, considering the slightly varying sample sizes in prior studies [40]. It is also analogous to the recent studies conducted in Pakistan using UTAUT technique [41].The distribution of the participants' age, occupation, education, vehicle ownership, income, and gender are detailed in Table 3.2.

3.5.1 Demographic characteristics

Table 3.2 presents a comprehensive overview of the demographic variables and their corresponding percentages in the population under study. It provides insights into various aspects such as gender, income, age, education, household size, ownership of motorcycles and cars within families, and occupation. In terms of gender distribution, males constitute 72.3% of the population, while females account for 27.8%. Overall, this comprehensive table provides valuable insights into the composition and characteristics of the population based on various demographic variables and their corresponding percentages.

Table 3.2: Demographic characteristics

Considered variable.	Frequency.	Percentile.
Gender.		
Male.	341	72.3
Female.	131	27.8
Age		
18–24	92	19.5
25-34	342	72.5
35-44	23	4.9
45-over	15	2.9
Education		
Intermediate	13	2.9
Bachelor	236	50
Masters/PhD	223	47.05
Household size		
02 persons	19	3.9
03 persons	56	11.7
O4 persons	73	15.6
05 persons	116	24.5
06 or more	208	44.11

Occupation		
Student	78	16.6
Govt. Employee	187	39.2
Private employee	52	11.1
Businessman	115	24.5
Unemployed	40	7.8
Monthly income		
Lower than 25K-PKR	23	4.9
25K to 40K - PKR	49	10.4
40 K to 60K - PKR	55	11.7
60K to 90K - PKR	82	17.4
90K to 120K - PKR	69	14.6
120K-more	194	41.1
Motorcycles owned by the family		
0	175	37.1
01	176	37.2
02	102	21.9
03 or over	19	3.9

Cars owned by the family		
0	134	28.4
01	194	41.1
02	110	23.5
03 or over	34	6.8
Physical Disability		
Yes	0	0
No	472	100

3.6 Model performance approach

The research utilizes SEM as it is effective in testing the hypothesis where latent constructs are related [42], and consistent with findings from prior investigations [43], [44], [45] To determine the assistances of standard and extended latent factors such as EA, So-inf, Env-Con, TST, CB, and Per-Val to TAM in predicting intention of adopting electric bikes, a series of models are developed. ML is selected as the method for conducting SEM in R utilizing the lavaan package [46]. The skewness and kurtosis indices demonstrate that all items in the data follow a normal distribution, thus satisfying the prerequisite for conducting ML-based SEM[47]. Confirmatory factor analysis was conducted initially, then structural models were developed to examine the hypothesized relationships among Per_Use, Per_EU, Per_Val, Env_Con, So_Inf, EA, CB, TST, and BI to adopt electric bikes. The explanatory power of the structural models generated through SEM analysis was evaluated using multiple indicators, including Absolute fit measures such as RMSEA, GFI, AGFI, and SRMR. Incremental fit indices, including NFI and CFI, were also considered. Additionally, parsimony fit indices such as PGFI and PNFI were utilized. [42].

CHAPTER 4. RESULTS AND DISCUSSION

4.1 Measurement Model

Prior to undertaking SEM, it is necessary to determine the factors validity and reliability [48]. To establish the measurement model, Conformity Factor Analysis is conducted to assess the discriminant validity and reliability of each item with respect to the factors [49]. It is determined that the majority of Cronbach's alpha, AVE, and CR values for the constructs fall within an acceptable range. (Cronbach alpha > 0.6), However, there is less value of Cronbach alpha for CB. So, it is further analyzed using CR and AVE. Thus, the reliability of measurement model's is validated. To enhance the trust in the model's validity, further AVE is also conducted for all latent variables. The values of AVE show less for few variables but they are considered for further analysis because Cronbach alpha is under acceptable range. Furthermore, the factor loading analysis also yields acceptable values greater than 0.5, as displayed in Table 4.1.

Table 4.1: Validity of the Measurement Model

Construct	Item	Factor loading	Cronbach's alpha	CR	AVE
Per-Use	Per-Use 1	0.78	0.8	0.789	0.438
	Per-Use 2	0.86			
	Per-Use 3	0.64			
Per-EU	Per-EU 1	0.61	0.63	0.692	0.328
	Per-EU 2	0.60			
	Per-EU 3	0.32			
	Per-EU 4	0.56			

	Per-Val 1	0.64	0.7	0.646	0.56
Per-Val	Per-Val 2	0.71			
	Per-Val 3	0.62			
	Env-Con1	0.58	0.81	0.570	0.332
Env-Con	Env-Con2	0.62			
	Env-Con3	0.84			
	Env-Con4	0.81			
So-Inf	So-Inf 1	0.87	0.83	0.851	0.524
	So-Inf 2	0.83			
	So-Inf 3	0.68			
EA	EA1	0.74	0.65	0.716	0.476
	EA2	0.65			
	EA3	0.50			
CB	CB1	0.60	0.36	0.492	0.122
	CB2	0.26			
	CB3	0.34			
TST	TST1	0.32	0.69	0.897	0.433
	TST2	0.42			
	TST3	0.56			

BI	BI1	0.70	0.72	0.864	0.295
	BI2	0.80			

Discriminant validity is used to validate the multi-collinearity among constructs thus discriminant validity of model is measured using the criteria of Fornell Lacker [50].

