FACULTY OF ECONOMICS AND
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Essays on Prospects of Electric Vehicles in Pakistan

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Articles

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Chapter 5: Willingness to pay for electric-two wheelers in Pakistan

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LIST OF ABBREVIATIONS

EV= Electric Vehicle

HEV= Hybrid Electric Vehicle

E2W= Electric Two-Wheeler

EM= Electric Motorcycle

EB= Electric Bicycle

ES= Electric Scooter

GHG= Greenhouse Gas

CNG= Compressed Natural Gas

UPS= Uninterrupted Power Supply

Summary

In this PhD thesis, we aim to understand the prospects of electric vehicles in a developing country like Pakistan. Pakistan is an energy deficient country facing long electricity blackouts. Hence, it would be interesting to understand which type of electric vehicle could be successful in Pakistan. There are three popular electric vehicles used globally in daily commuting, electric cars, hybrid electric vehicles and electric two-wheelers. Through the help of the literature review, we understood the driving and the resisting forces for each of the above-mentioned electric vehicles. We came to the conclusion that electric two-wheelers could be more feasible in developing countries due to its low purchase and operational cost. The hybrid electric vehicles also provide low cost of operation and environmental benefits. However, the high purchase price of hybrid electric vehicles makes it suitable for the affluent class in developing countries. The policies to support the implementation of electric cars would favour only the rich class as the purchase price is high. Hence, the supporting policies for the implementation of electric cars could be delayed unless the economies of the scale reduce the purchase price of electric cars.

In the second step, we narrowed our research to the electric two-wheelers in Pakistan. We tried to understand whether electric scooters, electric motorcycles or electric bicycles could be successful in Pakistan. In this regard, we conducted a survey in the two main cities of Pakistan. There was no major difference between the respondent of the two cities. We only recorded views of the current motorcycle users in Pakistan. In the survey, majority of the respondents preferred using their current petrol-based motorcycles instead of electric two-wheelers. These respondents identified issues such as high purchase price, high electricity blackouts and low top speed as resisting forces for the implementation of E2Ws in Pakistan. It is one of the major finding indicating that people can cope and use electric two-wheelers if the

purchase price is affordable even in high blackouts. People in Pakistan have resorted to alternative electricity generation technology such as diesel generator or Uninterrupted Power Supply (UPS) using the lead-acid battery. Hence, this could be the reason people have placed electricity blackouts less important than a high purchase price. Those respondents who selected electric two-wheelers as future mobility mode were mainly drawn towards electric motorcycles than electric bicycles or electric scooters. They preferred electric motorcycles due to their high speed and sporty look. The people who selected electric two-wheelers as future mobility mode regarded monetary benefits more important than environmental concern.

We further narrowed down our research asking the people the willingness to pay for electric-two wheelers. Through the help of Qualtrics survey application, we anticipated that there will be two sets of people, one in the favour of E2Ws and one against. We will ask the willingness to pay from the set of people. Those in favour of electric motorcycles were willing to pay 70000-80000 rupees ($446-$509). On the contrary, pro-petrol-based motorcycle respondents were only willing to pay 20000-30000 rupees ($191-$312) to consider electric motorcycles in the future. The respondents showed the least concern for electric scooters and electric bicycles. Hence, they were not discussed further. The majority of the respondents preferred the payment method of buying the electric motorcycle by paying the full purchase price without the support of external funding.

As electric motorcycle was the preferred choice of the respondents in the survey, we channelled our thesis direction to understand the influence of electric motorcycles on the environment, energy and economic benefits. By creating different scenarios, we understood that electric motorcycles would have minimum impact on the peak electricity demand and electricity consumption considering the national electricity grid. We also understood that there will be lower carbon emissions for the use of electric motorcycles than petrol-based motorcycles taking into account the current electricity mix in Pakistan. The results from the total cost of ownership also highlighted that even electric motorcycle have high purchase price the total cost of ownership will be less than petrol-based motorcycles.

It is suggested that electric motorcycles could be successful in Pakistan if the purchase price is equal to or lower than the average purchase price of electric motorcycles. The prospective customers will be mainly motivated by an affordable purchase price. Besides, the government should try to launch awareness schemes for electric motorcycles, support prospective investors and invest in green electricity generation to achieve the full benefits of electric motorcycles.

1 Introduction

The electric mobility offers considerable advantage due to zero emissions and low operational cost. Unfortunately, there is no prior research performed on the prospects of Electric Vehicles (EVs) in a developing country like Pakistan which faces frequent blackouts. In our thesis, we would try to untangle this problem by looking at which type of EVs could be favourable in a developing country like Pakistan. We would also unearth the perception and willingness to pay for EVs that could be suitable in a country like Pakistan. Lastly, we would understand whether such EVs would have any meaningful environmental and economic improvements on the local conditions of Pakistan.

1.1 Background

Electric mobility is almost negligible in a country like Pakistan. Currently, there are no electric-two wheelers or electric-four wheelers being operated in Pakistan. There is no charging infrastructure for any type of electric two-wheelers or four-wheelers in Pakistan. There is a minute presence of Hybrid electric vehicles in Pakistan which is less than 1% (authors own calculation due to lack of data) of the total passenger light-duty vehicles. In 2019, Pakistan launched its first National Electric Vehicle Policy (NEPV) (Haq, 2019). The policy aims to provide incentives for buyers, manufacturers and importers for electric vehicles in Pakistan. This policy targets that electric cars and electric two-wheelers should have at least a share of 30% and 50% of new sales in 2030. For the buyers, it is aimed to provide a general sales tax of 1% (17% for petrol-based vehicles) and lower tariff of electricity. Considering charging infrastructure, the policy aims to develop charging stations at least between 3-30 kilometres in every part of the country. It is instructed to state bank to low rate financing for EV manufactures. This policy lacks robustness, as it overlooks the type of electric vehicles which could be feasible in Pakistan considering the environmental and economic benefits. For example, whether electric motorcycle, electric scooter or electric bicycle could be successful. Moreover, the policy lacks vision as the current electric cars are more expensive, and it would favour the rich only if expensive charging infrastructure is installed by the government. As our thesis work was initiated before this policy, we aimed at understanding the driving and resisting forces for the different type of EVs in Pakistan. We also put the customer surveys and models to predict the type of EV which could be successful in Pakistan.

1.1.1 Current state of electric mobility in the globe

According to a study, China and the United States makes 65% of the global E4Ws users followed by Europe which comprises 23% of the global share (IEA, 2019). In 2016, six countries achieved E4Ws' share above 1% of their total passenger light-duty vehicles' (PLDV) sale. Among these countries, Norway was the incontestable global leader, with 29% E4Ws market in its PLDV share (International Energy Agency, 2017). Norway achieved this result due to pragmatic environmental policies involving a wide variety of incentives, tax reductions and exemption of road for E4Ws (Bjerkan, Nørbech, & Nordtømme, 2016; Simsekoglu, 2018). After Norway, the Netherlands and Sweden hold the highest E4Ws markets, having 6.4% and 3.4% PLDV share respectively. The majority of electric cars registered in the Netherlands, Sweden, and the United Kingdom were plug-in hybrid electric vehicles (PHEVs). In 2016, China, France, and the United Kingdom all had electric car market shares close to 1.5%. Whereas, China and France had BEV-oriented markets, as 75% of their E4Ws sold were BEVs, and only 25% were plug-in hybrid electric vehicles (PHEVs). Whereas, in Norway, Japan and the rest of the world, electric car sales on the average were equally divided between BEVs and PHEVs. Although, China led in the highest sale of

EVs in the world (1.7 million) from 2013-2018 yet, the market share of EVs is less than 5%. In other regions as India, the share of EVs was less than 1% (IEA, 2019).

Except for China, electric cars remain unpopular in developing regions. India has less than 1% E4Ws' share considering car ownership (IEA, 2019). When EVs are discussed, people generally think of electric cars, however, in the situation of the emerging countries such as China and Vietnam, an overwhelming number of E2Ws are sold (Doucette & McCulloch, 2011). This is mainly related to ease of travel and the low purchase price of E2Ws (M. Weiss, Dekker, Moro, Scholz, & Patel, 2015). In 2018, E2Ws had a sale of 30 million units and a total stock of 250 million units in China (Bakker, 2019). Market share for E2Ws is slowly growing for other Asian countries as well, such as India, Vietnam and Taiwan.

In developing countries, it is important to develop EVs that would resonate with the electrical power structure in those countries. A study by Ya Wu and Zhang (2017) observed the electricity mix in the developing countries. In that study, the adoption of HEVs was suggested as they yield higher energy and emissions savings for countries having a predominantly thermal-based electricity mix. The next question is affordability or cost of ownership for citizens. Considering the case of E4Ws, they are out of the reach for the common middle-class person due to higher purchase prices. In this regard, the way forward will be to promote E2Ws in developing countries. China is a prime example where E2Ws have been propelled to an exponential number (C. R. Cherry, Yang, Jones, & He, 2016; X. Lin, Wells, & Sovacool, 2017).

1.1.2 Current state of energy and electric mobility in Pakistan

Energy Situation

The current installed capacity for electricity production is 23321 MW. Currently, Pakistan is facing an enormous energy crisis that has created the electricity generation gap of over 5000 MW (Mirjat et al., 2017). Due to the energy gap, residents face daily blacks out between 6-14 hours in Pakistan (Ghafoor, Rehman, Munir, Ahmad, & Iqbal, 2016; Kamran, 2018). Blackouts could also increase anxiety associated with the charging of a BEVs (Colmenar-Santos, Muñoz-Gómez, Rosales-Asensio, & López-Rey, 2019). The current energy state in Pakistan is predominantly fossil-based (Ra, Rehman, & Asia, 2017). The current electricity mix in Pakistan comprises Oil (38.5%), Hydro (30.7%), Gas (25.7%), Nuclear (4.9%) and Coal (0.2%), defined in the figure below (Valasai et al., 2017). To achieve the full benefits of E2Ws in the future, Pakistan must invest in renewables and clean energy alternatives.

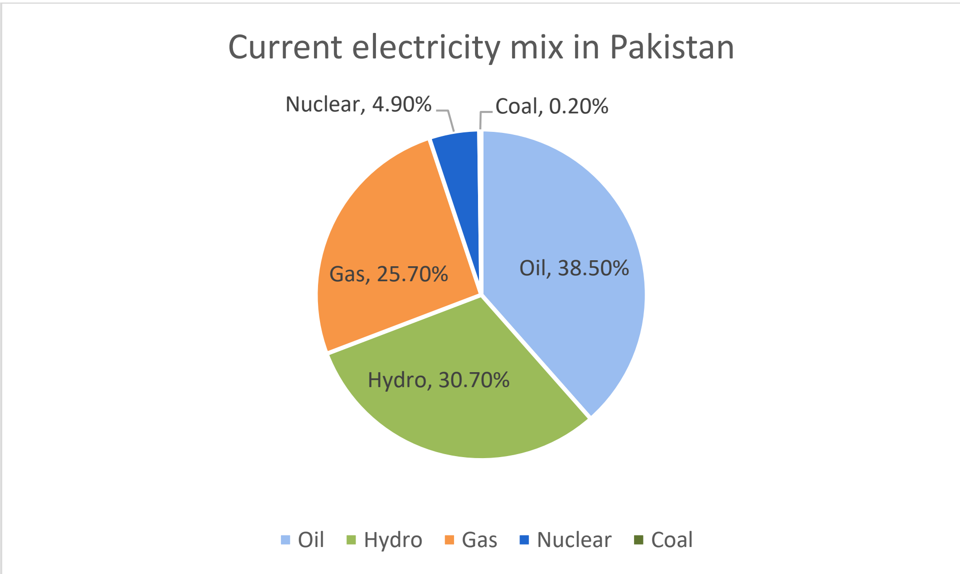

Figure 1. 1 Current electricity mix in Pakistan

<u>Mobility situation in Pakistan</u>

The most popular mode of travel in Pakistan is by petrol-based motorcycles (Ahmad, Batool, & Starkey, 2019; Hasan, 2015). The motorcycles encompass 61% of the total motor registered vehicles. People are inclined to purchase 70cc motorcycles, as they are fuel-efficient and affordable for the people of Pakistan. The average price of a 70cc vehicles varies between 40000-70000 rupees ($258-$452) (Industry, 2019; Pakistan Automotive Manufacture Association, 2018; pakwheeels, 2019). Besides, the transportation sector consumes 57% of the total oil consumption (Arshad & Ali, 2017). If there is a small shift from petrol-based motorcycles to E2Ws, there could significant gasoline savings. It will be interesting to understand the willingness to pay for E2Ws that has lower speed and high charging time than the popular petrol-based motorcycles. The gasoline motorcycle has a solid market in Pakistan for decades, as the motorcycles provide long range and reasonable mileage per litre (Hasan, 2015). Considering the presence of E2Ws and E4Ws, the market is nonexistent. On the contrary, there is a niche market for HEVs. The exact percentage or number of HEVs is unavailable due to the scarcity of data. Considering a rough estimate of imports from the Economic Survey of Pakistan in 2016, it can be estimated that less than 1% of the total cars in Pakistan are HEVs (Year Book, 2016). In recent times, Pakistan has witnessed an exorbitant rise in inflation and reduction of purchasing power. The lower-income strata of people would be fascinated by an alternative in two-wheel transportation mode, which has an affordable price and low operational cost than a conventional gasoline-based two-wheeler. Due to low operational cost E2Ws with a lower purchase price than gasoline-based two-wheeler may garner appeal among masses. In the light of above discussion, it was felt imperative to understand the prospects of EVs in Pakistan so to understand its impact on the energy, environment and economic situation of a common person.

1.1.3 Type of EVs used in the Thesis

In the literature review chapter, we use the five types of electric vehicles. These refer to the electric motorcycle, electric scooter, electric bicycle, electric car and hybrid electric vehicle. In the chapter of perception about electric two-wheelers, we focus on the electric motorcycle, electric bicycle and electric scooter.in the chapter of the willingness to pay we focus on the electric motorcycles only. Similarly, in the chapter of environment and economic analysis of electric two-wheelers, we focus on the electric motorcycle only.

1.2 Problem statement

The majority of the urban transportation sector is occupied with two-wheelers in Pakistan (Pakistan, 2016). It also engulfs more than 50% of the oil consumption of the country. If the current transportation system is improved, it could improve a substantial saving of energy and the reduction of harmful emission. Moreover, common men can also be relieved by the expensive use of petrol for travelling mode. In this situation, EVs paves the way due to its zero tail-pipe emissions and cheap mode of travel due to reliance on electricity. Hence, in this study, we will also try to understand how much petrol, carbon and monetary savings could be achieved by the introduction of electric two-wheelers.

We first must understand the type of electric vehicle that could be beneficial in Pakistan. There are no previous studies which highlight the type of electric vehicle (electric cars, electric two-wheelers or Hybrid electric vehicles) could be successfully implemented in a developing country like Pakistan (Rajper & Albrecht, 2020). For every type of new mobility, there are barriers and driving factors for entry in a market (Haddadian, Khodayar, & Shahidehpour, 2015). These can be understood by exploring the literature and background conditions of Pakistan. We also do not know how people will perceive and pay for a specific type of EV. There is also the dearth of knowledge regarding the impact of EVs can have on the energy, environmental and economic situation in Pakistan. Therefore, the problem statement revolves around the prospects of EVs considering the environment, economic and energy situation in Pakistan. The results and recommendations would help policymakers, producers and consumers clarify the type of electric vehicles that could be favourable in Pakistan.

1.3 Aim of the study

The aim is to understand the feasibility of electric vehicles in a developing country like Pakistan. We try to understand this feasibility by expanding our understanding of the literature. We also take the opinion of common men regarding the feasibility of the selected EVs. Lastly, we develop different models to understand the economic, energy-related and environmental influence of the electric vehicles. This results from the study could counsel the prospective policymakers, producers and consumers regarding the feasibility of EVs in Pakistan.

1.4 Research questions

Considering the above situation, we would have different research questions that need to be highlighted in this thesis work.

- **Q1.** Which kind of electric vehicle (electric cars, electric two-wheelers or hybrid electric vehicles) could be successful in Pakistan?
- **Q2** What will be the perceptions and willingness to pay for such vehicles?
- **Q3**. Influence of the selected electric vehicles on the energy and environmental situation in Pakistan?
- **Q4** What will be the total cost of ownership of the selected electric vehicles?

To address the aforementioned research questions, we briefly discuss the main chapters in this study.

1.5 A brief overview of the chapters

In the second chapter, we try to understand the driving and resisting factors for the different type of EVs in a developing country like Pakistan. In that chapter, we highlight the type of EVs that could be favourable in Pakistan. We used the methodology of the literature review to search keywords in the search engines of Google Scholar and Web of Science. We found that electric two-wheelers would be more feasible than electric cars or hybrids in the developing countries.

In the third chapter, the environment and energy aspect of the electric motorcycle were analysed. We discussed electric motorcycle only as it holds considerable potential than electric scooters or electric bicycles. We created a hypothetical electric motorcycle and compared its performance with the petrol-based motorcycle. To understand the impact of electric motorcycle on the grid, we assumed all the motorcycle connect to the grid at the same time. We analysed the future demand for electricity by the average annual growth of the previous years. The results from this study revealed that introducing electric motorcycles on a large scale would not affect electricity consumption or peak electricity demand. We compare the carbon and lead emissions from the hypothetical electric motorcycle with the petrol-based motorcycle, the results show that electric motorcycle has less carbon dioxide emissions but more solid emissions in the form of lead. To calculate the total cost of ownership, we calculated different cost overhead by looking at contemporary literature and allocated price accordingly. Considering, the total cost of ownership in a life span, petrol-based motorcycles are 1.8 times more expensive than electric motorcycles

In the fourth chapter, we conducted a survey in Pakistan, which inquired people regarding their future mobility option considering the electric scooters, electric motorcycles, electric bicycles or or petrol-based motorcycles. The majority of the respondents opted to use their current petrol-based motorcycle highlighting the resisting forces and inferior attributes of electric two-wheelers. Considering electric two-wheelers, majority of the respondents selected electric motorcycles than electric scooters or electric bicycles Those who selected electric two-wheelers were inquired regarding the reason for the selection. These respondents revealed that they were motivated for monetary savings than an environmental concern to opt for electric-two wheelers as future mobility. In that chapter, we also understood that the purchase price as a resisting force holds more significance than electricity blackouts which is a severe problem in Pakistan.

In the fifth chapter, through the help of Qualtrics application, we assessed the willingness to pay for electric- two-wheelers by the survey conducted in Pakistan. We analysed the payment preferences between the group who preferred motorcycles as future mobility mode than the group which preferred petrol-based motorcycle. Those who favoured electric two-wheelers as future mobility mode were willing to pay more than the purchase price of an average petrol-based motorcycle in Pakistan. On the contrary, people who preferred petrol-based two-wheelers as future mobility mode were only willing to pay significantly less than the purchase price of the average petrol-based motorcycle in Pakistan. The results showed that prospective electric two-wheeler's users were inclined to purchase the vehicle by paying the full purchase price without relying on external financial support.

2 Prospects of electric vehicles in Pakistan

Parts of the findings from this chapter are published in ‘Sustainability’ journal (MDP publishers) known as ‘Prospects of Electric Vehicles in the Developing Countries: A Literature Review’.

https://doi.org/10.3390/su12051906

2.1 Abstract

The electric mobility offers a low cost of travel along with energy and harmful emissions savings. Nevertheless, a comprehensive literature review is missing for the prospects of electric vehicles in developing countries. Such an overview will be instrumental for policymakers to understand the barriers and opportunities related to different types of EVs. We take the reference case of Pakistan because it faces energy crisis and EVs have not been introduced in Pakistan yet. Considering the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines, a systematic review was performed of the electronic databases Google Scholar and Web of Science for the years 2010–2020. The electric four-wheelers, hybrid electric vehicles and electric two-wheeler constituted the electric vehicles searched in the databases. Initially, 35 studies identified in the Web of Science that matched the criteria were studied. Later, 105 other relevant reports and articles related to barriers and opportunities were found by using Google Scholar and studied. The study revealed that electric four-wheelers would not be a feasible option in developing countries due to its high purchase price. On the contrary, electric two-wheelers could be beneficial as it comes with the lower purchase price. The hybrid-electric vehicles could also be beneficial in developing countries even with thermal-based electricity mix. From the literature review, it was concluded that if favourable policies are adopted there could be successful propagation of hybrid electric vehicles and electric two-wheelers in developing countries. For electric cars or electric four-wheelers (E4Ws), the situation could be favourable when E4Ws have a lower purchase price and lower cost of infrastructure. Future studies should be involved to consider

willingness to pay for different type of hybrid and electric two-wheelers in different developing countries.

Keywords
electric vehicles; driving forces; resisting forces; developing countries

2.2 Introduction

Electrification of mobility offers numerous benefits such as reduction on oil dependency and improvement of the environment (Sierzchula, Bakker, Maat, & van Wee, 2014). The electric mobility is represented by the Electric Vehicles (EVs) which consume less energy and emits zero tailpipe greenhouse gases (GHG) (M. V. Faria, Baptista, & Farias, 2014). Battery electric vehicles (BEVs) have largely been praised for their better energy-efficient system than internal combustion engine vehicles (ICEVs). Unfortunately, there has not been prior research which directs the type of EVs that could be more successful in developing country like Pakistan. Hence, we will explore the barriers and opportunities related to electric four-wheelers (E4Ws), electric two-wheelers (E2Ws) and hybrid electric vehicles (HEVs). The E2Ws include electric bicycles, electric motorcycles and electric scooters for our research. The main research question which kind of electric vehicles could be favourable in Pakistan is answered in this chapter. We try to understand the barriers and opportunities for each type of EV studied.

There are numerous forces which push and pull the equilibrium state of the established market for different mobility vehicles. Similarly, there are several driving forces associated with EV's adoption such as the reduction in greenhouse gas emissions (GHG), efficient energy use, gasoline savings and low operational cost. The resisting forces for the adoption of EVs include high purchase price, inadequate range, slow charging and new production adoption anxiety (Carley, Krause, Lane, & Graham, 2013; Egbue & Long, 2012; Newbery & Strbac, 2016). In this study, a comparative analysis will be performed to understand the resisting and driving force for adopting the different type of EVs in the developing countries. We used the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines to compose the methodology for the literature review. We narrowed our search by developing a search protocol and screening process. In the results, it was highlighted that E2Ws and HEVs hold more potential in developing countries than E4Ws. Except for HEVs, there is no established market for EVs in Pakistan. Besides, it is attempted to provide an overview that which type of EVs are feasible for consumers in the local conditions of Pakistan.

2.3 Background

We follow the country classification of developed and developing countries as prepared by the United Nations Organization (UNO) (UN, 2014). These countries are classified according to the measure of the gross national income and gross domestic product. The developing countries mainly fall in the regions of Africa, East Asia, South Asia, Western Asia, Latin America and the Caribbean. In the sections below, we highlight the type of EVs used in the study and electric mobility in the developed and developing countries.

2.3.1 Type of electric vehicles used in this study

In this study, prospects of E4Ws, E2Ws and HEVs in the developing countries are elaborated. The E4Ws and E2Ws depend solely on the battery as a source of power so these could be named as BEVs (Mohanty & Kotak, 2017). The E4Ws refer to electric four-wheelers or electric cars. The E4Ws have only the battery as a source of energy providing long-range capability around 200–300 km (Van Vliet, Brouwer, Kuramochi, Van Den Broek, & Faaij, 2011). The average price of E4Ws varies from $30,000 -$47,000 (Forbes, 2019). We use represent United States Dollar (USD/$) as an international currency to represent Pakistani Rupee or any other currency. The important parts of E4Ws could be divided into the motor controller, battery and electric motor (Helmers & Marx, 2016). The batteries are charged from the electricity grids by the different type of plugs. The type 1, type 2 and combination plugs are usually used in E4Ws having power up to 7.4 kW, 22 kW and 43 kW, respectively. Using the electric motor, the electrical energy is converted to mechanical energy to support the drivetrain (Helmers & Marx, 2016; Hug, 2015). The popular brand of E4Ws in the market is the Nissan Leaf. The second type of vehicle in the study is a hybrid electric vehicle or HEV, which combines both internal combustion engine and a battery pack to generate power for vehicle propulsion. The HEVs do not require external charging, and the necessary power is generated by the regenerative braking system and the internal combustion engine (Panday & Bansal, 2014). We consider the series-parallel type of HEV used in this study. The Toyota Prius is one popular type of series-parallel type of HEV. The price of an average HEV varies $24,000–$29,000 (Egbue & Long, 2012). We do not consider plug-in hybrid electric vehicles (PHEV) in this study as the purchase price is more expensive (Orsi, Muratori, Rocco, Colombo, & Rizzoni, 2016). Considering the term E2Ws, we focus on electric motorcycles, electric scooters and electric bicycles only. The speed of an electric bicycle, electric scooters and electric motorcycles range from ≤ 25 km h^{-1}, ≤ 45 km h^{-1} and > 45 km h^{-1} respectively (Guerra, 2019; Hwang, 2010; Jin et al., 2015). The tank to wheel electricity usage for electric bicycle, electric scooters and electric motorcycle ranges from 0.25 kWh km^{-1}, 0.25-4 kWh km^{-1}, and 4-6 kWh km^{-1} respectively. The electric scooters used in this study are not pedal-assisted, whereas, the bicycles are pedal-assisted (M. Weiss et al., 2015). The electric scooters resembled a Vespa style two-wheeler, whereas, the shape of electric motorcycle resembled a sporty look petrol-based motorcycle. The electric bicycle had a similar style as a normal bicycle. In this study, we use EVs to denote HEVs, E4Ws and E2Ws. We use BEVs to denote E4Ws and E2Ws only. For further clarification, different types of EVs are mentioned in the table below. In this table, some of the features do not apply to HEVs and the blank spot is represented by a dash.

Table 2. 1 Characteristics of different type of electric vehicles (EVs) used in this study in the international market (Daziano, 2013; Hayes & Davis, 2014; Orecchini, Santiangeli, & Dell-Era, 2014; Orsi et al., 2016; M. Weiss et al., 2015)

Characteristics	E4Ws	HEVs	Electric scooters	Electric motorcycle	Electric bicycle
Speed	≥ 150	≥ 180 km h^{-1}	≤ 45 km h^{-1}	≥ 70 km h^{-1}	≤ 30 km h^{-1}
Range in km per full charge	200–300	862	20–70	60-80	≤ 30
Charging time	3–8 hours	-	6-8 hours	6-8 hours	6-8 hours
Electricity consumed (kWh) per kilometre	0.15	-	0.045-0.2	0.07-0.1	≤ 0.015
Battery storage	24 kWh	0.8–1.3 kWh	0.5–15 kWh	0.5–15 kWh	0.3–6 kWh
Battery type	Predominantly lithium-ion battery used	Predominantly lithium-ion battery used	Lead-acid / lithium-ion batteries	Lead-acid / lithium-ion batteries	Lead-acid / lithium-ion batteries
Purchase price	\$30,000 - \$47,000	\$24,000–\$29,000	\$500-\$800	\$1000	\$200

2.4 Materials and Methods

2.4.1 Search Protocol

A search protocol was created primarily directing at the online search engines such as Google Scholar and Web of Science. Initially, synonyms were created for key terms as “electric vehicles”, “electric cars”, “hybrid electric vehicles”, “electric two-wheelers”, “electric motorcycles”, “electric bicycles”, “electric scooters” and “developing countries”. Similarly, we developed search protocols for the driving and resisting forces such as “energy savings” or “high purchase price” etc. We created separate Booleans for Google Scholar and Web of Science, which are attached in the Appendix. We allocated 10 years (2010-2020) time-period in our search engine to search above mentioned keywords. We also searched for the different types of EVs considering driving and resisting forces before 2010 as well when the required information was not available in the reference period. The electric, four-wheeler, hybrid electric vehicles and electric two-wheeler constituted the electric vehicles searched in the databases. These EVs and combination of the resisting and driving forces constituted the main search protocol elements in the databases. For the Web of Science search, we allowed Article, Book, Book chapter, Review and English language selection to retrieve the required records

2.4.2 Screening

We screened out unimportant articles not related to the EVs. The screening out of insignificant articles related to other scientific fields as medicine or physics was performed through the help of “analyse” feature incorporated in the Web of Science engine. We followed the PRISMA guidelines to select relevant studies in the field. The detailed methodology following PRISMA guidelines is given in the figure below.

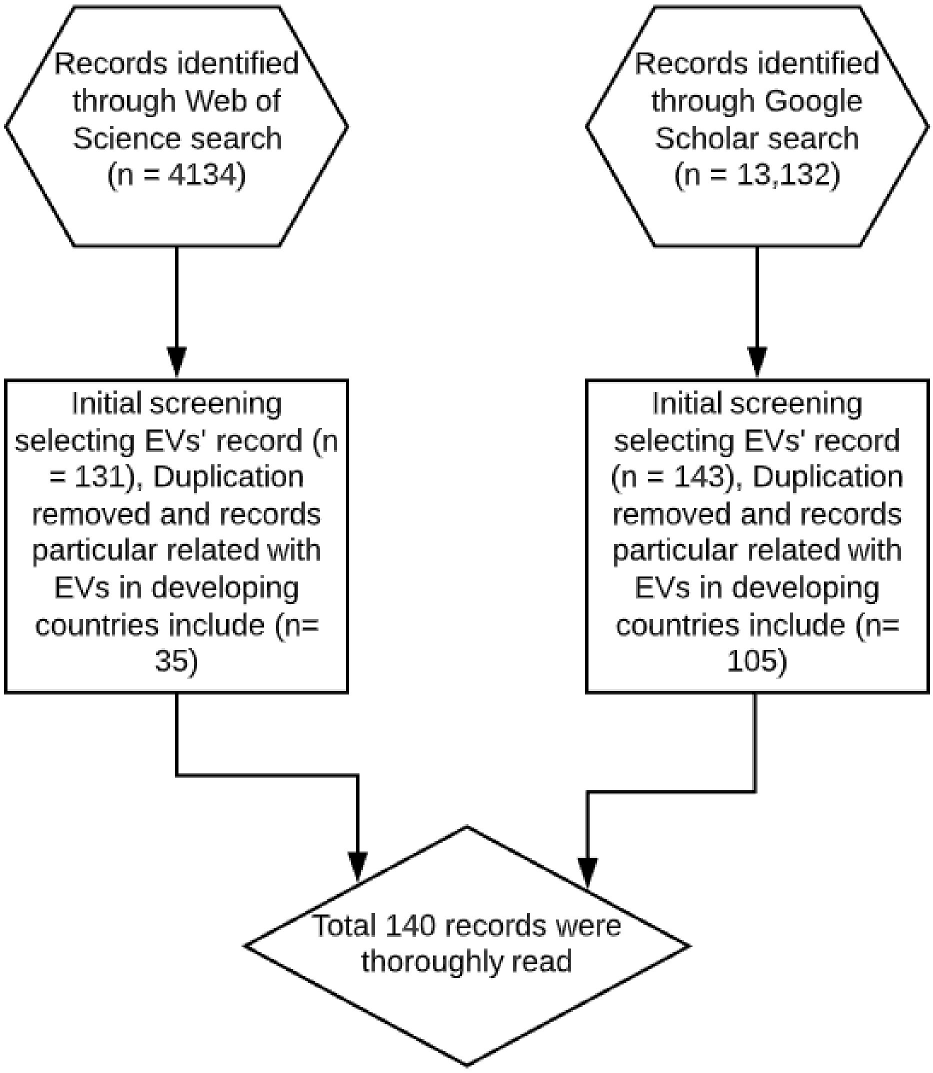

Figure 2.1 Overview of the screening process

In the second phase, duplicated records found in Google Scholar and Web of Science were removed. By reading the abstract and conclusion, we further narrowed down our research to 140 relevant and high impact articles. For the Web of Science engine, we found 35 important articles, whereas, 105 important articles were found using the Google Scholar engine. Some of the articles had reference to reports such as Global EV outlook which were found on Google Scholar and added to the reference section as well.

2.5 Results & Discussion

In the forthcoming section, we enlist important driving and resisting forces for the implementation of EVs in the context of the developing countries. Previous research involved barriers and opportunities about the developed countries, such as subsidies, incentives, data sharing or availability of public charging etc., but are not included in this study as we focus on the developing countries (Haddadian et al., 2015). In our study, we employ the driving and resisting forces by studying different literature focused on developing countries (M. R. Ahmed & Karmaker, 2019; Dhar, Pathak, & Shukla, 2017; Nepal & Jamasb, 2015; Prakash, Dwivedy, Poudel, & Shrestha, 2018; Shukla, Dhar, Pathak, & Bhaskar, 2014; Vidhi & Shrivastava, 2018; Wahab & Jiang, 2019). In the sections below we further elaborate the importance of these forces.

2.5.1 Overview of the driving forces for the EVs

No cost of infrastructure required for the government considering E2Ws and HEVs

The availability of infrastructure is instrumental to reduce range anxiety (Mendoza, Josa, Rieradevall, & Gabarrell, 2016). The infrastructure refers to charging stations needed for the BEVs to charge the vehicles (Davidov & Pantoš, 2017). The E4Ws require sophisticated infrastructure, whereas E2Ws do not require heavy infrastructure investment. An advantage of E2Ws is that their portable battery, which can be recharged via a standard wall outlet from home or office, renders the dedicated infrastructure unnecessary (M. Weiss et al., 2015). According to M. Weiss et al., (2015) if E2Ws substitute for car trips in China, it could eliminate large infrastructure investment. Similarly, HEVs disregard the need for external charging, as it generates required electrical power from its battery and engine (Çağatay Bayindir, Gözüküçük, & Teke, 2011; Hannan, Azidin, & Mohamed, 2014). It indicates that HEVs and E2Ws are more suitable for developing countries that lack the resources to develop the necessary infrastructure for the E4Ws.

The current situation in Pakistan is marred by budget deficit and debts (Jibran, Ali, Hayat, & Iqbal, 2016). Policies makers tend to reserve budget for facilities as health and education instead of focusing on transportation demand. The government is also reluctant to invest in infrastructure that would benefit the rich only. The secondary cause can be the lack of prudent transportation policies for Pakistan. As Karachi (regarded as the biggest city of Pakistan), has not witnessed a single advanced public transportation project as bus rapid transport or metro to meet its transport demand (Imran, 2009). Any transportation policy that overlooks the external investment could be a feasible option in the context of Pakistan. It indicates that large investment for E4Ws infrastructure would imprudent in Pakistan. Similarly, if the government is hesitant to invest in public infrastructure for E2Ws, people still can resort to home or office-based charging albeit change in habit may be required.

Affordable Purchase Price of E2Ws

The purchase price of electric cars and hybrids is very high for middle-income people in developing countries (Forbes, 2019). For the lower-income people, the option of medium-sized electric scooter or E2Ws can be attractive as sticker price is affordable than a gasoline-based car. The price of E2Ws ranges from 100 EUR (electric bicycle equipped with lead-acid batteries) to 5600 EURO (electric bicycles, electric scooters and electric motorcycles equipped with lithium-ion batteries (M. Weiss et al., 2015).

Pakistan can either import parts and assemble the E2Ws or start manufacturing its own version of E2Ws. The government should encourage private investors by easing regulation. If the aforementioned policies are adopted, there can be a decent market developed in Pakistan. The United Kingdom's (UK) committee on climate change claims that EVs may become cost-effective by 2020 (Newbery & Strbac, 2016). This study indicates that waiting for the economics of scale to decrease the price of E4Ws to become affordable for the middle class is a feasible option. The high-cost sticker price or purchase price of E4Ws and HEVs as a resisting force is discussed in the later section.

Low operational cost for final consumers

One of the major reasons to use EVs is fuel cost savings compared to gasoline vehicle (L. R. Jones, Cherry, Vu, & Nguyen, 2013). For EVs, the price of one joule of energy from electricity, irrespective of its energy mix, is lower than the price of the gasoline. The consumption for E4Ws is around 0.2 kWh/km (Brenna, Dolara, …, & 2014, 2014; Hawkins, Gausen, & Strømman, 2012; Metz & Doetsch, 2012; Wei Shen, Han, & Wallington, 2014; Y Wu et al., 2012). The minimum cost of a kilometre journey for EVs in Pakistan may be determined by looking at the current price of electricity in Pakistan. The average cost of one kilowatt-hour of electricity usage in Pakistan on average equals 15 rupees (HESCO, 2019). This can relate to 20 kWh per 100 kilometre which equals to 300 rupees ($1.92). Considering the HEVs, the average price to travel 100 kilometres can be around 400 rupees bearing in mind the average mileage of an HEV and contemporary price of petrol in Pakistan ("Shell Station Price Board | Shell Pakistan," 2019).

Like electric cars, E2Ws also have superior operational savings due to their reliance on electricity rather than gasoline. In a study in the United Kingdom (UK), the electric scooters' operational costs are 2.7 times less than the bestselling motorcycle and 5.9 times less than the bestselling car in the U.K (Bishop, Doucette, Robinson, Mills, & McCulloch, 2011). The E2Ws on average consume 0.015–0.045 kWh per kilometre considering tank-to-wheel energy use (Kerdlap & Gheewala, 2016; M. Weiss et al., 2015). So any low powered electric two wheeler's energy utilization would use 1.5 kWh for 100 kilometres. The operational cost considering electricity consumption will be around 22 rupees for 100 kilometres which seems affordable for the common person in Pakistan. The secondary reason can be that people would also save time and effort to refuel their vehicle from the gas stations which can increase their savings (Brownstone, Bunch, & Train, 2000).

From the above discussion, one can understand that the marginal cost of driving one kilometre by EVs is less than ICEVs. Hence, it is observed that the total cost of ownership, largely consist of fixed or sticker price, rather than the variable or operational cost (Langbroek, Franklin, & Susilo, 2017). The low operational cost can be motivating for the people of Pakistan to shift their current mode from gasoline-based vehicle to electric vehicles. The above discussion also emphasizes that the most cost cheap mode of travelling would be with E2Ws that could garner considerable popularity among masses.

GHG emissions savings for the government

Whether the energy mix is dependent on fossil fuels or not, the BEVs offer minimum GHG emission in well to wheel energy use (Orsi et al., 2016; W Shen et al., 2012; Ya Wu & Zhang, 2017; Zhou, Ou, & Zhang, 2013). GHG consists of carbon dioxide (CO_2), carbon monoxide (CO), ozone (O_3), sulphur dioxide (SO_2), nitrous oxide (NO_2), chlorofluorocarbons (CFC) and methane (CH_4). Generally, policymakers emphasize reducing CO_2 emissions in the transport sector (Ya Wu & Zhang, 2017).In a study conducted in Germany, it was found that revealed that E4Ws incur only 30-50% external environmental cost of an ICEV engine vehicle (Bickert, Kampker, Transport, & 2015, 2015). In another study conducted in China, hybrid electric vehicles (HEV) saved 1023, 0.189, 0.832, and 0.244 kilograms of CO_2, PM_{10}, NO_X, and SO_2 respectively, when HEV was driven and replaced by a conventional car for a year (Ya Wu & Zhang, 2017). A study performed by Orsi et al., (2016) considered the well-to-wheel CO_2

emissions in carbon-intensive electricity mix for different countries. The results from this study showed HEVs have lower CO_2 emissions than conventional gasoline cars or cars using compressed natural gas (CNG). In a study performed in China and India, small ranged E2Ws and E4Ws were studied using the tank-to-wheel method, it was examined that they emit less CO_2 gram per kilometre than their counterpart gasoline vehicles (Doucette & McCulloch, 2011). In a study conducted for the E2Ws in the UK, using the tank-to-wheel process, it was found that the E2Ws emit 3.8 and 1.8 times less GHG emissions than gasoline cars and motorcycles, respectively (Bishop et al., 2011) These studies highlight the fact that EVs save more GHG emissions than their counterpart gasoline vehicles.

The EVs are more beneficial to the environment when the electricity grid is cleaner (Onn, Chai, Abd Rashid, Karim, & Yusoff, 2017). When comparing the prospects of BEVs in the developed and developing countries, electrical power structure and power transmission efficiencies play a vital role. For example, in India, the electricity grid relies largely on thermal power and high line loss rate. On the contrary, France has a clean electricity grid and low LLR, therefore, EVs would be more environment friendly in such regions. It points out that EVs could be beneficial in a clean and efficient electricity mix (Ya Wu & Zhang, 2017). In the table below, we show how clean the national grid is for the prospect of EVs in different developing countries.

Table 2. 2 CO_2 emissions in grams per kWh in different developing countries.

Country	CO_2 Emissions in Grams per kWh	Reference	Year
China	758	(Jiang, Chen, Guan, Zhu, & Yang, 2016)	2016
India	928	(Jiang et al., 2016)	2016
Indonesia	632	(Jiang et al., 2016)	2016
Turkey	478	(Jiang et al., 2016)	2016
Mexico	547	(Jiang et al., 2016)	2016
Pakistan	566	(ul-Haq, Tariq, & Ali, 2017)	2017
Bangladesh	640	(Karmaker, Rahman, Hossain, & Ahmed, 2020)	2020

There are 18 million registered vehicles in Pakistan, the majority of them are comprised of gasoline-based vehicles (Pakistan, 2016). In Pakistan, 70% of CO_2 pollution is caused by vehicular emissions (M. I. Khan & Yasmin, 2014). The transport sector also leads to Particulate Matter(PM) emissions (PM_{10} and $PM_{2.5}$). The Particulate Matters suspended in the air of Pakistan are 6.4 times higher than the WHO guidelines (Stone, Schauer, Quraishi, & Mahmood, 2010). The PM emissions are caused by dirt from road and tire mixed with harmful emissions from vehicle and industrial plants. The diseases associated with air pollution is increasing day by day and approximately 500 million dollars are lost to the national exchequer annually due to the air pollution (N. A. Khan & el Dessouky, 2009; Liaquat, Kalam, Masjuki, & Jayed, 2010). From the above discussion, it can be generalized that if some of the users shift towards BEVs, Pakistan would observe positive savings in GHG emissions. However, the energy mix of Pakistan is mainly thermal-based (Mirjat et al., 2018a). This could also decrease the large-scale benefits EVs could bring. Another impediment is the use of lead-acid batteries used in E2Ws (popularly used in China due to low cost) (M. Weiss et al., 2015). From the above the discussion it could be understood, EV technology could bring green benefit on a large scale if the electricity mix is made clean and there is an effective disposal mechanism of lead-acid batteries in Pakistan.