Table 4.2 provided is called a Discriminant Validity table. It represents the correlations (or associations) between different constructs or variables in a research study. In this case, the constructs are represented by the abbreviations Per_Use, Per_EU, Per_Val, Env_Con, So_Inf, EA, CB, TST, and BI.

The tabulated data represent the correlations between pairs of constructs. For example, the value 1.000 on the diagonal represents the perfect correlation of a construct with itself (which is always 1). The other values in the table represent the correlations between different constructs.

Discriminant validity is a statistical concept that assesses the degree to which constructs or variables in a study are distinct from each other. It is important in research to ensure that the constructs being studied are separate and not measuring the same underlying concept. A discriminant validity table given is used to examine the correlations between constructs and determine if they are sufficiently different from each other.

In Table 4.2, the values outside the diagonal represent the correlations between different constructs. For example, the value 0.543 represents the correlation between Per-EU and Per-Use. Similarly, the value 0.686 represents the correlation between Per-EU and Per-Val.

Table 4.2: Discriminant validity

.	Per-Use	Per-EU	Per-Val	Env-Con	So-Inf	EA	CB	TST	BI
Per-Use	**1.000**								
Per-EU	0.543	1.000							
Per-Val	0.378	0.686	1.000						
Env-Con	0.427	0.557	0.432	1.000					
So-Inf	0.502	0.526	0.350	0.446	1.000				
EA	0.174	0.498	0.263	0.295	0.510	1.000			
CB	0.302	0.663	0.444	0.325	0.454	0.966	1.000		
TST	0.556	0.452	0.391	0.288	0.431	0.758	0.689	1.000	
BI	0.561	0.529	0.555	0.456	0.576	0.497	0.488	0.487	1.000

By examining the values, researchers can assess the discriminant validity of their constructs. If the correlations between constructs are relatively low (below a certain threshold value of 0.5), it suggests that the constructs are distinct and measuring different concepts.

4.2 Path Analysis

Two models are created to test the hypothesis. The first model satisfies the conditions of basic TAM model. The second model emphasizes the extended factors (Per-Val, Env-Con, So-Inf, EA, CB, TST). First model exclusively comprises the initial three hypotheses (Per-Use-BI, Per-EU -BI, Per-Use-Per-EU). Second model analyzes BI in adopting electric bike by expanding the simplified TAM to incorporate Per-Val, Env-Con, So-Inf, EA, CB, and TST, thereby evaluating all hypotheses (H1-H9) that were included in the present study. The model is extended by adding one by one latent factors and compared the evaluation of the model. at first stage the Per-Val was added to the basic TAM model and then Env-Con and it continue to add CB in last.

The rationale for selecting the two models is to evaluate the sensitivity of the extended factors pertaining to the acceptability of electric bikes in response to the fundamental components of the TAM model. Both models' fit indices meet the threshold values listed in Table 4.3, which is aligned with the results of Kline et al. and

Wang et al [42], [51]. Model 2, which incorporates all latent factors, has demonstrated greater explanatory capability compared to the basic TAM model.

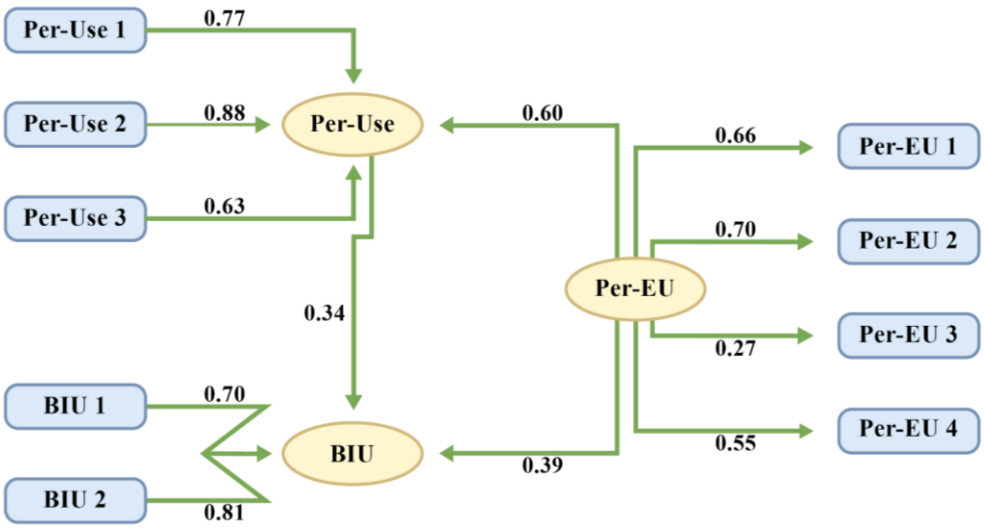

Figure 4.1: Path Analysis for Basic TA Model 1

The influence of Per-Use and Per-EU on BI was analyzed through SEM for the Basic TA model 1. The paths (links) associated with model 1, as depicted in Figure 4.1 , align with the hypotheses formulated in the conceptual model**.**