<u>Energy savings for the government</u>

EVs offer superior energy-saving performance than their counterpart gasoline vehicles. The energy savings may refer to petrol or gasoline savings due to switching on electric power for mobility. In other studies conducted in India, electric mobility despite being on small scale still saves around 44000 litres of gasoline and 109884 kilograms of CO_2 per day (International Energy Agency, 2017; Fame India, 2017). A study was performed by Guanghui Zhou, Ou, & Zhang, (2013) considered the life cycle assessment of E4Ws in China. The life cycle assessment involved two major aspects, total energy use from vehicle production to end-of-life and well-to-wheel energy use. This study revealed that E4Ws saves 35% more energy than conventional cars. Whereas, HEVs saved almost 20% more energy than ICEV cars. In another study performed by Orsi et al., (2016), using the well-to-wheel process, they compared HEVs and E4Ws. The results from this study revealed that HEVs consume twice the energy compared to E4Ws.

The E2Ws are considered to be more energy-efficient than their counterparts petrol-based two-wheelers (Deepanjan Majumdar, Majumder, & Jash, 2016). An E2W consumes 3 to 5 times less energy than a gasoline-based two-wheeler. Gasoline two-wheelers mostly use their energy (75%) in the tank to wheel process, whereas, E2Ws mostly use energy in the production stage (J. Weinert, Ogden, Sperling, & Burke, 2008). In a study conducted in the UK, electric scooters consume 6.1 and 2.9 times less energy than gasoline car and motorcycle respectively (Bishop et al., 2011). In China, the vast majority of the E2Ws are fitted with lead-acid batteries that carry an energy density of 30Wh kg$_{-1}$. On the contrary, E2Ws in Europe are equipped with lithium-ion batteries that are more expensive but provide an energy density up to 140 Wh kg$_{-1}$ (M. Weiss et al., 2015). A comparative analysis is performed in the table below, for energy consumption per kilometre among different electric modes and vehicles. As Pakistan imports, one-third of its energy requirement from fossil fuels, the introduction of E2Ws could help the government's dependence on oil.

Table 2. 3 Comparative analysis among different electric modes for the tank to wheel energy use (C. C. R. C. Cherry, 2007; M. Weiss et al., 2015)

Mode	**Tank-to-wheel energy use in kWh per kilometre**
Bicycles	0
E-Bikes	0.015 ± 0.005
Mid-size E2Ws or electric scooter	0.045 ± 0.02
Mid-size conventionally powered two-wheelers	0.25 ± 0.09
Large E2Ws or electric motorcycles	0.07 ± 0.0.3
Large conventionally powered two-wheelers	0.41 ± 0.13
E4Ws	0.15 ± 0.04
Conventional Passenger Cars	0.61 ± 0.22
Buses	0.30 ± 0.10
Electric rails (tram and train)	0.06 ± 0.016

The transportation sector uses 57% of oil in Pakistan, while the share of oil in energy production is 33% (Pakistan, 2016). This represents that the transportation sector almost consumes 18% of the total energy production in Pakistan. It may be assumed that electric mobility could increase energy efficiency and savings by reducing the oil dependency in Pakistan. The huge dependence of gasoline-based motorcycle can be reduced in Pakistan by replacing gasoline motorcycles with E2Ws. China has witnessed such a trend in the recent decade in which E2Ws replaced gasoline-based motorcycles (M. Weiss et al., 2015).

Considering EVs, it can be inferred that E2Ws consume significantly less energy than E4Ws or HEVs. Hence, in the developing countries, the most energy-efficient mobility mode would be E2Ws than HEVs, BEVs or any other conventional petrol-based vehicle.

Mode shift from public transportation in favour of final consumers

In a study by Kroesen (2017), it was concluded that wide use of E2Ws may induce public transportation and private car users to shift their current mode of transportation. It is highly unlikely that current public transport users in the developing countries would shift towards the use of E4Ws and HEVs, as the purchase price of E4Ws and HEVs is high. Despite this, public transportation has a fixed timetable of travel and more reliability to reach the destination in time, the monetary benefits and independence of mobility could induce public transport users to shift their mode of transportation towards E2Ws (Fairley, 2010).

Congestion cost

Road congestion primarily occurs due to imbalance among road capacity, kilometres travelled and the vehicle fleet size. Megalopolis cities in Asia witness low infrastructure for cars with enormous road congestion (Jraiw, 2003). Since road users do not take into account the impact of their route choice on other road users, every extra vehicle on the road imposes congestion cost for others. The main congestion cost involves time losses and speed-dependent fuel losses. From a study by (Jochem, Doll, & Fichtner, 2016), it is was analyzed that the increase in electric vehicles will not resolve the issue but it will almost be the same as the prevalence of ICEV. In the literature (de Haan, Peters, & Scholz, 2007; Klöckner, Nayum, & Mehmetoglu, 2013), it is found that the majority of the electric car owners already possess an ICEV engine, so ICEV car is not substituted. In that literature, it may be understood that E4Ws in contemporary era may increase road congestion. A way-out could be the use of E2Ws. Due to its smaller size, E2Ws can be handy to address congestion issues in large cities. Some research indicates that electric bikes are replacing personal journeys that may have otherwise been made by cars (Jennifer Dill & Rose, 2012; Fyhri & Fearnley, 2015; Johnson & Rose, 2015; Popovich et al., 2014; Q. Tan et al., 2014).

In 2006, Beijing lifted its ban on E2Ws, as the city was occupied with excessive congestion. From the study of (de Haan, Peters, & Scholz, 2007; Klöckner, Nayum, & Mehmetoglu, 2013) it is found that the majority of the electric car owners already possess an ICEV engine, so ICEV car is not substituted. From a study by (Jochem, Doll, & Fichtner, 2016) for EVs, it is was analysed that increase in electric vehicles will not resolve the issue but it will almost be the same as the prevalence of ICEV. Megalopolis cities in Asia witness low infrastructure for cars with enormous road congestion (Jraiw, 2003).

Whether EVs can reduce congestion remains an object of debate. Considering the local condition of Pakistan, it is unlikely that EVs will help reduce congestion. The traffic mix in Pakistan comprises more than 70% for two-wheelers and more than 15% for cars (Pakistan, 2016). The prospect of this mode switch remains dull considering the hot climate and comfort associated with conventional cars users which will restraint these cars users to shift E2Ws in Pakistan. There is a chance that electric cars can replace gasoline cars if the sticker price is at par with gasoline vehicles. Congestion will only reduce when cars owners will switch to E2Ws which seems unlikely in the local conditions of Pakistan.

2.5.2 Overview of the resisting forces for the EVs and their impact in Pakistan

<u>High cost of infrastructure required by the government for the implementation of E4Ws</u>

The charging infrastructure is an important component that reduces range anxiety for the BEVs. From the study of Krupa, it is found that intention to buy an EV is directly related to the availability of the recharging station (Krupa et al., 2014). In the contemporary era, the infrastructure investment seems to be a prerogative of the developed countries. In the United Kingdom, the government has vowed to allocate £250 million for the development of EV infrastructure (Graham-Rowe et al., 2012). If equipped with state of the art material such as communication software, the investment, and maintenance for one public charging could vary between 4000€ and 10,000€ (San Román, Momber, Abbad, & Sánchez Miralles, 2011).

It is the object of debate whether large-scale infrastructure investment should be allocated for EVs. In this regard (Mansour & Haddad, 2017), conducted a study for electric cars in the developing country of Lebanon (table below). The five types of mobility modes defined by energy consumption described in the figure are CNG, Liquefied Petroleum Gas (LPG), HEVS, PHEVs and EVs. In this figure, energy and emission savings are compared with infrastructure investment cost. HEVs tend to exhibit no infrastructure investment cost, whereas, electric cars in the form of BEVs tend to incur the highest infrastructure investment cost. In the previous section of driving forces, it was discussed that HEVs and E2Ws should be promoted in the developing countries, as they do not require substantial investment for infrastructure.

Table 2. 4 Energy and emissions savings considering infrastructure investment costs (Mansour & Haddad, 2017)

Impact of different mobility energy	**Investment**		**GHG savings**	
	High	***Low***	***High***	***Low***
LPG		Equal or less than 35 USD		23000 tons/year
CNG	Equal or less than 147 Million USD			19500 tons/year
PHEV & EV	Equal or less than 145 Million USD		132000-230000 tons per year	
HEV		No investment	105000 tons per year	

In the context of Pakistan, the government will be hesitant to invest in infrastructure for E4Ws, as it would benefit the rich only. Currently, the government will be motivated to provide feasible mobility options to low-income people. As discussed earlier, E2Ws and HEVs could work without a dedicated external charging system.

High price of E4Ws & HEVs

According to a study in the USA, the purchase price is one of the major barriers to purchase an EV (Carley et al., 2013). The sticker price of E4Ws is around $18,000-$70,000 more than a gasoline-based car (Budde, Wells, & Cipcigan, 2012; International Energy Agency, 2015; Ya Wu & Zhang, 2017). The adoption of E4Ws is high in developed countries such as Norway due to high purchasing power when compared to people than in developing countries such as India, who perceive the E4Ws expensive (Dhar et al., 2017; IEA, 2019; Simsekoglu, 2018). The current payback time for E4Ws is 20 years in comparison to a cheaper ICEV. In another study, it was found that the total cost of ownership of E4Ws takes 10 years to match the initial cost and ownership cost of an ICEV (R. Faria, Moura, Delgado, & de Almeida, 2012). Nevertheless, it is expected that it will drop down to less than 4 years until 2030 (Richardson, 2013). People with high income are less sensitive to prices and are likely to buy an E4W (F. Liao, Molin, Wee, & van Wee, 2017).

The low purchasing power of people inhibits the purchase of the high price tagged HEVs and E4Ws. Unless the economies of scale do not reduce the price of E4Ws and HEVs to an affordable price, the popularity of these type vehicles would not increase substantially in Pakistan. Besides, providing incentives and taxes for the purchase of expensive E4Ws and HEVs will be imprudent from the government considering it will favour the rich. The developing country like Pakistan can wait until the price of E4Ws and HEVs can be reduced through technological advancement and the economies of scale.

Electricity Blackouts and long charging time

From the study of Sanya Carley et al., (2013), the three most important impediments towards EVs adoption were identified as, sticker price, range anxiety and high charging time. Long charging time is one of the crucial aspects which influences people to consider EVs as an inferior product (Steinhilber, Wells, & Thankappan, 2013). Considering E4Ws, 100% charging requires 3-8 hours of charging with 1.4 kW maximum power (Hidrue, Parsons, Kempton, & Gardner, 2011). From the study of M. Weiss et al., (2015), we found that E2Ws have a battery capacity of 0.5-15 kWh which require 6-8 hours recharging from the wall outlet. The general pattern for charging a BEV is during the evening and night when tariffs are low and BEVs are idle (Shao, Guan, Ran, He, & Bi, 2017). It is clear that there is no cost-friendly option to charge BEVs rapidly. Long charging time for electric vehicles would remain to be stressful unless a sustainable technology option is developed. The problem of long charging time will be exacerbated when there is load shedding of electricity in a country due to the energy crisis. In the developing countries, there are frequent blackouts due to power crisis (R.-N. Liao & Yang, 2018). The major reason for the blackouts in Pakistan is the lack of effective policy-making to foresee the rising power demand and the lack of maintenance for the current assets (Kessides, 2013; Mirjat et al., 2018a). As discussed in the previous section, some areas of

Pakistan face more than 12 hours of blackouts due to an energy supply gap. Resultantly, the blackouts could increase charging anxiety associated with BEVs.

The blackouts causing charging anxiety can be regarded as the most significant impediment towards E2Ws and E4Ws adoption in Pakistan. The idea of E2Ws and E4Ws reliability to reach the desired destination remains questionable since the blackouts have no particular timetable. The prolong blackouts exacerbate anxieties associated with E2Ws and E4Ws such as range anxiety, the effort required for plugging and unplugging and long charging time anxiety. Therefore, to improve blackouts related charging anxiety, there must be the uninterrupted power supply or there can be a certain timetable for the blackouts. As discussed in the previous section, large-scale awareness schemes would have to be initiated to make people consider the charging option in blackouts. For instance, people would have to be made aware to charge vehicles as if they charge their cell phones.

People would prefer vehicles that do not require external charging considering the high prevalence of blackouts in Pakistan. Prevalence of blackouts also shows that people prefer vehicles that avoid the hassle of plugging and unplugging the charger. HEVs do not pose any threat on the grid, thereby, policymakers would appreciate this attribute but it may not have a huge impact in an energy deficient country. The blackouts were regarded as most influencing resisting forces.

Lack of government policies

It is a known fact that the government can create markets for different products and correct market failures if needed (Briggs, Webb, & Wilson, 2015; Nepal & Jamasb, 2015). In our context, marketing failure exists by providing a mobility mode which has less operational-cost than contemporary petrol-based mobility options. The market of EVs can be created, if there is special support from the government. The governments of India and China are the forerunner to promote policies supporting EVs. By the supervision of heavy industry in India, the faster adoption and manufacturing of electric vehicles (FAME) was initiated by the government in 2015 (Fame India, 2017). The FAME is directed towards motivating people to consider EVs in future. In some states, there is an exemption in registration tax of electric vehicles (International Energy Agency, 2017; Fame India, 2017). China, on the other hand, has introduced policies such as, banning the purchase of gasoline-based two-wheelers in cities, which face an enormous level of air pollution. Seven major urban centres of China have witnessed license plate restrictions waived for EVs. There are different tax waiver schemes for ownership of EVs in China (- International Energy Agency, 2017; Yang, 2010). Other studies (Sierzchula et al., 2014; Y. Zhang, Yu, & Zou, 2011), indicate that tax reduction and financial incentives as subsidies by the government also increase the awareness to consider EVs. Moreover, the adoption of EVs depends on technological improvement and economic incentives, such as sales tax (L. R. Jones et al., 2013). After 2010, China witnessed a huge adoption of E2Ws due to the low purchase price of E2Ws and the ban to purchase gasoline two-wheelers [(Jennifer Dill & Rose, 2012; Eccarius & Lu, 2020; Yang, 2010)]. Between 1999 and 2005, China witnessed a decrease in E2Ws' price by 30% from $380 to $240 due to the dropping costs and dwindling profit margins (J. Weinert et al., 2008).

There is lack of policies from the government in Pakistan such as awareness schemes, tax exemptions, and import friendly regulation to promote innovative technology such as EVs (Qureshi, Ullah, & Arentsen, 2017). Providing incentives to the rich class to buy HEVs or E4Ws does not seem reasonable in a developing country like Pakistan. So incentives may be introduced for middle and lower class people for the purchase of cheaper E2Ws. These incentives could be a waiver of registration tax, excise tax, toll tax and other related taxes.

For the rich class, there can be smaller incentives as registration waiver or toll exemption for HEVs and E4Ws. Investors can also be encouraged by policies to ease taxes and regulation for the import of E2Ws. Recently, Pakistan has slashed its import duties on cars from 50% to 25%, this means that a Tesla brought in for $80000 would pay $20000 as a customs duty resulting into $100000 as the final cost ("Pakistan Budget 2018," 2018). Still, there are many trade groups who advocate that such import duties should be reduced to a range of 0-5% to induce the affluent class to buy electric cars (Ahsan Mirza, 2017). Thereby, investors and buyers can be lured by the government to create a market for EVs in Pakistan. Besides, the government can also motivate investors to produce E2Ws locally.

Lack of awareness for final consumers

It is evident that people with environmental concern and awareness tend to purchase EVs. Besides, the marketing campaign is more effective for people with environmental concern than others (Krupa et al., 2014). Awareness about sustainability also increases the chance to buy EVs (Egbue & Long, 2012). Government's intention to raise awareness through advertising and financial incentives also lures the public to purchase electric vehicles. Lack of information or partial information on the available option also leads to the disproval of emerging technology (Sierzchula et al., 2014). In a study conducted in China by (Y. Zhang et al., 2011), people have limited knowledge of EVs performance features, charging interval, operational and maintenance cost. Thereby, it can be assumed that complete knowledge and awareness would actually circumvent the different anxieties associated with EVs, such as range anxiety, charging anxiety or resale anxiety.

In the conditions of Pakistan, awareness could be realized as a high impact force. In Pakistan, the idea of E2Ws and E4Ws for the common masses remain undisclosed. People neither have the idea that such a product exists nor they are aware of its attribute. It should be noted that awareness could act as a driving force if it is backed by proper policies. To create awareness in Pakistan, awareness scheme coupled with an incentive scheme needs to be initiated for EV technology. Previously, the government of Pakistan has shown interest to save gasoline energy by adopting compressed natural gas (CNG) technology through creating awareness, investment opportunities and ample regulatory framework. Resultantly, there was a massive adoption of CNG based vehicles and now there are almost 3.1 million registered CNG vehicles out of 6.1 million users (M. I. Khan & Yasmin, 2014; M. I. Khan, Yasmin, & Shakoor, 2015). It shows that people positively react to the government's awareness scheme with cheap transportation alternatives. Non-government agencies such as prospective investors would also have to create advertising strategies as their upcoming product. Lastly, the presence of awareness schemes can also dwindle anxieties associated with BEVs as new product adoption anxiety, range anxiety and resale anxiety etc.

Presence of a Strong Market for Gasoline-Based Vehicles

There is a high prevalence of gasoline-based vehicles in low-income countries such as Pakistan, India and Bangladesh (CEIC, 2017; Mansour & Haddad, 2017). In these countries, motorized two-wheelers' vehicles registration is higher than four-wheeled vehicles. In 2006 in China, motorized two-wheelers out-numbered passenger vehicle sale nearly 7 to 1. In India in 2009, two-wheelers vehicles accounted for 75% of all new vehicle sale (Doucette & McCulloch, 2011). In Pakistan in 2016, motorized-two wheelers registration was 70% of total vehicles, directing that more than half of the traffic mix consists of two-wheelers (Pakistan, 2016). If E2Ws are introduced in Pakistan, the gasoline-based market of motorcycles would provide grave competition due to its cheap price and high mileage. The gasoline motorcycles offer a low sticker price coupled with a good mileage per litre (Eccarius & Lu, 2020; Guerra, 2019; L. R. Jones et al., 2013; Weiss et al., 2015). These gasoline motorcycles do not deal with anxieties associated with E2Ws. From the discussion, it can be understood that to mitigate the market for gasoline motorcycles, the E2Ws would have to offer an added value. This added value can be in terms of the low purchase price, ease of instalment or battery replacement service etc. China banned the use of gasoline motorcycles in some cities, such a model can also be modelled in Pakistan.

Range anxiety for final consumers

Limited range is regarded as the biggest impediment in buying an electric vehicle (Bonges & Lusk, 2016). Range anxiety is defined as the driver's stress regarding the unavailability of battery life that may leave the driver stranded (Neubauer & Wood, 2014; Salah & Kama, 2017). Range anxiety includes both the actual and perceived range contributing to range anxiety. The range-anxiety primarily affects the sale of E4Ws (Bonges & Lusk, 2016; Tim Jones, Harms, & Heinen, 2016). Increase in speed, use of air conditions and outside temperature directly affects the energy consumption of a battery that may leave the driver to underestimate the performance of the BEVs (Neubauer & Wood, 2014). For example, a driver may travel 90 kilometres even if the BEVs can travel 100 km (Neubauer & Wood, 2014). Range anxiety is one of the main obstacles for the mass adoption of E2Ws as well. The range of a gasoline-based two-wheeler on average is 80–200 km (L. R. Jones et al., 2013). Whereas, the E2Ws are usually equipped with a lead-acid battery and offer a driving range between 30 and 70 km (Kerdlap & Gheewala, 2016; Deepanjan Majumdar et al., 2016).

Range anxiety for BEVs can be addressed by progressing battery technology (C. R. Cherry et al., 2016; Jennifer Dill & Rose, 2012). According to one study, range anxiety is reduced when there is a charging infrastructure that communicates within the network. The range anxiety for EVs can be reduced by providing sufficient information for its range (Carley et al., 2013). The new models of Tesla and other companies are trying their best to increase the range of electric vehicles through better energy density and technology (Cao, Electronics, & 2012, 2011; Thackeray, Wolverton, Environmental, & 2012, 2012). To reduce the range anxiety, there should be an increase in public charging and battery swap stations for BEVs (Bonges & Lusk, 2016; Jennifer Dill & Rose, 2012; R. Faria et al., 2012). Accurate information on vehicle performance, trip timing, distance and charging infrastructure availability can also mitigate range anxiety as well. However, in the real world, such information is rarely available (Neubauer & Wood, 2014). To regulate friction among drivers for charging BEVs in public charging stations, the following strategy could be adopted. Enforcing a time limit, dealing with ticketing, unplugging a fully charged vehicle and charging station's capacity to allow allowing multiple BEV's charging (Bonges & Lusk, 2016). Range anxiety is also reduced with sufficient experience using the BEVs in which the driver learns vehicle capabilities, appropriate driving techniques and journey planning (Jennifer Dill & Rose, 2012).

In Pakistan, a motorcycle trip is a popular choice of usage within the city or a village. For longer trips, cars and public transportation are used. The range of 25-30 kilometres for within city travel can be sufficient for electric-powered two-wheelers such as electric scooters or electric bicycles. If the public can be made aware of the range of E2Ws in Pakistan, they can adapt their driving habits accordingly. The 'Research and Development' is instrumental to overcome disadvantages related to E2Ws and E4Ws as small battery life, low range and low speed. However, the absence of a market for E2Ws and E4Ws together with poor economic situation impedes government and non-government agencies to invest in research and development.

Low speed for E2Ws

The E2Ws in the form of electric scooters or electric bicycles have an average speed of around ≤ 30 ≤ 45 km/hour (C. R. Cherry et al., 2016). In India, where the traffic is heavily mixed, the average speed varies between 16-18 km/hour (Deepanjan Majumdar et al., 2016). In comparison with conventional bicycles, the increase in speed and low effort are one of the main motivators to buy electric bicycles (T Jones, Harms, Geography, & 2016, 2016). In a study done in Vietnam, the consumers were willing to pay more, if speed and range are increased (L. R. Jones et al., 2013). In Pakistan, low speed would be regarded as a grave impediment because its competitor offers higher speed. Lower speed adaptation will difficult unless the population positively evaluates other benefits offered by E2Ws as superior fuel savings.

Resale of EVs

Consumers tend to resist new and unproven technology in their surroundings (Egbue & Long, 2012). A study by Oliver & Rosen (2010) indicated that perceived risk with new products partially impedes the decision to purchase. This risk perception is formulated by experience, emotions, non-technical sources and the media (Cocron & Krems, 2013a; Egbue & Long, 2012). Resale values of electric vehicles have been one of the major impediments to purchase electric vehicles along with high cost and low range (Kihm & Trommer, 2014). Social networks and media could impact values that affect consumer choices (Bronner & de Hoog, 2014). Sometimes, the private business holders are hesitant to adopt new technology as EVs, due to uncertainty and fear that public benefit will outweigh the private benefit of the company (Sierzchula et al., 2014). Unless there is the widespread use of EVs, people will always be hesitant of a new product resale in the market. The resale anxiety of EVs will diminish once users will observe the durability of the EVs, which will develop through market maturation (Lim, Mak, & Rong, 2015). Resale values of EVs have been one of the major impediments to purchase electric vehicles along with high cost and low range (Kihm & Trommer, 2014). Various attributes reflect the resale price of vehicles such as mechanical reliability, longevity, reputation and social trends.

In order to tackle the resale anxiety of electric vehicles in Pakistan, the government and private sector have to collaborate to create awareness schemes. The private sector refers to the investors in E2Ws such as suppliers, assemblers and E2W show roam owners. These schemes should highlight the success stories of durability and reliabilities of EVs in Norway and China. Moreover, resale anxiety can be gradually reduced when there will sufficient visibility of electric cars in a society backed by the word of mouth. If there is a positive experience by people other people would also purchase E2Ws in Pakistan. It shows that resale can improve drastically if there is a positive evaluation of the E2Ws.

Harmful Emissions

A study of well-to-wheel emissions by EVs from Ya Wu & Zhang, (2017) determined that E4Ws and HEVs reduce CO_2 emissions, but they could release more PM_{10}, SO_2 and NO_X in the air compared to an ICEV engine if the electricity mix is predominantly thermal. In that study, it was indicated that HEVs perform better in the energy mix that largely relies on coal in countries such as India and China, which have an unclean electricity mix. Besides, zero-emission benefits could not be reached, unless these Particulate Matters are controlled (G. Liu et al., 2014). Furthermore, efforts should be made to make the electricity mix as green as possible so the negative externalities related to EVs can be controlled (Choi, Shin, & Woo, 2018; Ya Wu & Zhang, 2017). It shows that Pakistan has to clean its electricity mix and make strategies for quick disposal of negative externalities related to the EVs

Most of the E2Ws in China use lead-acid batteries (Garche & Moseley, 2017). The solid lead waste for E2Ws is considerably higher than a gasoline motorcycle. These lead emissions are substantially high as 5-10 g/100 km, involving inefficient production and recycling process. The main issue for emissions in two-wheelers involves the production, distribution, and recycling of batteries (W. Liu, Tian, Chen, & Guo, 2017; M. Weiss et al., 2015). According to a study, 44%-70% of the lead waste of E2Ws' batteries goes into the environment. This can lead to groundwater and crop contamination. Almost two square meters of land is contaminated if four kilograms of lead-acid battery waste is abandoned (Tian, Gong, Wu, Agyeiwaa, & Zuo, 2014). In China, 95% of the total lead emissions are released at the end-of-life stage, due to an improper recycling process. There are alternatives to the lead-acid battery such as Lithium-ion (Li-ion) and nickel-metal hydride (Ni-MH) batteries, lithium-ion and Nikhil batteries, which weight half and have higher battery life.

However, they are four times expensive to the same energy providing a lead-acid battery. (M. Weiss et al., 2015). The technology to control these harmful emissions is mature and has an advantage due to the economies of scale (Santos, 2017). Although, emissions are lower for E2Ws, yet, solid waste and SO_2 for E2Ws are considerably high than a gasoline vehicle. Zero emissions benefits could not be reached, unless, these particulate matters are controlled. According to one study, 60% of the lead-acid content is recyclable. If there is a 100% collection rate of lead-acid batteries for recyclability, 98% of the total toxicity impact of the lead-acid batteries could be avoided (Kerdlap & Gheewala, 2016).

If lead-based E2Ws are adopted in Pakistan on a large scale, it could be an environmental problem unless the government adopts a proactive approach for their effective disposal. The technology to control these pollutants is mature and has an advantage due to the economies of scale (J. X. Weinert, Ma, Yang, & Cherry, 2005). Besides, efforts should be made to make the energy mix as green as possible so the negative externalities of the electric vehicles can be controlled.

Increase in demand for power

The effect on the grid is an object of debate among researchers. According to some scientists, it is expected that there will be a substantial amount of increase in the power demand after the increase in the usage of the electric vehicles (J. X. Weinert et al., 2005). It would induce power generators to increase their supply to the national grid (Doucette & McCulloch, 2011). The introduction of electric vehicles affects the performance, capacity and efficiency of the electric grid when the vehicle charging is unconstrained (Richardson, 2013). On the contrary, some researchers advocate that the total extent of energy extracted from the grid by electricity is comparatively small for EVs. In Milan, it is expected that only 3% of total electricity consumption will increase if BEVs share 30% of all PLDVs (Perujo & Ciuffo, 2010). A study in India was conducted with high electric vehicle scenario, it showed that even with high penetration of BEVs, the burden on electricity will not exceed more than 6% of overall demand for electricity (Dhar et al., 2017).

The smart charging algorithm is a useful technique to address the limitation on the transformer's capabilities when BEVs are connected to the grid. Some scientists believe that smart charging options can equal the overall load by the better use of the baseload units that require no further installation capacity (van der Kam & van Sark, 2015; Y. Zheng & Jian, 2017). The smart charging algorithm would also be useful to address the transformer's high load that can increase its temperature. Besides, smart meters and grids can also take back power from the electric vehicle itself to address peak demand period. Congestion problem in load can arise if BEVs are not managed without a conceptual framework for the management of the grid (J A P Lopes, Soares, & Almeida, 2011). Considering the electricity blackouts, if the grid doesn't provide the electricity for BEVs, the local consumer may rely on an alternative way to use diesel generators which is a cost-effective but hazardous to the environment option (Saxena, Gopal, Energy, & 2014, 2014).

In the context of developing country like Pakistan marred by frequent electricity blackouts, policymakers could be stressed with a slight increase in total consumption due to the adoption of BEVs. Unfortunately, no research has been performed to consider the impact of different types of BEVs on the peak electricity demand or total electricity consumption in the developing countries facing electricity blackouts.

Lack of safety for E2Ws on road

There has been a variating point of opinion among scientists for the safety of electric vehicles. A study by Jochem et al., (2016) analysed that the accident cost of EVs is equal to that of ICEV. On the contrary, some scientists advocate that silent motors increase the chance of an accident on a small number (Cocron & Krems, 2013a; Stelling-Kończak, Hagenzieker, & Wee, 2015). Considering E2Ws, the additional weighted lead-acid batteries used in China could increase the severity of the accident due to added inertia generated (Rose, 2012). In the developing countries, the safety of E2Ws would be a major issue since there are no separate lanes for two-wheelers on the road. Large scale adoption of E2Ws in the developing countries would require additional traffic safety regulations and adaptations of urban infrastructure (M. Weiss et al., 2015).

The traffic mix in Pakistan is shared among vulnerable road users, motorcyclists, car owners and hawkers equally. Traffic accidents are a common and high number in Pakistan (Jooma, Ali, & Shaikh, 2018; Nazir, Nadeem, & Véronneau, 2016). This may be primarily with the downtrodden conditions of the road coupled with non-existent enforcement. There are advanced active and passive features installed in HEVs and E4Ws, which make the drive quite safe. On the contrary, E2Ws can drastically increase the chance of accidents in Pakistan as E2Ws are equipped with heavy batteries, which makes manoeuvring difficult. Therefore, the government has to improve enforcement and improve road conditions so E2Ws remains a safe option on the roads of Pakistan.

Lack of E2Ws' capability to carry more people and weight

From the study of Dill & Rose (2012), half of the consumers complained that additional weight by the E2Ws is a problem. This study also revealed concerns from consumers that the weight can increase their anxiety for a flat tire. The users regard the weight of the battery as a burdensome option. Around 30%–40% of the weight of the E2W consists of the battery. The lead-acid battery used in E2W is considerably heavier than lithium-ion batteries (M. R. Ahmed & Karmaker, 2019). Additional weight can also be problematic in applying brakes or maneuvering the E2Ws (Huertas-Leyva, Dozza, & Baldanzini, 2018). As lithium-ion technology is expensive, people of the developing countries would rely on the lead-acid battery for their E2W. In a developing country like Pakistan, people usually use petrol-based two-wheelers to carry heavy items, such as the delivery of dairy-related products (REUTERS, 2012). Thereby, people may still resort to gasoline-based two-wheelers when carrying extra weight or people due to the low power of the E2Ws.

2.6 Conclusion

This literature review is focused on understanding the driving and resisting forces particularly directed towards the three types of electric vehicles (E4Ws, HEVs and E2Ws) in the developing countries with a particular focus in Pakistan. From the literature review, it could be understood that E2Ws are more feasible for developing countries whereas due to its low purchase price and low operational cost. The E2Ws holds the potential to provide energy and environmental and benefits without infrastructure investment. On the contrary, E2Ws face divergent resisting forces as lack of awareness, strong gasoline two-wheeler market and inferior characteristics (low speed and high charging time) than conventional motorcycles. The E2Ws could be a successful option in a developing country which have predominantly petrol-based two-wheelers in their traffic mix such as India and Pakistan. On the contrary, E2Ws face divergent resisting forces, such as lack of awareness, electricity blackouts, strong gasoline-based two-wheelers' market and inferior characteristics (low speed and high charging time). It is suggested to delay the implementation of E4Ws in the developing countries until the economies of scale can reduce the different costs associated with E4Ws. HEVs could also be propagated in the developing countries, as the purchase price is affordable than E4Ws. Besides, HEVs offer reasonable GHG savings even with a dirty electricity mix (Egbue & Long, 2012; Mansour & Haddad, 2017; Ya Wu & Zhang, 2017). In a nutshell, with proper policies HEVs and E2Ws can be successfully propagated in the developing countries. To bear the maximum environmental benefits of EVs in the developing countries, the electricity mix should also be made green.

2.7 Future Studies

As we understood from this chapter's results, E2Ws are a feasible option in developing countries. Future studies could be related to consider willingness to pay for E2Ws in the developing countries where E2Ws have not been introduced. It will be particularly interesting to understand whether electric bicycles, electric scooters or electric motorcycles will the preferred choice of future mobility by the respondents. Further studies could also be carried to understand the total cost of ownership, influence on the peak electricity demand, total electricity consumption and environmental impacts of E2Ws in a particular region or country.

2.8 Appendices

2.8.1 Appendix A: Boolean for Web of Science

#1 TS = ("electric vehicle "OR "electric vehicle*" OR "electric mobility" OR "electric mobility*" OR "EVs*" "BEVs*"OR "new electric vehicle" OR "new electric vehicle*" OR "battery electric vehicle" OR "battery electric vehicle*"))

#2 TS = ("electric car" OR "electric four wheeler*" OR "E4W*", OR "electric car*" OR "electric car*" OR "electric four wheelers"))

#3 TS= (“hybrid electric vehicle” OR “HEV*”OR "hybrid electric vehicle*"))

#4 TS = ("electric two wheeler" OR "electric two wheeler*" OR "E2W*"))

#5 TS= ("electric scooters" OR "electric scooter*" OR "mid size electric two wheeler" OR "mid size electric two wheeler*" OR “electric bicycle” OR “electric motorcycle” OR “large size electric two wheeler”))

#6 TS = (“Underdeveloped country*” OR “Underdeveloped country” OR “Developing country*” OR “Developing country” OR “low income country*” OR “Low income country” OR “Low GDP country” OR “Low GDP country* ” OR “Under developed countries*” OR “Under developed countries” OR “Developing countries*” OR “Developing countries” OR “low income countries*” OR “Low income countries” OR “Low GDP countries” OR “Low GDP countries* ”))

#7 #5 OR #4 OR #3 OR #2 OR #1

Final search #7 AND #6

2.8.2 Appendix B: Boolean for Google Scholar

Example of one type of electric mobility (electric scooter)

#1 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND GHG

#2 electric scooters OR mid size electric two wheeler OR electric car OR electric four OR hybrid electric vehicle OR HEV AND developing countries AND energy

#3 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND infrastructure

#4 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND operational cost

#5 electric scooters OR mid size electric two wheeler AND developing countries AND purchase price

#6 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND public transportation

#7 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND congestion

#8 electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND purchase price

#9 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND government policy

#10 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND awareness

#11 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND gasoline two-wheeler

#12 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND range anxiety

#13 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND long charging time

#14 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND emissions

#15 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND power generation

#15 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND low speed

#16 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND resale

#17 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND road safety

18 electric scooters OR mid size electric two wheeler OR electric car OR electric four wheeler OR hybrid electric vehicle OR HEV AND developing countries AND weight

2.8.3 Appendix C: Classification of barriers and opportunities according to the literature

Table 2. 5 Appendix: Classification of barriers and opportunities

No	***Reference***	***Barriers***	***Opportunities***	***Focus Group(s)***
1	(Sierzchula et al., 2014)			Consumer and Government
2	(M. V. Faria et al., 2014)			Government
3	(Carley et al., 2013)			Society at large
4	(Egbue & Long, 2012)			Government, consumers, society at large
5	(Van Vliet et al., 2011)			Consumers, Producers
6	(Helmers & Marx, 2016)			Consumers, Producers
7	(Hug, 2015)			Producers
8	(Panday & Bansal, 2014)			Producers
9	(Orsi et al., 2016)			Government, producers, consumers, society at large

10	(UN, 2014)			Society at large
11	(Forbes, 2019)			Consumers
12	(Carley et al., 2013)			Consumers and producers
13	(M. Weiss et al., 2015)			Government, producers, consumers, society at large
14	(Daziano, 2013)			Consumers
15	(Hayes & Davis, 2014)			Government and consumers
16	(Orecchini et al., 2014)			Producers and consumers
17	(IEA, 2019)			Government, producers, consumers, society at large
18	(International Energy Agency, 2017)			Government, producers, consumers, society at large
19	(Bjerkan et al., 2016)			Consumers and producers
20	(Simsekoglu, 2018)			Consumers
21	(Doucette & McCulloch, 2011)			Society at large
22	(Bakker, 2019)			Government, producers, consumers, society at large
23	(Ya Wu & Zhang, 2017)			Consumers and society at large
24	(C. R. Cherry et al., 2016)			Consumers
25	(X. Lin et al., 2017)			Consumers
26	(Haddadian et al., 2015)			Government and society at large
27	(Vidhi & Shrivastava, 2018)			Government, producers, consumers, society at large
28	(Prakash et al., 2018)			Government and consumers

29	(Shukla et al., 2014)			Government, producers, consumers, society at large
30	(Dhar et al., 2017)			Government, producers, consumers, society at large
31	(M. R. Ahmed & Karmaker, 2019)			Government, producers, consumers, society at large
32	(Nepal & Jamasb, 2015)			Government
33	(Wahab & Jiang, 2019)			Consumers and producers
34	(W Shen et al., 2012)			Producers and society at large
35	(Zhou et al., 2013)			Government, producers, consumers, society at large
36	(Bickert et al., 2015)			Government and consumers
37	(Bishop et al., 2011)			Producers and consumers
38	(Onn et al., 2017)			Government and producers
39	(Jiang et al., 2016)			Government
40	(ul-Haq et al., 2017)			Government and producers
41	(Karmaker et al., 2020)			Government and producers
42	(Fame India, 2017)			Government, producers, consumers, society at large
43	(D Majumdar, Majumder, & Jash, 2016)			Government and producers
44	(Daemme et al., 2017)			Producers
45	(de Assis Brasil Weber, da Rocha, Smith Schneider, Daemme, & de Arruda Penteado Neto, 2019)			Government and producers

46	(Mendoza et al., 2016)			Government, producers and consumers
47	(Davidov & Pantoš, 2017)			Consumers
48	(Hannan et al., 2014)			Consumers and producers
49	(Çağatay Bayindir et al., 2011)			Producers
50	(L. R. Jones et al., 2013)			Government, producers, consumers, society at large
51	(Brenna et al., 2014)			Producers
52	(Hawkins et al., 2012)			Government and producers
53	(Metz & Doetsch, 2012)			Government and producers
54	(Wei Shen et al., 2014)			Government, producers, consumers, society at large
55	(Y Wu et al., 2012)			Government, producers, consumers, society at large
56	(Kerdlap & Gheewala, 2016)			Producers and consumers
57	(Tuayharn, Kaewtatip, & ..., 2015)			Producers and consumers
58	(Kroesen, 2017)			Government, producers, consumers, society at large
59	(Fairley, 2010)			Government and producers
60	(Rao, Mohan Rao, & Ramachandra Rao, 2012)			Government, producers, consumers, society at large
61	(Shabbar Ali, Adnan, Muhammad Noman, Baqueri, & Fazal Abbas Baqueri, 2014)			Government and consumers

62	(Rizwan, Suresh, & Rajasekhara Babu, 2017)			Consumers
63	(Chik Cheong & Loh, 2013)			Society at large
64	(Jochem et al., 2016)			Government and producers
65	(Qian & Soopramanien, 2011)			Consumers
66	(Klöckner et al., 2013)			Consumers and producers
67	(Jochem, Babrowski, & Fichtner, 2015)			Consumers and producers
68	(Van Acker & Witlox, 2010)			Consumers
69	(J Dill & Rose, 2012)			Consumers
70	(Fyhri & Fearnley, 2015)			Government, consumers, society at large
71	(Johnson & Rose, 2015)			Consumers
72	(Popovich et al., 2014)			Consumers
73	(Q. Tan et al., 2014)			Government, producers, consumers, society at large
74	(Krupa et al., 2014)			Government, producers, consumers, society at large
75	(Graham-Rowe et al., 2012)			Consumers and producers
76	(San Román et al., 2011)			Government, producers, consumers, society at large
77	(Mansour & Haddad, 2017)			Government, producers, consumers, society at large
78	(Budde et al., 2012)			Society at large
79	(International Energy Agency, 2015)			Government, producers, consumers, society at large
80	(R. Faria et al., 2012)			Consumers

81	(Richardson, 2013)			Consumers and government
82	(F. Liao et al., 2017)			Government, producers, consumers, society at large
83	(Briggs et al., 2015)			Government, producers, consumers, society at large
84	(Yang, 2010)			Consumer and producer
85	(- International Energy Agency, 2017)			Government, producers, consumers, society at large
86	(Eccarius & Lu, 2020)			Government, producers, consumers, society at large
87	(Y. Zhang et al., 2011)			Consumers
88	(M. I. Khan et al., 2015)			Government and consumers
89	(M. I. Khan et al., 2015)			Government and consumers
90	(CEIC, 2017)			Government and consumers
91	(Pakistan, 2016)			Government and consumers
92	(Guerra, 2019)			Consumers and producers
93	(Neubauer & Wood, 2014)			Consumers and producers
94	(Salah & Kama, 2017)			Producers
95	(Bonges & Lusk, 2016)			Producers, consumers and society at large
96	(Tim Jones et al., 2016)			Producers
97	(Cao et al., 2011)			Producers
98	(Thackeray et al., 2012)			Producers
99	(Steinhilber et al., 2013)			Consumers and producers

100	(Hidrue et al., 2011)			Consumers
101	(Shao et al., 2017)			Consumer and producer
102	(R.-N. Liao & Yang, 2018)			Producers and consumer
103	(Kessides, 2013)			Producers, consumers and society at large
104	(Mirjat et al., 2018a)			Society at large
105	(G. Liu et al., 2014)			Consumers
106	(Choi et al., 2018)			Government and consumers
107	(Garche & Moseley, 2017)			Producers, consumers and society at large
108	(W. Liu et al., 2017)			Producers, consumers and society at large
109	(Tian et al., 2014)			Producers, consumers and society at large
110	(Santos, 2017)			Government
111	(João A.Peças Lopes, Soares, & Almeida, 2011)			Government and producer
112	(Perujo & Ciuffo, 2010)			Producers, Consumers and Government
113	(Y. Zheng & Jian, 2017)			Producers and government
114	(van der Kam & van Sark, 2015)			Producers and government
115	(Saxena et al., 2014)			Consumers and government
116	(Amjad, Rudramoorthy, & Neelakrishnan, 2011)			Consumers and producers
117	(Zhu, Song, Sheng, & Zhou, 2019)			Consumers
118	(Oliver & Rosen, 2010)			Producers and consumers
119	(Cocron & Krems, 2013b)			Consumers
120	(Bronner & de Hoog, 2014)			Consumers
121	(Lim et al., 2015)			Producers and consumers

122	(Kihm & Trommer, 2014)			Government and producers
123	(Stelling-Kończak et al., 2015)			Consumers and producers
124	(Rose, 2012)			Government, producers, consumers, society at large
125	(REUTERS, 2012)			Consumers
126	(Huertas-Leyva et al., 2018)			Consumers and producers
127	(Newbery & Strbac, 2016)			Consumers and producers
128	(Shah & Zeeshan, 2016)			Consumers
129	(Simon & Buckley, 2018)			Consumers, government and producers
130	(Sung, 2010)			Consumers
131	(Yousif, Ai, Anwar, & Yin, 2019)			Producers and government
132	(Testa, Cosic, & Iraldo, 2016)			Consumers and producers
133	(Perwez, Sohail, Hassan, & Zia, 2015)			Consumer producer and government
134	(pakwheeels, 2019)			Consumers
135	(Nasir & Ur Rehman, 2011)			Consumers and government
136	(Miller, Hofstetter, Krohmer, & Zhang, 2011a)			Consumers and producer
137	(Liaquat et al., 2010)			Consumers and government
138	(Langbroek et al., 2017)			Producers and consumers
139	(Koossalapeerom et al., 2019)			Government and consumer
140	(Kamran, 2018)			Government, producers, consumers, society at large

3 Environmental and economic analysis of electric motorcycles in Pakistan

The aim is to send this paper to the journal of 'Transportation and environment' of Elsevier publishers.