Table 4.3: Goodness-of-fit metrics

Fit index	**Model**	**Critical value**
Absolute		
RMSEA.	0.078	<0.08
SRMR.	0.048	<0.08
GFI.	0.958	>0.90
AGFI.	0.922	>0.90

Incremental		
NFI.	0.926	>0.90
CFI.	0.943	>0.90
TLI.	0.915	>0.90
Parsimony		
PGFI.	0.511	>0.50
PNFI.	0.67	>0.50

Note: "Root means square error of approximation (RMSEA), goodness-of-fit statistic (GFI), Adjusted goodness-of-fit (AGFI), Standard root mean square residual (SRMR). Normal-fit index (NFI) and comparative fit index (CFI). Parsimony fit indices; Parsimony goodness-of-fit (PGFI), Parsimonious Normed Fit index (PNFI)"

As illustrated in Figure 4.1, there is a positive correlation between Per_Use and BI to use electric bikes, aligning with hypothesis H1. Likewise, empirical evidence indicates a positive relation between BI and Per_EU towards the use of electric bikes firmly supports hypothesis H2. Additionally, in Model 1, the hypothesis H3 is validated, suggesting Per_EU exerts a positive influence on the Per_Use of electric bikes. According to the simplified model, individuals who hold a positive perception regarding the utility and user-friendliness of electric bikes are more intended to use them in future. Model 1, representing a simplified version of the TAM, provides valuable insights into the behavioral intentions linked with the adoption of electric bikes. Nevertheless, the main objective of the study is to enhance this model by integrating additional factors related to electric bike adoption. Consequently, to assess all hypotheses within a unified model, Model 2, illustrated in Figure 4.2, along with their factor loadings in Figure 4.3 is presented (all are significant *** P<0.001; * P <0.05). Path coefficients, standard errors, and p values are provided in Table 4.4.

Table 4.4: Conceptual Model Path Analysis/ Path diagram for Extended TA Model 2

Path relationship	Path coefficient	Results	Std.Err	P(>|z|)
Per_Use - BI	0.60	Supportive	0.050	0.004
Per_EU - BI	0.59	Supportive	0.091	0.000
Per_EU - Per_Use	0.60	Supportive	0.134	0.000
CB - Per_EU	0.61	Supportive	0.106	0.000
Per_Val - Per_EU	0.42	Supportive	0.076	0.000
TST - Per_EU	0.60	Supportive	0.128	0.025
EA - Per_Use	-0.01	Not supportive	0.093	0.001
SI - Per_Use	0.37	Supportive	0.067	0.000
EC - Per_Use	0.28	Supportive	0.089	0.000