3.1 Abstract:

The electric motorcycles hold considerable potential to provide energy savings, environmental benefits and low cost of travel. As Pakistan is an energy deficient country facing frequent electricity blackouts, we will explore the influence of electric motorcycles on the national electricity grid, environment, energy savings and cost benefits to the final consumers. To understand the impact of electric vehicles on the national grid, we assume that all the electric motorcycles are connected to the grid for a certain period under different scenarios. We calculate the future total electricity consumption and peak electricity demand by looking at the previous year record and calculating the average annual growth rate. For CO_2 emissions we calculate well to tank emissions by electric motorcycles and compare it with the tank to wheel emissions by the conventional motorcycles. The lead emissions are taken by taking standard emissions of the electric motorcycle by exploring contemporary literature. The total cost of ownership is calculated by looking at different expenses incurred by electric motorcycles over a lifetime. The results indicate that the adoption of the electric motorcycle could increase energy savings and monetary benefits. Despite substantial CO_2 savings, full environmental benefits could be achieved when there is an effective lead disposal mechanism

Keywords: electric motorcycles, environmental benefits, energy-savings, the total cost of ownership, peak electricity demand.

3.2 Introduction

The diffusion of the electric motorcycle (EM) offers numerous benefits as carbon reduction, energy conservation and low cost of mobility for the final consumer. The electric-two-wheeler (E2Ws) have established a strong market in Asian countries such as China, Taiwan and Vietnam (Huang, Kuo, & Chou, 2018; L. R. Jones et al., 2013; M. Weiss et al., 2015).

In this study, we develop a hypothetical medium power E2W. We consider this E2W as an electric motorcycle (EM) due to its sporty shape and medium-sized power. We narrowed down our research to EMs as the results from previous chapters highlighted that people prefer EMs as future mobility mode among other E2Ws. The conventional motorcycles (CMs) having a petrol-based engine are referred with power equal or less 125cc, whereas the EMs are equipped with a medium-sized power motor (M. Weiss et al., 2015). Since EMs does not exist in the Pakistani market, this chapter aims to understand the influence of the EMs under different scenarios. We will explore the influence of EMs on the national electricity grid, harmful emissions and energy savings under the local condition of Pakistan. We will also apprehend the total cost of ownership of this EM using different data resources from Pakistan and abroad

We assume the dispersion of the EMs under three scenarios. In the first scenario, we assume EMs obtain 10% share of the total two-wheelers predicted in 2030. In this scenario, we assume the government would play a role in creating awareness for the EMs. A growing body of literature supports the idea that government plays a pivotal role in the promotion of green utilization (Huang et al., 2018; Testa et al., 2016). The government can also motivate prospective users by waiving off the registration and excise taxation. The government would also support leading brands of EMs to introduce E2Ws in Pakistan by reducing or eradicating onerous custom duties and taxation. Previously, the government of Pakistan has created a market for compressed natural gas vehicles in Pakistan by supporting the investors through different policies (M. I. Khan & Yasmin, 2014). For the 20% scenario of EM in 2040, we assume that the price of the two-wheelers and replacement cost of the batteries will fall due to the economies of scale. There are many studies which direct the price of E2Ws will fall in the coming decade due to the advancement in battery technology (Guerra, 2019; Huang et al., 2018; M. Weiss et al., 2015). It is widely anticipated that battery price of lithium-ion would reduce substantially in the coming decade. (Nykvist & Nilsson, 2015) However, we will assume EMs would still use lead batteries, so we could understand the limit of harmful emissions caused by the EMs in the future. In 2050 it is assumed that EMs would share 30% of the total two-wheelers. We assume that high consumer confidence and positive word of mouth for the EMs would lead to the higher sale of electric motorcycles. This is the most optimistic scenario when there is the favourable environment for EMs with government incentives, low battery cost and consumer confidence. The results from the study indicate that considerable monetary, energy and carbon dioxide (CO_2) savings could be achieved by the adoption of EMs in Pakistan.

In the first section, we will first check the influence of the EMs on the peak electricity demand and total electricity consumption. In the second part, we observe the impact of the EMs the environment considering CO_2 and lead emissions. In the subsequent part, we observe the total cost of ownership the final consumer would bear.

3.2.1 Prediction of motorized two-wheelers in Pakistan for the years 2030, 2040 and 2050

Around 1.7 million new petrol-based motorcycles were sold in Pakistan in 2018 (Pakistan Automotive Manufacture Association, 2018). Due to unavailability of exact data for the depreciation or disposal of current motorcycle users, an estimated annual average growth rate of 2.5% is taken as a benchmark to predict the future growth of two-wheelers in Pakistan. This 2.5% resembles the rate of increase of motorcycle users in the last seven years (Pakistan Economic Survey, 2018).

The lack of data for present motorcycle users propelled us to take previous year data and calculate average annual growth to achieve motorcycle users in the future. Hence, 2010 is taken as reference year to predict the future growth of motorcycle users. In 2010, the total of the number of motorized two-wheelers were 5468000 (Economic survey of Pakistan, 2010). With the 2.5% growth rate, it is expected that the total number of motorized two-wheeler will increase up to 8959955, 11469500 and 14681929 for the year 2030, 2040 and 2050. The table below represents the 10%, 20% and 30% share of EMs from the total predicted frequency of petrol-based motorcycles in the future for different years. We use the percentages below to forecast different scenarios which are explained in the later sections.

Table 3. 1 Expected frequency of EMs and CMs in the future scenario

Year	**Predicted frequency of petrol-motorcycle**	**Predicted electric motorcycles as an approximate from the total petrol-based motorcycles**		
		10% EMs	20% EMs	30% EMs
2030	8959955	$0.89*10^6$	$1.79*10^6$	$2.68*10^6$
2040	11469500	$1.14*10^6$	$2.29*10^6$	$3.44*10^6$
2050	14681929	$1.46*10^6$	$2.93*10^6$	$4.40*10^6$

3.2.2 EM characteristics

The selected E2W resembles the shape of the CD70 petrol-based motorcycle available in Pakistan. In Pakistan, sports style motorcycles are more popular than scooter style two-wheelers (Pakistan Economic Survey, 2018). The size of this electric motorcycle is assumed to be equal or less than 120 cm_3. This model with the full capacity weighs 100 kilograms (kg) (Koossalapeerom et al., 2019).

As the range on full charging of the electric motorcycle varies from 20-120 kilometres, we assume that the electric motorcycle has a travelling range of 100 kilometres which require continuous battery charging of 8 hours (J. X. Weinert, Burke, & Wei, 2007; M. Weiss et al., 2015). We expect that people would charge their motorcycle for 4 hours to travel 50 kilometres approximately. This high charging time is allocated so that people do not cope with any charging or range anxiety the next day. According to a study, on average the majority of the people travelled less than 40 kilometres by petrol-based motorcycles for their daily travel in Karachi, Pakistan (Hasan & Raza, 2011). In an optimistic situation, it is anticipated that people of Pakistan would consider charging 50 kilometres to avoid any anxiety to cover their daily travel. In this study, it is assumed that people will charge their EM for 4 hours to travel approximately 50 kilometres for the next day. It is expected that 4 hours of charging of an EMs would consume 2.25 (0.045*50) kWh electricity. The EMs could be charged from the standard wall power outlet. The below table provides the specification for the petrol-based motorcycles and EMs.

Table 3. 2 Characteristics of the EMs and CMs used in the survey

Characteristics of EM and CM	**EM**	**CM**
Weight	100 kg	82 kg
Distance per full charge	60 km	425 km
Powertrain	Lead-acid battery 24 volts 24Ah	70 cc 4 stroke engine
Maximum speed	70 km/hour	80 km/hour
Fuel economcy	22 Km/kWh	50 km/ Litre
Price per 100 kilometre	38 rupees ($0.24) for 100 km	228 rupees for 100 kilometres

3.3 Materials and Methods

3.3.1 Influence of EMs on the peak electricity demand and total electricity consumption

The previous years' government reports and literature review is analysed to forecast rise in peak electricity demand and total electricity consumption The average annual growth rate formula is used to predict the annual increase of consumption of electricity usage and rise in peak electricity demand. Following is the formula for the average annual growth rate.

$$AAGR = \left(\frac{1}{n}\right) * \ln(\frac{End\ Period\ Value}{Beginning\ Period\ Value}) \quad 1$$

AAGR = Average annual growth rate

n = Number of year(s)

ln = Natural logarithm

Due to the lack of hourly electric supply data, it is assumed that all EMs connect at the same time in the peak demand period in Pakistan. This could be the time when most of the working people return to their homes and plugin their EMs. The highest peak demand period for in Pakistan is from 6:30 p.m. to 10:30 p.m. (HESCO, 2019). In this period, it is assumed that there of no electricity blackouts in a hypothetical area and all the EMs connect at the same time-period. We also test the impact on the total consumption and peak electricity demand for different years considering all two-wheelers are electric. We will use 10%, 20% and 30% share of EMs (considering the total share of two-wheelers) for the years 2030, 2040 and 2050.

3.3.2 Total Cost of ownership

We employ the tool of the total cost of ownership (TCO) to understand whether EMs are economically viable for the final consumers. The total cost of ownership (TCO) is aimed to understand the original cost of any good or service (Hagman, Ritzén, Stier, & Susilo, 2016). The TCO model use will highlight the ownership cost of the most popular CM with a hypothetical product of an EM in Pakistani market setting. The use of current data from the industry and government websites has been instrumental to obtain different overheads for TCO. Besides, existing national and international literature data is calibrated to the current national trends in Pakistan to forecast TCO. Individual factors for the TCO have been defined, analysed and computed into the results. Modelling different variables in Excel has made the TCO model more robust. The concept of the future value has been incorporated to the predict the increase in the price of electricity, petrol, maintenance expenditure and battery replacements for future years. The range of assumptions may not be immaculate for the EMs. However, the results indicate the TCO difference between CM and EM for prospective consumers. All prices have been converted to US Dollars with the rate of December, 2019.

In this study, we compare the hypothetical vehicle of EM with the most popular 70cc. As the average age or useful age of CM is 6 years in Pakistan, we assume the useful life of EM is also 6 years (Shah & Zeeshan, 2016). To understand the TCO, we consider the present value of all future cash flows of different expenditure incurred by the consumers as maintenance, battery replacement etc. The discount rate is obtained from the state bank of Pakistan, which helps to understand the future worth of current investments. The discount rate is the rate the central bank charges to other commercial banks for loans, or usually it is the rate to discount future cash flow (Investopedia, 2020). Besides, the discount rate is obtained usually by incorporating adaptive expectation of inflation to control the economy (W. Ahmed, Haider, & Iqbal, 2012). However, We designate an average of 11% as the discount rate obtained from the state bank considering the current period (State Bank of Pakistan, 2019). Generally, the discount rate depends on the pure time preference rate, the growth rate of per capita income/consumption and the elasticity of marginal utility of income/consumption (Ramsey formula). The social discount rate higher in the developing countries due to (Lopez, 2008). The formula for the present value is mentioned below.

$$PV = FV/\ (1 + i\ )^{n} \qquad 2$$

FV = Future value

PV = Present value

i = discount rate

n = Number of years

This leads to the formulation of the TCO for electric motorcycles, which takes into account the purchase price, one-time motorcycle registration and vehicle tax etc. The formula for the TCO for EM is defined below.

$$TCO\ (EM) = P + T + OE + BR + ME - RS \qquad 3$$

$TCO\ (EM)$ = Total cost of ownership for electric motorcycles

$P =$ Purchase price

$T =$ Excise and registration and tax

$OE =$Operational expenses (electricity usage)

$BR =$ Battery replacement (not applied to CMs)

$ME =$ Maintenance expense (Tyre and body maintenance)

$RS =$ Resale value

Similarly, we can calculate the total cost of ownership for the CMs. However, there are other expenditure overheads involved in CMs which are mentioned in the formula below.

$$TCO\ (CM) = P + T + OE + RO + RS + RE + ME - RS \qquad 4$$

P = Purchase price

T = Excise and registration and tax

OE =Operational expenses (petrol usage)

RO = Replacing oil/air filter

RE = Replace engine oil

ME = Maintenance expense (Brake, chain or tire maintenance)

RS = Resale value

<u>Sensitivity analysis</u>

We also perform the sensitivity analysis to understand the change in the total cost of ownership if input values are altered (Palmer, Tate, Wadud, & Nellthorp, 2018). The sensitivity analysis spots factors that contribute to the risk rather than quantifying risk (Nurhadi, Borén, & Ny, 2014). The sensitivity analysis has been used in several fields of research related to the total cost of ownership. These include transportation, environment, marketing, and medicine (Bubeck, Tomaschek, & Fahl, 2016; Kappner, Letmathe, & Weidinger, 2019; Montgomery, Ogden, & Boehmke, 2018; Swart et al., 1999).

Considering the sensitivity analysis of our study, we alter the travel routine of prospective users and the specification of the EMs. We consider the following assumptions. A low EM user travels less than an average EM user. A high traveller user travel higher than average use. Whereas the medium user will travel equally to the average traveller. On the other hand, we alter the performance features and cost features of the EMs such as battery life, purchase price, price of electricity, maintenance cost and resale value. In this way, we could have different scenarios of high, medium and low for human and vehicle characteristics for the TCO considering the sensitivity analysis.

3.3.3 Carbon and lead emissions

Due to the scarcity of data, the study is confined only to lead and carbon emissions by the adoption of EMs under different scenarios. We compare the carbon emissions by a popular 70 cc CM in Pakistan with the hypothetical EM developed for this study. We simply derive a comparative ratio to calculate carbon emissions for EMs in the whole life span of six years. Similarly, we take the lead emissions by EMs by looking at contemporary literature by taking a standard emission. Due to the limitation of the data, the tank to wheel CO_2 emissions of the CM and well to tank emission for EMs (as it uses electricity) were only considered in this study.

3.4 Results

3.4.1 Prediction of electricity demand in Pakistan for the years 2030, 2040 and 2050

The total electricity consumption of electricity for the year 2017 in Pakistan was 90.3 Tera Watt hours (TWh). This study by (Mirjat et al., 2018b) revealed that electricity consumption will escalate with an average annual growth rate of 8.35%. For the year 2040 and 2050, we expect that the demand for electricity will recede due to convergence of economic development. Thereby, we expect that electricity consumption will grow by 7.35% for the decade of 2030-2040 and 6.35% for the decade of 2040-2050. In our study, we have considered this average annual electricity demand to forecast total electricity consumed per annum in TWh. Below table represents the total electricity consumed per year in TWh for the above-mentioned scenarios. This electricity demand forecast for the years 2030, 2040 and 2050 commensurates with the estimation of other researchers (Gul & Qureshi, 2012; Ishaque, 2017; Mirjat et al., 2018b; Perwez et al., 2015).

According to National Transmission and Dispatch Company (NTDC), the peak electricity demand in 2017 was 257171 Mega Watt (MW) (NATIONAL TRANSMISSION & DESPATCH &

COMPANY, 2018; Yousif et al., 2019). Further investigation from the report by NTDC revealed that in the last 18 years, the peak demand for electricity has grown with an average annual rate of 5.7% from 2019 onwards. We assume that peak electricity demand grows with 5.7% from the year 2019 till 2030. From 2030 onwards, we assume that peak electricity demand grows by 4.7%. Similarly, we assume that from 2040 onwards, the peak electricity demand grows by 4%. The predicted peak demand periods and total electricity consumption for the years 2030, 2040 and 2050 are mentioned in the table below.

Table 3. 3 Predicted peak electricity demand and an increase in total electricity consumption

Year	Predicted peak demand in MW	Predicted total electricity consumed per year TWh
2019	30191	124
2030	50771	301
2040	80557	611
2050	119244	1131

3.4.2 Influence of EMs on the total electricity consumption

We obtain the daily electricity consumption by the product of daily consumption (2.25 kWh).If on average the electric motorcycle travels at least 50 kilometres and consumes 0.045 kWh energy per kilometre than EMs would consume 2.25 kWh per day. with the frequency of total EM predicted for years, 2030, 2040 and 2050. We can use this 2.25 kWh energy to multiply with all the EMs considering the assumption that they travel at least 50 kilometres. Later, the daily consumption is multiplied by 365 to obtain annual consumption. The annual consumption of EMs is divided by the total annual consumption of the population. The prediction of EMs is discussed in the introduction section. The below results represent year-wise prediction for EMs on the national grid. There was no significant influence found by connecting EMs to the national grid under any scenario. The product of the total electricity consumption and predicted EM in different scenario results the total electricity consumed by EMs in one year. We then compare the total electricity consumption by EMs with total electricity consumption by the population. In the below scenario, the percentage of electricity consumption remained less than 0.3% indicating that EMs would not pose a threat to the national grid.

Table 3. 4 Total electricity consumption by EMs as a percentage of total consumption

Year	Percentage of EMs on the road	Predicted EMs	Total TWh consumed by EMs per year	Total electricity consumed by the population in TWh	Total electricity consumption by EMs as a percentage of total electricity consumption by the population
2030	10%	$0.895*10^6$	0.725	301	0.24%
2040	20%	$2.29*10^6$	1.858	611	0.30%
2050	30%	$4.4*10^6$	3.567	1131	0.31%

Note:

From table 5.4 onwards we have represented values in millions ($x*10^6$) and billions ($x*10^9$)

Even if we assume all the two-wheelers are electric in 2019, they would not have considerable influence on the total consumption. The detailed percentage-wise distribution is shown in the table below for different years. This shows that even in the most radical situation EMs would put the load on the total consumption by less than 5%.

Table 3. 5 Total electricity consumption in one year considering 100% conversion of two-wheelers

Year	All two-wheelers are electric	Daily consumption of electricity by EMs (kWh)	Daily consumption in kWh	Annual consumption in kWh by EMs	Annual consumption in TWh by EMs	Total electricity consumption by EMs as a percentage of total electricity consumption by 100 % conversion
2019	$6.8*10^6$	2.25	$15.3*10^6$	$5.6*10^9$	5.6	4.5%
2030	$8.95*10^6$	2.25	$20.1*10^6$	$7.25*10^9$	7.26	2.41%
2040	$11.4*10^6$	2.25	$25.8*10^6$	$9.29*10^9$	9.29	1.52%
2050	$14.6*10^6$	2.25	$33*10^6$	$1.18*10^{10}$	11.89	1.05%

3.4.3 Influence of EMs on the peak demand situation

For calculations, we assume that all EMs are connected at the same time-the period between the peak demand period for four consecutive hours. In that period we assume that there are no electricity blackouts. We assume these EMs consumes 562 watts per hour electricity which equals 0.1561 watts per second. We multiply per second consumption with all EMS connected simultaneously. We than divide the peak electricity demand produced at one second due to the connectivity of the EMs with the total peak electricity demand at one second. Below table represents the influence of EMs on the peak demand period in different scenarios for the years 2030, 2040 and 2050.

Table 3. 6 Influence of EMs on the peak demand situation under different scenarios

Year	Percentage of EMs on the road	Peak electricity demand period (MW)	Predicted EMs	Watts consumed per second by EMs	Megawatts consumed per second by EMs	Influence of connecting EMs to the national grid as a percentage of peak electricity demand
2030	10%	50771	$0.89*10^6$	$0.13*10^6$	0.139	0.0002%
2040	20%	80557	$2.29*10^6$	$0.35*10^6$	0.357	0.0004%
2050	30%	119244	$4.40*10^6$	$0.68*10^6$	0.687	0.0005%

For the 10% scenario in 2030, all the EMs will collectively draw 139775 (895996*.156) watts per second or 0.1399 Megawatt per second from the national grid in one second. The peak electricity demand is calculated to be 50771 megawatts in 2030 (The annual average growth rate of peak electricity demand is calculated by the last 15 years from the report of National transmission and dispatch company). If 895996 EMs are connected at the same, the influence of these EMs will be minimal, as peak demand period denoted in MW will only be influenced by 0.00027% (0.1399/50771*100). Similar calculations could be performed for the years 2040 and 2050 when E2Ws share 20% and 30% share of the total two-wheelers. Above table represents the share of the EMs for the mentioned years.

In a radical scenario, we look at the total petrol-based two-wheelers in 2019 and assume that they are all converted as electric motorcycles. The peak electricity demand is calculated to be 30191 in 2019. In the year 2019, it is expected that is 6828783 two-wheelers on roads in Pakistan. We assume that it is connected with a charger that consumes 562 watts per hour electricity which equals to 0.156 watts per second. When all EMs are connected simultaneously, it will draw 1065290 watts (0.156*6828783) or 1.065 megawatts from the grid in one second. In the results, we can observe that peak demand would not be impacted by the presence of EMs, as it will affect the grid by (1.066/29096*100) 0.0035%. Similar calculations could be performed for the years 2030, 2040 and 2050, which would have a minimal influence on the peak electricity demand. Below table represents different scenarios considering peak demand period and the influence of EMs.

Table 3. 7 Influence of EMs on the peak demand situation under considering 100% conversion of two-wheelers

Year	**Predicted E2Ws**	**Peak electricity demand period (MW)**	**Influence of EMs on peak demand (MW)**	**Influence of connecting EMs to the grid as a percentage of peak electricity demand**
2019	$6.8*10^6$	30191	1.066	0.0035%
2030	$8.9*10^6$	50771	1.397	0.0027%
2040	$11.4*10^6$	80557	1.790	0.0020%
2050	$14.6*10^6$	119244	2.291	0.0019%

We again test this hypothesis with a high-power charger for the EMs in the year 2019, extracting 5625 or 1.562 watts per second. When all EMs are connected simultaneously it will draw 10669973 (1.5625*6828783) watts or 10.66 (Megawatts per second). The influence of these EMs is minimum as well, as it will affect the peak demand with only 0.035% (10.66/30191*100). From the above observations, it can be inferred that 100% replacement of CMs by EMs would not pose any threat to the peak demand period in the coming years. This shows that even in the most radical situation when all two-wheelers are converted to CMs with a high power charger, they will still have a minimum impact on the grid in the peak demand period. Mainly this is due to the higher increase in peak electricity demand and total electricity consumption than the low growth of electric mobility in Pakistan.

3.4.4 Influence of EMs on carbon and lead emissions

Transportation and energy sector contribute to the 50% emissions of CO_2 in Pakistan (Danish, Baloch, & Suad, 2018). The rapid increase in the number of two-wheelers has exponentially increased the carbon and lead emissions in urban areas of Pakistan (Nasir & Ur Rehman, 2011). A substantial amount of CO_2 can be related to the large presence of two-wheelers in the transportation sector of Pakistan (Pakistan, 2016).

Based on the life-cycle analysis of EMs, CO_2 emissions are lower than petrol-based motorcycles (Guerra, 2019). Whereas, sold waste (lead emissions and battery disposal) from EMs operation is considerably higher than petrol-based motorcycles. Due to the production and recycling proves, lead emissions are estimated to be 5-10 g/km (C. Cherry, 2007; J. Weinert et al., 2008; C. Zhang, Wang, Sullivan, Han, & Schuetzle, 2001). Despite, having zero tail-pipe emissions, E2Ws carry batteries that are energy-intensive. The clean electricity mix is required to full environmental benefits of EMs (M. Weiss et al., 2015). In this study, we have confined the environmental influence of EMs to CO_2 and lead emissions only.

<u>CO2 emissions related to the adoption of EMs</u>

Due to the limitation of the data, we will only consider the tank to wheel CO_2 emissions of the CM and well to tank emission for EMs as it uses electricity. The tank to wheel process is involved in driving the vehicle by using the stored energy. Whereas, the tank to wheel process involves mining, transporting and storing the energy in the vehicle (Woo, Choi, & Ahn, 2017). Due to the lack of data, we did not use the whole well to wheel process for above-mentioned technologies. The emission of CO_2 depends on the carbon intensity of the electricity grid (J. Weinert et al., 2008). In Pakistan, there is 604 grams of carbon dioxide (CO2) emission utilizing 1 kWh of electricity (International Energy Agency, 2019). Considering, an EM requires 0.045 kWh to travel one kilometre, the CO_2 emissions would be 0.02718

(0.045*0.604) kilogram per kilometre. These calculations can be used to calculate annual and life span emissions of CO_2. From the study of Shah and Zeeshan (2016), the CO_2 emission for the petrol-based motorcycle was 0.05254 kilogram per kilometre. Using the above two assumptions we can understand the difference of CO_2 emissions between CMs and EMs. The below table represents CO_2 (kg) emissions per kilometre considering electric and conventional motorcycles.

Table 3. 8 Difference ratio between EMs and CMs considering CO2 emissions per kilometre

Emission type	Electric motorcycle	Conventional motorcycle	Difference ratio
CO_2	0.027	0.052	1.93

It can be observed from the above table that CMs emits almost twice the amount of CO_2 than EMs. We can use this difference ratio (1.93) to understand the CO_2 emissions by the EMs for the years 2030, 2040 and 2050. Considering the daily average of 2.25 kWh, the EM would use 821 (2.25*365) kWh annually. In a life span, it would consume 4927.5 (821*6) kWh by taking into account the average life span of 6 years. We could calculate the annual and life span CO_2 emissions by the product of total kWh and emission per kWh. Below table represents CO_2 (kg) emissions saved under different scenarios considering the adoption of EMs

Table 3. 9 CO_2 (kg) emissions under different scenarios by the adoption of EMs in 2030

Years	% of EMs	Predicted EMs*	Total kWh consumed by EMs per year	CO_2 emissions per year by EMs	Life span CO_2 emissions by EMs	Life span CO_2 emissions by CMs	CO_2 emissions after the adoption of EMs
2030	10%	$0.89*10^6$	$735*10^6$	$441*10^6$	$2.78*10^9$	$5.3*10^9$	$2.58*10^9$
2040	20%	$2.2*10^6$	$1.88*10^9$	$1.13*10^9$	$7.12*10^9$	$13.7*10^9$	$6.62*10^9$
2050	30%	$4.40*10^6$	$3.61*10^9$	$2.17*10^9$	$13*10^9$	$25.1*10^9$	$12.1*10^9$

In the above table, we observe the difference in EMs and CMs when they travel similar kilometres in their life spans. We could observe that in the scenario of 10% diffusion of EMs, 2586760388 kilograms (2781463 tons) of CO_2 emission could be saved. According to a study, 45 million tons of CO_2 is emitted by the transportation sector. Even if we assume the transportation emissions remains the same for the year 2030, the 10% convergence of electric motorcycle could save 6% of the total emissions. This direct that a drastic reduction of CO_2 in the air could be achieved if all CMs are made electric.

Lead-acid emissions related to the adoption of EMs

The adoption of lead-based EMs comes with the major negative externality of the lead emissions. The lead emissions are not tailpipe emissions but rather than emissions from the production, recycling and disposal procedures extended over the lifecycle of the EMs. The disposal of lead-based emissions will be a challenge for the government since lead emissions through different vehicles have been phased out in Pakistan (Shah & Zeeshan, 2016). In a study in China study, it is shown that there are 0.05-grams emissions per kilometre for E2Ws (J. Weinert et al., 2008). These lead emissions mainly arise from lead production and recycling phase. We consider this assumption for the EM that if it travels 50 kilometres daily, it will discharge 2.5 grams (50*0.05) of lead-acid emissions daily due to travelling. Hence, EM would release 912 (2.5*365) grams of lead-acid emissions annually. In a lifetime (6 years), it would release 5472 (912*6) grams or 5.4 kilograms of lead-acid in the environment. The table below represents the influence of 10%, 20% and 30% influence of EMs in the future scenario considering lead-acid emissions.

Table 3. 10 Lifetime lead emissions (kg) for the EMs

Year	% of EMs	Predicted E2Ws	Daily lead emissions in kilograms	Yearly lead emission in kilograms	Lifetime emission lead emission in kilograms
2030	10%	$0.89*10^6$	2240	$0.81*10^6$	$4.9*10^6$
2040	20%	$2.29*10^6$	5735	$2.09*10^6$	$12.5*10^6$
2050	30%	$4.40*10^6$	11011	$4.01*10^6$	$24*10^6$

In the above scenario, none of the scenarios presents small damage to the environment concerning lead-acid emissions. It is interesting to note that lead-acid battery emissions are a grave problem in Pakistan already since the uninterrupted power supply (UPS) are rampant use in Pakistan. According to a study, there are more 250000 users of UPS lead based-batteries in Pakistan (Gelani et al., 2018). There is a dearth of data for the emissions, but it can be expected that these batteries would also release the same amount of lead emissions per kWh.

Lead-acid battery use in EMs could face backlash from the pro-environmental groups. The influence of these batteries could only be minimized when there is an effective lead-acid recycling and disposal mechanism or use of lithium-ion batteries for EMs. The EMs with lithium-ion batteries are significantly higher in the purchase price. It would require government subsidy or other benefits to comprise the higher purchase price of lithium-ion batteries used in E2Ws. There is the probability that lithium-ion battery prices will fall in the coming decade due to the economies of scale (Diouf & Pode, 2015). Until now there are no proper plans or eviction strategies for lead-acid battery emissions in Pakistan. Thereby, the government would have to introduce strategies to cope with lead emissions if EMs are introduced in Pakistan. It is expected that the price of lithium-ion batteries will fall in the coming years.

3.4.5 Influence of EMs on the energy sector

If all CMs are converted to electric, a significant amount of petrol or gasoline could be saved. On average, CM would travel 50 kilometres per litre (pakwheeels, 2019) for one day. Considering the daily average, CM uses 365 litres of petrol per year. Whereas, E2Ws could consume 821 kWh per annum considering 2.25 kWh daily. The total savings in petrol and monetary savings are shown in the table below.

Below table represents energy and monetary savings under different scenarios. The petrol prices were obtained from the official state oil company which is 114 rupees per litre ($0.77) (PSO, 2019). As discussed in the previous section, we assume the average price of one unit of electricity (kWh) in Pakistan amounting to 15 rupees ($0.09) (HESCO, 2019). In the table below, we calculate 10%, 20% and 30% share of EMs of the total CM. If 10% of CM users switch to EM, it would cost around 11 million ($70796) Pakistani rupees for their electricity usage. Whereas, the operational cost of using 10% CM of the total motorcycle would be around 37.2 ($239421) million Pakistani rupees. This shows that 26.2 million ($168624) Pakistani rupees could be saved even in a minimum scenario of 10% conversion of CMs to EMs. Similarly, further scenarios are shown in the table below.

Table 3. 11 Impact of EMS on the energy sector (showed in Pakistani rupees)

Year	% of two-wheelers	Predicted EMs	Total kWh consumed by EMs per year	Total litres of petrol consumed by EMs per year	Cost of electricity for 10% EMs	Cost of petrol for 10% CMs	Monetary saving
2030	**10%**	$0.895*10^6$	$735*10^6$	$327*10^6$	$11*10^9$	$37.2*10^9$	$26.2*10^9$
2040	**20%**	$2.29*10^6$	$1.88*10^9$	$837*10^6$	$28.2*10^9$	$95.4*10^9$	$67.1*10^9$
2050	**30%**	$4.4*10^6$	$3.61*10^9$	$1.60*10^9$	$54.2*10^9$	$183*10^9$	$129*10^9$

3.4.6 Total cost of ownership

We calculate the current and future expenses for EM and CM and discount the annual cash flows to calculate the present value. We subtract the resale value in the last year for both CM and EM. The total discounted values lead to a Net Present Value (NPV) which would be a key element considering the TCO.

Purchase price

In this study, we allocate a hypothetical purchase price of 105000 rupees ($678) by studying different literature, reports and documents of the international prices of EMs (Eccarius & Lu, 2020; Wahab & Jiang, 2019; M. Weiss et al., 2015; Zhu et al., 2019). These prices were calibrated and approximated to a price that would reflect the average price of EM if introduced in Pakistan. This EM had purchase price higher than average 70 cc petrol-based motorcycles available in the markets of Pakistan. The most popular petrol-based motorcycle has an average price of 70500 rupees ($454) (pakwheeels, 2019; "XE - Currency Authority," 2019).

Total registration and one-time tax

The one-time total tax incurred on registration and life cycle use of the petrol-based (with power capacity less 150 cc) motorcycle is 2800 rupees ($18) in Pakistan. We assume the same tax standards can be applied to an EM which is not yet introduced in Pakistan.

Operational expenses

To understand the operational expense of EMs we consider electricity expenses. We take the average price of electricity unit (kWh) in Pakistan amounting to 15 rupees ($0.09) (HESCO, 2019). By looking at the past years' trend, we could calculate, the average annual increase in the price of one electricity unit. We could understand on average, price of one unit of electricity increases by 10% (HESCO, 2019; Shahbaz Rana, 2018; Simon & Buckley, 2018). Considering the average travelling of 50 kilometres per day, EM's user would travel 18250 kilometres in the whole year. In this study, we understand that an EM uses 0.045 kWh to travel one kilometre, so the total energy consumed would be 821 (0.045*18250) kWh per year. We also understand that price of one unit increases by 10% (calculated by previous years trend), so the future value for the cost of one unit (kWh) endured by the consumer would be 15 rupees ($0.096), 16.5 rupees ($0.10), 18.1 rupees ($0.11), 19.9 rupees ($0.12), 21.6 rupees ($0.13)and 24.1 rupees ($ 0.15) for the year 2019, 2020, 2021, 2022, 2023 and 2024. The total price of electricity would be 12319 rupees ($79.61), 13550 rupees ($87.56), 14905 rupees ($96.32), 16396 rupees ($105.95), 18035 rupees ($116.654) and 19839 rupees ($128) for the years 2019, 2020, 2021, 2022, 2023 and 2024 respectively.

The operational expense for the CM is considered using the price of petrol. To calculate the FV of the petrol prices, we look at the historical trend of the petrol price and assume an average growth rate of 10.47% for one litre of petrol (PSO, 2019). As discussed earlier, we assume that CM would consume one litre per day to cover its daily trip with an average of 50 kilometres. The NPV of the operational cost of the EM and CM is 183087 rupees ($1178) and

246698 rupees ($1587) for six years respectively. The operational cost of the EM is 63611 ($409) rupees cheaper than CMs.

Battery replacement

The cost of the replacement of the lead-acid battery is assumed to be 18% of the total cost of the electric two-wheeler (Tuayharn et al., 2015). This equals to 18900 ($121) rupees considering the purchase price of 105000 ($677) rupees. As the useful life of the E2Ws is expected to be 6 years, we assume that battery change is required approximately after two years of usage. Hence, the battery is replaced twice in the lifetime of the electric motorcycles (Huang et al., 2018; Tuayharn et al., 2015). The future value is determined by considering the discount rate of the State Bank of Pakistan which is equal to 11% (State Bank of Pakistan, 2019). The cost of the battery replacement for the first and second time would be 23286 ($150) and 28691 ($185) rupees respectively. The battery replacement cost is not applied for the CMs.

Maintenance expense

The maintenance for body, tyres and brakes for EMs is allocated as 3000 rupees per annum, and net present value could be determined with the discount rate. We also include the battery change as maintenance expense which is twice in its lifetime. The NPV value of total maintenance expense including the battery, battery, tyres and brakes for EMs in a lifetime would be 56617 rupees ($364). The maintenance expense for CMs includes additional overheads as the change of engine oil, replacing plugs etc. The NPV of total maintenance expense for the CMs would 105170 rupees ($676). We could observe that the total maintenance expense for the CMs is almost twice than E2Ws.

Resale value

For the EMs, the resale value is designated as 30% of the purchase price. The low resale value is due to the non-existential market for EMs and battery replacement expense that can occur due to high usage in the last couple of years. The resale value will be subtracted from the total amount to calculate the TCO. In this case, 31500 rupees ($203.8) would be subtracted from the total expenses. The resale value of the CMs is designated as 50% of the purchase price of the CMs. In this case, it will be 35250 rupees ($227). The present value of the resale of EM and CM is 18693 rupees ($120) and 30456 rupees ($196) respectively.

3.4.7 Final TCO calculations

These results also reveal that the purchase price of the CM (70500 rupees or $455) is 33% cheaper than EMs (105000 rupees or $678). The operational cost of CMs is 35% more expensive than E2Ws. The maintenance expense for E2Ws is almost half than that of CMs according to our calculations. After 6 years, the resale value of E2Ws is expected to be 30% of the purchase price due to the depleted battery, non-existential market and the depreciation factor. The petrol-based motorcycle has been given 50% resale value due to a strong market, availability of spare parts and the presence of established petrol-based motorcycle companies. The TCO for EM is 217173 rupees ($1402). Whereas for a CM it is 448212 rupees ($2340). The TCO of both vehicle type shows that CMs are 1.6 times more expensive than EMs. In the results, it could be inferred that the TCO for the E2Ws is lower than petrol-based motorcycles. The two tables below show the total cost of ownership for EMs and CMs.

Table 3. 12 Total cost of ownership for EMs

TCO	Year					
-	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Purchase price	105,000					
Total registration and one-time tax	2,800					
Total price of electricity	12318	13,550	14,905	16,396	18,035	19,839
Cost of battery change	-		23,790		29,311	
Body, brake and other repair and maintenance	3000	3330	3,696	4,102	4,554	5,055
Resale value	-					(31,500)
Annual cost incurred	123118	16,880	42,391	20,499	51,901	(-6,605)
Present Value	**123,118**	**15,207**	**34,406**	**14,988**	**34,189**	**(3,919)**
TCO	***217990***					

Table 3. 13 Total cost of ownership for CMs

TCO	Year					
-	2019	2020	2021	2022	2023	2024
Purchase price	70,500					
Total registration and one-time tax	2,800					
Total operational cost	41,610	45,966	50,779	56,095	61,969	68,457
Replacing air/oil filters	1,200	1,332	1,478	1,641	1,821	2,022
Replacing spark plug	250	277	308	341	379	421
Replacing engine oil	6,300	6,993	7,762	8,616	9,563	10,615
Body/brakes/chain/tire maintenance	3,000	3,330	3,696	4,102	4,554	5,055
Resale value						(-35,250)
Annual cost incurred	125,660	57,899	64,024	70,797	78,288	51,321
Present Value	**125,660**	**52,161**	**51,963**	**51,766**	**51,570**	**30,456**
TCO	***447,991***					

3.4.8 Sensitivity analysis of TCO

For further calculations, we will designate the above calculations and scenario as the baseline scenario. This baseline scenario can be referred to as the medium travel and medium price scenario. In our calculation, we can assume that the TCO had medium price components. We will measure different components of the TCO in the low, medium and high scenario. In the following paragraphs, we put light on different components of the TCO under different scenarios.

Purchase price of the EMs

To check the sensitivity analysis of the purchase price, we will now consider the low price and high price electric motorcycles. For the high price electric motorcycle, we will assume that it is double of the baseline scenario price. Hence, we have considered the of purchase price 210000 ($1353) rupees which is double of the baseline scenario price (105000 rupees ($676)). We could assume that these motorcycles would have higher speed, advance motor and higher range. On the contrary, the low purchase price of electric motorcycles would have low speed and low range. We have designated the purchase price of 70500 ($454) rupees which is equal to the popular two-wheeler motorcycle in Pakistan.