*** p < 0.001; ** p < 0.01; * p < 0.05

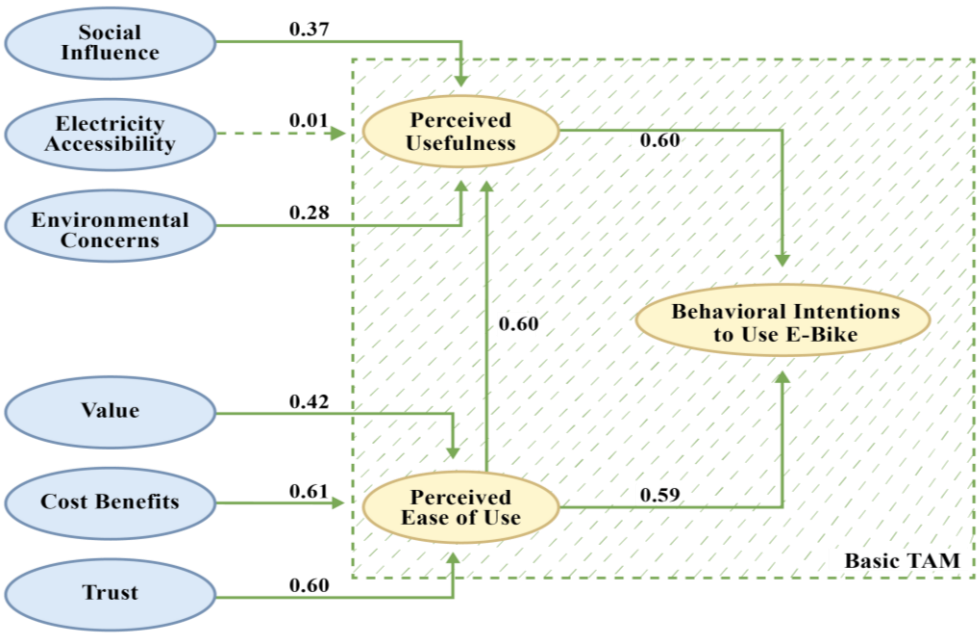

Figure 4.2: Conceptual path diagram for extended TA Model 2

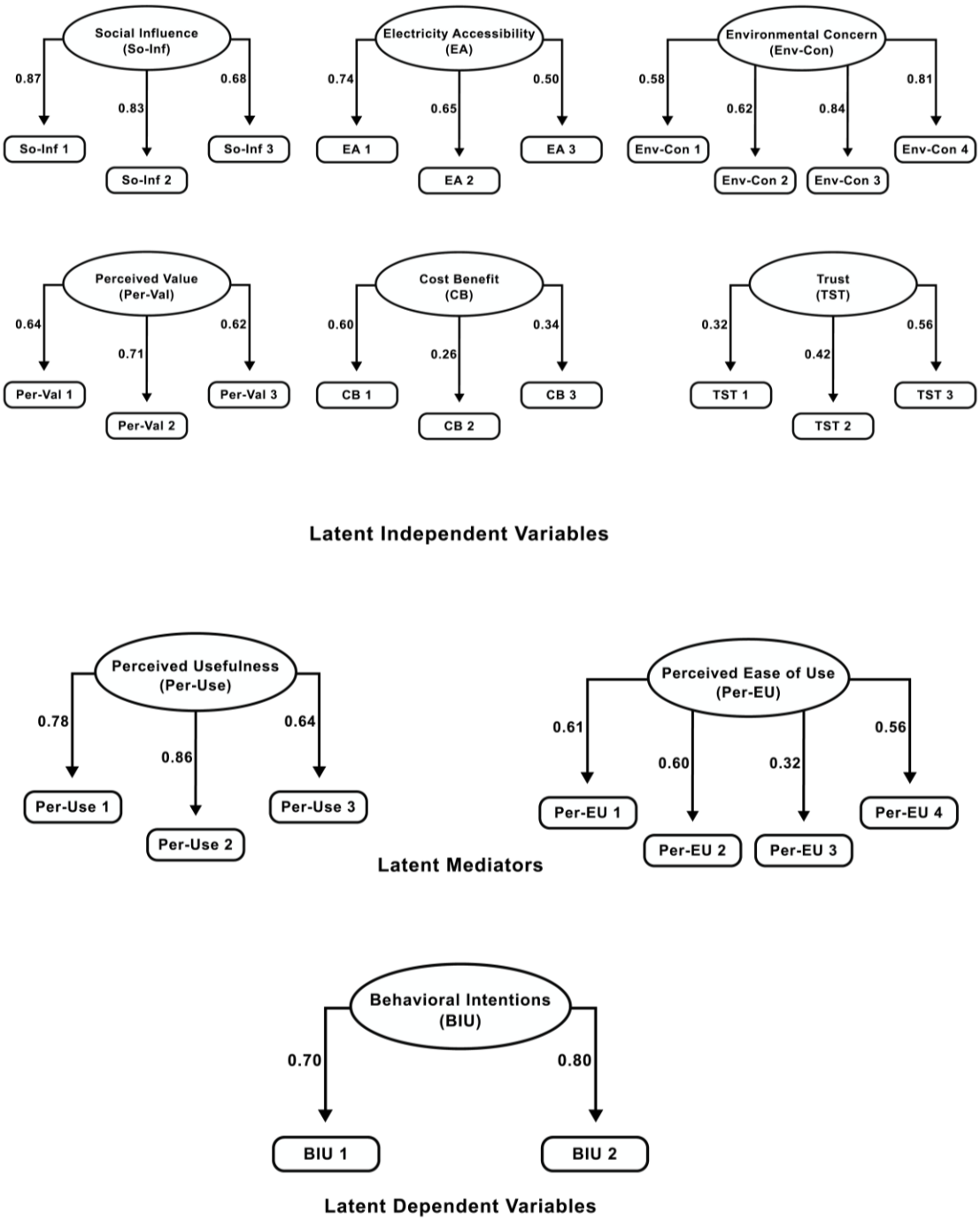

Figure 4.3: Factor loadings for extended TA Model 2

The path relationships for the extended TA Model 2 with extended variables are presented in Figure 4.2. Considering Table 4.4, the results suggest that most of the relationships are supportive, with positive influences between the constructs. Nevertheless, the relationship between EA and Per-Use is not supportive, potentially attributed to an insignificant path coefficient. Another factor influencing this

discrepancy is the public's reservations concerning electricity-related issues, such as load shedding and the limited charging infrastructure in Pakistan. This indicates a noteworthy concern among individuals regarding these electricity aspects.

CHAPTER 5. IMPLICATIONS

Researchers have been spurred to explore methods to facilitate the adoption of environmentally-friendly alternatives like electric bikes, driven by the prevalence of traditional motorcycles in developing countries. [52]. This study aimed to identify the psychological factors that influence the adoption of electric bikes, with the goal of informing policy interventions that can accelerate their uptake. Moreover, the study aimed to validate the effectiveness of the TAM, augmented with additional variables, in forecasting individuals' attitude to adopt electric bikes. Accordingly, the study's findings offer valuable perspectives for stakeholders interested in devising marketing strategies to promote electric bike sales in developing countries. Furthermore, the study highlights the significance of Env_Con and Per_Val in relation to the adoption of electric bikes.

The study presented evidence affirming the positive impacts of Per_Use, Per_EU ,Env_Con, CB and Per_Val on BI to adopt electric bikes, in line with previous studies[53]. The results indicate that individuals who have strong environmental concerns and perceive high value in electric bikes are more inclined to purchase them. Similarly, individuals who perceive electric bikes as highly useful are more likely to adopt them.