Discount Rate

We also devise the discount rate based on the assumption of the State bank of Pakistan. We could assume a favourable and non-favourable scenario for the EMs. Hence, the discount rate is also given low, medium and high rate on the assumptions that the State bank will increase or decrease the discount rate based on the policy measure for the EMs. If there is favourable policy measures EMs would be given low discount rate and unfavourable policy measures would result in a higher rate. We take the medium scenario, as the current discount rate from the State bank of Pakistan which is 11%. For the favourable and unfavourable scenario, we assume that the State bank would have a discount rate of 8% and 14% respectively.

Cost of the battery replacement

The cost of the battery would also be increased or decreased by the type of EMs in consideration. As we consider the battery replacement cost to be 18% of the total purchase price of the EM, the price of the replacement of the battery would be 12690 ($81), 18900

(121) and 378000 ($243) rupees for the low, medium and high priced vehicle respectively. The battery price will be discounted to the year it will be replaced. The frequency of replacement is also discussed in the forthcoming part which depends on the number of kilometres travelled by a prospective EM user.

Registration and one-time tax

Similarly, we designate the registration and one-time tax equal to the price of 1400 rupees, 2800 rupees and 5600 rupees considering the low, medium and high scenarios. We design the scenario based on the assumption that the government may charge a low, medium or high one tax on the introduction of EMs in Pakistan. The charging of low to high registration or tax could determine favourable perception towards E2Ws as a new mobility product by the government.

Operational cost

The price of one unit of electricity (1 kWh) is also distributed on low, medium and high price. We can consider in the low tariff scenario that the government offers a low unit of electricity for the EM users. The low price of one unit of electricity can also be correlated that the people are charging theirE2Ws in the time-period when electricity tariffs are low. On the worst-case scenario, the government imposes higher tariffs on EM's users or EM's users charge their vehicle in peak electricity demand period when tariffs are high. In the light of our discussion, we allocate the price of the unit in this situation as 12, 15 or 20 rupees.

As discussed in the earlier literature that medium-powered E2Ws would consume 0.045 kWh of energy per kilometre, whereas high powered E2Ws consume the energy of 0.07 kWh per kilometre. The higher energy for E2Ws is consumed due to higher performance such as increased speed. Hence, in this section, we would assume that low and medium powered EM would consume 0.045 kWh. Whereas, high powered EM would consume 0.07 kWh of electricity per kilometre.

Maintenance cost

For the maintenance cost, we allocate the expense that resonates the purchase price. For the high purchase prices EM the maintenance cost is also double. Whereas, for the low purchased priced EMs the maintenance expense is also lower. The maintenance expense for the low, medium and high purchased priced EM is 2200, 3000 and 6000 rupees. In the forthcoming parts, we discuss the influence of EM's travellers who are high users in terms of the number of kilometres travelled. The people who travel a longer distance than average would also face high maintenance cost. Thereby, for the people who travel a longer distance in one day, we double the maintenance cost. Hence, the maintenance cost for the high travelling user would be 4400, 6000 and126000 rupees. The description of the maintenance expense is provided in the table below.

Resale price

For the resale price, we allocate a value of 25%, 30% and 35% for the low, medium and high purchase priced EMs. As discussed in the previous section that low resale value is assigned to EMs due to their innovative nature and non-existential market.

Travel distance

We discuss the low, medium and high travellers in this part. It is assumed that on a daily basis, the low, medium and high traveller would cover a distance of 25, 50 and 75 kilometres respectively. In one year, the low, medium and the high prospective users would travel 9125, 18250 and 27375 kilometres respectively. Resultantly, the battery replacement, maintenance cost and operational cost (use of electricity to charge EMs) would be affected. For the low, medium and high travellers, the battery would be changed in 4 years, 2 years and 1 year respectively. Besides, the operational cost would also be affected as the EM users would have low or higher expenses.

<u>Total scenarios</u>

A total of 9 scenarios are constructed to understand sensitivity analysis. The three scenarios are related to the cost of the vehicle component such as purchase price, battery replacement cost, maintenance etc. Besides, the three components were established related to the frequency of travelling distance in a year. Hence, when we combined vehicle components and frequency of travelling for1 a total of 9 scenarios. We have placed the 9 scenarios in the Appendices section for further clarity.

If we compare the extreme scenario of high-cost EMs and high travelling by the prospective user with the normal or baseline scenario, we find that the operational cost of EM is considerably less than CMs. It shows that the purchase price plays an important element in the total cost of ownership. The cost of the battery replacement plays an important part in the TCO of the EMs as frequent travellers would incur more cost of the battery replacement. Hence, battery replacement could be the second most important component in the TCO of the EMs after purchase price. The TCO for these scenarios is presented in the table below.

Table 3. 14 TCO under different scenarios

	Low priced EMs	Medium priced EMs	High priced EMs
Low-frequency Travel	122163	162139	321459
Medium-frequency travel	160420	217173	429492
High-frequency travel	242659	326828	694124

If we compare the TCO of the EMs with the TCO of the CMs (447991), we find that except high priced EM with the high frequency of travelling, EMs is still cheaper than CMs. As the average user travels around 50 kilometres we can conclude that most of the people would find EMs cheaper than CMs.

3.5 Conclusions and future research

In this study, we observe that EMs would not pose any threat to the peak electricity demand or total electricity consumption in the coming years. We also calculate that significant amount of CO_2 emission could be saved with the introduction of EMs. However, the introduction of lead-acid batteries in EMs could pose a threat with the increased lead emissions. The lead-acid emissions from EMs could also be harmful until there is an effective disposal mechanism laid by the government.

Considering TCO, we calculated that EMs would be less expensive investments than CMs in the longer term. We observe that the purchase price is the main constituent in the TCO of EMs. If the purchase price is introduced at a lower price, people would have a greater economic benefit with EM’s ownership. EMs perform better in other expenses as well such as operational and maintenance cost. However, it is assumed the CMs would still have better resale due to an excellent established market and customer trust. The concept of EMs is also new to the common people of Pakistan.

If the data is available, complex and precise models should be created for electric cars and hybrid electric vehicles to predict future scenarios. The government should make an effort so that such data is easily accessible.

3.6 Appendices

3.6.1 Appendix A: Low priced EMs

Table 3. 15 Appendix: A: Low priced EM with low travel

Low priced EM with low travel

Assumptions/Inputs						
Price of battery	12,690					
Discount rate	8%					
Highest price of unit	12	13	15	16	18	19
Kilometers travelled	9,125	9,125	9,125	9,125	9,125	18,250
Annual energy consumption	411	411	411	411	410.63	821

	1	2	3	4	5	6
TOC	Year					
-	2019	2020	2021	2022	2023	2024
Purchase price	70,500					
Total registration and one-time tax	1,400					
Total price of electricity	4,927.50	5,420	5,962	6,559	7,214	15,871.5 8
Cost of battery change	-				17,265	
Body, brake and other repair and maintenance	2,200	2,376	2,566	2,771	2,993	3,233
Resale value	-					(17,625)
Annual cost incurred	79,028	7,796	8,528	9,330	27,472	1,479
Present Value	**79,028**	**7,219**	**7,312**	**7,406**	**20,193**	**1,007**

TOC	**122,164** **($787)**

Low priced EM with medium travel

Table 3. 16 Appendix A: Low priced EM with medium travel

Assumptions/Inputs						
Price of battery	12,690					
Discount rate	8%					
Highest price of unit	12	13	15	16	18	19
Kilometers travelled	18,250	18,250	18,250	18,250	18,250	18,250
Annual energy consumption	821	821	821	821	821	821

	1	2	3	4	5	6
<u>TOC</u>	Year					
-	2019	2020	2021	2022	2023	2024
Purchase price	70,500					
Total registration and one-time tax	1,400					
Total price of electricity	9,855	10,841	11,925	13,117	14,429	15,872
Cost of battery change	-		14,801		17,265.0 0	
Body, brake and other repair and maintenance	2,200	2,376	2,566	2,771	2,993	3,233
Resale value	-					(17,625)
Annual cost incurred	83,955	13,217	29,292	15,888	34,687	1,479
Present Value	**83,955**	**12,238**	**25,113**	**12,613**	**25,496**	**1,007**

TOC	**160,420 ($1034)**

Low priced EM with high travel

Table 3. 17 Appendix A: Low priced EM with high travel

Assumptions/Inputs						
original price of battery	12,690					
Discount rate	8%					
Highest price of unit	12	13	15	16	18	19
Kilometers travelled	27,375	27,375	27,375	27,375	27,375	27,375
Annual energy consumption	1,232	1,232	1,232	1,232	1,232	1,232

	1	2	3	4	5	6
TOC	Year					
-	2019	2020	2021	2022	2023	2024
Purchase price	70,500					
Total registration and one-time tax	1,400					
Total price of electricity	14,783	16,261	17,887	19,676	21,643	23,807
Cost of battery change	-	13,705	14,801	15,988	17,265	18,645
Body, brake and other repair and maintenance	4,400	4,752	5,132	5,543	5,986	6,465
Resale value	-					(17,625)
Annual cost incurred	91,083	34,718	37,820	41,206	44,894	31,292
Present Value	**91,083**	**32,146**	**32,425**	**32,711**	**32,999**	**21,297**

TOC	**242,660 ($1564)**

3.6.2 Appendix B: Medium priced EMs

Medium priced EM with low travel

Table 3. 18 Appendix B: Medium priced EM with low travel

Assumptions/Inputs						
Price of battery	18,900					
Discount rate	11%					
Highest price of unit	15	17	18	20	22	24
Kilometers travelled	9,125	9,125	9,125	9,125	9,125	9,125
Annual energy consumption	411	411	411	411	411	411

	1	2	3	4	5	6
TOC	Year					
-	2019	2020	2021	2022	2023	2024
Purchase price	105,000					
Total registration and one-time tax	2,800					
Total price of electricity	6,159	6,775	7,453	8,198	9,018	9,920
Cost of battery change	-				28,691	
Body, brake and other repair and maintenance	3,000	3,330	3,696	4,103	4,554	5,055
Resale value	-					(31,500)
Annual cost incurred	116,959	10,105	11,149	12,301	42,263	(16,525)
Present Value	**116,959**	**9,104**	**9,049**	**8,994**	**27,840**	**(9,807)**

TOC	**162,140 ($1045)**

Medium priced EM with medium travel

Table 3. 19 Appendix B: Medium priced EM with medium travel

Assumptions/Inputs						
Price of battery	18,900					
Discount rate	11%					
Highest price of unit	15	16	18	19.	21.96	24
Kilometers travelled	18,250	18,250	18,250	18,250	18,250	18,250
Annual energy consumption	821	821	821	821	821	821

Medium price with medium travel	1	2	3	4	5	6
TOC	Year					
	2019	2020	2021	2022	2023	2024
Purchase price	105,000					
Total registration and one-time tax	2,800					
Total price of electricity	12,319	13,551	14,906	16,396	18,036	19,839
Cost of battery change	-		23,286		28,691	
Body, brake and other repair and maintenance	3,000	3,330	3,696	4,103	4,554	5,055
Resale value	-					(31,500)
Annual cost incurred	123,119	16,881	41,888	20,499	51,281	(6,605)
Present Value	**123,119**	**15,208**	**33,997**	**14,989**	**33,780**	**(3,920)**

TOC	**217,173 ($1400)**

Medium priced EM with high travel

Table 3. 20 Appendix B: Medium priced EM with high travel

Assumptions/Inputs						
Price of battery	18,900					
Discount rate	11%					
Highest price of unit	15	17	18	20	22	24
Kilometers travelled	27,375	27,375	27,375	27,375	27,375	25,550
Annual energy consumption	1,232	1,232	1,232	1,232	1,232	1,150

	1	2	3	4	5	6
TOC	Year					
-	2019	2020	2021	2022	2023	2024
Purchase price	105,000					
Total registration and one-time tax	2,800					
Total price of electricity	18,478	20,326	22,359	24,594	27,054	27,775
Cost of battery change	-	20,979	23,286	25,848	28,691	31,847
Body, brake and other repair and maintenance	6,000	6,660	7,393	8,206	9,108	10,110
Resale value	-					(31,500)
Annual cost incurred	132,278	47,965	53,037	58,648	64,853	38,233
Present Value	**132,278**	**43,212**	**43,046**	**42,883**	**42,721**	**22,689**

TOC	**326,829 ($2107)**

3.6.3 Appendix C: High priced EMs

High priced EM with low travel

Table 3. 21 Appendix C: High priced EM with low travel

Assumptions/Inputs						
Price of battery	37,800					
Discount rate	14%					
Highest price of unit	20	22	24	26	29	32
Kilometers travelled	9,125	9,125	9,125	9,125	9,125	9,125
Annual energy consumption	639	639	639	639	639	639

	1	2	3	4	5	6
TOC	Year					
-	2019	2020	2021	2022	2023	2024
Purchase price	210,000					
Total registration and one-time tax	5,600					
Total price of electricity	12,775	14,053	15,458	17,004	18,704	20,574
Cost of battery change	-				63,843.0 0	
Body, brake and other repair and maintenance	6,000	6,840	7,798	8,889	10,134	11,552
Resale value	-					(73,500)
Annual cost incurred	234,375	20,893	23,255	25,893	92,681	(41,373)
Present Value	**234,375**	**18,327**	**17,894**	**17,477**	**54,874**	**(21,488)**

TOC	**321,459 ($2072)**

High priced EM with medium travel

Table 3. 22 Appendix C: High priced EM with medium travel

Assumptions/Inputs						
Price of battery	37,800					
Discount rate	14%					
Highest price of unit	20	22	24	27	29	32
Kilometers travelled	18,250	18,250	18,250	18,250	18,250	18,250
Annual energy consumption	1,278	1,278	1,278	1,278	1,278	1,278

High price with medium travel	1	2	3	4	5	6
TOC	Year					
-	2019	2020	2021	2022	2023	2024
Purchase price	210,000					
Total registration and one-time tax	5,600					
Total price of electricity	25,550	28,105	30,916	34,007	37,408	41,149
Cost of battery change	-		49,125		63,843	
Body, brake and other repair and maintenance	6,000	6,840	7,798	8,889	10,134	11,552
Resale value	-					(73,500)
Annual cost incurred	247,150	34,945	87,838	42,896	111,385	(20,799)
Present Value	**247,150**	**30,654**	**67,589**	**28,954**	**65,949**	**(10,802)**

TOC	**429,492 ($2769)**

High priced EM with high travel

Table 3. 23 Appendix C: High priced EM with high travel

Assumptions/Inputs						
Price of battery	37,800					
Discount rate	14%					
Highest price of unit	20	22	24	27	29	32
Kilometers travelled	27,375	27,375	27,375	27,375	27,375	27,375
Annual energy consumption	1,916	1,916	1,916	1,916	1,916	1,916

High price with high travel	1	2	3	4	5	6
TOC	Year					
-	2019	2020	2021	2022	2023	2024
Purchase price	210,000					
Total registration and one-time tax	5,600					
Total price of electricity	38,325	42,158	46,373	51,011	56,112	61,723
Cost of battery change	-	43,092	49,125	56,002	63,843	72,781
Body, brake and other repair and maintenance	12,000	13,680	15,595	17,779	20,268	23,105
Resale value	-					(73,500)
Annual cost incurred	265,925	98,930	111,093	124,791	140,222	84,109
Present Value	**265,925**	**86,780**	**85,483**	**84,230**	**83,023**	**43,683**

TOC	**649,124 ($4185)**

4 Insight and perceptions towards electric two-wheelers in Pakistan

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4.1 Abstract:

The research is directed towards the prospects of electric two-wheelers in an energy deficient country like Pakistan which faces frequent, long and unscheduled electricity blackouts. A stated preference survey was performed to gather views regards different driving and resisting forces for electric-two wheelers in two cities of Pakistan. The majority of the respondents were inclined to petrol-based motorcycles instead of electric two-wheelers. The important barriers towards the success of E2Ws were identified as high purchase price, the prevalence of frequent blackouts, low speed and low range. The respondents who selected electric-two wheelers as future mobility choice, based their decision on monetary savings than environmental benefits. It is concluded that if electric two-wheelers are to be introduced in Pakistan, the purchase price should be lower or equal than petrol-based motorcycles. Besides, the government would also have to create awareness and control the prevailing energy crisis to attract prospective customers for electric two-wheelers.

Keywords: Electric two-wheelers, Electricity blackouts, Advantages, Drawbacks

4.2 Introduction

In the recent era, there has been increased pollution and motorization in Pakistan (B. Lin & Raza, 2019; Pakistan Automotive Manufacture Association, 2018). The way forward could be Electric two-wheelers (E2Ws) that offer non-dependence on oil, zero tail pipeline emissions and a cheap mode of travel (M. Weiss et al., 2015). The people of Pakistan would be attracted by a cheaper mobility option as the common man is burdened by the continuous increase in the price of petrol (Pakistan Bureau of Statistics, 2018b). China has been a forerunner in introducing E2Ws which have been an instrumental part of its urban mobility

(J. X. Weinert et al., 2005). Other Asian countries such as Vietnam and Taiwan have also developed stable markets for E2Ws (L. R. Jones et al., 2013; M. Weiss et al., 2015). Unfortunately, Pakistan has not developed any market for E2Ws. Before 2019, there was no prior policy introduced by the government to support electric vehicles. This could also be related to the energy scarcity Pakistan is facing, as the country does not have a stable energy situation as compared to China. The huge energy crisis results in frequent, prolonged and untimed blackouts in Pakistan on a regular basis (Aized, Shahid, Bhatti, Saleem, & Anandarajah, 2018). Previously, no literature has shed light on whether E2Ws could successfully propagate in energy-deficient countries. It will be interesting to observe how people would perceive attributes of E2Ws such as high charging time in the presence of extended blackouts.

In this chapter, we try to understand people's perception and insight towards E2Ws. We would also understand how which barriers or opportunities people consider more important. Previous research is directed towards reducing the technical barriers related to E2Ws such as low range, high battery weight and limited battery capacity (Axsen, Kurani, & Burke, 2010; Egbue & Long, 2012; Sovacool & Hirsh, 2009). However, there are other social challenges in the developing countries which could impede technology as E2Ws. These may include energy crisis, lack of awareness, and lack of government support (Kamran, 2018; Miller, Hofstetter, Krohmer, & Zhang, 2011b).

The main research question would be to understand the choice of future mobility in the light of E2Ws. This question could further spur into the barriers and opportunities related to E2Ws. Besides, we could also understand the demographic influence of the for the choice of different mobility modes. Since E2Ws are an unfamiliar product, a survey is designed in this study to understand the key driving and resisting factors for the prospects of E2Ws in

Pakistan. Insights from the study will help the policymakers craft ideas to increase the acceptance of E2Ws based on customer's perceptions. It can also help policymakers devise ways to counter socio-technical barriers for the adoption of E2Ws in Pakistan. Thereby, it is expected that this survey would provide first-hand knowledge for the future of E2Ws in Pakistan.

It also needs to be understood whether the main motivation to purchase E2Ws is an environmental concern or any other reason (Graham-Rowe et al., 2012; W. Li, Long, Chen, & Geng, 2017). The main motivation is to understand whether people will have future purchase decision due to environmental concerns or monetary benefits. From the study by Hidrue, people are inclined towards EVs due to its fuel savings than being environment-friendly (Hidrue et al., 2011). Hence, this survey will provide an understanding of whether people are cost or environment-conscious in the purchase of E2Ws.

In the first section, light is put on the current energy and transportation situation of Pakistan. Besides, the literature review is explored for the current research advantages, drawback, customer perception and individual characteristics for E2Ws. It is followed by the methodology section, in which the survey design and the related statistics are discussed. In the succeeding section, the future mobility option is discussed considering individual characteristics such as education, age, occupation and household income. In the later sections, the top concerns and reasons for not purchasing E2Ws are discussed. Lastly, policy recommendations and implication are discussed in light of the results obtained from the study.

4.3 Background

4.3.1 Advantages of E2Ws

E2Ws offer better operational savings than their counterpart gasoline vehicles. In China, the operational cost of E2Ws was $0.007/km in comparison with $0.031/km of gasoline two-wheelers (C. C. R. C. Cherry, 2007; M. Weiss et al., 2015). The E2Ws on the average consume 0.015-0.045 kWh per kilometre considering different types of E2Ws. Looking at the available literature and current market of E2Ws worldwide, the price of travelling per kilometre is established for E2Ws. The energy consumption of 100 kilometres is assumed to be 7 kWh, 4.5 kWh and 1.5 kWh for an electric motorcycle, electric scooter and electric bicycle respectively (C. Cherry, 2007; M. Weiss et al., 2015). In Pakistan, if the average price of electricity is taken 15 rupees per unit or kWh, it would cost around 38 rupees ($0.24), 30 rupees ($ 0.19) and 23 rupees (($0.14) for 100 kilometres of travel by electric motorcycle, electric scooter and electric bicycle respectively (HESCO, 2019) ("XE - Currency Authority," 2019). Whereas, an average 70cc motorcycle consumes 2.5. litres of petrol to cover 100 kilometres (pakwheeels, 2019).With a petrol-based two-wheeler, it would cost around 285 ($1.83) rupees to travel 100 kilometres ("Shell Station Price Board | Shell Pakistan," 2019). Above calculation indicate the E2Ws offer superior monetary savings.

A major advantage of E2Ws is the flexibility to use a portable battery. The E2Ws can be charged from the standard wall outlet rendering an external charging infrastructure unnecessary (C. C. R. C. Cherry, 2007; M. Weiss et al., 2015). Any transportation policy that does not require external investment could be beneficial as Pakistan is facing severe economic conditions (Jibran et al., 2016). If there is no availability of public infrastructure by the government, E2Ws carry the potential to be charged at home or office.

Currently, Pakistan has more than 18 million registered vehicles (Pakistan, 2016). Besides, 70% of the CO_2 pollution is caused by motorized vehicles. Due to pollution, there is a loss of 500 million dollars to the national exchequer annually due to health and care in Pakistan(N. A. Khan & el Dessouky, 2009; Liaquat et al., 2010). It can be inferred that electrification of mobility could substantially reduce the pollution if prudently adopted by the government. E2W's benefits could not be realized unless there is a clean energy mix and efficient battery disposal mechanism developed in Pakistan

The E2Ws consumes 3-5 times less energy than gasoline-based motorcycles (C. C. R. C. Cherry, 2007; M. Weiss et al., 2015). In a study conducted in the U.K, the E2Ws seem to utilize 6.1 and 2.9 times less energy than a gasoline car and motorcycle respectively (Bishop et al., 2011). Besides, India saves around 44000 litres of gasoline despite having a small market of EVs (Fame India, 2017). In Pakistan, almost 57% of the oil used is utilized in the transportation sector (Arshad & Ali, 2017). The huge dependence on oil can be reduced with the switch of petrol-based motorcycles to E2Ws.

4.3.2 Drawbacks of E2Ws

The purchase price of EVs has been one of the foremost aspects for the acceptance of EVs (Brownstone et al., 2000). For low-income people, the option of low priced E2W could be attractive. The price of E2Ws varies from a cheap vehicle of 100 euros ($111) (E2Ws equipped with lead-acid batteries used in China) to 5600 euros ($6227) (E2Ws fitted with lithium-ion batteries used in Europe) (M. Weiss et al., 2015). The low price improves the perception towards E2Ws and important indicator to purchase the E2Ws. In another study done in Vietnam the probability to purchase E2Ws reduces when the price is increased (L. R. Jones et al., 2013). In this study, a hypothetical price is established for the E2Ws which is slightly higher than the current gasoline-based two-wheelers in Pakistan. The hypothetical purchase price of the electric motorcycle was is more than double the purchase price of an average petrol-based two-wheeler in Pakistan. The price of electric motorcycle, electric scooter and the electric bicycle was evaluated by considering prices in the international market and contemporary literature. The results from the study will help one understand the priority of purchase price in comparison to other constraints.

The conventional E2Ws could be charged from the standard wall outlet in 8 hours (M. Weiss et al., 2015). Long charging time is an instrumental aspect to consider E2Ws as an inferior product (Steinhilber et al., 2013). From the study of Jones, one can find that willingness to pay for EVs increases as the charging time is decreased (L. R. Jones et al., 2013). The high charging time causes more stress in terms of time and effort when large electricity blackouts are existing in a country like Pakistan (Mirjat et al., 2018a). The general pattern of EV charging is at night (Shao et al., 2017). Pakistan faces variable and unscheduled blackouts which could also increase charging anxieties (Jamil, 2013). For the expansion of E2Ws, there must be an uninterrupted power supply. It would be interesting to note how people of Pakistan would rank blackouts and high charging time in comparison to other resisting forces as a high price or low range for E2Ws.

In this study, Chinese based E2Ws are taken as a model which have lead-acid batteries. These E2Ws have low speed and limited range compared to petrol-based motorcycles. In a study done by Egbue & Long, (2012), the range was regarded as the biggest impediment to adopt an EV. The range anxiety refers to the fear of being stranded in the middle of the journey (Neubauer & Wood, 2014). In some other studies, people were willing to pay more on the increase of range in their EVs (Hidrue et al., 2011; L. R. Jones et al., 2013). Besides, severe hot weather can deplete the performance and range of E2Ws (J. Weinert et al., 2008). The battery performance of E2Ws could be challenging for users as Pakistan has a warm climate (Nasim et al., 2018). Moreover, the speed of E2Ws could vary around 10-50 kilometres per hour (L. R. Jones et al., 2013; J. Weinert et al., 2008). According to a report conducted in India, low speed is one of the major reasons that E2W have not been successful and remains a niche market (SIAM, 2017). In Pakistan, some people cover long journeys between cities and villages that last hours using their gasoline motorcycles. In Pakistan, the average distance travelled from home to work and back is almost 35 kilometres (Majid et al., 2018; Numbeo.com, 2019). Therefore, it is interesting to understand how much people rank low range and low speed as impediments to purchase E2Ws in Pakistan. Inferior speed is one of the main impediment for the success of E2Ws (M. Weiss et al., 2015).

The disapproval of emerging technology is related with lack or partial information (Sierzchula et al., 2014). According to the report of the Society of Indian automobile manufacturer association, people generally have less knowledge and awareness about EVs (SIAM, 2017). Currently, Pakistan's government lacks policies such as awareness or friendly schemes to promote an innovative product (Qureshi et al., 2017). Awareness can also be increased by announcing an incentive-based policy such as reduction of sales tax on E2Ws (Y. Zhang et al., 2011). Awareness about sustainability also increases the chance to buy EVs (Egbue & Long, 2012). Marketing campaigns also increases the awareness and motivation to purchase EVs (Krupa et al., 2014). Previously, the government has successfully launched schemes to promote compressed natural gas (CNG) cars (M. I. Khan et al., 2015). This was achieved through ample regulatory framework, awareness schemes and investor-friendly environment. It can be understood that awareness can be created if the government and private sector work together.

4.3.3 Consumer perception towards purchasing E2Ws

Attitudes and perceptions are the positive or negative view of an object after an individual's mental experience (Egbue & Long, 2012; W. Li et al., 2017). According to a study, attitudes are the most effective method to understand the intention to adopt EVs (Plötz, Schneider, Globisch, & Dütschke, 2014). Individuals are inclined to options that maximize their utilities considering the knowledge of alternatives and budget (Yetano Roche, Mourato, Fischedick, Pietzner, & Viebahn, 2010). Besides, prospective customers are inclined towards a vehicle which would elevate their self-identity (W. Li et al., 2017; Noppers, Keizer, Bolderdijk, & Steg, 2014).

There is supporting literature that young and middle-aged group with high education are likely to adopt EVs (Carley et al., 2013; Hackbarth & Madlener, 2013; Hidrue et al., 2011). In a study by Egbue & Long, (2012) & Hackbarth & Madlener, 2013; Plötz et al., (2014), it was found that people engaged in the technical occupation are more inclined to purchase EVs than others. The influence of income to purchase has been a topic of debate among scholars. Some studies, direct that income does not play a vital role in the purchase decisions of EVs (Bjerkan et al., 2016; Hidrue et al., 2011; Y. Zhang et al., 2011). However, these studies are mainly conducted in developed countries with subsidies supporting their purchase decision for EVs. Contrarily, some studies reflect the income indeed plays a pivotal role in the purchase of EVs (Erdem, Şentürk, & Şimşek, 2010; X. Li, Xue, Chen, & Li, 2013). In this study, we will understand whether age, education, income and occupation play a significant role in the selection of the E2Ws. A brief understanding of the customer's perception for the EVs is mentioned below.

Table 4. 1 Contemporary studies on the perceptions for Electric vehicles

Reference	Focus/attributes	Methods	Results
(J. H. Wu, Wu, Lee, & Lee, 2015)	Image, risk, value and perceived usefulness	Structure equation modelling and fuzzy set qualitative comparative analysis	Image, risk, value, and perceived usefulness are key factors of purchase intentions
(Wahab & Jiang, 2019)	Price, government subsidy, the performance of the electric motorcycle	Logit and probit models	Perception of price, performance and range plays an important in the adoption of electric motorcycles
(Chiu & Tzeng, 1999)	Operating cost, reliability, maximum speed and emission level	Multinomial logit models	Those who receive high education are most supportive of electric motorcycles
(Sung, 2010)	Education, top speed and operational cost	Binary logistic regression	High education leads to a high probability of selecting an electric motorcycle in the future
(Guerra, 2019)	Fuel, charging time, range, demographic features	Mixed logit models	Respondents with high household income are more likely to purchase electric motorcycles than petrol-based motorcycles. Young respondents were more likely to purchase electric motorcycles

(Sung, 2010)	Education, operational cost and speed	Binary logistic regression	Higher educated people are inclined to purchase to electric motorcycles more then petrol-based motorcycles
(Satiennam, T., Satiennam, W., Tankasem, P., Jantosut, P., Thengnamlee, J., & Khunpumphat, 2014)	Demographic features, acceptance perception of electric motorcycles	Structure equation modelling	Students and government employees showed more inclination towards electric motorcycles as future mobility mode
(Zhu et al., 2019)	Purchase price, sales tax, repair fees, driving speed and load capacity	Binary logistic regression	Considering electric motorcycles, respondents were more concerned about the purchase price, sales tax and repair fees than driving speed and load capacity
(C. C. R. C. Cherry, 2007)	Technical characteristics of people as age, gender, number of households	Binomial logistic regression	Speed of E2Ws could motivate public transport users and conventional bicyclists to consider E2Ws in the future

4.4 Material and methodology

4.4.1 Survey

To understand the future mobility preferences, the respondents were asked to choose E2Ws or petrol-based motorcycles. Those who selected E2Ws were asked reasons for the selection. Similarly, the respondents who didn’t select E2Ws were asked reasons for their choice. In this way, we could understand the preference towards E2Ws highlighting the driving and resisting factors for the implementation of E2Ws in Pakistan. The graph below represents a schematic presentation of the questionnaire in the survey.

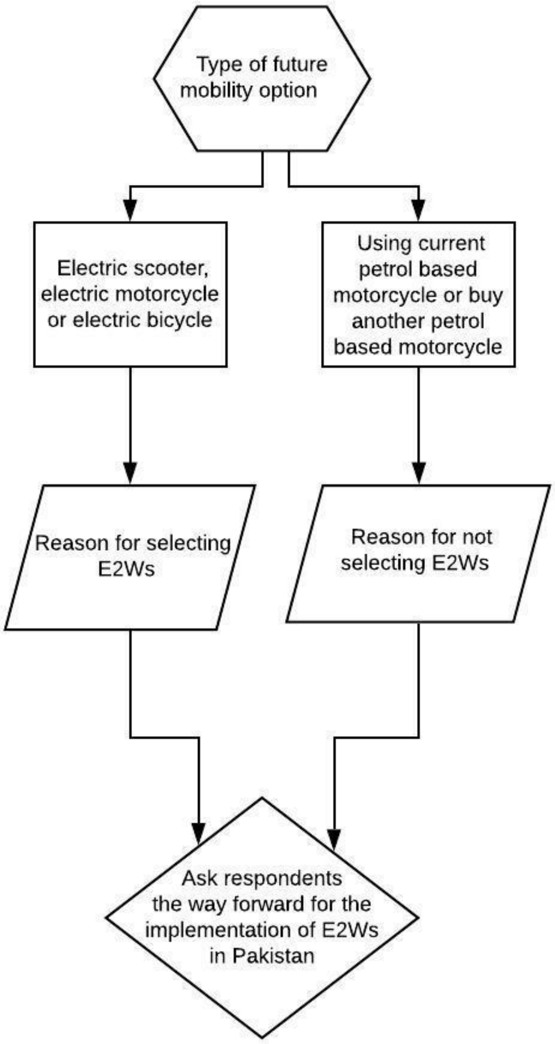


Figure 4. 1 Flow of questions to understand the barriers and opportunities of E2Ws

The platform of Qualtrics was used to design the survey. The survey was mostly conducted by university students who were given some training to conduct the survey. The students were given an anonymous and reusable link to conduct the survey. These students distributed this link among their friends, family and acquaintances. As the anonymous link was reusable, the students were also encouraged to conduct person to person interviews randomly. The first author interviewed 40 face to face random respondents close to the gas station to understand the customer's perspective. The Internet Protocol (IP address), survey filling time and pattern of answers were checked to eradicate duplicate or incorrect forms filled by the respondents. The majority of the survey was conducted through cell phones/ tablets of the through an individual and anonymous link sent from the students to their acquaintances. Some of the survey forms were disseminated online through social media and emails. Efforts were made for the distribution of the anonymous link and a large number of students (> 30) so that the sample does not suffer from the sample selection bias. However, the large majority of the people were middle to high income and internet users. So we can relate that the sample was convenient. The statistical tool of SPSS 25 was used to calculate the statistical association among the different variables. The general masses in Pakistan were unaware of E2Ws and their attributes. Thereby, a brief presentation about E2Ws was given by the person who conducted the survey in the beginning. This brief discussion was intended to help respondents understand the attributes of E2Ws, such as low operational cost and reliance on electricity than petrol-based motorcycles.

In the survey, the E2Ws are defined as electric motorcycles, electric scooters and electric bicycles. The technical features such as top speed, range, electricity units (kWh) consumption, duration of battery and time to full charging were evaluated from the available literature (C. R. Cherry, Weinert, & Xinmiao, 2009; L. R. Jones et al., 2013; M. Weiss et al., 2015). These features were revalued considering different literature, market information, contemporary prices of electricity and petrol-based prices in Pakistan (C. R. Cherry et al., 2009; Industry, 2019; L. R. Jones et al., 2013; pakwheeels, 2019; M. Weiss et al., 2015). The tank to wheel electricity usage for electric bicycle, electric scooters and electric motorcycle ranges from

0.015 kWh km^{-1}, 0.045-1 kWh km^{-1}, and 0.07-0.1 kWh km^{-1} respectively (M. Weiss et al., 2015). The medium-speed E2Ws are used in this study, as the price of high-speed E2Ws is considerably high (Guerra, 2019). To understand the influence of purchase price, a hypothetical price was assigned to electric motorcycles, electric scooters and electric bicycles. The hypothetical price was derived from converting prices of E2Ws in the international market and calibrating to the Pakistani market's prices. All of the three E2Ws had purchase price higher than average 70 cc petrol-based motorcycles available in the markets of Pakistan. The most popular petrol-based motorcycle has an average price of 70500 ($455) rupees (pakwheeels, 2019). A brief explanation of the various attributes used in the table is provided below the survey, the E2Ws were defined as electric motorcycles, electric scooters and electric bicycles. The technical features such as top speed, range, electricity units (kWh) consumption, duration of battery and time to full charging were evaluated from the available literature (C. R. Cherry et al., 2009; L. R. Jones et al., 2013; M. Weiss et al., 2015).

Additionally, the current electricity price, petrol price and gasoline motorcycle features were developed from supplier companies located in Pakistan (Industry, 2019; pakwheeels, 2019). The sticker price of electric motorcycles and electric scooters were deliberately given a higher price than current petrol-based motorcycles. This was done to understand how people could react to a higher price for E2Ws than petrol-based choice. In this chapter, the scope of the research is limited to the perception towards the future mobility choice. We understand the perception towards E2Ws by their future mobility choice and reason for the decision. The positive perception for E2Ws is evaluated if the respondents choose any of the E2Ws as a future mobility option. The survey questionnaires are attached in Appendix A of the chapter of the conclusion and policy recommendations. Due to the length survey questions, we have placed it in the end for reader's convenience. Other questionnaires related to prospective payment preferences and willingness to pay are covered in the forthcoming chapter.

The figure below enlists all the technical and price-based features of the above-mentioned vehicles used in the survey.

Specifications*	***Electric Motorcycle***	***Electric Scooter***	***Electric Bicycle***	***Conventional Motorcyle (Honda CD70)***
				
Expected Beginning Price	105000	58000	50000	70500
Range per full charge	60	40	30	440 Kilometers (55 Kilometers per litre)
Top speed	70 kmh	45 kmh	30 kmh	80 kmh
Electricity Units(kWh) consumed per 100 Km	2.5	2	1.5	NA
Price per 100 kilometers	38 Rupees	30 Rupees	23 Rupees	163 Rupees
Duration of Battery consumption	1 year	1 year	1 year	NA
Battery Repurchase price	12000 Rupees	12000 Rupees	12000 Rupees	NA
Time to full charging	6 Hours	6 Hours	6 Hours	NA
Home charging availability	Yes, conventional wall plugs	Yes, conventional wall plugs	Yes, conventional wall plugs	NA
Other maintenance	0	0	0	1000 Rupees (Oil change, plugs issue)

Figure 4. 2 E2Ws displayed to the respondents in the survey

4.4.2 Statistical data analysis

In this study, the Pearson Chi-square test is used to understand the strength of association among different choices for education, age, occupation and household income with future mobility choices. Using Pearson Chi-square, we could understand how likely the observed distribution is due to chance. Using the chi-square test, p-values of 1%, 5% and 10% denote the highest to the lowest significant association among the variables. An association with p-value < 0.01 shows that there is strong evidence of the association between variables The Pearson chi- uses the idea to compare the observed and expected frequencies. The chi-square test for the two-way table can be represented by the equation below

$$Q_p = \sum_{i=1}^{s} \sum_{j=1}^{r} \frac{(n_{ij} - m_{ij})^2}{m_{ij}} \quad (1)$$

and

$$m_{ij} = \frac{n_i n_{ij}}{n} \qquad 2$$

$\mathbf{Q_p}$ = Pearson chi-square statistics considering chi-square distribution with (s-1)(r-1) degrees of freedom when the row and column values are independent

$\mathbf{m_{ij}}$ = Represents the expected value of the frequencies in the ith row and jth column

$\mathbf{n_{ij}}$ = Represents the marginal total

When more than 20% of cells in a table have expected count less than 5, we employ either Fisher's exact test or Monte Carlo method to compute significance. As Fisher's exact test was computationally intensive in SPSS, we used the Monte Carlo method in tables which had more than 20% of expected cells having values less than 5. The Monte Carlo simulation method creates distribution similar to that found in the sample and considers several samples (the default of 10000 used in this study) to find the significance value (Andy Field, 2013). In the following sections, we analyse the different association from the survey and relate the results based on different categories.

4.4.3 Multinomial logistic regression

The multinomial logistic regression model (MNM) is used to choose a categorical variable over other choices (Al-Alawi & Bradley, 2013). It is also used to find the strength of relationship among the choices of the categorical variables. It is used when there are more than two outcomes categories (A Field, 2013). The simplistic framework and flexibility make it the ideal choice-based decision making (Egbue & Long, 2012; A Field, 2013; Janes, 2001). The probability $P_{i,n}$ to choose an individual n chooses an alternative i from a set of alternatives j in C (C is a set that consolidates all the potential alternatives). In the equation $u_{i,n}$ is the utility function generating as an individual chooses from an alternative i from a set of alternatives j in C.(Train & Winston, 2007).

$$P_{i,n} = \frac{e^{u_{i,n}}}{\sum_{j \in C_n} e^{U_{j,n}}} \qquad 3$$

In our study, we have applied multinomial logistic regression to understand whether other resisting forces hold more importance than electricity blackouts. In the process, one reference or baseline variable will be assigned to the dependent variable. The independent variables include age, occupation, income and education. The dependent variable for the resisting forces can have a baseline or reference category of electricity blackouts. In the example below, we allocate the number 4 to electricity blackouts considering as dependent variable. We could give the value of $Y_{1,}$, $Y_{2,}$ $Y_{3,}$..., to these categorical dependent variables. As the dependent variables are categorical, these probabilities for these variables are achieved by applying the logarithmic function. The logarithms are used to untangle the exponential aspect of some value. Hence, the exponential values of the $Y_{1,}$, $Y_{2,}$ $Y_{3,}$..., are achieved from untangling the logit values of the following equations. For each value $Y_{1,}$, $Y_{2,}$ $Y_{3,}$ .., separate values of intercept and the coefficients are achieved using SPSS 25. An example is defined below the equation.

$$Y_1 = \text{logit}\frac{P(Y=1)}{P(Y=4)}$$

$$= \beta° + \beta1\ (\text{education}) + \beta2\ (\text{age}) + \beta3\ (\text{Income}) + \beta4\ (\text{Occupation})$$

$$+ \beta5\ (\text{Monthly income})$$

Similarly, other equation could also be attained with different coefficients and intercepts for, $Y_2 = \text{logit}\frac{P(Y=2)}{P(Y=4)}$, $Y_3 = \text{logit}\frac{P(Y=3)}{P(Y=4)}$, and $Y_4 = \text{logit}\frac{P(Y=5)}{P(Y=4)}$.etc.

In this study, we consider p-values, 1%, 5%, and10% to measure significance. These three values represented a low, medium and high-level significant association respectively. Any value above these standards was recognized as not significant. The model fit is found by pseudo R_2 values. The three values of R_2 namely Nagelkerke, McFadden, and Cox and Snell are used in this study. The three values of R_2 are used, since the regression model with categorical variables does not deal with one R_2 value (A Field, 2013; Rasmussen, 2007).