Entities in the public and private sectors responsible for advancing the adoption of electric transportation in developing nations with minimal electric bike usage, like Pakistan, necessitate a marketing strategy geared towards fostering behavioral changes among individuals. [54], [55]. The notable and favorable impacts stemming from environmental concerns on behavioral intentions to purchase electric bikes underscore the significance of heightening environmental awareness. Agencies may advertise the environmental benefits of electric bikes to accelerate the behavioral shift among individuals on the basis of environmental concerns. Furthermore, educational interventions aimed at increasing awareness regarding the environmental degradation caused by traditional fuel-based motorcycles can contribute to bolstering individuals' environmental concerns. Consequently, this can positively influence their intentions to adopt electric bikes.

Increased environmental awareness can strengthen individuals' environmental concerns, leading to a higher rate of adoption of electric bikes. To enhance the value of electric bikes, promotional messages and campaigns can highlight their most beneficial features. Furthermore, the implementation of a transportation policy that subsidizes the total cost of electric bikes may contribute to increasing their Per_Val.

Ultimately, a policy-oriented approach to managing Per_Val can greatly enhance the adoption of electric bikes among the general public, given its substantial impact on behavioral intentions, as supported by the empirical results obtained in this study.

The empirical findings indicated that an increase in Per_Use directly correlates with positive effects on BI to adopt electric bikes. Initiatives focused on educating individuals about electric bike functionalities and enhancing knowledge regarding electric bikes may aid in augmenting usefulness regarding electric bikes. As per the study findings, individuals with a deeper understanding of electric bike functionalities are more inclined to adopt electric bikes. The study reveals that Per_EU substantially enhances Per_Use regarding electric bikes. Therefore, spreading awareness about electric bike features through social media campaigns, promotional messages, advertisements, and educational interventions may assist individuals in adopting electric bikes by augmenting Per_Use and Per_EU.

The acceptance of electric bikes by considerate individuals has significant implications for planning and can guide the successful implementation of electric bikes in the near future. Based on the findings of this study, several policy planning suggestions can be derived:

1. Promoting environmental concerns: Increasing awareness about the socio-economic benefits of electric bikes and raising awareness about carbon emissions from a driving perspective can effectively promote environmental concerns and contribute to the acceptance of electric bikes.
2. Enhancing electric bike quality: Improving the quality of electric bikes is crucial in increasing individuals' attitude to adopt them. This can be achieved by focusing on factors such as performance, reliability, and durability.
3. Government support: Efficient development of electric bikes requires support from the government. Policies and initiatives that provide incentives, subsidies,

or regulatory frameworks can greatly facilitate the adoption and growth of the electric bike industry.

4. Integration of complementary services: Implementing different strategies, such as the establishment of electric charging stations, can enhance the usefulness of electric bikes. By creating a supportive infrastructure, individuals are more likely to perceive electric bikes as a convenient and practical transportation option. By considering these policy planning suggestions, we can pave the way for a successful and widespread adoption of electric bikes, benefiting both individuals and the environment.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

The study's findings furnish evidence supporting the relevance of the TAM in elucidating the adoption of electric bikes in Pakistan. Specifically, Per_Use and Per_EU were identified as significant factors influencing individuals' behavioral intentions to use electric bikes. Additionally, factors including Per_Val, Env_Con, So_Inf, EA, CB, and TST were identified as significant contributors to the adoption of electric bikes. These findings highlight the complex decision-making processes involved in individuals' choices regarding sustainable transportation technologies. Based on these results, numerous implementation strategies can be proposed to foster the adoption of electric bikes in Pakistan.:

1. Awareness Campaigns: Develop targeted awareness campaigns to educate the public about the benefits of electric bikes, emphasizing their environmental advantages, cost-effectiveness, and user-friendliness. Highlight how electric bikes can improve work productivity and overall performance.
2. Infrastructure Development: Invest in the creation of appropriate infrastructure, such as charging stations, dedicated cycling lanes, and secure parking facilities, to support the use of electric bikes. Address concerns related to electricity accessibility (EA) and provide a convenient and safe environment for electric bike users.
3. Social Influence: Harness the power of social influence (So-Inf) by involving influential individuals, including opinion leaders, celebrities, and community figures, to endorse and promote the use of electric bikes. Encourage peer-to-peer recommendations and testimonials to build trust and enhance social acceptance.
4. Government Support: Collaborate with government organizations to formulate policies and incentives that encourage the adoption of electric bikes. This may include subsidies or tax incentives for electric bike purchases, as well as funding for infrastructure development.
5. Pricing and Financing: Work towards making electric bikes more affordable and accessible to a wider population. Explore financing options, installment plans, and partnerships with financial institutions to facilitate ownership of electric bikes.

6. Maintenance and Service: Ensure the availability of reliable maintenance and service facilities for electric bikes. Train mechanics and service providers to understand and effectively address the unique requirements of electric bikes, thereby instilling trust (TST) and reliability.
7. Collaboration with Educational Institutions: Partner with educational institutions to incorporate electric bike education and awareness programs into their curriculum. Foster research and development initiatives to enhance electric bike technology and address specific challenges in the local context.

By implementing these strategies, stakeholders can foster greater acceptance and adoption of electric bikes in Pakistan, leading to a more sustainable and environmentally friendly transportation system.

REFERENCES

[1] C.-D. Chen, Y.-W. Fan, and C.-K. Farn, 'Predicting electronic toll collection service adoption: An integration of the technology acceptance model and the theory of planned behavior', *Transp. Res. Part C Emerg. Technol.*, vol. 15, no. 5, pp. 300–311, Oct. 2007, doi: 10.1016/j.trc.2007.04.004.

[2] T. Eccarius and C.-C. C. Lu, 'Powered two-wheelers for sustainable mobility: A review of consumer adoption of electric motorcycles', *Int. J. Sustain. Transp.*, vol. 14, no. 0, pp. 1–17, Jan. 2020, doi: 10.1080/15568318.2018.1540735.

[3] M. Hussain, A. R. Butt, F. Uzma, R. Ahmed, T. Islam, and B. Yousaf, 'A comprehensive review of sectorial contribution towards greenhouse gas emissions and progress in carbon capture and storage in Pakistan', *Greenh. Gases Sci. Technol.*, vol. 9, no. 4, pp. 617–636, Aug. 2019, doi: 10.1002/ghg.1890.

[4] U. Shakeel, 'Electric vehicle development in Pakistan: Predicting consumer purchase intention', *Clean. Responsible Consum.*, vol. 5, p. 100065, Jun. 2022, doi: 10.1016/j.clrc.2022.100065.

[5] Y. Rasool, S. A. H. Zaidi, and M. W. Zafar, 'Determinants of carbon emissions in Pakistan's transport sector', *Environ. Sci. Pollut. Res.*, vol. 26, no. 22, pp. 22907–22921, Aug. 2019, doi: 10.1007/s11356-019-05504-4.

[6] G. R. Timilsina and A. Shrestha, 'Transport sector CO2 emissions growth in Asia: Underlying factors and policy options', *Energy Policy*, vol. 37, no. 11, pp. 4523–4539, 2009, doi: 10.1016/j.enpol.2009.06.009.

[7] U. Ali *et al.*, 'Innovative Citizen's Services through Public Cloud in Pakistan: User's Privacy Concerns and Impacts on Adoption', *Mob. Netw. Appl.*, vol. 24, no. 1, pp. 47–68, Feb. 2019, doi: 10.1007/s11036-018-1132-x.

[8] M. Murugan and S. Marisamynathan, 'Estimation of two-wheeler users' mode shift behavior and policy analysis to encourage electric-bike adoption in India', *Case Stud. Transp. Policy*, vol. 10, no. 3, pp. 1673–1685, Sep. 2022, doi: 10.1016/j.cstp.2022.06.006.

[9] L. F. Goodman *et al.*, 'Electric bicycles (e-bikes) are an increasingly common pediatric public health problem', *Surg. Open Sci.*, vol. 14, pp. 46–51, Aug. 2023, doi: 10.1016/j.sopen.2023.06.004.

[10] X. Zhou, Y. Ji, Y. Yuan, F. Zhang, and Q. An, 'Spatiotemporal characteristics analysis of commuting by shared electric bike: A case study of Ningbo, China', *J. Clean. Prod.*, vol. 362, p. 132337, Aug. 2022, doi: 10.1016/j.jclepro.2022.132337.

[11] R. Chanda, V. Pabalkar, and T. Mishra, 'Exploring the factors that lead to a positive behavior in Indian consumers purchasing a sustainable-fuel efficient two wheeler', *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 11 Special Issue, pp. 252–260, 2019, doi: 10.35940/ijitee.K1050.09811S19.

[12] B. Cohen, 'Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability', *Technol. Soc.*, vol. 28, no. 1–2, pp. 63–80, 2006, doi: 10.1016/j.techsoc.2005.10.005.

[13] F. D. Davis, R. P. Bagozzi, and P. R. Warshaw, ‘User Acceptance of Computer Technology: A Comparison of Two Theoretical Models’, *Manag. Sci.*, vol. 35, no. 8, pp. 982–1003, Aug. 1989, doi: 10.1287/mnsc.35.8.982.

[14] Y. Barnard, M. D. Bradley, F. Hodgson, and A. D. Lloyd, ‘Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability’, *Comput. Hum. Behav.*, vol. 29, no. 4, pp. 1715–1724, Jul. 2013, doi: 10.1016/j.chb.2013.02.006.

[15] F. D. Davis, ‘Information Technology Introduction’, vol. 13, no. 3, pp. 319–340, 1989.

[16] K. Ambak *et al.*, ‘Driver intention to use electric cars using technology acceptance model’, *ARPN J. Eng. Appl. Sci.*, vol. 11, no. 3, pp. 1524–1528, 2016.

[17] P. A. Plazier, G. Weitkamp, and A. E. V. Den Berg, ‘Exploring the adoption of e-bikes by different user groups’, *Front. Built Environ.*, vol. 4, no. August, pp. 1–8, 2018, doi: 10.3389/fbuil.2018.00047.