4.4.4 Binary logistic regression

The binary logistic regression also follows the same principle as the multinomial logistic regression. Instead of using multiple equations, it uses a single probability equation. In the equation below, we can find the formula for binary logistic regression.

$$PY(Y) = \frac{1}{1 + e^{-(b_0 + b_1 X_{1i})}} \quad 4$$

In the above equation, we can understand that $PY(Y)$ could be labelled as the probability of Y occurring. Moreover, the base of natural logarithms.is represented by e. In the equation, the predictor variable is represented as X_1, and coefficient b_1 embedded with the predictor. The b_0 represented as the constant.

4.4.5 Heckman two-stage model

The Heckman two-step approach is used to remove the sample selection in any study (R. Tan & Lin, 2019). The two-step method in our study will help us to select people who are willing to pay for E2Ws and their favourable outcome (electric scooter, electric motorcycle or electric bicycle).

The petrol-based respondents who earlier cited that they were not willing to pay for E2Ws, were asked again if there is a minimum price they could consider and pay for E2Ws. The respondents who were considering to buy another petrol-based motorcycle were created a separate sample. We only focused on the respondents who cited to buy another motorcycle because they showed an intention to buy a vehicle. Besides, people who used petrol-based motorcycles could have just bought a petrol-based motorcycle.

The first part of the Heckman model revolves around the selection of whether people are willing to pay for E2Ws or not. The independent variables for the selection were age, occupation, income and education. The equation for the willingness to pay is as follows:

$$Willingness\ to\ pay\ for\ E2Ws = \gamma_0 + \gamma_i(Indpendent\ variables) + u_i \qquad 5$$

$$Willingness\ to\ pay\ for\ E2Ws = \frac{1,\ If\ respondents\ agree}{0,\ If\ respondents\ disagree} \qquad 6$$

We embedded the variables of age, education, household income and occupation as independent variables with the outcome category.

The dependent variable of the choice of the E2Ws could be described as follows.

$$Choice\ of\ E2Ws = \beta_0 + \beta_i(Dependent\ variables) + \varepsilon_i \qquad 7$$

Resultantly, we would have the following equation as follows.

$$Choice\ of\ E2Ws:$$

$$= \frac{\beta_0 + \beta_i(Dependent\ variables) + \varepsilon_i, if\ respondents\ agree\ to\ consider\ E2W = 1}{Not\ observed,\ if\ repondents\ do\ not\ agree = 0} \qquad 8$$

If we replace all the variables into equation 9 and 10, we would have the following estimations equation for each stage as following.

Stage 1: Selection

$$Willingness\ to\ pay\ for\ E2Ws\ (0,1) = \gamma_0 + \gamma_1(Age) + \gamma_2(Occupation) + \gamma_3(Education) + \gamma_4(Income) + u_i \qquad 9$$

Stage 2: Outcome

$$Choice\ of\ E2Ws = \gamma_0 + \gamma_1(Age) + \gamma_2(Occupation) + \gamma_3(Education) + \gamma_4(Income) + u_i \qquad 10$$

4.5 Results and discussion

4.5.1 Descriptive statistics

A total of 2011 respondents participated in the survey. Majority of the respondents were from the vicinity of Hyderabad (76%), which is one of the big cities of Pakistan. Some of the survey respondents were collected from Karachi (24%), which is the biggest city of Pakistan. The two cities were selected to increase the survey size for the survey. There was no significant difference in choices found among the respondents for the two cities in filling the survey questionnaires. The survey couldn't represent the point of view of the whole nation, but an effort has been to present the opinion of petrol-based motorcycle users who are technologically aware and inclined towards a cost-friendly travelling option. The majority of the survey sample consisted of young people as 74% of the sample had age equal or less than 30 years. Besides, more than half of the sample size (55%) had a graduate or postgraduate degree, hence, the sample size represented fairly young and educated respondents. Most of the individuals had a monthly household income of 60000 ($387) rupees or less (65%). The average income of people in Pakistan is around is 35000 ($226) rupees per month (Pakistan Bureau of statistics, 2016). This shows that most of the respondents belonged to the upper-middle-class people of Pakistan, as their monthly income was above the average household income. The students were enthusiastic to participate in the survey (43%). The level of education is regarded as instrumental in the survey, as this stratum of respondents is regarded modern and aware of contemporary technologies. The motorcycle users in Pakistan only consists of male drivers. The survey was directed towards male motorcycles users only and the female respondents were not considered in the results. People who do not use motorcycles were not considered. Besides, the affordability of motorcycles by lower-income males also refrains females for much input in the purchase decision. In this survey, most of the respondents possessed 70 cc engine (64%) than other higher engine models (36%). The majority of the respondents also revealed that they had bought the motorcycle paying full price (86%) than instalments (14%). Due to the smaller frequencies, age above 35 years, income above 80000 rupees ($516) and education above Masters degree are combined in one larger group in their respective categories. Similarly, occupation groups of 'retired' and 'other' are combined into personal business as most of the respondents revealed they are occupied in their private businesses. The high prevalence of young, student, high educated and high-income respondents in the survey will help to understand the difference with other groups such as non-student, high age, low educated and low-income respondents.

The survey sample used in our study depicts relatively rather closely to the demographic features of Hyderabad and Karachi. The urban areas of Hyderabad and Karachi have a majority young population less than 30 years old. In our survey, the main respondents were also young with a majority falling in the category of thirty years' age (Pakistan Bureau of Statistics, 2018a; Year Book, 2016). The literacy rate is also high (60%) in urban areas like Hyderabad in Pakistan (Population welfare department, 2018). We can expect that half of them could be pursuing a graduate degree or higher. In our survey, almost half of the respondents had a bachelors degree or higher. The income categories of our survey are also relatively similar to the results from the Household integrated economic survey of Pakistan (Pakistan Bureau of statistics, 2016). The occupational profile of Pakistan was difficult to achieve due to the lack of data and the presence of students in the profile. Nevertheless, we take this survey sample as correct due to its first nature.

Below results present detail analysis of the choices made in the survey. The sample characteristics are shown in the table below.

Table 4. 2 Characteristics of the sample population of the survey

Characteristics of the sample population		
Sample attributes		%
Age	Less than 20 years	15.6%
	20-25 years	37.8%
	25-30 years	21.3%
	30-35 years	11.5%
	Above 35 years	13.9%
Education	Less than 12 years of education	14.0%
	12 class education	31.0%
	Bachelors degree	38.2%
	Masters degree or higher	16.8%
Monthly household income	Less than 20000 rupees	21.3%
	20000-40000 rupees	27.4%
	40000-60000 rupees	16.8%
	60000-80000 rupees	11.2%
	More than 80000 rupees	23.3%
Current Occupation	Government servants	7.8%
	Private company employees	21.7
	Personal business	26.7%
	Student	43.8%

4.5.2 Future Mobility option

To understand the inclination for E2Ws, the respondents were asked to choose among E2Ws or petrol-based motorcycles. In this survey question, it was inquired whether people are inclined towards a new mobility mode such as an E2W or petrol-based motorcycle. Most of the people responded that they have heard about E2Ws but were unsure about its attributes. Most of the people were confused about the features the E2Ws could have such as top speed and changing time in real life. It shows that people are relatively unaware of the attributes of E2Ws. When E2Ws' attributes were made clear, respondents still showed their reservations to purchase E2Ws in future. Below is the table which provides the descriptive frequencies of the choice of the mobility-mode.

Table 4. 3 Choice of future mobility by respondents in the survey

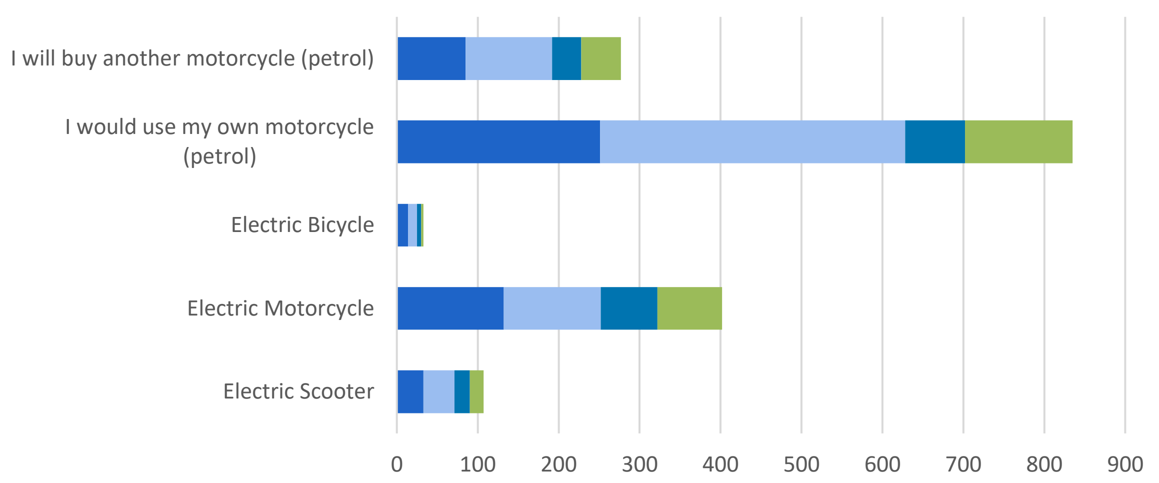
Future mobility option	Frequency	Valid Percentage
Electric Scooter	107	6.4
Electric Motorcycle	407	24.6
Electric Bicycle	34	2.0
I would use my current petrol-based motorcycle	837	50.3
I will switch to another petrol-based motorcycle than my current motorcycle	278	16.7
Total	1663	100.0

In the table above, one could observe that the majority of the respondents (67% = use their current petrol-based motorcycle (50.3%), or switch to another petrol-based motorcycle = (16.7%)) were not considering to use E2Ws in the future. Only, 33% of respondents were inclined to consider E2Ws in the future with 24.6% cited to consider the purchase of an electric motorcycle in the future. One could observe that only 2% of people opted for electric scooter electric bicycle. This survey results highlight that respondents do not consider E2W as feasible vehicles in their daily travel trips. This may be related to its slow speed and limited range. People of Pakistan are also standard conscious, they consider bicycle use as a sign of low prestige. The low selection of electric bicycle in this survey is an example of the notion.

This result is in congruence to the study of J. H. Wu et al. (2015) which directs that customer image of the product plays an important role in the intention purchase as in our study only a small number of people chose electrics scooters and electric bicycle due to inferior attributes and unfamiliar shape. This It also highlights that government and non-government agencies would have to work together to create awareness for E2Ws so that anxiety for a new mobility product could be reduced. In the following section, we show the choice of mobility coupled with socio-demographic features. We will not indulge in the deep analysis as we only represent the data and choices made by different groups. The chi-square is used in forthcoming paragraphs to understand the influence of age, income, education and occupation on future mobility.

Education

There was a significant Chi-square association found between future mobility choice and education ($p\text{-value} < 0.01$). The graphical representation of the choices is shown in the figure below.



	Electric Scooter	Electric Motorcycle	Electric Bicycle	I would use my own motorcycle (petrol)	I will buy another motorcycle (petrol)
12th class educated	33	132	14	251	85
Bachelors	38	120	11	377	107
Less than 12 years of education	19	70	5	74	36
Masters or above	17	80	3	133	49

Figure 4. 3 Education level and choice of future mobility

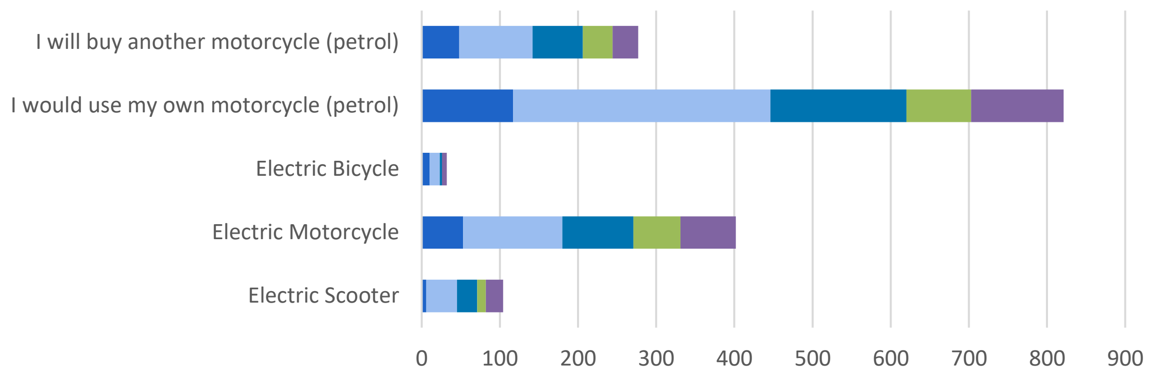
Table 4. 4 Pearson Chi-square result for education level and choice of future mobility

Q_p	df	p-value
42.48	12	0.00002

The above table and graph show that electric scooters were mostly chosen by people having a Bachelors degree. The electric motorcycle and bicycle were chosen by people having at least 12 years of education. People who chose to use current petrol-motorcycle or another petrol motorcycle had also Bachelors degree.

Age

There was a significant Chi-square value found between future mobility choice and age (p-vaue= 0.001). The graphical representation of the different mobility choices with age categories is defined in the figure below.



	Electric Scooter	Electric Motorcycle	Electric Bicycle	I would use my own motorcycle (petrol)	I will buy another motorcycle (petrol)
Less than 20 years	6	53	10	117	48
20-25 years	39	127	13	329	94
25-30 years	26	91	3	174	64
30-35 years	11	60	0	83	38
Above 35 years	22	71	6	118	33

Figure 4. 4 Age and choice of future mobility

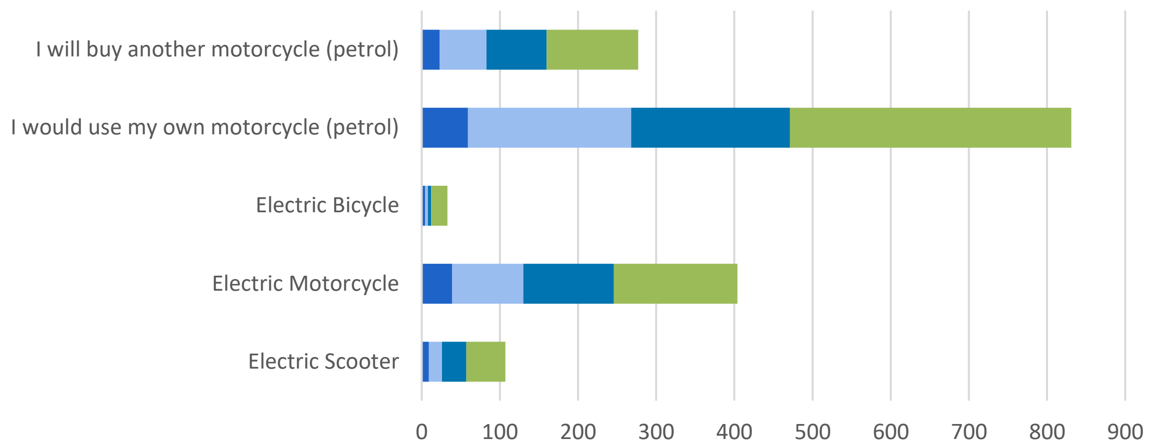
Table 4. 5 Pearson chi-square result for age level and choice of future mobility

Q_p	df	p-value
39.90	16	0.001

From the results, we can find that respondents aged between 20-25 years had the most visible and dominant group in every mobility choice. The second most dominant group in the selection of E2Ws was age category 25-30 years. Hence, in the survey majority of the respondents, were between the age category of 20-30 years who chose mobility choice.

Occupation

There was low significant association was found between the occupation category and future mobility choice (p-value < 0.1). The graphical representation of the different mobility choices with occupation categories is defined in the figure below.



	Electric Scooter	Electric Motorcycle	Electric Bicycle	I would use my own motorcycle (petrol)	I will buy another motorcycle (petrol)
Government servants	9	39	4	59	23
Private company employees	17	91	4	209	60
Personal business	31	116	4	203	77
Student	50	158	21	360	117

Figure 4. 5 Occupation and choice of future mobility

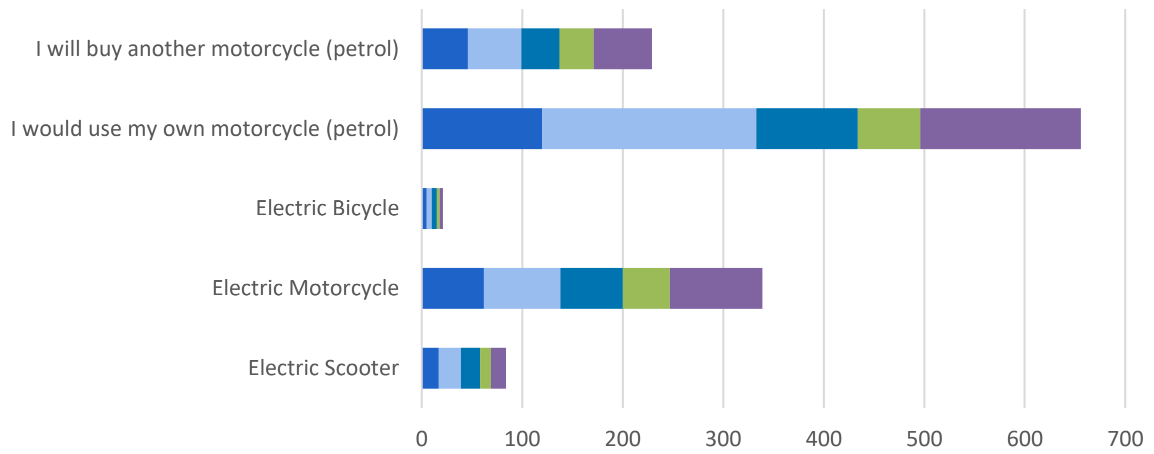
Table 4. 6 Pearson chi-square result for occupation and choice of future mobility

Q_p	**df**	**p-value**
19.031	12	0.088

The students were the majority of the group who cited to use their current motorcycle. People who were private company employees were also largely concerned to use their current motorcycle. Considering other option such as the electric scooter, electric motorcycle, electricity bicycle or buying another petrol-based motorcycle, students and people with personal business dominated the occupation category. Considering the figure above, almost all occupation groups chose petrol-based motorcycles over E2Ws as future mobility option

<u>Household-Income</u>

There was a low significant association found between income and future mobility choice (p-value < 0.1). The graphical representation of different mobility choices with the household income is shown in the table below.



	Electric Scooter	Electric Motorcycle	Electric Bicycle	I would use my own motorcycle (petrol)	I will buy another motorcycle (petrol)
Less than 20000	17	62	5	120	46
20000-40000	22	76	5	213	53
40000-60000	19	62	5	101	38
60000-80000	11	47	3	62	34
More than 80000	15	92	3	160	58

Figure 4. 6 Household income and choice of future mobility

Table 4. 7 Pearson chi-square result for household income and choice of future mobility

Q_p	df	p-value
25.58	16	0.078

The majority of the respondents who chose electric motorcycle had a household income of more than 80000 rupees. Those who chose electric scooter and the electric bicycle had a household income of 20000-40000 rupees. The people who chose using another petrol-based motorcycle in the future had an income of either 20000-40000 rupees or more than 80000 rupees. The majority of the respondents choosing to use their current motorcycle had an income of 20000-40000 rupees.

4.5.3 Binary logistic regression

At the beginning of the thesis, we used multinomial logistic regression. However, we found non-independence from irrelevant alternatives. Later, it was decided to use the Nested logit model which allows some similarity between alternatives and groups them together (Buckley, 1988). However, there was the profound choice of electric motorcycles in the pro E2W nest and use of current motorcycle in the pro-petrol-based group. Hence, we decided to group the choices of E2Ws (electric motorcycle, electric scooter and electric bicycle) in one group and choices of the petrol-based motorcycle (I will use my current motorcycle and I will continue using another petrol motorcycle) in another group. In other words, these can also be stated 'Yes' and 'No' for E2Ws. The best way out was to use Binary logistic regression.

The dependent variables could be future mobility choice by E2Ws or petrol-based motorcycle. We allocate the reference category as the E2Ws. The independent variables are allocated as age, income, occupation and education. Below is the table representing the Binary logistic regression.

Table 4. 8 Binary logistic regression and future mobility choice

Parameter estimates	
Model combination	**I will use a petrol-based motorcycle**
	Odds ratio
Intercept	0.245
Education	
Less than 12 years of education	0.856
12th class (Intermediate)	**1.36***
Bachelors	0.619
Masters degree or above	0a
Occupation	
Government servant	1.20
Private company employees	**1.53****
Personal business	**1.41***
Student	0a
Household-income	
Less than 20000 rupees	1.492
20000-40000 rupees	1.827
40000-60000 rupees	1.948
60000-80000 rupees	1.195
More than 80000 rupees	0a
Age	
Less than 20 years of age	**2.19*****
20-25 years	**1.53****
25-30 years	1.05
30-35 years	0.959
Above 35 years	0a

Notes
The reference category for the dependent variables: I will use E2Ws in future
Omnibus test > 0.01
Hosmer and Lemeshow test = 0.016
0a = reference category for independent variables
Cox and Snell = 0.067, Nagelkerke = 0.04
** p-value < 0.10, ** p-value ≤ 0.05, *** p-value*

The model didn't represent an ideal fit, nevertheless, we would discuss the significant results in our thesis. In the results, we found out that people with 12 years of education were motivated to buy a petrol-based motorcycle instead of an E2Ws. This directs that prudent mobility decision does not necessarily have to commensurate with high education. The results highlight that respondents with less education also understood the attributes E2Ws well and made rational decisions for their future mobility choice. These results go against earlier research which advocates high education increases the chance of selecting EVs (Carley et al., 2013; Hidrue et al., 2011).

We also observe that private company employees and personal business-related individuals also are more to be attracted to petrol-based motorcycles. These groups are financially independent, and it shows that they do not consider E2Ws as monetarily beneficial. Our results go against the findings of B. K. Sovacool, Kester, Noel, & de Rubens (2018) that emphasize that private company employees are attracted towards EVs.

The age category of less than 20 years and 20-25 had significant values and were likely to consider petrol-based motorcycle. In our study, the inclination of young respondents is towards petrol-based motorcycles than E2Ws which contradicts previous research that young people are more inclined towards EVs (Carley et al., 2013; Hackbarth & Madlener, 2013; Hidrue et al., 2011). As young people are sensation seeking, the idea of the slow speed of E2Ws could be a major resisting force for the E2Ws.

We didn't any find any significant value for household income. However, we can observe in the above table that most of the socio-demographic groups were attracted towards petrol-based motorcycles than E2Ws.

4.5.4 Heckman two-stage selection test fo respondents with purchase intentions to buy another petrol-based motorcycle in the future

The Heckman two-stage model has also been used to understand market entry, purchase intentions and public perceptions for electric vehicles (Dutta & Vasudeva, 2019; R. Tan & Lin, 2019). The Heckman two-stage model has been widely used in the field of economics, social sciences, or rural development (Cepoi, Donţu, Şalaru, & Şalaru, 2016; Khoi, Gan, Nartea, & Cohen, 2013; Lennox, Francis, & Wang, 2012; Peng, Kang, & Jiang, 2013; Puhani, 2000).

In our study, the Heckman two-stage model is used to understand whether people are willing to pay a new technology such as electric two-wheelers (selection stage) and choice of mobility if they select E2Ws that could be an electric scooter, electric motorcycle or electric bicycle (outcome stage). Hence, the "selection stage" would be the binary-choice (Yes, No) whether people will be willing to pay any amount to consider E2Ws in the future. The outcome stage would be the choice of different E2Ws (electric scooters, electric motorcycles and electric scooters). The independent variables in both the stages are age, household income, education and occupation.

This question was only asked from the respondents who said in the survey section that they would consider buying a new petrol-based motorcycle in the future. Hence, we could understand whether people who are willing to pay for a new petrol-based motorcycle in the future will be inclined to consider E2Ws as a future mobility mode. Besides, we can also understand the type of E2Ws that can be purchased by people using this model. The Heckman two-stage estimation also corrects any sample selection bias occurred due to non-random selection (Do & Park, 2019).

In the selection stage, out of the total pro-petrol respondents considering to buy a petrol motorcycle in the future (278), 255 people answered the question if they are willing to pay a minimum purchase price for the E2Ws. Out of this subgroup who answered the willingness to pay question, 166(65%) were of the choice to pay some amount and 88(35%) didn't agree to pay any amount.

The second part of this section revolves around the outcome part of the Heckman two-stage model. In this part, we ask the respondents the type of E2W will they prefer in the future after consenting on the willingness to pay. A total of 157 respondents answered this question. The majority of the respondents in this category were inclined towards electric motorcycles (139= 88.5%). Besides, only a small percentage of the respondents selected electric scooters (14= 8.9%) and electric bicycles (4= 2.5%). Some of the entries had missing demographic features (age, occupation, income and education) which were deleted to make the model more robust. In the Heckman model, only had 146 useful entries were found that answered both stage model questions.

Below tables provide the results of the Heckman two-stage model.

Table 4. 9 Summary statistics of the Heckman two-stage model

Heckman selection model	**Two-step estimates**	**Number of observations**	**=**	**208**
(regression model with sample selection)		Selected	=	146
		Non-selected	**=**	**62**
		Wald chi2(14)	**=**	**1.75**
		Prob > chi2	**=**	**1**
		Rho	=	1
		Sigma	=	1.56

Note: two-step estimate of rho = 1.3905274 is being truncated to 1

Table 4. 10 Selection stage of the Heckman model

Selection Stage	**Coef.**	**Std. Err.**	**z**
Age			
20-25 years	0.33	0.33	0.99
25-30 years	0.36	0.39	0.93
30-35 years	0.17	0.44	0.38
Above 35 years	-0.05	0.46	-0.11
Occupation			
Private company employees	0.45	0.42	1.07
Personal business	-0.30	0.40	-0.76
Student	-0.30	0.45	-0.67
Education			
Bachelors	0.34	0.24	1.42
*Less than 12 years of education***	***0.69***	***0.33***	***2.07***
*Masters degree or above**	***0.59***	***0.31***	***1.89***
Household Income			
*20000-40000****	***-0.99***	***0.37***	***-2.67***
*40000-60000****	***-1.14***	***0.39***	***-2.95***
*60000-80000 rupees****	***-1.00***	***0.39***	***-2.58***
*More than 80000***	***-0.84***	***0.35***	***-2.40***
Mills/ Lambda	1.56	2.21	0.71

Note: Significant values are in bold and Italic
Age less than 20 years, government servants, 12 years education and household-income less than 20000 were the reference categories for age, occupation, education and income respectively
** p-value < 0.10, ** p-value ≤ 0.05, *** p-value ≤ 0.01*

Table 4. 11 Outcome stage of the Heckman model

Outcome Stage	**Coef.**	**Std. Err.**	**z**
Age			
20-25 years	0.37	0.53	0.70
25-30 years	0.29	0.65	0.45
30-35 years	0.29	0.60	0.49
Above 35 years	0.04	0.61	0.07
Occupation			
Private company employees	0.40	0.60	0.66
Personal business	-0.22	0.59	-0.37
Student	-0.15	0.59	-0.26
Education			
Bachelors	0.23	0.48	0.49
Less than 12 years of education	0.61	0.81	0.76
Masters degree or above	0.39	0.73	0.54
Household Income			
20000-40000	-0.92	0.94	-0.97
40000-60000	-1.02	1.14	-0.89
60000-80000 rupees	-0.80	1.01	-0.79
More than 80000	-0.58	0.84	-0.70

Note: Significant values are in bold and Italic
Age less than 20 years, government servants, 12 years education and Household-income less than 20000 were the reference categories for age, occupation, education and income respectively (categories chosen due to higher frequency)
** p-value < 0.10, ** p-value ≤ 0.05, *** p-value ≤ 0.01*

The Coefficients help us to understand the alteration in the probit of a unit change in each independent variable and its impact on the dependent variable (assume that other factors remain unchanged). The sign of the coefficient also indicates the impact on the dependent variable. A positive sign will increase the chance of the selection of the E2W. Whereas, a negative sign will decrease the chance of the selection of E2Ws. The significant categories in the above tables are highlighted in bold and Italic.

Considering the selection stage, all the categories of the household-income had a significant and negative influence on the selection of the E2Ws. For example, respondents with a household income of 40000-60000 rupees were less likely to choose E2Ws (compared with respondents with the household-income of less than 20000 rupees which is the reference category). It shows that irrespective of income being high or low, these groups were less likely to choose E2Ws. Considering the education category, respondents with education less than 12 years and respondents with a Masters degree had a positive and significant impact on the selection of the E2Ws. It shows that these respondents (Masters degree holders and Education less than 12 years) were more likely to choose an E2Ws than respondents with the education level of 12 years (reference category). Our results show that level of education didn't play a significant impact on the selection of E2Ws as low and high educated accepted E2Ws likewise.

Considering the outcome stage, the dependent variable was the choice of different E2Ws. There was no significant relations ship found for the independent variables of age, occupation, education and income for the outcome stage. All categories of household-income had a non-significant and negative impact on the choice of different E2Ws. Similarly, the occupation category of students and personal business owners had a negative and non-significant impact on the choice of different E2Ws. All other socio-demographic features had a positive and non-significant impact on the outcome stage.

Difference Binary logit model and Heckman selection stage

In this paragraph, we focus on the difference between Binary logit model and the 'Selection stage' of the Heckman model. Both models have a selection stage of 'Yes' and 'No' for E2Ws. However, both have a different set of respondents. In the Binary model, we include all the pro-petrol-based respondents who didn't select E2Ws initially. Whereas, in the Heckman selection stage we only had respondents who cited to buy another motorcycle and answered the willingness to pay question for the second time.

In the Binary logistic regression, we didn't find any significant value for the household income group, but they had high odds of selecting petrol-based motorcycles. In the Heckman model, we found significant values for all categories of household income respondents that preferred petrol-based motorcycles than E2Ws.

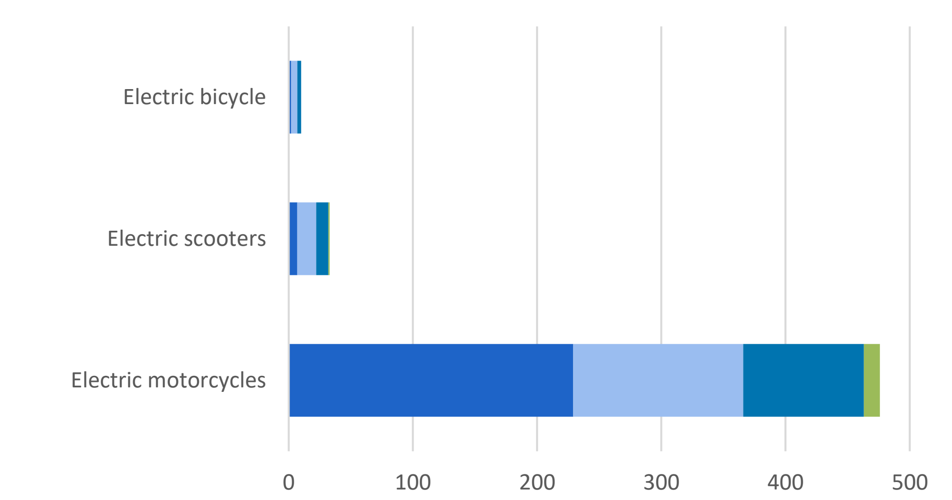
In the Binary regression for occupation category, we found significant values for the private company employees and government servants who preferred petrol-based motorcycles than E2Ws. In the Heckman selection stage, we couldn't find any significant values for the occupation categories.

In the Binary model for age category, we found significant values for the age category of education up to 12 years favouring petrol-based motorcycles. Considering the Heckman model, significant values for both Masters degree and education less than 12 years were found who favoured petrol-based respondents. We couldn't find that only higher educated respondents are attracted to E2Ws.

We can understand comparing both models that all the socio-demographic categories favoured petrol-based motorcycles than E2Ws. It directs that socio-demographic groups can act differently if we reduce samples based on their previous choice of mobility.

4.6 Reasons for purchasing E2Ws

We performed cross-tabulation to understand whether there is a significant relationship between the reasons for purchasing E2Ws and future mobility option We found a significant association found between future mobility option and reasons for choosing E2Ws (p-value = 0.049), indicating there is a strong association between both categories. As the majority of the respondents had chosen electric motorcycles, they were inclined towards low operational cost than environmental benefits or low maintenance features for E2Ws. This shows that people are not ready to invest in a mobility product that would solely serve the purpose of environmental benefits. People who chose electric bicycles and electric scooter were inclined towards environmental benefits, but the frequency is low (compared to electric motorcycles) to give a conclusive statement. Our results are incongruent with the study of Sanya Carley et al. (2013) and Hidrue et al. (2011) in which people are inclined to use EVs due to their monetary savings than environmental benefits. In the future mobility choice section 3.5.2, we discuss why people have not chosen electric bicycle and electric scooter as a future mobility option. Below tables represent the reason to purchase E2Ws and chi-square results.



	Electric motorcycles	Electric scooters	Electric bicycle
Low operational cost	229	7	2
Environmental benefits	137	15	5
Low maintenance cost	97	10	3
Other	13	1	0

Figure 4. 7 Main concern for purchasing E2Ws

Table 4. 12 Pearson chi-square result for not purchasing E2Ws

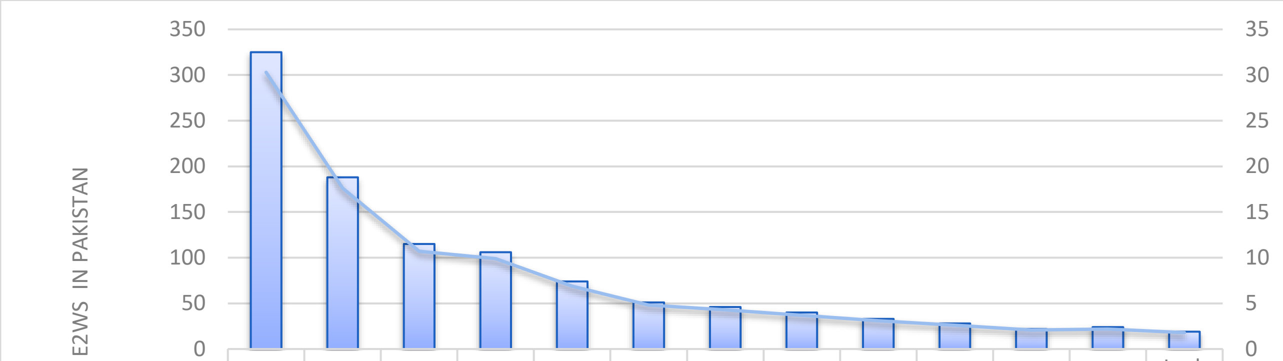
Q_p	df	p-value
12.59	6	0.049*

Notes

*Monte Carlo method used as some of the categories had expected count less than 5

4.7 Reasons for not purchasing E2Ws

The top concerns shown by the respondents were identified as the high purchase price (30.3%), blackouts (17.6%), low driving speed (10.7%) and low range (9.9%). Considering Pearson chi-square, there was no significant association found between the people who selected gasoline motorcycles and reasons for not purchasing E2Ws (p-value > 0.1). The most influencing factors are defined below.



	High purchase price	High electricity blackouts in Pakistan	Low driving speed	Low range	High charging time	Unavailability of charging stations	Resale problem	Awareness issue	Other	High operational cost	Theft problem battery	Unavailability of spare parts	Lack of power to carry high weight (suppliers use it carry weig...
Frequency	325	188	115	106	74	51	46	40	33	28	22	24	19
Percentage	30.3	17.6	10.7	9.9	6.9	4.8	4.3	3.7	3.1	2.6	2.1	2.2	1.8

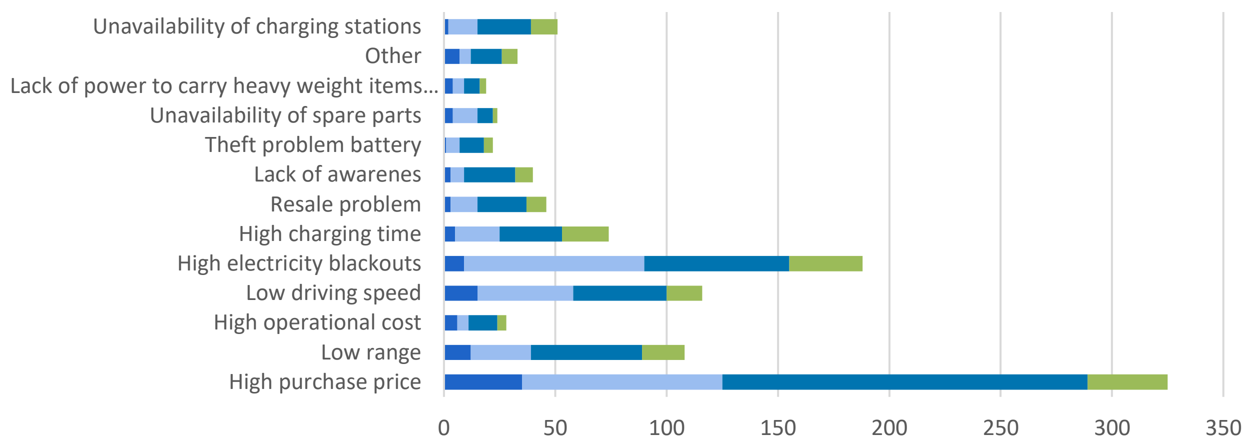
Table 4. 13 Main concerns shown by respondents for not selecting E2Ws by percentage and frequency

In the above equation, one could observe that the purchase price plays a dominant role in the purchase decision of E2Ws. This shows that the increase in purchase price lowers the probability that the E2W will be chosen as future mobility mode, which is similar to the findings from L. R. Jones et al., (2013)and Wahab & Jiang, (2019). In the survey, the respondents gave comments that this higher price was not justified, as the E2Ws had inferior attributes. In the energy scarce country, it was believed that respondents would prioritize the elimination of the electricity blackouts as the most important motivating force. However, people ranked load-shedding below the purchase price. This show that despite the energy crisis in the developing countries, the purchase price is the most influencing factor to motivate customers for an innovative product. There is no direct literature found that blackouts increase charging anxiety associated with E2Ws in developing countries. However, in this study, many respondents acknowledged that electricity blackouts would increase their charging anxiety and effort to plugin and plug-out the E2Ws. Additionally, considerable time could be wasted to charge the vehicle in scheduled electricity blackouts. In the results, it is observed that slow driving speed was the third most influencing factor. In Pakistan, the proximity to basic life needs as hospitals and education are far-flung. Therefore, people rely on high speedy mobility mode to reach their destination. The E2Ws in general and particularly used in this survey had a slow driving speed than petrol-based motorcycles. It directs that increased driving speed could motivate people to consider E2Ws in the future. The fourth motivating factor to introduce E2Ws in Pakistan was decreasing the charging time. This problem also deals with the presence of blackouts Pakistan. The E2W considered in this survey requires a charging time of at least 6 hours. The high charging time could cause more charging anxiety in the presence of prolonged blackouts outs. Other motivating forces, such as awareness or theft issues had less frequency or impact as visible in the survey choice. Hence, it could be inferred that the favourable scenario for E2Ws could be created in Pakistan if they are introduced at a low purchase price with high top speed, reduced charging time and controlled electricity blackouts.

4.7.1 Education and reasons for not purchasing E2Ws

There was a significant association found between the variables of household income and reasons for not purchasing E2Ws ($Q_p = 75$, $df = 36$, $p\text{-value} < 0.01$). The Monte Carlo method was used to find the p-value as more than 20% cells in the above table had expected count less than 5. One could observe that respondents with less than 12 years of education or less showed almost equal concern for important barriers for E2Ws in Pakistan such as electricity blackouts, low driving speed, high purchase price or low range. Hence, it could be inferred that people with less education understand the attributes E2Ws well and made rational decisions.

Below table represents the respective choices.

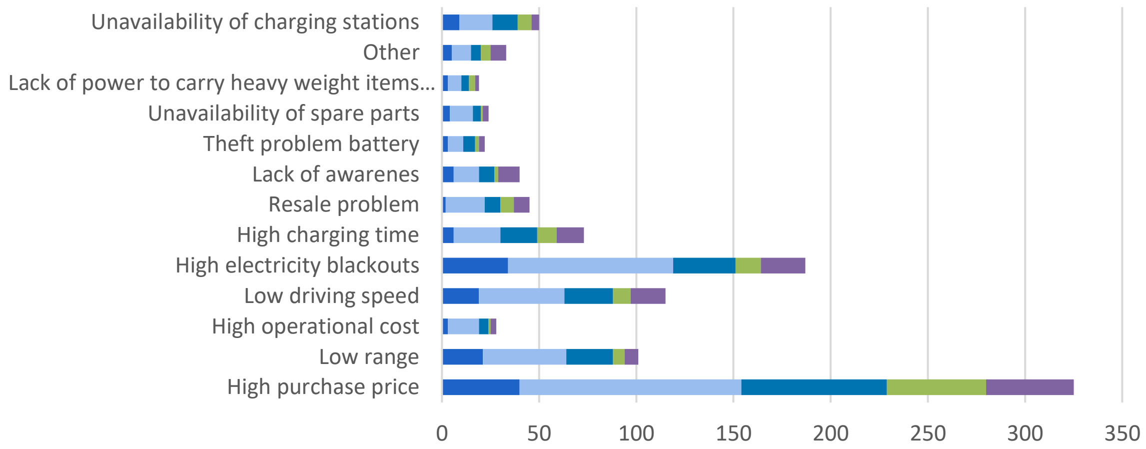


	High purchase price	Low range	High operational cost	Low driving speed	High electricity blackouts	High charging time	Resale problem	Lack of awarenes	Theft problem battery	Unavailability of spare parts	Lack of power to carry heavy weight items (used in supply of items)	Other	Unavailability of charging stations
Less than 12 years education	35	12	6	15	9	5	3	3	1	4	4	7	2
12 years education	90	27	5	43	81	20	12	6	6	11	5	5	13
Bachelors	164	50	13	42	65	28	22	23	11	7	7	14	24
Masters or more	36	19	4	16	33	21	9	8	4	2	3	7	12

Figure 3.1 Education and reasons not purchasing E2Ws

4.7.2 Age and reasons for not purchasing E2Ws

There was no significant association found between the variables of age and reasons for not purchasing E2Ws (Qp =60, df = 48, p-value = 0.102). The Monte Carlo method was used to find the p-value as more than 20% cells in the above table had expected count less than 5. It shows that respondents above the age of 25 years are more concerned for non-technical features of E2Ws. Whereas, respondents with age less than 25 years were more concerned for features as low range, high operational cost, low driving speed, high electricity blackouts, unavailability of spare parts and lack of power to carry heavy items involving more technical features of E2Ws. Below figure represents the detail top concerns and age variable.