[18] M. Kroesen, ‘To what extent do e-bikes substitute travel by other modes? Evidence from the Netherlands’, *Transp. Res. Part Transp. Environ.*, vol. 53, pp. 377–387, 2017, doi: 10.1016/j.trd.2017.04.036.

[19] C. R. Cherry, J. X. Weinert, and Y. Xinmiao, ‘Comparative environmental impacts of electric bikes in China’, *Transp. Res. Part Transp. Environ.*, vol. 14, no. 5, pp. 281–290, Jul. 2009, doi: 10.1016/j.trd.2008.11.003.

[20] V. Zeithaml, ‘Consumer Perceptions of Price, Quality, and Value: A Means-End Model and Synthesis of Evidence’, *J. Mark.*, vol. 52, no. 3, pp. 2–22, 1988, doi: 10.1177/002224298805200302.

[21] L. Han, S. Wang, D. Zhao, and J. Li, ‘The intention to adopt electric vehicles: Driven by functional and non-functional values’, *Transp. Res. Part Policy Pract.*, vol. 103, pp. 185–197, Sep. 2017, doi: 10.1016/j.tra.2017.05.033.

[22] S. Wang, J. J. Wang, J. Li, J. J. Wang, and L. Liang, ‘Policy implications for promoting the adoption of electric vehicles: Do consumer’s knowledge, perceived risk and financial incentive policy matter?’, *Transp. Res. Part Policy Pract.*, vol. 117, no. January, pp. 58–69, Nov. 2018, doi: 10.1016/j.tra.2018.08.014.

[23] M. R. Mehdi, M. Kim, J. C. Seong, and M. H. Arsalan, ‘Spatio-temporal patterns of road traffic noise pollution in Karachi, Pakistan’, *Environ. Int.*, vol. 37, no. 1, pp. 97–104, 2011, doi: 10.1016/j.envint.2010.08.003.

[24] M. Ghazizadeh, J. D. Lee, and L. N. Boyle, ‘Extending the Technology Acceptance Model to assess automation’, *Cogn. Technol. Work*, vol. 14, no. 1, pp. 39–49, Mar. 2012, doi: 10.1007/s10111-011-0194-3.

[25] T. Franke, I. Neumann, F. Bühler, P. Cocron, and J. F. Krems, ‘Experiencing Range in an Electric Vehicle: Understanding Psychological Barriers’, *Appl. Psychol.*, vol. 61, no. 3, pp. 368–391, 2012, doi: 10.1111/j.1464-0597.2011.00474.x.

[26] G. Prati *et al.*, ‘Evaluation of user behavior and acceptance of an on-bike system’, *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 58, pp. 145–155, Oct. 2018, doi: 10.1016/j.trf.2018.06.005.

[27] J. K. Choi and Y. G. Ji, 'Investigating the Importance of Trust on Adopting an Autonomous Vehicle', *Int. J. Hum.-Comput. Interact.*, vol. 31, no. 10, pp. 692–702, Oct. 2015, doi: 10.1080/10447318.2015.1070549.

[28] L. Winslott Hiselius and Å. Svensson, 'E-bike use in Sweden – CO2 effects due to modal change and municipal promotion strategies', *J. Clean. Prod.*, vol. 141, pp. 818–824, 2017, doi: 10.1016/j.jclepro.2016.09.141.

[29] Y. Wu and L. Zhang, 'Can the development of electric vehicles reduce the emission of air pollutants and greenhouse gases in developing countries?', *Transp. Res. Part Transp. Environ.*, vol. 51, pp. 129–145, Mar. 2017, doi: 10.1016/j.trd.2016.12.007.

[30] J.-C. Tu and C. Yang, 'Key Factors Influencing Consumers' Purchase of Electric Vehicles', *Sustainability*, vol. 11, no. 14, p. 3863, Jul. 2019, doi: 10.3390/su11143863.

[31] P. Jochem, P. Plötz, W. S. Ng, and W. Rothengatter, 'The contribution of electric vehicles to environmental challenges in transport', *Transp. Res. Part Transp. Environ.*, vol. 64, no. July, pp. 1–4, 2018, doi: 10.1016/j.trd.2018.06.022.

[32] I. Panagiotopoulos and G. Dimitrakopoulos, 'An empirical investigation on consumers' intentions towards autonomous driving', *Transp. Res. Part C Emerg. Technol.*, vol. 95, no. January, pp. 773–784, 2018, doi: 10.1016/j.trc.2018.08.013.

[33] C. Cherry and R. Cervero, 'Use characteristics and mode choice behavior of electric bike users in China', *Transp. Policy*, vol. 14, no. 3, pp. 247–257, 2007, doi: 10.1016/j.tranpol.2007.02.005.

[34] 'Understanding bike sharing use over time by employing extended technology continuance theory - ScienceDirect'. Accessed: Aug. 22, 2023. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0965856418316768?via%3Dihub

[35] L. Buckley, S.-A. Kaye, and A. K. Pradhan, 'Psychosocial factors associated with intended use of automated vehicles: A simulated driving study', *Accid. Anal. Prev.*, vol. 115, no. April, pp. 202–208, Jun. 2018, doi: 10.1016/j.aap.2018.03.021.