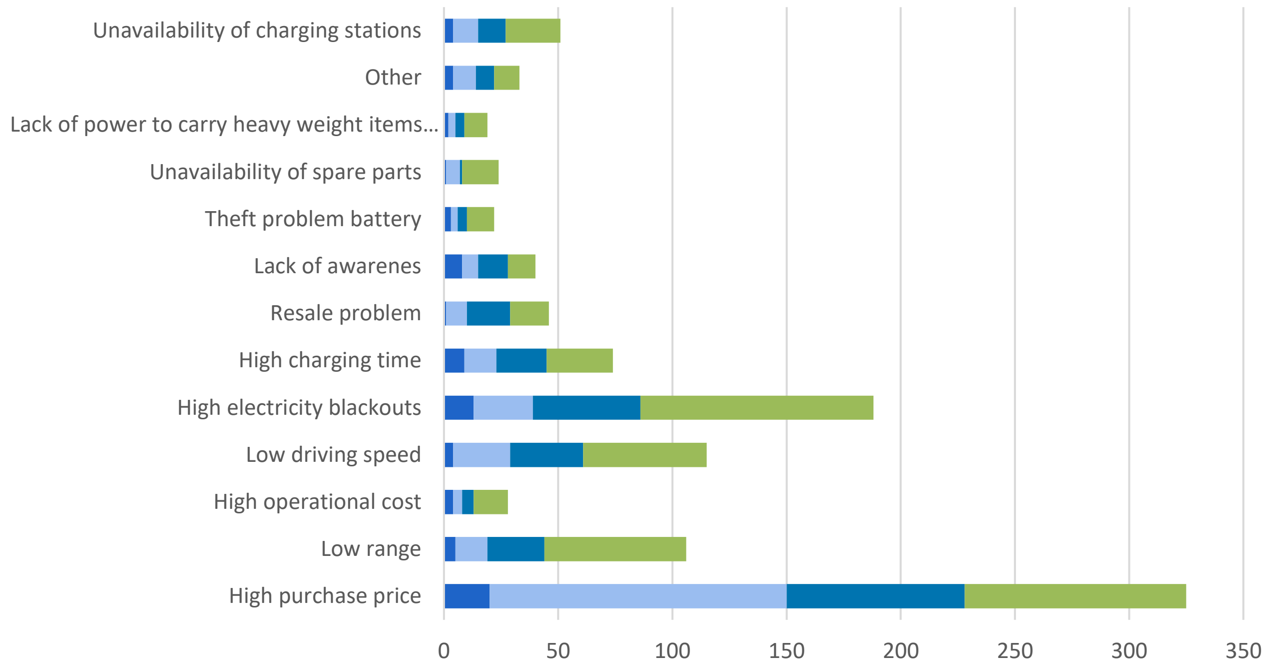


	High purchase price	Low range	High operational cost	Low driving speed	High electricity blackouts	High charging time	Resale problem	Lack of awarenes	Theft problem battery	Unavailability of spare parts	Lack of power to carry heavy weight items (used in supply of items)	Other	Unavailability of charging stations
Less than 20 years	40	21	3	19	34	6	2	6	3	4	3	5	9
20-25 years	114	43	16	44	85	24	20	13	8	12	7	10	17
25-30 years	75	24	5	25	32	19	8	8	6	4	4	5	13
30-35 years	51	6	1	9	13	10	7	2	2	1	3	5	7
Above 35 years	45	7	3	18	23	14	8	11	3	3	2	8	4

Figure 3.2 Age and the reasons for not purchasing E2Ws

4.7.3 Occupation and reasons for not purchasing E2Ws

There was a significant association found between the age and occupation for not purchasing E2Ws (Qp =119, df = 36, p-value < 0.01). In the results, students showed less concern for high purchase price than other occupational groups, as students are financially dependent on their elders. Besides, the non-student occupational group showed more apprehension awareness and resale problem as their top concerns. It highlights that people need word of mouth to understand the features of E2Ws better than relying on the information provided in the survey. The figure below represents the choices between occupations and reasons for not purchasing E2Ws.

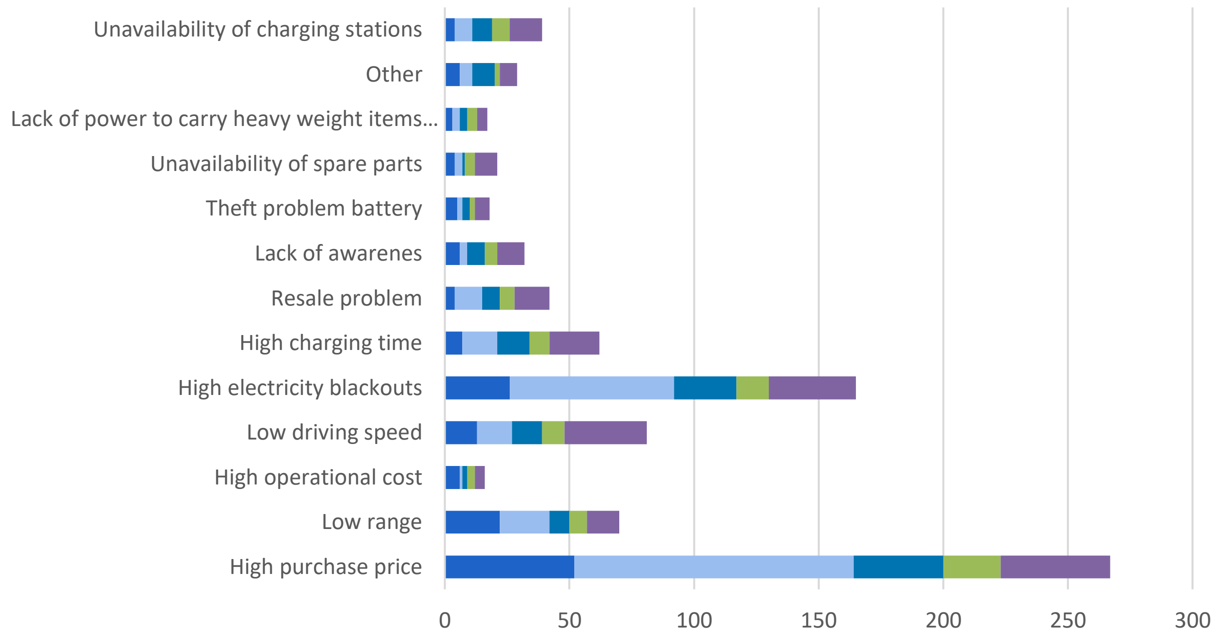


	High purchase price	Low range	High operational cost	Low driving speed	High electricity blackouts	High charging time	Resale problem	Lack of awarenes	Theft problem battery	Unavailability of spare parts	Lack of power to carry heavy weight items (used in supply of items)	Other	Unavailability of charging stations
Government servants	20	5	4	4	13	9	1	8	3	1	2	4	4
Private company employees	130	14	4	25	26	14	9	7	3	6	3	10	11
Personal business	78	25	5	32	47	22	19	13	4	1	4	8	12
Student	97	62	15	54	102	29	17	12	12	16	10	11	24

Figure 3.3 Occupation sand reason for not purchasing E2Ws

4.7.4 Household-Income and reasons for not purchasing E2Ws

There was a significant association found between the variables of household income and reasons for not purchasing E2Ws (Qp =103, df = 48, p-value < 0.01). In the above table, 20% of the cells had expected count than 5, thereby the Monte Carlo method was employed. The household income groups falling in categories more than 40000 rupees were most concerned about high purchase price as a major resisting force for their decision against E2Ws. Hence it shows that respondents with low income are more price-sensitive than high-income groups. The choices of other income groups didn't reveal any important finding. A descriptive of the choices are present in the figure below.



	High purchase price	Low range	High operational cost	Low driving speed	High electricity blackouts	High charging time	Resale problem	Lack of awarenes	Theft problem battery	Unavailability of spare parts	Lack of power to carry heavy weight items (used in supply of items)	Other	Unavailability of charging stations
Less than 20000	52	22	6	13	26	7	4	6	5	4	3	6	4
20000-40000	112	20	1	14	66	14	11	3	2	3	3	5	7
40000-60000	36	8	2	12	25	13	7	7	3	1	3	9	8
60000-80000	23	7	3	9	13	8	6	5	2	4	4	2	7
More than 80000	44	13	4	33	35	20	14	11	6	9	4	7	13

Figure 3.4 Income and the reasons for not purchasing E2Ws

4.7.5 Main barriers and multinomial logistic regression

As blackouts studies have not been previously carried out, we can test whether other resisting forces such as high price could outweigh blackouts. We can perform a multinomial logistic regression in this regard We place the barriers as the dependent variables and place blackouts in the reference category. We place socio-demographic variables such as age, occupation, education, and income as the independent variables. We consider both people who want to continue using their current motorcycle and people indicated to buy another motorcycle in the future as both categories rejected E2Ws in the early phase. Below is the table representing the multinomial logistic regression.

Table 4. 14 Multinomial regression and main barriers to implement E2Ws

Parameter estimates											
Model combination	**High purchase price**	**Low Rage**	**High operational cost**	**Low driving speed**	**High charging time**	**Resale problem**	**Awareness issue**	**Battery theft problem**	**Unavailability of spare parts**	**Lack of power to carry heavy items**	**Unavailability of charging stations**
	Odds ratio	Odds ratio	Odds ratio	Odds ratio	Odds ratio	Odds ratio	Odds ratio	Odds ratio	Odds ratio	Odds ratio	Odds ratio
Intercept	-1.32	-3.270	-24.400	-1.25	-0.644	-1.95	-2.82	-2.07	-2.3	-2.58	-1.78
Age											
Less than 20 years age	1.019	**4.77*** **	0.159	2.388	0.647	0.358	1.056	0.688	1.135	0.429	1.924
20-25 years	0.957	**3.78***	0.24	0.840	0.708	1.580	1.052	0.456	1.049	0.554	1.397
25-30 years	1.160	3.308	0.97	1.556	1.221	1.594	0.822	0.950	1.963	1.690	1.529
30-35 years	1.478	1.079	0.542	1.453	1.145	2.476	0.267	1.870	4.36	3.686	1.952
Above 35 years	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a
Occupation											
Government servant	**3.75*****	**4.78****	**27.63*****	2.786	0.765	0.651	**17.73*****	2.595	1.911	0.805	2.226
Private company employees	**2.784****	**2.51***	3.495	**2.88****	1.354	1.219	**5.52****	0.957	1.884	0.873	2.608
Personal business	**2.18****	1.934	2.438	1.940	1.188	1.792	**5.19*****	0.575	0.160	0.422	1.494
Student	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a
Education											
Less than 12 years of education	1.530	0.876	1.236	1.877	0.861	0.860	0.360	1.162	2.502	2.486	0.695
12th class (Intermediate)	**2.39****	1.851	2.079	2.343	1.501	2.194	2.487	2.206	2.504	2.780	1.369
Bachelors	**5.63*****	**4.96****	**18.39****	2.765	1.396	2.682	2.995	1.872	**18.72*****	**15.83****	0.610

Masters degree or above	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a
Income											
Less than 20000 rupees	**1.98***	2.218	1.373	**0.341****	0.549	0.508	1.235	1.622	0.322	0.840	0.487
20000-40000 rupees	0.624	1.040	**0.0788****	**0.178*****	**0.277*****	0.435	**0.192****	**0.132***	**0.164*****	0.284	**0.265****
40000-60000 rupees	1.205	0.950	0.214	**0.238*****	0.767	0.650	0.719	0.997	**0.129***	0.790	0.984
60000-80000 rupees	1.730	2.520	2.611	0.806	0.900	1.600	1.541	1.195	1.277	1.618	1.828
More than 80000 rupees	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a

Notes

The reference category for the dependent variables: the choice of electricity blackouts as the major resisting force

a = reference category for independent variables

a = reference category for independent variables

Cox and Snell = 0.291, Nagelkerke = 0.294 and McFadden = .0.077

** p-value < 0.10, ** p-value ≤ 0.05, *** p-value ≤ 0.01*

Likelihood Ratio Tests; Significance = 0.04

The model didn't represent an ideal fit as we can observe from the Likelihood ratio chi-square test. We also had low values for Cox and Snell, Nagelkerke and McFadden. In the coming paragraphs, we shed light on the significant results.

Age

We found a significant relationship of age with the resisting factor of the low range of E2Ws. The age category of respondents less than 20 years (*p-value* < 0.01, odd ratio = 4.77) and 25-30 years (*p-value* < 0.1, odd ratio = 3.78) were more likely to choose low range as a resisting force for E2Ws than electricity blackouts. This shows that young people are more likely to have range anxiety than older or mature age group.

Occupation

Considering the odds ratio in the occupation sector, government servants were more likely to choose high purchase price (*p-value* < 0.01, odd ratio = 3.75), low range (*p-value* < 0.05, odd ratio = 4.78), high operational cost (*p-value* < 0.01, odd ratio = 27.63), and awareness (*p-value* < 0.01, odd ratio = 17.73) as a resisting force than electricity blackouts.

Private company employees were are likely to consider the high purchase price (*p-value* < 0.05, odd ratio = 2.78), low range (*p-value* < 0.1, odd ratio = 2.51), low driving speed (*p-value* < 0.05, odd ratio = 2.88) and awareness issue (*p-value* < 0.05, odd ratio = 5.52) than electricity blackouts.

The respondents with personal business were more likely to choose high purchase price (*p-value* < 0.05, odd ratio = 2.18) and awareness issue (*p-value* < 0.01, odd ratio = 5.19) than electricity blackouts.

Education

The respondents who had a Bachelors degree were more likely to choose high purchase price (*p-value* < 0.05, odd ratio = 2.78), low range (*p-value* < 0.05, odd ratio = 2.78), high operational cost (*p-value* < 0.05, odd ratio = 2.78), unavailability of spare parts (*p-value* < 0.05, odd ratio = 2.78) and lack of power to carry heavy items (*p-value* < 0.05, odd ratio = 2.78) as a resisting force than electricity blackouts.

Those respondents who had 12 years of education were more likely to consider the high purchase (*p-value* < 0.05, odd ratio = 2.39) price than electricity blackouts as a resisting force.

Household income

The respondents who had house income less than 20000 rupees (*p-value* < 0.1, odd ratio = 1.98) were more likely to choose high purchase price as a resisting force than electricity blackouts. On the contrary, this income group was less likely to choose the low driving speed (*p-value* < 0.05, odd ratio = 2.39) as a resisting force than electricity blackouts.

The income group of 20000-40000 were less likely to choose high operational cost (*p-value* < 0.05, odd ratio = 0.078), low driving speed (*p-value* < 0.01, odd ratio = 0.178), high charging time (*p-value* < 0.05, odd ratio = 0.277), awareness issue (*p-value* < 0.05, odd ratio = 0.192), battery theft problem (*p-value* < 0.05, odd ratio = 0.132), unavailability of spare parts (*p-value* < 0.01, odd ratio = 0.164) or unavailability of charging stations (*p-value* < 0.05, odd ratio = 0.265) as a resisting force for E2Ws than electricity blackouts.

The respondents falling in the income group of 40000-60000 were less likely to opt low driving speed (*p-value* < 0.01, odd ratio = 2.38) or unavailability of spare parts (*p-value* < 0.1, odd ratio = 0.129) as a resisting force for E2Ws than electricity blackouts.

From the above discussion, it can be inferred that people with Bachelors' degree, government or private employees considered the technical (low range, high charging time etc.,) or non-technical issues (purchase price, operational cost and awareness) more important than electricity blackouts. People with bachelors' degree, government or private employees can be regarded as financially and socially stable. Hence, this stable group values technical or non-technical aspect of E2Ws higher than electricity blackouts. Thereby, it indicates that stable respondents could compromise on electricity blackouts if E2Ws are introduced with the low purchase price and good performance.

4.7.6 Way forward to implement E2Ws in Pakistan

In the end, the consumers were asked which motivating factor would increase their chance to buy an E2W in the future. A total of 1053 respondents answered the question. The percentage-wise distribution of the answer is provided in the figure below.

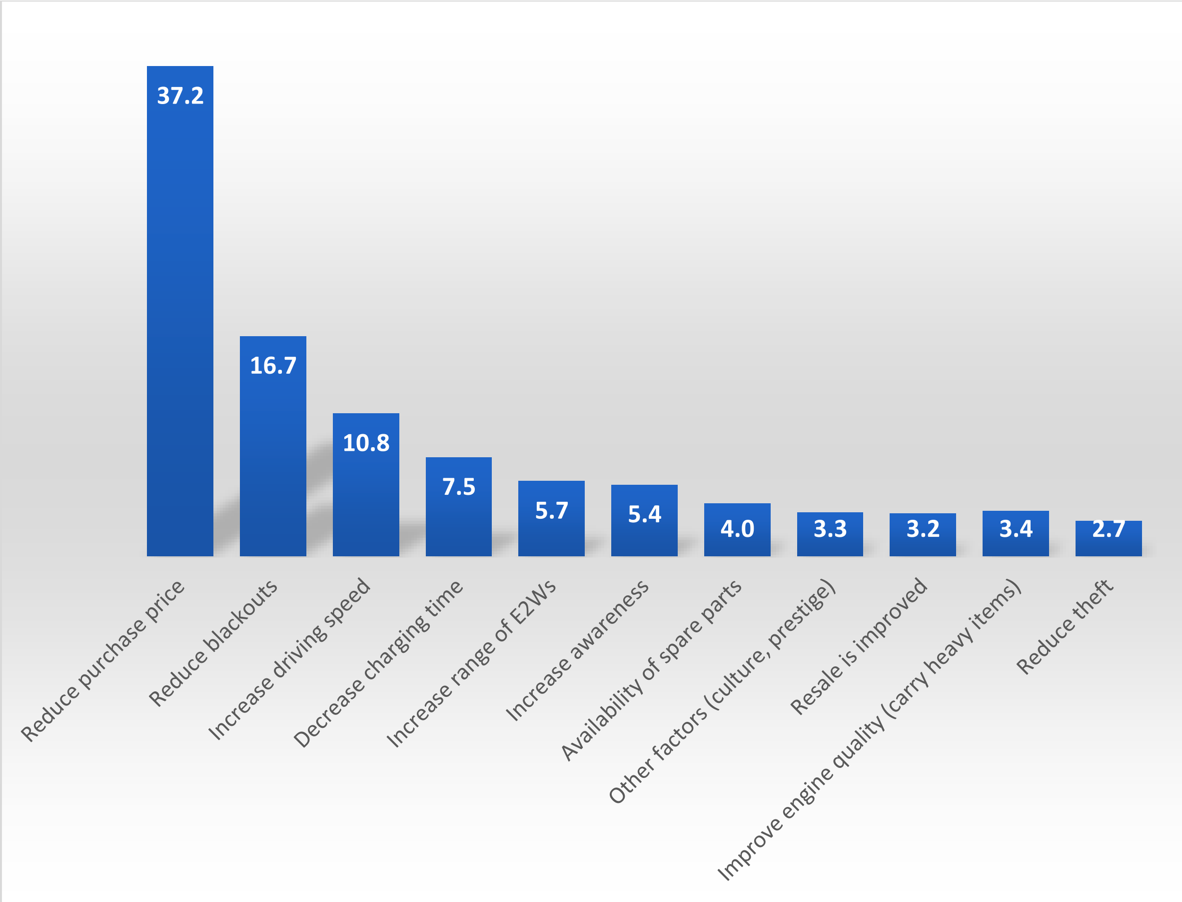


Figure 4.8 Percentage-wise distribution of the important factor that could increase the chance of buying an E2W in the future

We could observe that respondents identified non-technical barriers such as high purchase price and electricity blackouts with high importance than technical barriers such as driving speed and charging time. We could also understand that purchase price or affordability would be the prime solution to motivate people to consider E2Ws in the future. However, other results hold a similarity with section 3.7 in which similar problems are discussed in the context of Pakistan.

Further investigation from the respondents revealed that the scooter style or bicycle-style motorcycle would be a sign of low prestige. If E2Ws are introduced in Pakistan, the shape should match the style of contemporary petrol-based motorcycle or have a sporty look.

Some important representative responses include; “Pakistani people usually check the durability, resale value, speed, and petrol average (charge is this case) if these things are improved and charging stations are established around the city. People might start adopting electric two-wheelers” Another respondent commented, “Electric two-wheeler can be adopted in Pakistan if they are not too expensive and the battery life is up to the mark at least 3-4 years and the battery should be replaceable if life is completed”. Some of the respondents emphasized the government’s role to improve awareness and create markets for the E2Ws. In face to face interviews, some of the respondents argued that load-shedding is not a big problem for E2Ws’ charging as people of Pakistan have adopted alternative means of producing electricity at homes through petrol-based generators and uninterrupted power supply (UPS) through lead-acid batteries. Some of the respondents expressed their reservation against increasing fuel prices which could increase the popularity of E2Ws in Pakistan.

From this open-ended question, it can be realized that people still require more communication regarding the detailed information regarding E2Ws’ attributes. Besides, respondents showed the government's involvement and word of mouth plays an important part to create a trust for the innovative mobility product. The exact verdict for the E2Ws would require user experience for a considerable time-period.

4.8 Power of current motorcycle and the influence on the purchase of E2Ws

In this section, we try to understand whether high-performance of a current motorcycle engine has any role to play for the selection of E2Ws in the future. We divide the respondents into two categories, those who want to continue using their current motorcycle and those who are planning to buy a new petrol-based motorcycle. These respondents were asked whether there is any cost that they will be willing to consider and pay for E2Ws. We have used the cross-tabulation function to understand their current mobility mode choice and future mobility consideration for E2Ws. For the power of the motorcycle, it was divided into two categories: "70cc motorcycle" and "100cc motorcycle or above".

4.8.1 Respondents with the opinion: continue using their current motorcycle

In this section, the majority of the respondents used a 70cc motorcycle. The results are presented in the figure below.

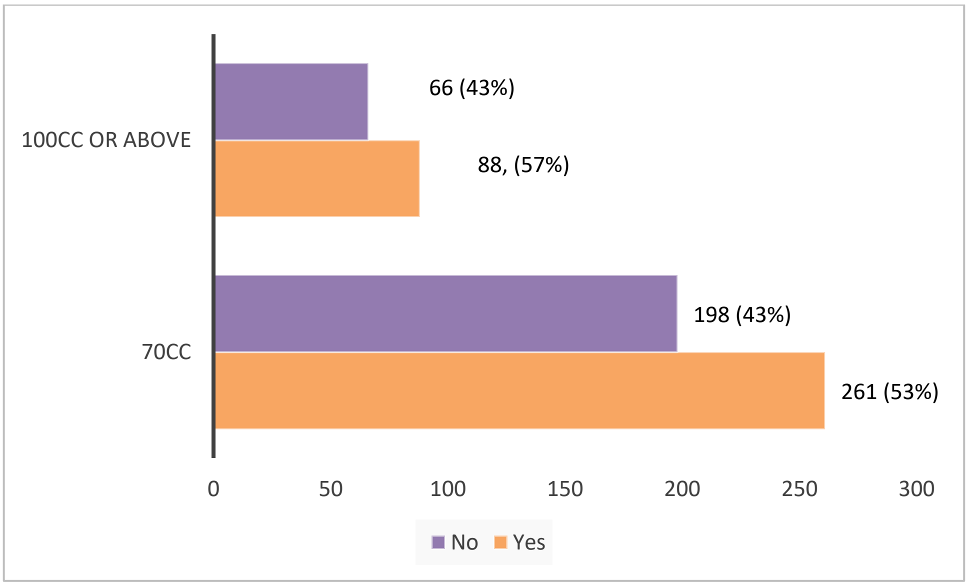


Figure 4. 9 Power of the motorcycle and future mobility decision considering respondents who want to use their current motorcycle

Both categories of 70cc or and above show a 57% inclination towards E2Ws and 43% towards their current mobility mode. It directs that the high power of the motorcycles does not hold considerable influence when respondents make future purchase decisions regarding E2Ws.

4.8.2 Respondents with the opinion: Buy another motorcycle in the future

In the following section, we observe that respondents with 100cc or more engine are more likely to buy E2Ws than respondents with a 70cc engine. However, if the sample size had more respondents in number these results would have more influence.

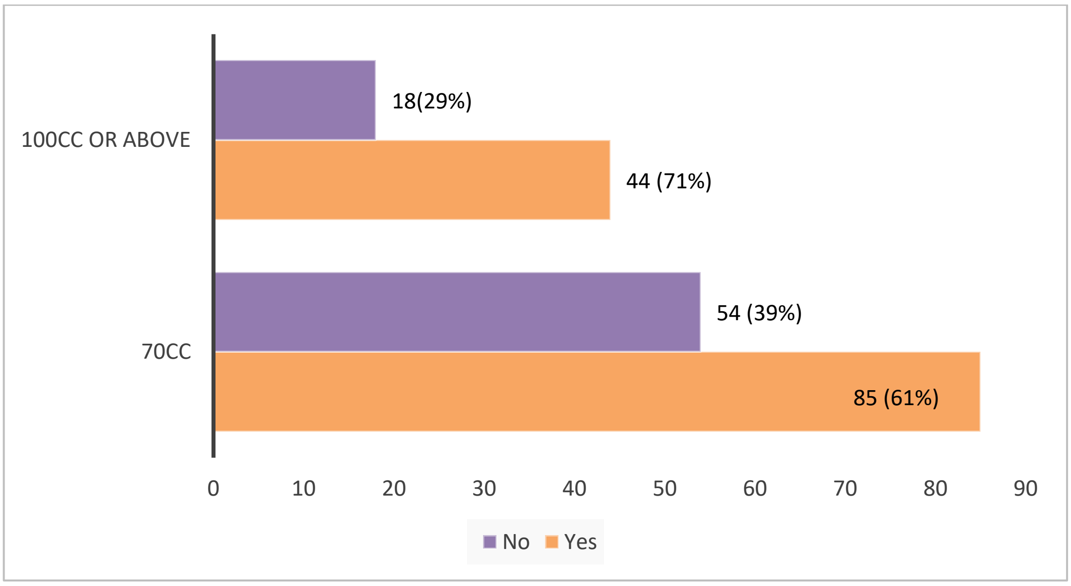


Figure 4. 10 Power of the motorcycle and future mobility decision considering respondents who want to buy another motorcycle in the future

Comparing respondents who want to use their current motorcycle and people who want to buy another motorcycle, we could understand that people with the intent to "buy another motorcycle" are more motivated to buy E2Ws irrespective of having 70cc or 100cc engine motorcycle.

4.8.3 Respondents with a Honda motorcycle

As this group had the highest number of respondents (400), we will try to understand in this section whether this group's purchase of E2Ws' was influenced by the power of their current mobility engine. Below graph presents the power of the engine and future mobility choice.

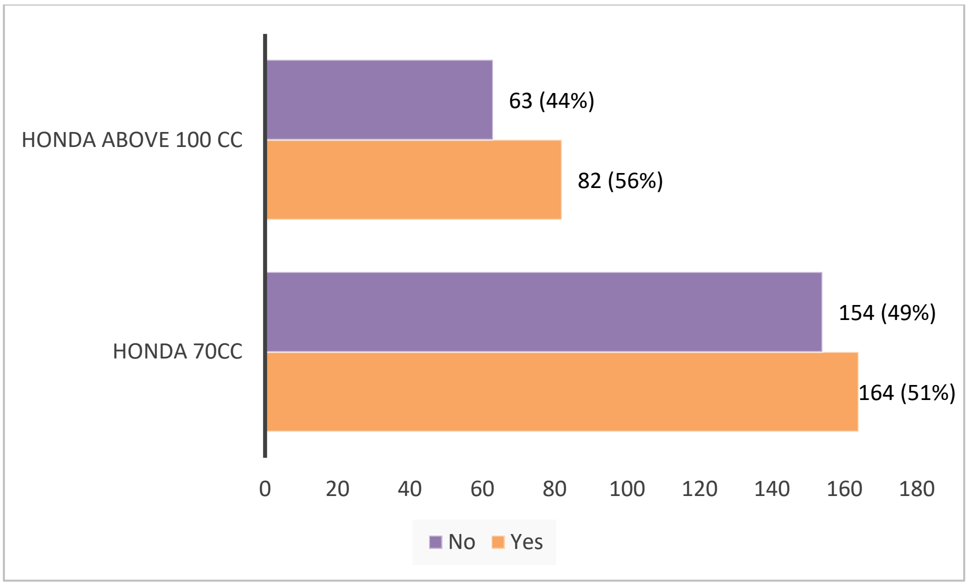


Figure 4. 11 Power of the motorcycle and future mobility decision considering respondents who want to use a Honda motorcycle

We observe that 51% (164) from the total (308) respondents possessing a Honda 70 cc motorcycle were willing to pay a minimum purchase price for the E2Ws. On the other hand, 56% of the total of (145) respondents possessing a Honda 100cc were inclined to buy E2Ws. This shows that people with Honda motorcycle with a powerful engine higher than 70 cc were more likely to buy an E2W.

4.9 Conclusion and policy recommendations

The idea of E2Ws was met with lackluster support in Pakistan. Most of the respondents of the survey favoured to use petrol-based motorcycles (66% = use current petrol-based motorcycle = 50.3% , use other motorcycle in the future = 16.7%) than E2Ws. The respondents identified major resisting factors for E2Ws as high purchase price, frequent blackouts, low speed, and high charging time. Awareness issue as a resisting force for E2Ws was more identified in working-class people and age group above 35 years.

Besides, young people and students were not motivated to consider E2Ws as their future mobility choice. Primarily, people considered that the purchase price of E2Ws should be at par or less than average petrol-based motorcycle price. The findings from the survey revealed that people are more pro cost than pro-environment considering their mobility options.

Additionally, people thought that blackouts are a grave impediment towards the propagation of E2Ws. Government has to improve the energy condition to reduce blackouts so e-mobility can be promoted in Pakistan. Thirdly, people also complained of low speed of E2Ws as a great impediment. People perceived the technical features as low speed not match with their current petrol-based motorcycle. The government can promote E2Ws by providing separate lanes, so they can reach their destinations in time despite the low speed. The government also should reduce heavy import taxes and regulation, so private investors could be encouraged to spend on E2Ws. Lastly, in order to popularize the E2Ws, government and private sector have to work effectively to create awareness.

5 Willingness to pay for electric-two-wheelers in Pakistan

This chapter is ‘under review’ in ‘Research in Transportation and Business Management’ journal of the Elsevier publication.

5.1 Abstract:

This study is focused on the prospects of electric two-wheelers (E2Ws) in an energy deficient country like Pakistan, which faces frequent, long and unscheduled electricity blackouts. The energy deficiency could lead to electricity blackouts which could increase anxieties associated with the inferior attributes of E2Ws, such as long charging time, limited range and effort to plug in and plug out the vehicle. This study will aim to understand the willingness to pay for E2Ws in Pakistan considering electricity blackouts. We use E2Ws to their lower operational cost in comparison to the petrol-based motorcycle. Using the contingent valuation method, a survey was conducted in two major cities of Pakistan to the willingness to pay for E2Ws. In this survey, most of the respondents chose petrol-based motorcycles than E2W as the future mobility option. Respondents with young age, high income, students, or high education were also not attracted towards E2Ws. The pro-E2W's respondents were willing to pay a purchase price in the range of 70000-80000 rupees ($446-$509) for E2Ws. The respondents who were not interested in E2Ws stated purchase price range of 20000-30000 ($191-$312) for E2Ws. Despite severe electricity blackouts, people ranked high purchase price as the most important barrier for the propagation of E2Ws in Pakistan. In conclusion, it is suggested to introduce a purchase price which is equal or lower than current petrol-based motorcycles in Pakistan.

Keywords: Willingness to pay, electric two-wheelers, blackouts, purchase price

5.2 Introduction

The increase in motorization along with exorbitant harmful emissions pose a dangerous environmental and traffic situation for the commuting and non-commuting residents of Pakistan

(B. Lin & Raza, 2019; Pakistan Automotive Manufacture Association, 2018). The way forward could be the adoption of clean vehicles such as Electric two-wheelers (E2Ws). The E2Ws are on the rise in China and other South Asian countries, due to their zero tailpipe emissions and low operational expenses (C. R. Cherry et al., 2009; J. Weinert, Ma, & Cherry, 2007; T. Weiss, Cobb W, L, V, & N, 2017; Zhu et al., 2019). In China, the E2Ws have an operational cost of $ 0.007 per kilometre in comparison to $ 0.031 per kilometre of gasoline two-wheelers (J. X. Weinert et al., 2005). The current E2Ws offered in Asian markets have lower speed and high charging time than conventional vehicles (C. R. Cherry et al., 2009; J. Weinert et al., 2008).

The main research question involves how much people are willing to pay considering the different socio-demographic features. We employ the methodologies of ordinal logistic regression to understand how much people are willing to pay for E2Ws. Pakistan is also facing an energy crisis that results in long and unscheduled blackouts. These blackouts could increase anxieties associated with E2Ws such as long charging time, limited range and unavailability of charging stations. It is interesting to understand the willingness to pay for E2Ws in an energy deficient country marked by electricity blackouts. In this regard, a stated preference survey was carried out in two cities of Pakistan. Previous studies have also used the stated preference survey method to understand the demand for clean vehicles (Beggs, Cardell, & Hausman, 1981; Calfee, 1985; Dagsvik, Wennemo, Wetterwald, & Aaberge, 2002; Hidrue et al., 2011). The stated preference is also ideal in a situation where there is limited knowledge for an innovative mobility product (L. R. Jones et al., 2013; Louviere & Hensher, 1983). One of the main reason for the non-acceptance of electric vehicles (EVs) has been a high purchase price (Noel et al., 2019). This chapter will help policymakers understand how much people are willing to pay if they show an interest in the purchase of the electric two-wheelers. Hence, the ideal purchase price evaluated in this study could help policymakers to grasp an introductory purchase price for E2Ws for Pakistan. We have used three vehicles as electric bicycles, electric scooters and electric motorcycles as reference vehicles to understand the willingness to pay in comparison to petrol-based motorcycles. The survey was conducted in the two major cities of Pakistan namely, Hyderabad and Karachi. The survey was confined to motorcycle users as they were considered prospective E2W's users. These petrol-based motorcycle users could provide more insight into technical and non-technical aspects such as speed or purchase price than other mobility users.

As indicated by the total cost of ownership (in the previous chapter) and survey result that the initial purchase price is the most considerable influence for the purchase of E2Ws. It also indicates that a higher purchase price for E2Ws could lead to rejection of such technology. Hence, the initial price should be controlled by the government so that the producer and the consumer should benefit from it. We also try to understand whether people are inclined towards E2Ws by paying the vehicle through instalments or full purchase price. This could help the policymakers such as the government and producer to understand if people are ready to purchase through instalments or paying the full purchase price. The private showroom owners could benefit if the people choose to use the E2Ws by instalments, indicating that the government could support such ventures.

In the first section, the literature review is explored for the current research on willingness to pay for E2Ws. In the succeeding section, the future mobility option is discussed considering individual characteristics such as education, age, occupation and household income. In the later sections, the results of the willingness to pay for E2Ws in Pakistan is discussed. We also discussed the contemporary business models used in the petrol-based two-wheelers in Pakistan. From the results, it can be inferred that E2Ws in Pakistan should be introduced which have a considerably lower price than petrol-based motorcycles.

5.3 Background

Willingness to pay for E2Ws

The willingness to pay could be defined as the maximum price at or below which a customer will certainly buy one unit of product (Miller et al., 2011b). The willingness to pay for a product or a service is vital in developing a new product, performing value audits or formulating competitive strategies. For policymakers, the willingness to pay for EVs is instrumental in understanding the estimation of demand or designing optimal pricing strategies (Miller et al., 2011b). There is always a maximum and minimum price that can be promptly asked from a customer. A direct price asking strategy is known as the direct measure to approach the willingness to pay (Breidert, Hahsler, & Reutterer, 2006). In this study, this direct approach or strategy is used to achieve the desired results. In our study, we ask the maximum and minimum purchase price by creating two groups of pro-based motorcycle respondents and pro-E2W respondents. In this study, we use this approach to achieve optimal pricing strategy.

This study used the contingent valuation method (CVM) which is used to quantify people's willingness to pay for products that are not present in the market (Bonini, Biel, Gärling, & Karlsson, 2002). The CVM is a type of stated preference approach that considers the hypothetical market system to understand the willingness to pay for an innovative environmental product (Carson, 2000; Hadker, Sharma, David, & Muraleedharan, 1997; Zhu et al., 2019). There are various studies which highlight that the CVM has been widely used to understand the willingness to pay for EVs (Bjerkan et al., 2016; Hidrue et al., 2011; B. Lin & Tan, 2017; Potoglou & Kanaroglou, 2007; Y. Zhang et al., 2011). In this survey, discrete choices were asked for the willingness to pay for E2Ws. The discrete choice questions are convenient in data analysis (Zhu et al., 2019). Considering EVs, previous studies revolve around demand studies using stated preference analysis in some form (Beggs et al., 1981; Calfee, 1985). Stated preference surveys are instrumental to understand future buying when there is limited knowledge or market for a product (Loomes, 1997). In a study by Zhu et al. (2019), the contingent valuation method was employed to understand the future mobility of E2Ws. In this study, respondents who were pro E2Ws were asked the amount of 1000 Macau Pataca (MAO) above their current mobility mode to buy electric motorcycles. If they agreed, they were inquired again if they can pay 2000 MAO over their current mobility mode. Those people who were willing to pay above for electric motorcycles but not agreeing for 1000 MAO were asked again. This time they were asked 500 MAO. Hence, this study develops three price ranges for the people who were willing to pay above their current mobility mode. A similar choice based willingness to pay for EVs was conducted in China (B. Lin & Tan, 2017).

Based on the stated preference choice used in this survey, the respondents were asked to choose among petrol-based motorcycles or the three types of E2Ws. The electric motorcycle, electric scooter and electric bicycle constituted the three types of E2Ws used in this survey (see Figure in the previous chapter). However, we inquired willingness to pay by creating pro-E2Ws and pro-petrol-based group.

Product development and competitive strategies mostly rely on the customer's response to different prices. According to a study, 8-15% of all companies develop pricing strategies based on optimal consumer behaviour (Breidert et al., 2006). Besides, the optimal pricing strategy largely depends on valid estimates on the WTP (Balderjahn, 2003). In another study, it is was evaluated that WTPs is systematically higher in hypothetical settings where the subjects are not obliged for purchase decision at the end (Sattler & Nitschke, 2003). The concept of eliciting a maximum and minimum purchase price is used in these circumstances. This study aims to develop a price range which is helpful when a future customer has limited knowledge about the unfamiliar product (Wang, Venkatesh, & Chatterjee, 2007).

The willingness to pay for the purchase price of EV is equally important as paying for contemporary gasoline vehicle (Carley et al., 2013; Graham-Rowe et al., 2012). In a study by Graham-Rowe et al., (2012), it was evaluated the high price of EVs should be justified by the superior attributes. An increase in the purchase price lowers the probability that an E2W is chosen as future mobility mode (L. R. Jones et al., 2013). Despite the lower operational cost due to the usage of electricity, the higher purchase price does not seem to attract customers on a wider scale (Coffman, Bernstein, & Wee, 2017). Therefore, we will understand through this study, how much people are willing to pay for E2Ws considering its low operational cost and inferior attributes. In a recent study by Zhu et al (2019), respondents revealed a low acceptance and willingness to pay for electric motorcycles than petrol-based motorcycles. In a study by Wahab & Jiang (2019), the odds of selecting an electric motorcycle is reduced, if the purchase price is higher than the fuel-based motorcycle. In another study by Luke Jones and Eric Guerra (Guerra, 2019; L. R. Jones et al., (2013), people are inclined to pay additional amounts on the purchase of E2Ws, if the speed, charging time or range is improved. Some of the research studies direct that consumers willing to pay for electric motorcycles on the presence of financial benefits, like service incentives, subsidies or tax breaks (Eccarius & Lu, 2020; L. R. Jones et al., 2013). The customer intention to adopt an E2W also depends on the image of the vehicle in society (J. H. Wu et al., 2015). Previous studies considering the willingness to pay for the EVs are mentioned below.

Table 5. 1 Contemporary studies on the willingness to pay for EVs

Reference	Focus/attributes	Methods	Results
(Hidrue et al., 2011)	Driving range, charging time, pollution, acceleration	Random class utility model used to understand the willingness to pay for future electric vehicles by conducting a web-based survey	People were willing to pay $10000-16000 for EVs they favour than gasoline vehicles
(K. Lebeau, Mierlo, Lebeau, Mairesse, &	Maximum speed, charging time, driving range	Personal interview and a web-based survey, simple descriptive statistics	Only 27% of people are willing to pay more than conventional vehicles

Macharis, 2013)			
(Zhu et al., 2019)	Purchase price, driving speed, and load capacity education level, income level	Binary logistic regression	The mean willingness to pay for electric motorcycle is 1315 Macau Pataca (MOP) which is far lower than the current ordinary fuel motorcycle of 8000 MOP
(L. R. Jones et al., 2013)	Gasoline prices, sales tax	Mixed logit model	The consumer on the average is willing to pay 10 million Vietnamese dongs for the improvement in speed, charging time and range of the electric two-wheelers.