[36] N. S. Davcik, 'The use and misuse of structural equation modeling in management research: A review and critique', *J. Adv. Manag. Res.*, vol. 11, no. 1, pp. 47–81, Jan. 2014, doi: 10.1108/JAMR-07-2013-0043.

[37] H. Baumgartner and C. Homburg, 'Applications of structural equation modeling in marketing and consumer research: A review', *Int. J. Res. Mark.*, vol. 13, no. 2, pp. 139–161, Apr. 1996, doi: 10.1016/0167-8116(95)00038-0.

[38] V. Venkatesh and F. D. Davis, 'A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies', *Manag. Sci.*, vol. 46, no. 2, pp. 186–204, Feb. 2000, doi: 10.1287/mnsc.46.2.186.11926.

[39] Y. Wang, S. Wang, J. Wang, J. Wei, and C. Wang, 'An empirical study of consumers' intention to use ride-sharing services: using an extended technology acceptance model', *Transportation*, vol. 47, no. 1, pp. 397–415, Feb. 2020, doi: 10.1007/s11116-018-9893-4.

[40] J. Lee, F. Baig, M. A. H. Talpur, and S. Shaikh, ‘Public Intentions to Purchase Electric Vehicles in Pakistan’, *Sustainability*, vol. 13, no. 10, Art. no. 10, Jan. 2021, doi: 10.3390/su13105523.

[41] Department of Computer Science Institute of Business Administration, Karachi, M. M. Khan, and W. Mahmood, ‘Technology Adoption in Pakistani Banking Industry using UTAUT’, *Int. J. Inf. Technol. Comput. Sci.*, vol. 14, no. 1, pp. 32–42, Feb. 2022, doi: 10.5815/ijitcs.2022.01.04.

[42] R. B. Kline, *Principles and practices of structural equation modelling*, 4th ed. 2015.

[43] T. Okada, T. Tamaki, and S. Managi, ‘Effect of environmental awareness on purchase intention and satisfaction pertaining to electric vehicles in Japan’, *Transp. Res. Part Transp. Environ.*, vol. 67, no. January 2019, pp. 503–513, 2019, doi: 10.1016/j.trd.2019.01.012.

[44] H. S. Chen, B. K. Tsai, and C. M. Hsieh, ‘Determinants of consumers’ purchasing intentions for the hydrogen-electric motorcycle’, *Sustain. Switz.*, vol. 9, no. 8, pp. 1–12, 2017, doi: 10.3390/su9081447.

[45] J.-H. Wu, C.-W. Wu, C.-T. Lee, and H.-J. Lee, ‘Green purchase intentions: An exploratory study of the Taiwanese electric motorcycle market’, *J. Bus. Res.*, vol. 68, no. 4, pp. 829–833, Apr. 2015, doi: 10.1016/j.jbusres.2014.11.036.

[46] Y. Rosseel, ‘lavaan : An R Package for Structural Equation Modeling’, *J. Stat. Softw.*, vol. 48, no. 2, pp. 1–36, Dec. 2012, doi: 10.18637/jss.v048.i02.

[47] Y. Rosseel, ‘The lavaan tutorial’, The lavaan tutorial.

[48] W. H. Finch and B. F. French, *Latent Variable Modeling with R*. 2015. doi: 10.4324/9781315869797.

[49] J. Wu, H. Liao, J. W. Wang, and T. Chen, ‘The role of environmental concern in the public acceptance of autonomous electric vehicles: A survey from China’, *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 60, pp. 37–46, 2019, doi: 10.1016/j.trf.2018.09.029.

[50] C. Fornell and D. F. Larcker, ‘Evaluating Structural Equation Models with Unobservable Variables and Measurement Error’, *J. Mark. Res.*, vol. 18, no. 1, pp. 39–50, Feb. 1981, doi: 10.1177/002224378101800104.

[51] Y. Wang, S. Wang, J. Wang, J. Wei, and C. Wang, ‘An empirical study of consumers’ intention to use ride-sharing services: using an extended technology acceptance model’, *Transportation*, vol. 47, no. 1, pp. 397–415, Feb. 2020, doi: 10.1007/s11116-018-9893-4.

[52] T. Eccarius and C.-C. Lu, ‘Powered two-wheelers for sustainable mobility: A review of consumer adoption of electric motorcycles’, *Int. J. Sustain. Transp.*, vol. 14, no. 3, pp. 215–231, Jan. 2020, doi: 10.1080/15568318.2018.1540735.

[53] Y. N. Sang and H. A. Bekhet, ‘Modelling electric vehicle usage intentions: An empirical study in Malaysia’, *J. Clean. Prod.*, vol. 92, pp. 75–83, 2015, doi: 10.1016/j.jclepro.2014.12.045.

[54] I. Mukhtar, ‘Electric vehicle push struggles to accelerate in Pakistan’, *Reuters*, Mar. 2020.

[55] N. Arshad, N. Ullah, B. T. Khan, M. A. Javed, M. M. Arslan, and M. H. Qureshi, ‘Electric Vehicles in Pakistan: Policy Recommendations’, 2019.