(Guerra, 2019)	Purchase prices, speed, range, charging time	Mixed logit model	Respondents were willing to pay a 7-13% premium for motorcycles with 10 kilometres long charging time or an hour shorter charge time
(Chiu & Tzeng, 1999)	Speed, range, age, education and gender	Multinomial logit models	Males are more willing to pay than females for increasing maximum speed

5.4 Methodology

5.4.1 Survey

The willingness to pay section was the second part of the survey used in our study. Section 3.4.1 highlights how the survey was conducted.

There are previous studies in the literature which highlight that respondents were initially asked to look at a product and its price and later required to cite their willing to pay for such the product (Cooper, Hanemann, & Signorello, 2002; Kim, Lee, & An, 2018; McNamee, Ternent, Gbangou, & Newlands, 2009). The initial purchase price is also called the bidding price or initial bid (Park & Chang, 2019). In the study by Lo & Jim (2015), respondents were allowed to chose from a range of prices for a product which they seem suitable for the purchase of in the future. The selection of a particular choice from the given option is called payment card method. The payment card in which lot of information is provided is known as an anchored payment card (B. Lin & Tan, 2017). Besides, this study indicated that the range of different prices reduces the cognitive burden to think for a price by the respondent himself. We use this anchored payment card method in our study. We first present respondents with a price shown to them or a bidding price. Those who do not wish to choose E2Ws or present a protest bid (stating no or zero price) were asked again to state a purchase price that they willing to pay for E2Ws. There are some studies in which respondents are asked twice for their choice. Considering the example of Zhu et al., (2019), the same set of respondents were asked twice. First, they were asked the willingness to accept E2Ws. Later, similar respondents were asked the willingness to pay for E2Ws, irrespective of their previous choice. On the next set of questions, the people who quoted a positive response for E2Ws were asked a high price to settle for the E2Ws. Whereas, the people who said no are asked were asked a low price in which they could compromise. This type of asking question twice is known as a dichotomous choice contingent method. Several studies have been related to the dichotomous style choice contingent method (Jim & Chen, 2006; Lee & Heo, 2016; Watson & Ryan, 2007; Zhu et al., 2019). (Lee & Heo, 2016) (Jim & Chen, 2006) (Watson & Ryan, 2007). In our study, we also ask twice from but from the pro-petrol respondents only to choose a price for E2Ws. Hence, in our study, we use a modified version of the dichotomous payment method coupled with the anchored payment card. However, we could not find any literature that resembled our methodology.

As noted in the literature, respondents state a high purchase price when they are not obliged to make a purchase decision in the end (B. Lin & Tan, 2017). To counter this situation, a comparative analysis was performed by asking maximum purchase price from pro-E2Ws and pro-petrol-based motorcycle respondents. The purchase price shown to the respondents were inspired by the international literature and small level companies' information which tried to introduce electric motorcycles in Pakistan. The initial purchase price shown to the respondents would motivate them to state a purchase price in which they could afford the electric motorcycle. This purchase represents the actual price that some electric motorcycles were introduced in Pakistan but could not generate any market position (Pro Pakistani, 2017). This initial purchase price of the electric motorcycle was higher than an average petrol-based motorcycle sold in Pakistan (Pakwheels, 2010). However, this high purchase price could resonate with the true value for E2Ws that were introduced in Pakistan on a small level (Isha Lodhi, 2017; Pro Pakistani, 2017). Initially, all respondents were asked about the future mobility choice that included electric motorcycles, electric scooter, electric bicycle, using their current petrol-based motorcycle or choosing another petrol-based motorcycle. There has been the previous study by Guerra (2019) in which the vehicles were shown and asked about the future mobility choices. The respondents who chose the petrol-based motorcycle could be regarded as pro-petrol respondents. On the other hand, the respondents who chose E2Ws as future mobility option could be regarded as pro-environment or pro-E2Ws. With the help of discrete choice models, the pro E2Ws respondents were inquired to state a maximum purchase price (ranging from 20000,30000… more than 150000 rupees) after looking at the attributes of the E2Ws. These pro-E2Ws were asked further questions regarding payment method and reason for purchasing E2Ws. The respondents who selected petrol-based motorcycle as future mobility option were further inquired through a separate loop of question using the Qualtrics tool. The pro-petrol-based motorcycles were asked again if there is a maximum purchase price they could consider to buy E2Ws in the future. Those who selected 'yes' were further inquired to state a maximum purchase price from a set of choices (ranging from 20000,30000…more than 150000 rupees). Further questions were asked for the reason for not selecting E2Ws and payment methods to purchase E2Ws. It was predicted that pro-petrol-based motorcycle respondents will state a small purchase price than pro-environment respondents. Hence, the highest and lowest willingness to pay for E2Ws could be derived from the purchase decisions of the pro-E2Ws and pro-petrol-based motorcycle respondents respectively. By using Qualtrics and segregation of pro-E2Ws and pro-petrol-based motorcycle respondents, we created subgroups to understand the payment preference of EMs. This is a new method to capture the contingent valuation method which was not found in the literature.

The figure below represents the flow of questions used in the Qualtrics survey form to understand the mobility choice along with purchase decisions. Due to the low frequency of electric scooters and electric bicycle we have limited our discussion to the electric motorcycle in this chapter.

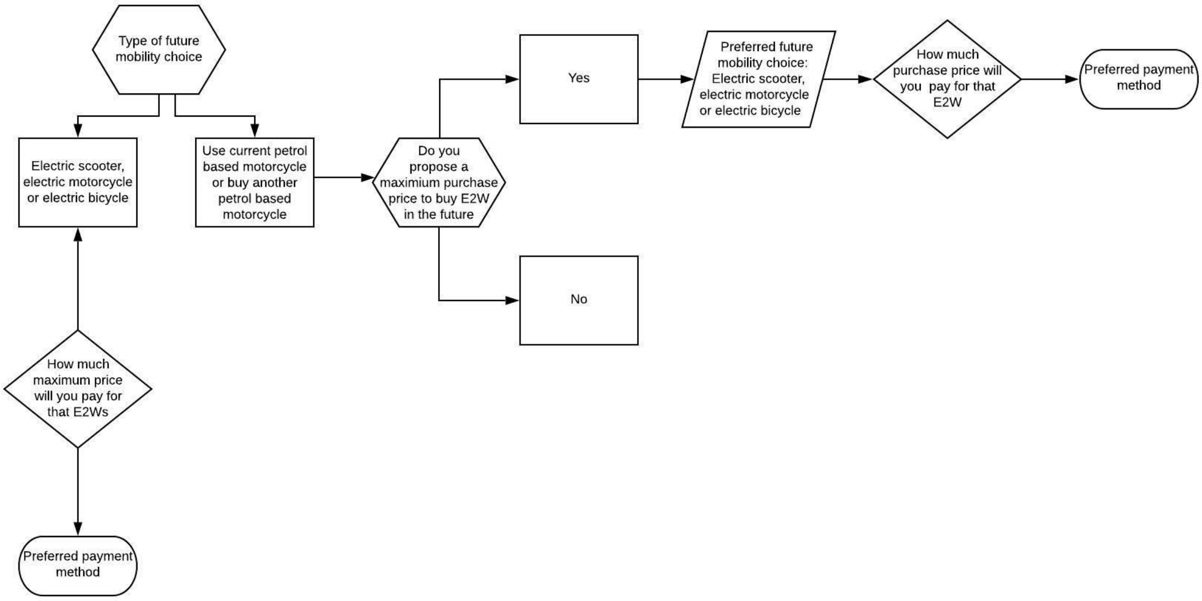


Figure 5. 1 Flow chart of questions used to obtain the maximum willingness to pay for E2Ws

5.4.2 Ordinal logistic regression

The ordered logit model is used when the dependent variables follow some kind of order and logical sequence (Dlamini, Tesfamichael, Shiferaw, & Mokhele, 2020). In this model, each level of the dependent relationship has a similar relationship with the independent variables. The results of the coefficients can be interpreted in similar ways like the binary or multinomial logistic regression. The ordinal logistic regression can be written as follows (Williams, 2006)

$$P\ (Y_i > j) = p_1 +\ p_2 + .. + p_j = \frac{\exp\left(a_j +\ X_i B_j\right)}{1 + \left[a_j + \exp\left(X_i B_j\right)\right]}, j = 1.2 \ldots M - 1 \quad (1)$$

In the above equation, j = 1, 2..., J is the dependent variables. X is a matrix (n x p) of independent variables, a_j and B (a vector (px1)) are p + J parameters which are to be estimated. Thereby, $P\ (Y_i > j)$ measures the probability of Y falling at or below than a provided j.

The odds ratio can be calculated using equation 1.

$$Odds = \frac{P\ (Y \le j)}{1 - P\ (Y \le j)} = \frac{P_1 + P_2 + ..P_j}{P_{j+1} + P_{j+2} + ..P_J} \qquad 2$$

The calculation of the natural logarithms by transforming equation 2 to a linear form would result in the odds ratio. When the coefficient value is positive, the probability to move to the higher ordinal category would be optimistic.

5.5 Willingness to pay as stated by the Pro-petrol respondents

As in the previous section, the willingness to pay is defined as the maximum purchase price when people will definitely buy one unit of product. It was anticipated in the survey that there will be a group of respondents who will consider E2Ws as a future mobility option while another group will opt for petrol-based motorcycles. The choice of the highest frequency would reveal the maximum purchase price both groups are comfortable to pay for the E2Ws. This maximum purchase price quoted by the respondents could be the highest and the lowest willingness to pay for E2Ws by the two groups mentioned above.

The people who selected petrol-based motorcycles were asked again if there is any purchase price that they were willing to buy E2Ws in the future. A total of 1049 respondents answered the question. Considering the response, 602 (57%) of the pro-petrol motorcycles respondents were positive to state a price they would purchase the E2Ws. Despite, giving them the option to state the lowest price for E2Ws, 447 (43%) referred to continue using petrol-based motorcycles. This indicates that some of the respondents are not willing to purchase the E2Ws due to low attributes in comparison to petrol-based motorcycles. The figure below describes maximum respondents are comfortable to pay for the E2Ws.

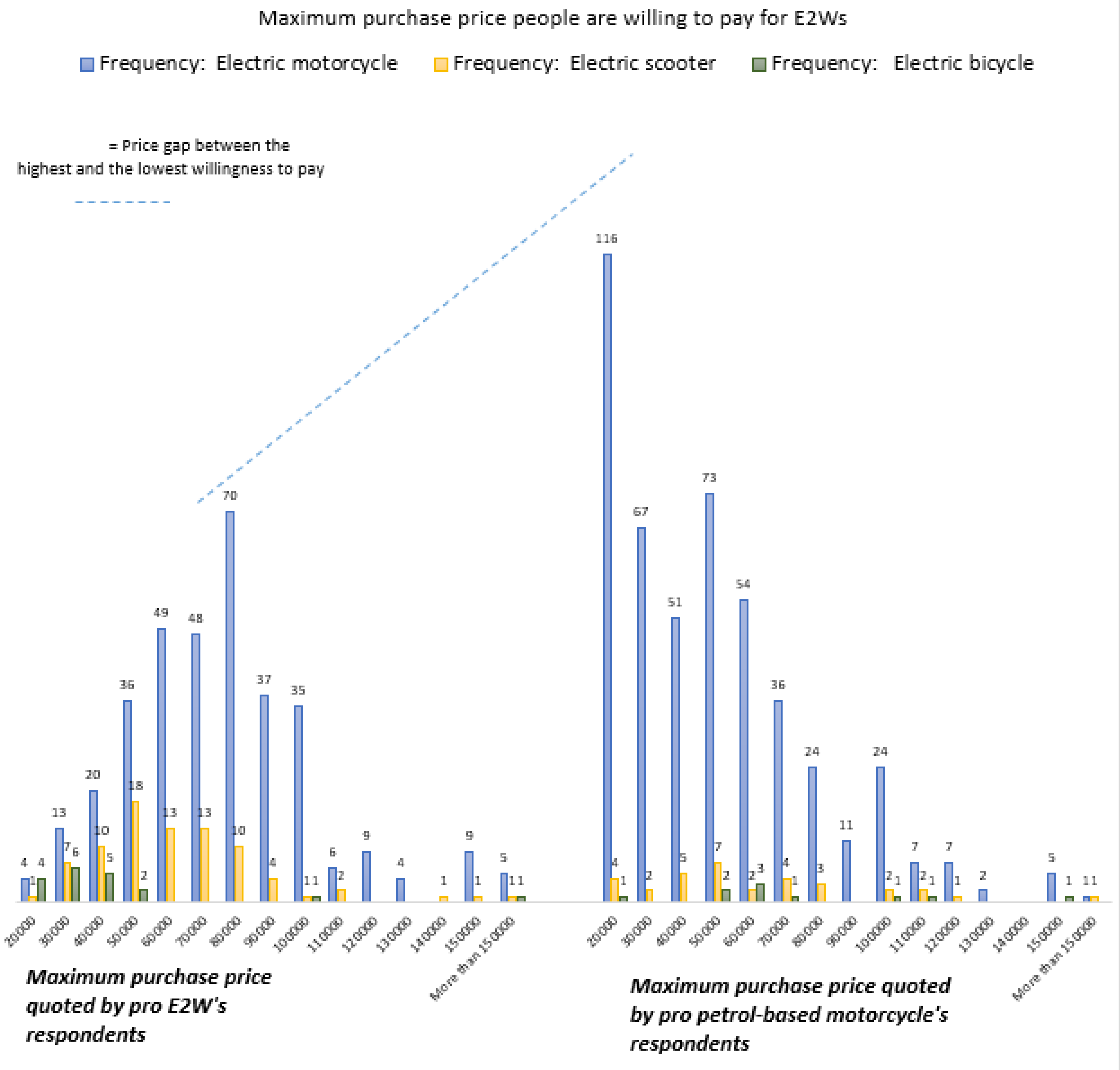


Figure 5. 2 Maximum purchase respondents are willing to pay for E2Ws

From the above frequencies, it is realized that electric motorcycle was the most popular choice among the E2Ws. It highlights that there is almost non-existential willingness to pay for electric scooter or electric bicycle. Therefore, we will further reserve our discussion in this section to electric motorcycles as future mobility choice only. In the figure above, after looking at the specific attributes the pro E2Ws' respondents quoted the highest frequency falling in the categories of 70000-80000 ($446-$509) rupees considering electric motorcycles. This quoted price is 20000-30000 ($127-$191) rupees more than the average price people pay for the purchase of petrol-based motorcycles in Pakistan. However, it is also 35000-45000 ($236-$286) less than the introductory and hypothetical price shown to them in the survey. The hypothetical purchase price was used as a source of priming to motivate respondents to quote a purchase price they are comfortable to pay. Hence, the results reveal that respondents were inclined towards electric motorcycles which have a lower purchase price.

Considering the petrol-based motorcycles who were asked again to quote a purchase price, most of the respondents cited a purchase price of 20000 ($127) and 30000 ($191) rupees as the price of electric motorcycles. This price is 20000-30000 ($127-$191) rupees less than the average price of petrol-based motorcycles available in Pakistan. It is also 705000-80500 ($449-$513) rupees less than the sticker price used in this survey. It directs that respondents who are unwilling to consider E2Ws as future mobility would require a substantially reduced purchase price to motivate them.

As discussed in the above paragraphs, the highest and lowest willingness to pay for E2Ws could be described as 70000-80000 ($446-$509) and 20000-30000 ($127-$191) respectively. The difference between the highest and lowest willingness to pay is around 50000-60000 ($318-$382) rupees. This difference of 50000-60000 ($318-$382) could be abridged if the government provides extra benefits like free parking, tax benefits or exemption from government registration fees to motivate people towards E2Ws. If the government provides the above-mentioned benefits, the ideal purchase price for an electric motorcycle could be 40000 ($254) rupees or more. This purchase price coupled with extra benefits could attract prospective customers to pay for electric motorcycles.

From the above results, one can infer that the average price that could motivate future users should be less than petrol-motorcycles available in Pakistan. The study relates to the study of Zhu et al., (2019), in which respondents were willing to pay less than the offered purchase price. If additional benefits are not provided by the government or private institutions, the ideal price would be around 30000-40000 ($191-$254) rupees that could attract pro E2Ws or pro-petrol-based motorcycles to consider electric motorcycles in the future. This price would be affordable by the lower-income people and it would be less than the average 70cc petrol-based motorcycle price in Pakistan.

5.5.1 Willingness to pay as stated by the respondents who are considering to buy another petrol-based motorcycle in the future

To get more insight and understand the willingness to pay among pro-petrol-based respondents we divided the respondents into two categories. These consisted of respondents who were willing to buy another petrol-based motorcycle and the people who were in the mode to continue using their current motorcycle. A total of 1049 answered the question (also discussed in previous paragraphs). The respondents who opted to use their current motorcycle were 795. Out of the total of pro current motorcycle respondents, 436 opted to quote a price they would comfortable to pay a minimum purchase price for E2Ws and 359 refused to quote a purchase price. These respondents could also had bought a new motorcycle, and they were unwilling to negotiate any price for the E2Ws.

On the other hand, out of the total pro buying new petrol-based motorcycle respondents, 166 were willing a minimum purchase price they would be comfortable to purchase the E2Ws. Whereas, 88 pro buying new petrol-based motorcycle respondents refused to quote a minimum purchase price. The people who refuse can be regarded as people who display a protest bid or not paying any price for the E2Ws. The frequency and percentage-wise distribution of the two groups is shown in the figure below.

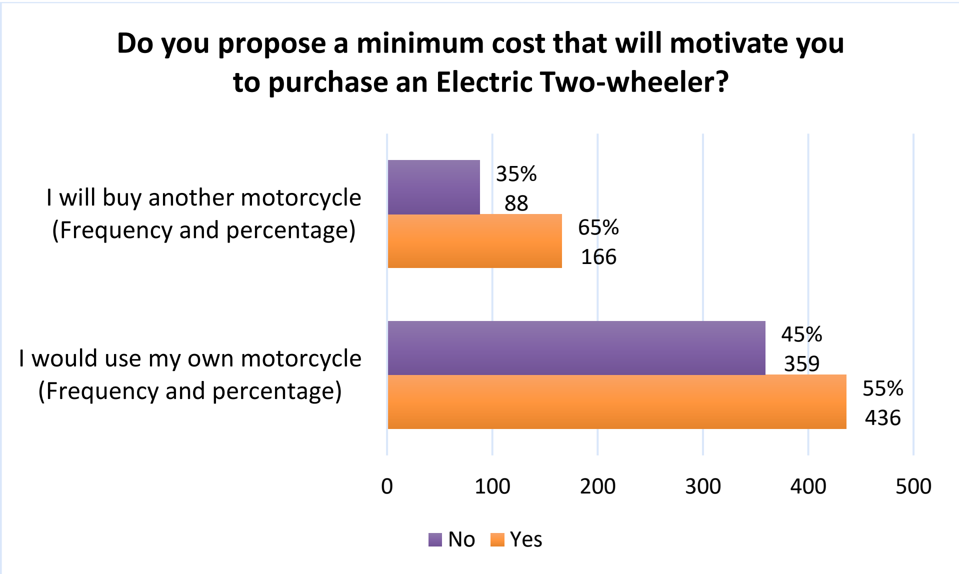


Figure 5. 3 Frequency and table of the willingness to pay from the pro-petrol respondents

In the below figure, we observe that respondents who opted to buy other motorcycle had a higher willingness to pay for EMs than respondents who opted to continue using their current petrol-based motorcycle.

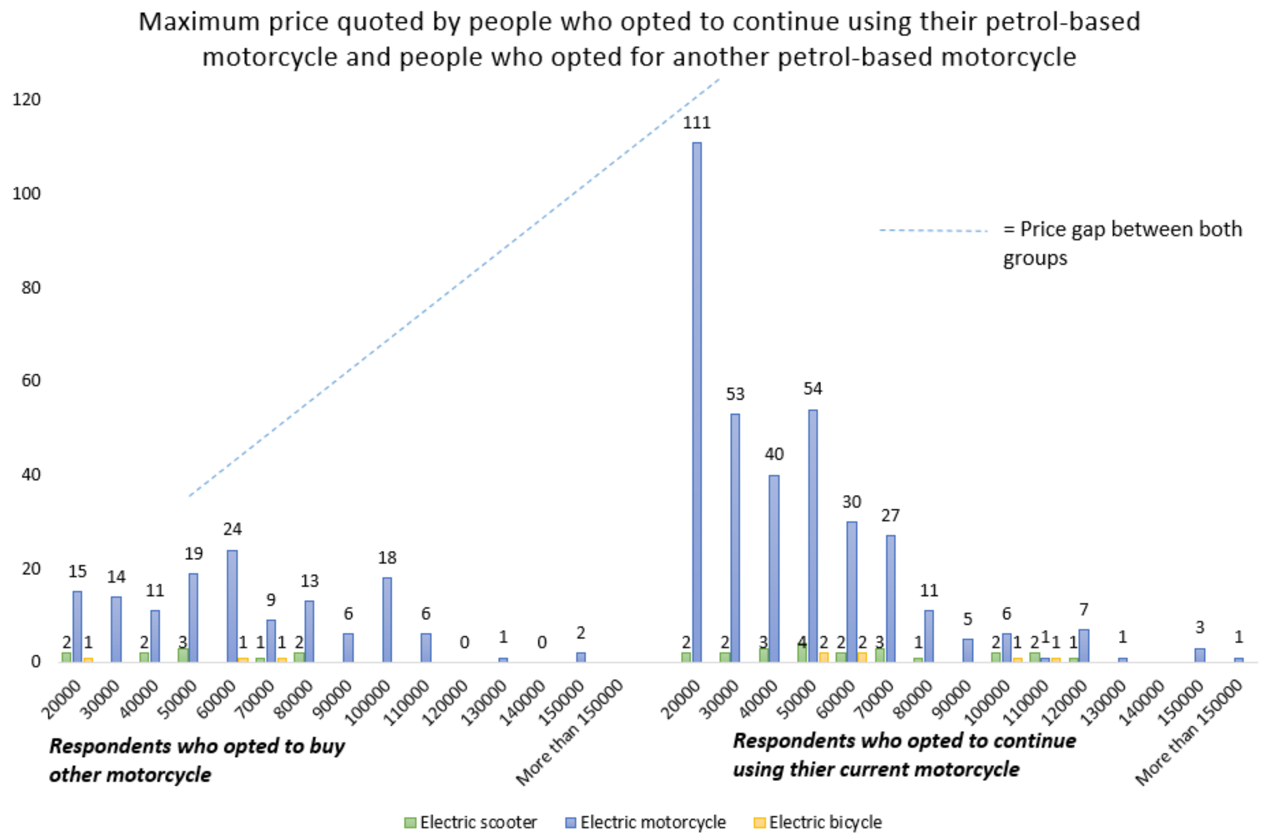


Figure 5. 4 Difference of willingness to pay for EM among pro-petrol-based motorcycle respondents

We observe that respondents who opted to buy other motorcycle had a higher willingness to pay for EMs than respondents who opted to continue using their current petrol-based motorcycle. The group interested to buy other motorcycle suggested purchase price of 50000 ($321) and 60000 ($386) rupees (prevalent by the frequency), whereas, respondents interested in using their current petrol-based motorcycle suggested a price of 20000 ($128) and 30000 rupees ($193). This directs that respondents who are considering to buy a new petrol-based motorcycle would pay a higher purchase price for EMs than respondents who consider continuing their current petrol-based motorcycle.

We also did a comparative analysis of pro E2Ws respondents and the people willing to buy another motorcycle in the future. The results are shown in the figure below.

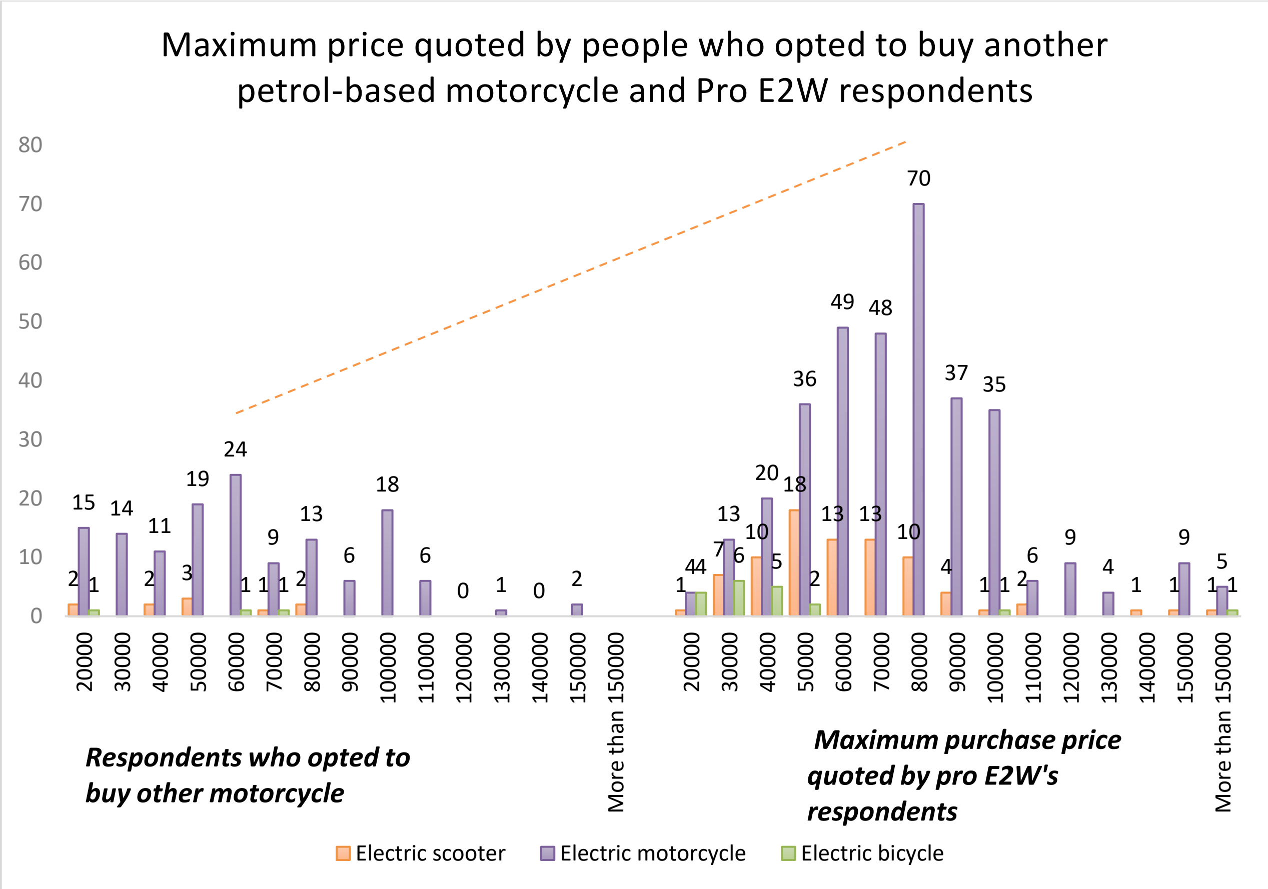


Figure 5. 5 Difference of willingness to pay for EM among people who prefer another motorcycle and pro E2Ws respondents

The highest price paid by the people who wanted to buy another motorcycle was 20000 rupees less than pro E2Ws respondents. On average people pay 40000-50000 rupees for petrol-based motorcycle. Hence, respondents who opted to buy another motorcycle could be willing to pay more than the average petrol-based motorcycle in Pakistan.

5.5.2 Ordinal logistic regression: Willingness to pay from respondents who are willing to buy another petrol-based motorcycle

The respondents who were willing to buy other petrol-based motorcycle were sub-sampled as they had shown an indication of the purchase of two-wheeler in the future (278 respondents). In the earlier section of the survey, respondents were asked the current motorcycle they own and the purchase price for their conventional motorcycle. Out of the total 278 respondents from the sample (people who wanted to buy a new petrol-based motorcycle), only 91 had answered both the questions of the willingness to pay question for petrol-based motorcycles and E2Ws. Hence, we explore the difference between the willingness to pay for E2Ws and the petrol-based motorcycle they already have in use. This difference (approximate) will be our dependent variable. We will understand how much the independent variables of age, education, household income and occupation influence the difference of the willingness to pay between current mobility and future mobility mode.

In the first column of the table below, we show the price that our sample in consideration paid for their current petrol-based motorcycle. In the second succeeding column, willingness to pay for E2Ws was present. In the third column, the price difference between the current motorcycle and willingness to pay for E2Ws is shown. We could formulate four categories from the payment difference between petrol-based motorcycle and E2W. These could be categorized as who paid very less (difference of more than 5000 rupees), moderately less (difference of less 50000 rupees), moderately high (willing to pay 0-50000 thousand rupees more than their current motorcycle) and very high((willing to pay more than 50000 rupees) for the E2Ws in comparison to their current petrol-based motorcycles. The higher willingness to pay can be obtained by the positive and high difference. Whereas, the lower willingness to pay can be obtained by a higher negative difference (Q. Zheng, Wang, & Lu, 2018).

Table 5. 2 Difference between willingness to pay for E2Ws and petrol-based motorcycles

Payment for petrol motorcycles	Willingness to pay for E2Ws	Difference between actual payment for petrol-based motorcycle and willingness to pay (Approximate)	Impact of payment difference in comparison to petrol-based motorcycles
70000	30000	-40000	Moderately Below
55000	100000	-45000	Moderately Below
35000	40000	-5000	Moderately Below
80000	60000	-20000	Moderately Below
30000	100000	70000	Considerably High
55000	90000	35000	Moderately High
45000	90000	45000	Moderately High
45000	80000	35000	Moderately Below
65000	60000	-5000	Moderately Below
30000	60000	30000	Moderately High
70000	100000	30000	Moderately High
70000	50000	-20000	Moderately Below
45000	20000	-25000	Moderately Below
100000	70000	-30000	Moderately Below
70000	100000	30000	Moderately High
90000	50000	-40000	Moderately Below
116500	80000	-35000	Moderately Below
45000	110000	65000	Considerably High
40000	60000	20000	Moderately High
105000	150000	35000	Moderately High
100000	80000	-20000	Moderately Below
116000	50000	-65000	Considerably Below
50000	100000	50000	Moderately High
50000	90000	40000	Moderately High
40000	30000	-10000	Moderately Below
45000	20000	-25000	Moderately Below
70000	100000	30000	Moderately High
45000	100000	65000	Moderately High
110000	150000	45000	Moderately High
40000	110000	70000	Moderately High
45000	110000	65000	Moderately High

45000	80000	35000	Moderately High
70000	30000	-40000	Moderately Below
35000	50000	15000	Moderately High
45000	60000	15000	Moderately High
30000	40000	40000	Moderately High
110000	20000	-90000	Considerably Below
110000	20000	-90000	Considerably Below
60000	20000	-40000	Moderately Below
35000	20000	-15000	Moderately Below
45000	40000	-5000	Moderately Below
70000	40000	-30000	Moderately Below
70000	110000	40000	Moderately High
145500	40000	105000	Considerably High
36500	60000	25000	Moderately High
30000	100000	-70000	Considerably Below
40000	30000	10000	Moderately High
43000	60000	15000	Moderately High
50000	20000	-30000	Moderately Below
45000	30000	-15000	Moderately Below
70000	60000	-10000	Moderately Below
80000	100000	20000	Moderately High
70000	60000	-10000	Moderately Below
45000	20000	-25000	Moderately Below
116000	30000	-85000	Considerably Below
60000	50000	-10000	Moderately Below
50000	20000	-30000	Moderately Below
127000	20000	-100000	Moderately Below
70000	30000	-40000	Moderately Below
75000	50000	-25000	Moderately Below
100000	50000	-50000	Moderately Below
35000	70000	35000	Moderately High
70000	30000	40000	Moderately High
95000	100000	5000	Moderately Below
115000	100000	-15000	Moderately Below
60000	40000	-20000	Moderately Below
48500	100000	50000	Moderately High
45000	50000	5000	Moderately High
65000	50000	-15000	Moderately Below
70000	60000	-10000	Moderately Below
127500	80000	-47500	Moderately Below
45000	60000	15000	Moderately High

50000	60000	10000	Moderately High
35000	50000	15000	Moderately High
35000	50000	15000	Moderately High
45000	70000	25000	Moderately High
45000	60000	15000	Moderately High
70000	90000	20000	Moderately High
70000	80000	-10000	Moderately Below
129500	60000	-70000	Considerably Below
45000	50000	50000	Moderately Below
70000	60000	-10000	Moderately Below
45000	60000	15000	Moderately High
70000	60000	-10000	Moderately Below
70000	60000	-10000	Moderately Below
35000	50000	15000	Moderately High
45000	60000	15000	Moderately Below
90000	100000	30000	Moderately High
45000	80000	35000	Moderately High
45000	70000	25000	Moderately High

In the figure below we present the percentage wise distribution for the people who are willing to pay E2Ws in comparison to petrol-based two-wheelers.

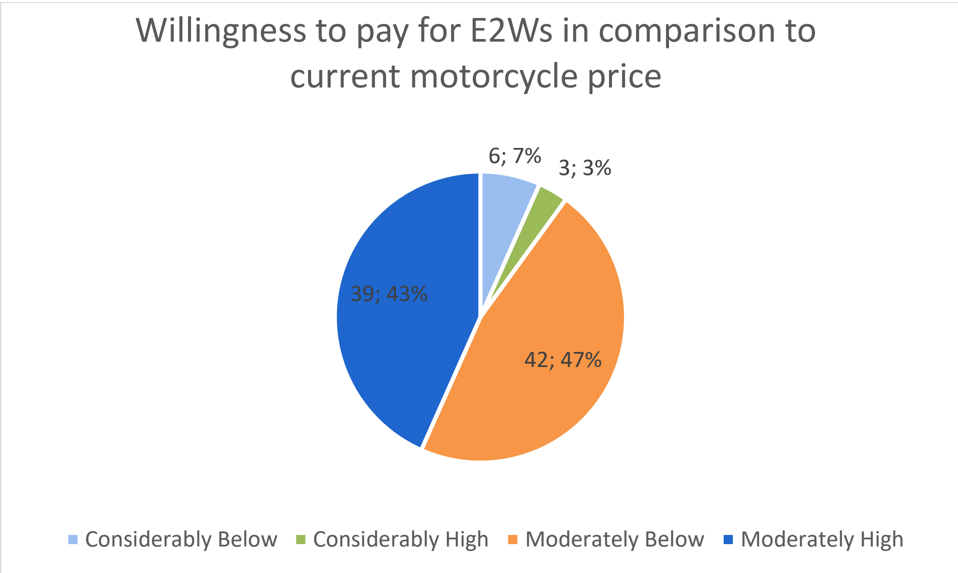


Figure 5. 6 Willingness to pay for E2Ws in comparison to petrol-based motorcycles

As the majority of the respondents chose moderately below their current motorcycle price, we will further look into the demographic feature of this group.

Table 5. 3 Demographic features and the willingness to pay for E2Ws in comparison to petrol-based motorcycles

Demographic features		**Willingness to pay for E2Ws in comparison to petrol-based motorcycles**			
		Considerably less	Moderately less	Moderately high	Considerably high
Age	Less than 20 years	0	7	9	0
	20-25 years	2	11	9	2
	25-30 years	2	12	5	1
	30-35 years	1	7	8	0
	Above 35 years	1	6	8	0
Occupation	Government servants	0	4	4	0
	Private company employees	0	17	8	1
	Personal business	2	8	10	1
	Student	6	43	39	3
Education	Less than 12 years of education	1	3	5	0
	12 years education	1	12	17	1
	Bachelors degree	2	15	11	2
	Masters degree	2	13	6	0
Household-Income	Less than 20000 rupees	1	9	6	0
	20000-40000 rupees	1	9	6	2
	40000-60000 rupees	1	8	3	0
	60000-80000 rupees	1	3	8	1
	More than 80000 rupees	2	9	11	0

From the above table, we can infer that most of the sub-category of this sample also chose the option of "paying moderately less" less than their current mobility mode. Hence, it highlights that majority of this sample were willing to pay less than the price they paid for their current mobility mode.

The succeeding table shows the ordinal logistic regression of people paid considerably below, moderately below, moderately high and considerably for E2Ws in comparison to their current mobility mode. We could dummy the payment difference by 1, 2, 3 and 4. Hence, we could develop an ordered logit model difference these four categories. The independent variables were defined age, occupation, education and household income.

Table 5. 4 Ordinal logistic regression considering the difference in the willingness to pay for the people who wanted to buy another petrol-based motorcycle in the future

Demographics	***Coef.***	***Std. Err.***	***z***	***P>|z|***	***[95% Conf. Interval]***	
Age						
20-25 years	-0.04	0.84	-0.04	0.97	-1.69	1.61
25-30 years	-1.34	1.15	-1.16	0.25	-3.59	0.92
30-35 years	-0.35	1.20	-0.29	0.77	-2.69	2.00
Above 35 years	-0.23	1.29	-0.18	0.86	-2.77	2.31
Occupation						
Private company employees	-0.86	0.83	-1.04	0.30	-2.49	0.76
Personal business	-0.94	0.91	-1.03	0.30	-2.73	0.85
Student	-1.34	1.04	-1.29	0.20	-3.37	0.69
Education						
Bachelors	-0.51	0.58	-0.87	0.38	-1.66	0.64
Less than 12 years of education	-0.71	0.94	-0.75	0.45	-2.55	1.13
Masters degree or above	**-1.66**	**0.77**	**-2.16**	**0.03**	**-3.17**	**-0.15**
Household-income						

20000-40000	0.64	0.84	0.76	0.45	-1.01	2.29
40000-60000	0.17	0.90	0.19	0.85	-1.59	1.94
60000-80000 rupees	**1.99**	**0.92**	**2.17**	**0.03**	**0.19**	**3.79**
More than 80000	1.02	0.81	1.27	0.21	-0.56	2.60
/cut1	-4.14	1.33			-6.75	-1.54
/cut2	-1.10	1.20			-3.46	1.26
/cut3	2.31	1.33			-0.29	4.91

Notes: i. Age less than 20 years, government servants, 12 years education and income less than 20000 were the reference categories for age, occupation, education and income respectively.

Ii. Education with Masters degree category and income of 60000-80000 rupees had significant results.

iii Significant values are in represented in bold

iv. Probability chi2: 0.40

v. Pseudo R2: 0.087

The above model didn't represent an ideal fit as we didn't achieve the reasonable Pseudo R square and Chi-square values. However, we discuss the significant results in this section. In the results, we could only find significant values for the categories of Masters degree education and household-income of 60000-80000 rupees. As we have a negative coefficient for the holders of a Master degree, it shows that for a unit increase in the independent variable there is predicted decrease in the log odds of falling at a higher category of the dependent variable. In simple words, Masters degree holders are less likely to pay a higher purchase price difference for E2Ws than the reference category of the independent variable (people having education of 12 years). It shows that the willingness to pay for E2Ws actually decreased when people had higher education (considering this sub-sample).

On the other hand, people with a household-income of 60000-80000 rupees had a positive coefficient. The positive coefficient estimate that a unit increase of the independent variable will increase the odds of falling at a higher category of the dependent variable. In simple words, respondents of the household-income category of 60000-80000 rupees were more likely to pay a higher purchase price difference for E2Ws than the reference category of the independent variable (respondents with the household income of less than 20000 rupees). Other household income categories of 20000-40000, 40000-60000, more than 80000 rupees were more likely to pay for the higher price difference as well, however, significant values could not be found for these income categories to consolidate the claim. Apart from household house income, other categories for age, education and occupation have negative coefficient values (indicating that there were less likely to pay a higher purchase price) but with insignificant p-values. It can be inferred that respondents with higher house-hold monthly income and education lower than a Masters degree education were more likely to pay higher for E2Ws considering this sub-sample.

5.5.3 Payment by the full purchase price or instalments

Out of the 91 respondents, none had purchased their petrol-based motorcycles on instalments. However, after selecting E2Ws as future mobility mode, 23 (26%) respondents showed interest to buy E2Ws on instalments and 68 respondents (74%) showed interest by paying the full purchase price. This indicates that paying by instalments would increase for E2Ws if the pro-petrol-based respondents selected E2Ws as future mobility mode.

Table 5. 5 Willingness to pay considering instalments or full purchase price

Willingness to pay for E2Ws	Full purchase price	Instalments
Considerably less	3	3
Moderately less	10	33
Moderately high	7	32
Considerably high	3	0

5.5.4 Environmental concern

To understand whether this group had any concern for environmental benefit, we divided the reason for purchase into pro-environment and “other” (low operational cost, low maintenance cost, other) categories. We found that 33(36%) respondents chose E2Ws due to environmental concern and 58(64%) chose other option. It shows that these respondents were highly influenced by other concern than the environment. The majority of the pro-environment respondents belonged to the category of people who were willing to pay moderately less than their current petrol-based motorcycles. Below is the table to show the ordinal category of the willingness to pay for E2Ws considering environmental concern.

Table 5. 6 Willingness to pay and environmental concern

Willingness to pay for E2Ws	Environmental concern	Other
Considerably less	1	5
Moderately less	18	25
Moderately high	13	26
Considerably high	1	2

5.5.5 Influence of barriers and the willingness to pay

In this section, we try to understand the major barriers that prompted this sub-sample respondent to disregard E2Ws in the earlier phase. As there are only 91 respondents we could compile our main barriers into monetary issues (purchase price, resale problem, operational cost), charging related issues (long charging time, range anxiety, high load shedding, unavailability of charging station) and Other usage-related issues (low driving speed, awareness issues, theft, low power and unavailability of spare parts). The cross-tabulation of the willingness to pay and barriers is shown in the table below.

Table 5. 7 Willingness to pay and major concerns

Willingness to pay for E2Ws	Monetary issues	Range/Charging related issue	Other usage related issues
Considerably less	3	3	0
Moderately less	4	14	15
Moderately high	12	14	10
Considerably high	2	1	0

The above table shows that people who paid moderately high for E2Ws showed monetary concern more in the earlier phase. Whereas, usage-related issues were more highlighted by the people who are willing to pay moderately less than their current mobility mode. The top concern identified by all group was the range related issue. Hence, range and charging related issues are the top concern for the people who are willing to buy another motorcycle in future and also willing to buy E2Ws in the future. It also indicates that people who are concerned about the range issues would care less for subsidies than people who have a major monetary concern.

We also tried to understand whether any statistically significant difference exists between the willingness to pay and concern for this sub-sample. We conducted an ordinal logistic regression in this regard. However, we could not find any statistically significant results to be reported here. The results are shown in the table below. In the previous chapter, we have highlighted barriers and socio-demographics variables using the multinomial logistic regression.

Table 5. 8 Ordinal logistic results: Willingness to pay and top concerns

Parameter Estimates							
Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
Considerably less	-2.562	0.5197	-3.58	-1.543	24.296	1	0
Moderately less	0.282	0.372	-0.448	1.011	0.573	1	0.449
Moderately high	3.399	0.6675	2.091	4.708	25.936	1	0
Monetory concern	0.073	0.5101	-0.926	1.073	0.021	1	0.886
Vehicle related concern	0.082	0.5023	-0.903	1.066	0.026	1	0.871
Other concern	0[a]						
(Scale)	1[b]						

Goodness of fit: Pearson chi-square: 1.25 (Good fit)

Dependent Variable: Category difference

Base category: Considerably high,

Base category for independent variable:
a. Set to zero because this parameter is redundant

b. Fixed at the displayed value.

Note: This table maybe moved in the Appendix after review from the exam members

5.6 Methods of payments

In a developing country like Pakistan, some people rely on private micro-finance to purchase expensive products such as motorcycles. Motorcycle financing is predominantly performed by private showroom owners. This process involves one-time small lump-sum payment followed by monthly payments to clear the total purchase price abided by contractual agreement between the showroom owners and motorcycle purchasers. The private owners are flexible to allow clearing the vehicle in 6-60 months with small interest rates. This allows consumers to own a petrol-based motorcycle with a minimum hassle. As there is no literature available to further enlighten private financing of motorcycle, respondents were asked in the survey to share the methods of payment for their current and future mobility mode to facilitate the understanding of this topic. We compiled all the willingness to pay for E2Ws, in this survey, 84% of the current motorcycle users owned their vehicle by paying the full purchase price. Only 16% stated using private financing by monthly instalments to own a motorcycle. The frequency and percentage of their current petrol-based motorcycle are shown in the figure below.

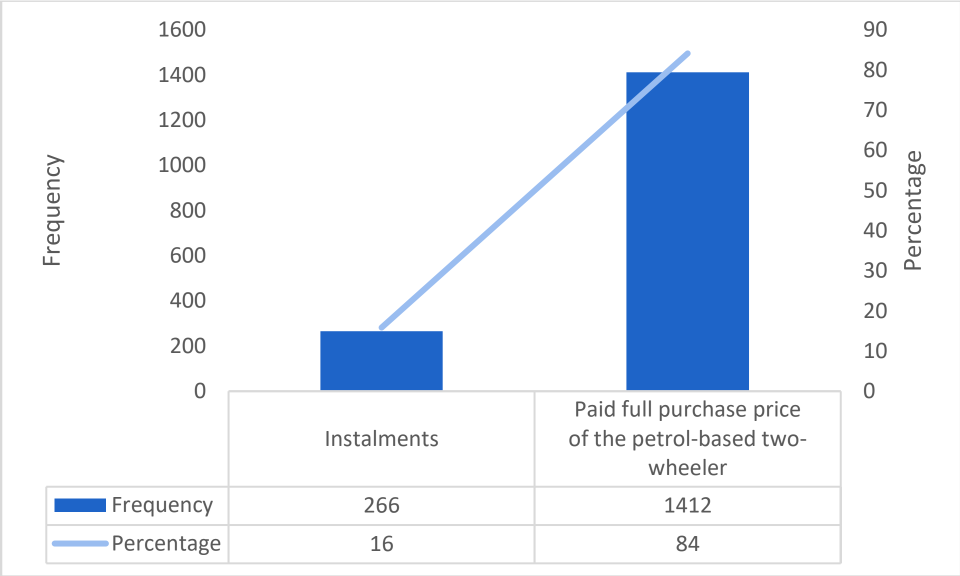


Figure 5. 7 Frequency and percentage of their current mobility mode (petrol-based motorcycle users)

Similarly, respondents who selected E2Ws as future mobility option opted to pay the full purchase price instead of instalments. We compiled the choices of the pro E2W respondents and pro-petrol-based choices for E2Ws. The figure below clarifies the respondents are inclined to purchase E2Ws by paying the full purchase price.

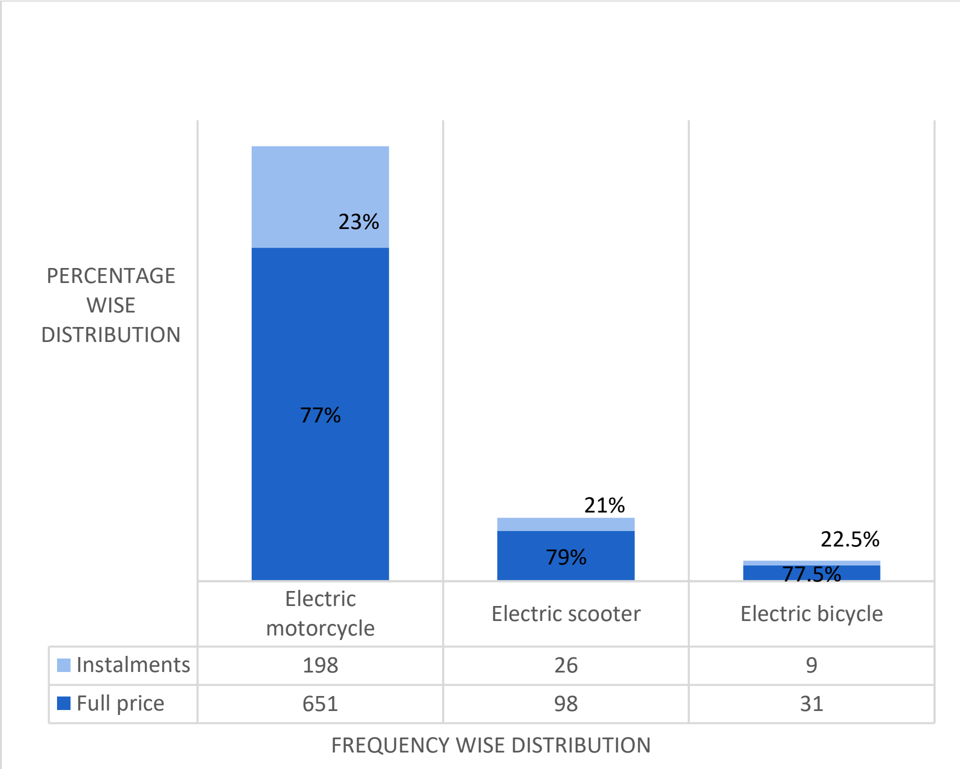


Figure 5. 8 Choice of prospective E2W users regarding payment in the full purchase price or instalments

As discussed earlier, there lacked literature regarding the inclination of people who opt for private financing for their motorcycle purchase in Pakistan. From this survey, it is highlighted that these prospective E2W's users are persuaded towards private showroom financing instead of banks. Hence, the respondents who chose payment though instalments were inquired whether they will prefer banks or private showroom owners for instalments. A total of 219 answered the question, most of the respondents preferred instalments by private motorcycle showroom owners. The figure below provides the percentage and frequency of their choices.

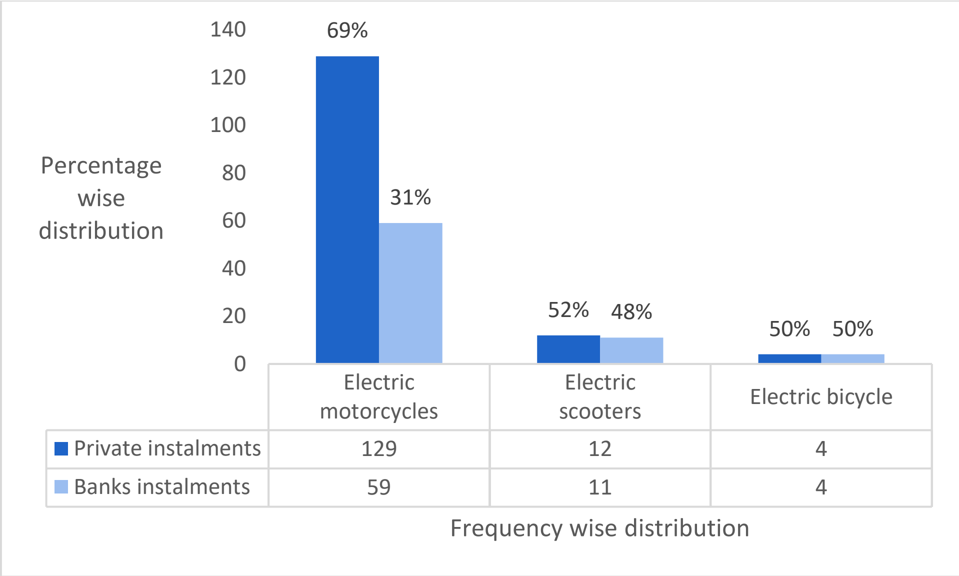


Figure 5. 9 Choice of prospective E2W users regarding financing by instalments through banks or private showrooms

It was instrumental to understand how many months would people usually like to own their vehicle by paying off the monthly instalments. It will clarify whether business models, such as clearing the vehicles in 12 months or less through instalments could be feasible in Pakistan. In this regard, we combined the results of pro-E2W and pro-petrol-based motorcycle users. In the results, it is highlighted that people would like to pay off their vehicle in one year. The results are shown in the chart below.

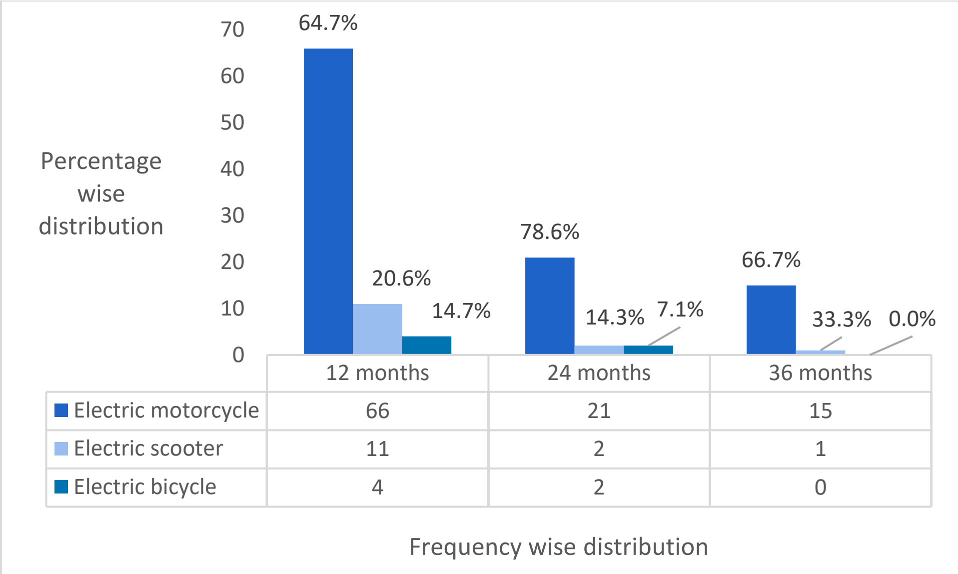


Figure 5. 10 Choice of prospective E2W users considering preferred monthly instalments

A total of 122 people answered this question. It can be inferred that most of the people in Pakistan prefer paying the full purchase price rather than paying on instalments. Those who pay on instalments prefer motorcycle financing through private showroom owners which could be cleared in 12 months. This information could be influential to develop business models that would influence the introduction of E2Ws in Pakistan.

5.7 Need for financial assistance

As the hypothetical purchase price shown to the respondents was higher than an average petrol-based motorcycle, it was anticipated in the survey design that many of the respondents would state a lower purchase price for the E2Ws. This show that these respondents would either consider the purchase price given in the survey to be high or require other financial support. Through the help of the Qualtrics application, those respondents who stated a lower purchase price than the purchase price shown to them in the survey were identified and inquired further. They were asked whether they need a subsidy from the government, bank loan, loan from any other financial institution or they do not require financial support. A detailed description of the response of the percentage-wise distribution is shown below considering the pro-E2W or pro.

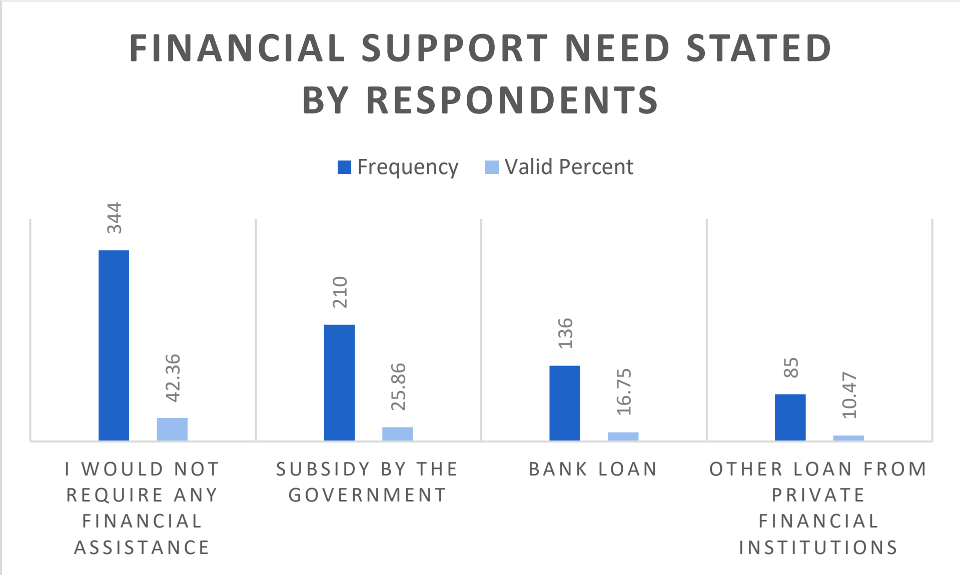


Figure 5. 11 Financial support stated by the respondents

From the above results, it could be understood that the majority of the respondents do not require any financial assistance. Those who stated financial need preferred private loan (private loan (221)= bank loan (136) + other institutes (85)) than subsidy by the government (210). It highlights that respondents had a vague understanding and trust issues for the government's subsidy.

5.8 Conclusion and policy implications

In this chapter, we established the willingness to pay for E2Ws in Pakistan. We understood that respondents clearly selected electric motorcycles as future mobility mode, hence, we reserved our discussion to electric motorcycles. Through the help of Qualtrics, we established a maximum willingness to pay for electric motorcycles from pro-petrol-based and pro E2Ws respondents. The preferred price gap between the two groups highlighted the ideal price that could be formulated with a certain degree of intuition

By the help of the survey, we could understand the payment methods that prospective electric motorcycles users would be comfortable to pay. We found in our survey that current petrol-based motorcycles owners had bought their vehicle by paying the full purchase price. Similarly, majority of the respondents (pro-E2Ws and pro-petrol-based respondents) were more inclined to buy the electric motorcycles by paying the full purchase price than instalments. The respondents who selected paying off electric motorcycles on instalments preferred motorcycle financing through private institutions than banks. The prospective electric motorcycle preferred to clear off their monthly financing in one year. The majority of the prospective E2W's users stated that they would not depend on external financing as financial help. However, those who stated a need for external financial support preferred private loans indicating that subsidies from the government are not popular. It indicates that the government would need to create trust by providing robust subsidies schemes. On the contrary, it also highlights that respondents may not have understood the notion of subsidies completely. As Pakistan is a developing country, the concept of subsidy may not be well understood among the masses. Hence, that could also be the reason that the majority of the people have chosen loans as a form of financial support.

In conclusion, the low purchase price was the main motivating factor to lure current petrol-based motorcycle users to consider E2Ws in the future. Besides, sports shaped, or electric motorcycle would have to be introduced in Pakistan with a price range between 30000-40000

($191-254) rupees. If there are additional benefits by buying electric motorcycles, people may compromise for a higher purchase price.

5.9 Limitations and future research

Further research could be carried out about the willingness to pay about separate features are improved in the motorcycle such as high speed and low charging time. However, this can only be possible after electric motorcycles have a small-scale market in developing countries.

6 Conclusion and policy recommendations

In this thesis study, we tried to evaluate the prospects of electric vehicles in Pakistan. We first performed a literature review to understand the which type of electric vehicles could be feasible in a developing country like Pakistan. We found that HEVs, also offer considerable environmental benefits with low cost of travel. However, the price of HEVs is high which is suitable for the high-income group of Pakistan. We found that E2Ws could be suitable in developing countries like Pakistan due to the popularity of petrol-based two-wheelers in Pakistan. Later, we conducted a survey to understand the perceptions and willingness to pay for the electric two-wheelers. We found that the majority of the people preferred petrol-based motorcycles over electric two-wheelers. Considering E2Ws, the preferred choice among the electric two-wheelers was electric motorcycles. Respondents chose electric motorcycles due to its high speed and sports style shape which resembled the petrol-based motorcycle in Pakistan. Considering the barriers for E2Ws in Pakistan, the most striking result was the identification of the purchase price than electricity blackouts. Despite, high electricity blackouts which could increase the charging anxiety, respondents preferred purchase price as the most important force for the implementation of E2Ws in Pakistan. It shows that low purchase price for the introduction of electric motorcycles would be the most important factor for the success in Pakistan. However, electricity blackouts can negatively influence other resisting forces such as high charging time, limited range and unavailability of charging stations. If the charging anxiety factors (high blackouts, high charging time, low range) are combined it would have more influence than monetary factors (high purchase price, resale, low operational cost) for the purchase of E2Ws. Considering the willingness to pay, the majority of the respondents preferred that the price of the electric motorcycle should be less than current petrol-based motorcycles in Pakistan. In the results, we found that electric motorcycles would have minimum effect on the peak electricity demand and total electricity consumption. Besides, electric motorcycles would have lower carbon emissions than petrol-motorcycles. However, lead-based emissions considerably increase after the usage of electric motorcycles. Considering the total cost of ownership, petrol-based motorcycles are 1.8 times more expensive than the hypothetical electric motorcycle developed for this study.

6.1 Recommendations for the government

The respondents suggested that reducing the high purchase price, eradicating electricity blackouts, limiting high charging time and increasing top speed could create a favourable situation for the introduction of E2Ws in Pakistan. However, the above suggestions could not be immediately implemented in Pakistan. In the present scenario, the government has limited resources to reduce blackouts immediately (Valasai et al., 2017). The lack of finances would impede the government to invest in the research and development of E2Ws to decrease charging time, improving high speed or subsidizing E2Ws (Global Economy, 2017). The way forward could be to adopt practical policies for customers and investors. These include creating awareness schemes to deal with the charging of E2Ws in electricity blackouts (Mohanty & Kotak, 2017). People could be made aware to charge their vehicles in similar patterns as they charge their cellphones in electricity blackouts. Besides, the full environmental benefits for E2Ws can only be achieved if the electricity is made green. We saw in our results that considerable carbon emissions can be controlled with the introduction of E2Ws. Hence, new energy investment for energy security should be based on green energy investments (Mansour & Haddad, 2017). Other policies that do not require a heavy investment include waiving off the vehicle registration fees, reducing annual taxes on the vehicles and providing toll-free benefits for the owners of E2Ws. Private investors could be motivated to invest in E2Ws by lowering "custom and import taxes" (SIAM, 2017). Besides, the purchase price of the electric motorcycle was regarded as the greatest impediment towards the implementation of E2Ws in Pakistan. Thereby, it is suggested to introduce the purchase price of the electric motorcycle which should be equal or less than petrol-based motorcycles in Pakistan. The ideal purchase of such electric motorcycle could be 30000-40000 ($191-254) as it is less than an average 70cc petrol-based motorcycles in Pakistan. Hence, E2Ws could be introduced in Pakistan with affordable price along with additional benefits for customers and investors. Among the E2Ws, the majority of the respondents identified electric motorcycles as a favoured option due it better performance and shape than electric scooters or electric bicycles. Therefore, the future investors of E2Ws in Pakistan should focus on introducing electric motorcycles which resembles the look of conventional motorcycles. The people cited monetary benefits than environmental benefits for their choice. Our study commensurates with previous research that people value monetary benefits more important environmental benefits for the purchase of EVs (Hidrue et al., 2011; P. Lebeau, Macharis, & Van Mierlo, 2016). People also identified speed as the top five major concern for E2Ws. Therefore, it directs that speedy electric motorcycle can also induce users towards E2Ws. In this survey, people were inclined toward having loans than subsidy. It directs that people may have a poor evaluation of government support or they have a lack a clear understanding of the concept of subsidy (Khalid & Salman, 2020). Rather than providing subsidy which requires substantial capital, easy loan schemes with low interest can be introduced to purchase E2Ws. This recommendation commensurate with the finding from our survey that people preferred loans over subsidy options.

Lastly, it is recommended to delay the implementation of electric cars in Pakistan unless the purchase price of such vehicles is reduced in the international market.

6.2 Critical analysis

The survey design could have been more effective if the choices were limited. For example, household income choices could have been limited to three or four choices. Besides, unpopular choices should have been removed while conducted the pilot survey. These include electric bicycle which had a low frequency of choice.

We could have not included the choice of petrol-based respondents who had recently purchased a petrol-based motorcycle. The recent purchase induces respondents to not consider E2Ws if they were given the option. A large sample from one city could have been gathered to achieve significant results. Effort should have been made to randomly select all the respondents.

6.3 Limitations and future research

This study would open the avenues for further research for the prospects of EVs in Pakistan. Further research could relate the impact of connecting electric motorcycles, electric cars, electric scooters and electric bicycles on the national grid by considering different electricity blackouts scenarios in Pakistan. For example, with the help of advanced modelling energy scenarios, we could understand how would electric motorcycles affect the national grid under different peak electricity demand scenarios. Future research could also be directed towards, connecting the electric motorcycle to the grid and understand its impact on electricity blackouts reduction. Besides, the total cost of ownership and environmental impact could be calculated for other EVs such as electric cars, electric scooters, electric bicycles and Hybrid electric vehicles. For the affluent people in the developing country, the perceptions and willingness to pay for electric cars can also be calculated.

Lastly, due to the lack of resources, a large number of survey respondents could not be gathered. The large sample size could have achieved more significant results. For example, we got have got a higher number for unpopular choices as electric bicycles which would have made comparison easier for other choices. In my capacity, I should have gathered as many people in person. If I would have to improve my survey, I would have conducted the survey my so that survey sample selection bias should have been eliminated. I would have limited the options of demographic features to a maximum of four option. It could also increase the significance among variables. I would have limited my survey to one city only and try to represent data so that they are an exact representation of the sample.

6.4 Appendix A: Survey

Survey- Prospects of electric two-wheelers in Pakistan

Start of Block: Default Question Block

Q1 What is your name?

____

Q2 What is your cell phone/mobile number?

____

Q3 What is your age?

▼ 15-20 years (1) ... 65-70 years (10)

Q4 What is your highest level of education?

- ◯ Not educated (1)
- ◯ Primary (8)
- ◯ Middle (4)
- ◯ Matric (5)
- ◯ Intermediate (6)
- ◯ Bachelors (7)
- ◯ Masters (2)
- ◯ PhD (3)

Q5 What is your current occupation?

- ○ Government servants (26)
- ○ Private company employees (27)
- ○ Personal business (28)
- ○ Student (29)
- ○ Retired (30)
- ○ Other (31) ____

Q6 How much is your salary or monthly household income from work/business in Rupees?

▼ Less than 20000 (1) ... 500000 plus (14)

Q7 Company of the motorcycle in use?

- ○ United (120)
- ○ Road Prince (121)
- ○ Honda (122)
- ○ Ravi (123)
- ○ Yamaha (124)
- ○ Suzuki (125)
- ○ DYL (126)
- ○ Unique (130)
- ○ Qinqi (127)
- ○ Other (129) ____

Display This Question:

If Company of the motorcycle in use? = United

Q8 What is the model ?

○ United US 70 (Current price 38000) (1)

○ United US 100 (Current price 44500) (2)

○ United US 125 Euro II (Current price 68500) (3)

○ United US 100 Jazba (55000) (4)

○ United US 150 Ultimate Thrill (140000) (5)

Display This Question:

If Company of the motorcycle in use? = Road Prince

Q9 What is the model?

- Road Prince RP 70 Passion (Current price PKR 40,000) (1)
- Road Prince Wego 150 (Current price PKR 180,000) (2)
- Road Prince Robinson 150 (Current price PKR 200,000) (3)
- Road Prince RP 110 (Current price PKR 46,000) (4)
- Road Prince Twister 125 (Current price PKR 110,000) (5)
- Road Prince RX3 (Current price PKR 425,000) (6)

Display This Question:

If Company of the motorcycle in use? = Honda

Q10 What is the model?

- ○ Honda CG 125 (Current price 116,500) (1)
- ○ Honda CD 70 (Current price 70,500) (2)
- ○ Honda Pridor (Current price 96,500) (3)
- ○ Honda CB 150F (Current price 191,900) (4)
- ○ Honda CB 125F (Current price 161,900) (5)
- ○ Honda CB 250F (Current price 640,000) (6)
- ○ Honda CB 500X (Current price unavailable) (7)
- ○ Honda CBR 150R (Current price 660,000) (8)
- ○ Honda CBR 500R (Current price 1,250,000) (9)
- ○ Honda CD 70 Dream (Current price 74,500) (10)
- ○ Honda CG 125 Dream (Current price 106,900) (11)
- ○ Honda CG 125 Special (Current price 134,900) (12)
- ○ Honda Deluxe (Current price 129,500) (13)

Display This Question:

If Company of the motorcycle in use? = Ravi

Q11 What is the model?

- Ravi Piaggio Storm 125 (Current price 112,000) (1)
- Ravi Humsafar 70 (Current price 40,000) (2)
- Ravi Premium R1 (Current price 43,000) (3)

Display This Question:

If Company of the motorcycle in use? = Yamaha

Q12 What is the model?

- Yamaha YBR 125 (Current price 144,500) (1)
- Yamaha YBR 125G (Current price 149,500) (2)
- Yamaha YB 125Z (Current price 127,500) (3)
- Yamaha YZF-R3 (Current price unavailable) (4)

Display This Question:

If Company of the motorcycle in use? = Suzuki

Q13 What is the model?

- ◯ Suzuki GS 150(Current price 162,000) (1)
- ◯ Suzuki GD 110S (Current price 155,000) (2)
- ◯ Suzuki GD 110 (Current price 119,000) (3)
- ◯ Suzuki GS 150 SE (Current price 180,000) (4)
- ◯ Suzuki GSX-R600 (Current price 1,950,000) (5)
- ◯ Suzuki Bandit (Current price 1,450,000) (6)
- ◯ Suzuki Gixxer 150 (Current price 625,000) (7)
- ◯ Suzuki GR 150 (Current price 243,000) (8)
- ◯ Suzuki Hayabusa (Current price 2,600,000) (9)
- ◯ Suzuki Inazuma (Current price 599,000) (10)
- ◯ Suzuki Inazuma Aegis (Current price 1,000,000) (11)
- ◯ Suzuki Intruder (Current price 1,700,000) (12)
- ◯ Suzuki Raider 110 (Current price 101,400) (13)
- ◯ Suzuki Sprinter ECO (Current price 98,400) (14)

Display This Question:

If Company of the motorcycle in use? = DYL

Q14 What is the model?

- ◯ DYL Dhoom YD-70 (Current price 55,000) (1)
- ◯ Other (2) ____

Display This Question:

If Company of the motorcycle in use? = Unique

Q15 Write the model?

- ◯ Unique Xtreme UD 70 (Current price 47,000) (1)
- ◯ Unique UD 100 (Current price 85,500) (2)
- ◯ Unique UD 125 (Current price 75,500) (3)
- ◯ Unique Crazer UD-150 (Current price 170,000) (4)

Q16 How did you buy the motorcycles?

○ Paid full price of the vehicle (1)

○ Installments (2)

Display This Question:

If How did you buy the motorcycles? = Paid full price of the vehicle

Q17 How much price did you pay to buy your motorcycle?

____

Display This Question:

If How did you buy the motorcycles? = Installments

Q18 Which mode of payment did choose for paying your installments?

○ Private company (Showroom) (1)

○ Bank (2)

Display This Question:

If How did you buy the motorcycles? = Installments

And Which mode of payment did choose for paying your installments? = Private company (Showroom)

Q19 How much advance payment did you pay for your motorcycle for the private company?

____

Display This Question:

If How did you buy the motorcycles? = Installments

And Which mode of payment did choose for paying your installments? = Private company (Showroom)

Q20 How much monthly installments did you pay for your motorcycle for the private company?

____

Display This Question:

If How did you buy the motorcycles? = Installments

And Which mode of payment did choose for paying your installments? = Bank

Q21 How much advance payment did you made for the Bank?

____

Display This Question:

If How did you buy the motorcycles? = Installments

And Which mode of payment did choose for paying your installments? = Bank

Q22 How much monthly installments do you pay for the Bank?

____

Display This Question:

If How did you buy the motorcycles? = Installments

Q23 How much monthly installments have you booked your two wheeler?

○ 12 (1)

○ 24 (2)

○ 36 (3)

○ 48 (4)

○ 60 (5)

Q24 How much will you pay for an Electric two-wheeler which has no petrol cost?

▼ 10000 (1) ... More than 150000 (16)

Q25 Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on installments?

- ○ Electric Motorcycle (2)
- ○ Electric Scooter (1)
- ○ Electric Bicycle (3)
- ○ I would use my own motorcycle (4)
- ○ I will buy other motorcycle (5)

Page Break

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = Electric Motorcycle

Q26 Why did you choose Electric Motorcycle?

- ○ Low cost in daily travel (operational cost) (1)
- ○ Environment friendly (2)
- ○ Low maintenance cost (3)
- ○ Other (4) ____

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = Electric Motorcycle

Q27 How much are you willing to pay for the electric motorcycle you selected after looking at the purchase price and other features of an electric motorcycle?

▼ 10000 (1) ... More than 150000 (16)

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = Electric Motorcycle

Q28 Will you pay the full price of an electric motorcycle or in installments?

○ Full price (1)

○ Installments (2)

Display This Question:

If How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 10000

And Will you pay the full price of an electric motorcycle or in installments? = Installments

Q29 Which business model, will you select to pay your instalments?

○ 12 months (4)

○ 24 months (5)

○ 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 20000

Q30 Which business model, will you select to pay your installments?

- 12 months (4)
- 24 months (5)
- 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 30000

Q31 Which business model, will you select to pay your installments?

- 12 months (4)
- 24 months (5)
- 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 40000

Q32 Which business model, will you select to pay your installments?

○ 12 months (4)

○ 24 months (5)

○ 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 50000

Q33 Which business model, will you select to pay your installments?

- 12 months (4)
- 24 months (5)
- 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 60000

Q34 Which business model, will you select to pay your installments?

- 12 months (4)
- 24 months (5)
- 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 70000

Q35 Which business model, will you select to pay your installments?

◯ 12 months (4)

◯ 24 months (7)

◯ 36 months (8)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 80000

Q36 Which business model, will you select to pay your installments?

◯ 12 (4)

◯ 24 months (5)

◯ 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 90000

Q37 Which business model, will you select to pay your installments?

- ◯ 12 months (4)
- ◯ 24 months (5)
- ◯ 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 100000

Q38 Which business model, will you select to pay your installments?

◯ 12 months (4)

◯ 24 months (5)

◯ 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 110000

Q39 Which business model, will you select to pay your installments?

◯ 12 months (4)

◯ 24 months (5)

◯ 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 120000

Q40 Which business model, will you select to pay your installments?

◯ 12 months (4)

◯ 24 months (5)

◯ 36 months (7)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 130000

Q41 Which business model, will you select to pay your installments?

◯ 12 months (4)

◯ 24 months (5)

◯ 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 140000

Q42 Which business model, will you select to pay your installments?

- 12 months (4)
- 24 months (5)
- 36 months (6)

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

And How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 150000

Or How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = More than 150000

Q43 Which business model, will you select to pay your installments?

○ 12 months (4)

○ 24 months (5)

○ 36 months (7)

Display This Question:

If How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 10000

Or How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 20000

Or How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 30000

Or How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 40000

Or How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 50000

Or How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 60000

Or How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 70000

Or How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 80000

Or How much are you willing to pay for the electric motorcycle you selected after looking at the pur... = 90000

Q44 You have evaluated less price of for the Electric motorcycle that could be available, What kind of help you can suggest overcoming the price gap?

- ◯ Subsidy by the government (1)
- ◯ Bank Loan (2)
- ◯ Other Loan from Private Financial Institution (3)
- ◯ I do not require any financial assistance (4)
- ◯ Other (5) ____

Display This Question:

If Will you pay the full price of an electric motorcycle or in installments? = Installments

Q45 Which type of monthly instalment do you prefer?

- ◯ Private installment (Motorcycle showroom) (1)
- ◯ Bank installment (2)

Page Break

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = Electric Scooter

Q46 Why did you choose Electric Scooter ?

◯ Low cost in daily travel (operational cost) (1)

◯ Environment friendly (2)

◯ Low maintenance cost (3)

◯ Other (4) ____

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = Electric Scooter

Q47 How much are you willing to pay for the electric scooter you selected after looking at the purchase price and other features of an Electric Scooter?

▼ 10000 (1) ... More than 150000 (16)

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = Electric Scooter

Q48 Will you pay the full price of an Electric scooter or in installments?

◯ Full price (1)

◯ Installments (2)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 10000

Q49 Which business model, will you select to pay your installments?

◯ Image:1000 i (5)

◯ Image:10000 ii (6)

◯ Image:1000 iii (8)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 20000

Q50 Which business model, will you select to pay your installments?

○ Image:2000 i (4)

○ Image:2000 ii (5)

○ Image:2000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 30000

Q51 Which business model, will you select to pay your installments?

○ Click to write Choice 1 (4)

○ Image:3000 ii (5)

○ Image:3000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 40000

Q52 Which business model, will you select to pay your installments?

○ Click to write Choice 1 (4)

○ Image:4000 ii (5)

○ Image:4000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 50000

Q53 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:5000 ii (5)
- ◯ Image:5000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 60000

Q54 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:6000 ii (5)
- ◯ Image:6000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 70000

Q55 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:70000 iii (5)
- ◯ Image:7000 ii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 80000

Q56 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:8000 ii (5)
- ◯ Image:8000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 90000

Q57 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:9000 ii (5)
- ◯ Image:9000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 100000

Q58 Which business model, will you select to pay your installments?

- ○ Click to write Choice 1 (4)
- ○ Image:100000 ii (5)
- ○ Image:100000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 110000

Q59 Which business model, will you select to pay your installments?

- ○ Click to write Choice 1 (4)
- ○ Image:110000 ii (5)
- ○ Image:110000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 120000

Q60 Which business model, will you select to pay your installments?

◯ Click to write Choice 1 (4)

◯ Image:120000 ii (5)

◯ Image:120000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 130000

Q61 Which business model, will you select to pay your installments?

◯ Click to write Choice 1 (4)

◯ Image:130000 ii (5)

◯ Image:130000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 140000

Q62 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:140000 ii (5)
- ◯ Image:140000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 140000

Q63 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:140000 ii (5)
- ◯ Image:140000 iii (6)

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

And How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 150000

Or How much are you willing to pay for the electric scooter you selected after looking at the purcha... = More than 150000

Q64 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:150000 ii (5)
- ◯ Image:150000 iii (6)

Display This Question:

If How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 10000

Or How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 20000

Or How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 30000

Or How much are you willing to pay for the electric scooter you selected after looking at the purcha... = 40000

Q65 You have evaluated less price of for the Electric scooter, What kind of help you can suggest overcoming the price gap?

◯ Subsidy by the government (1)

◯ Bank Loan (2)

◯ Other Loan from Private Financial Institution (3)

◯ I would not require any financial assistance (4)

◯ Other (5) ____

Display This Question:

If Will you pay the full price of an Electric scooter or in installments? = Installments

Q66 Which type of monthly installment do you prefer?

- ○ Bank installment (1)
- ○ Private installment (Motorcycle showrooms) (2)

Page Break

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = Electric Bicycle

Q67 Why did you choose an Electric bicycle?

- ○ Low cost in daily travel (operational cost) (1)
- ○ Environment friendly (2)
- ○ Low maintenance cost (3)
- ○ Other (4) ____

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = Electric Bicycle

Q68 How much are you willing to pay for the electric bicycle you selected after looking at the purchase price and other features of an electric bicycle?

▼ 10000 (6) ... More than 150000 (21)

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = Electric Bicycle

Q69 Will you pay the full price of an Electric bicycle or in installments?

- ◯ Full price (1)
- ◯ Installments (2)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 10000

Q70 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (6)
- ◯ Image:10000 ii (7)
- ◯ Image:1000 iii (8)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 20000

Q71 Which business model, will you select to pay your installments?

- ○ Click to write Choice 1 (4)
- ○ Image:2000 ii (5)
- ○ Image:2000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 30000

Q72 Which business model, will you select to pay your installments?

- ○ Click to write Choice 1 (4)
- ○ Image:3000 ii (5)
- ○ Image:3000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 40000

Q73 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:4000 ii (5)
- ◯ Image:4000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 50000

Q74 Which business model, will you select to pay your installments?

- Click to write Choice 1 (4)
- Image:5000 ii (5)
- Image:5000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 60000

Q75 Which business model, will you select to pay your installments?

- Click to write Choice 1 (4)
- Image:6000 ii (5)
- Image:6000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 70000

Q76 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:70000 iii (5)
- ◯ Image:7000 ii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 80000

Q77 Which business model, will you select to pay your installments?

- ◯ Click to write Choice 1 (4)
- ◯ Image:8000 ii (5)
- ◯ Image:8000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 90000

Q78 Which business model, will you select to pay your installments?

- Click to write Choice 1 (4)
- Image:9000 ii (5)
- Image:9000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 100000

Q79 Which business model, will you select to pay your installments?

- Click to write Choice 1 (4)
- Image:100000 ii (5)
- Image:100000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 110000

Q80 Which business model, will you select to pay your installments?

- Click to write Choice 1 (4)
- Image:110000 ii (5)
- Image:110000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 120000

Q81 Which business model, will you select to pay your installments?

◯ Click to write Choice 1 (4)

◯ Image:120000 ii (5)

◯ Image:120000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 130000

Q82 Which business model, will you select to pay your installments?

◯ Click to write Choice 1 (4)

◯ Image:130000 ii (5)

◯ Image:120000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 140000

Q83 Which business model, will you select to pay your installments?

- ○ Click to write Choice 1 (4)
- ○ Image:140000 ii (5)
- ○ Image:140000 iii (6)

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

And How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 150000

Or How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = More than 150000

Q84 Which business model, will you select to pay your installments?

◯ Click to write Choice 1 (4)

◯ Image:150000 ii (5)

◯ Image:150000 iii (6)

Display This Question:

If How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 10000

Or How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 20000

Or How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 30000

Or How much are you willing to pay for the electric bicycle you selected after looking at the purcha... = 40000

Q85 You have evaluated less price for the Electric bicycle, What kind of help you can suggest overcoming the price gap?

◯ Subsidy by the government (1)

◯ Bank Loan (2)

◯ Other Loan from Private Financial Institution (3)

◯ I would not require any financial assistance (4)

◯ Other (5) ____

Display This Question:

If Will you pay the full price of an Electric bicycle or in installments? = Installments

Q86 Which type of monthly installment do you prefer?

◯ Private installment (Motorcycle showrooms) (1)

◯ Bank installment (2)

Page Break

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = I would use my own motorcycle

Or Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = I will buy other motorcycle

Q87 Why would you not prefer to buy an electric two wheeler?

○ High purchase price (1)

○ Range is low (2)

○ The operational cost is not low (3)

○ Driving Speed is slow (4)

○ Load shedding is high in Pakistan (5)

○ Charging time is high (6)

○ Resale problem (7)

○ Awareness issue (8)

○ Theft problem battery (9)

○ Unavailability of charging stations (13)

○ Unavailability of spare parts (10)

○ Lack of power to carry high weight (suppliers use it carry weights such as dairy products etc) (11)

○ Other (12) ____

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = I would use my own motorcycle

Or Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = I will buy other motorcycle

Q88 What will motivate you to purchase an electric two wheeler?

- ◯ Reduce purchase price (1)
- ◯ End load shedding (2)
- ◯ Range issue resolved (Improve battery or increase charging points in the city) (3)
- ◯ Increase speed (4)
- ◯ Decrease charging time (5)
- ◯ Increase awareness (6)
- ◯ Reduce theft (7)
- ◯ Availability of spare parts (8)
- ◯ Improve Engine quality and model to carry more weight (12)
- ◯ Resale is improved (11)
- ◯ Other (10) ____

Display This Question:

If Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = I would use my own motorcycle

Or Look at the option Electric two wheelers below, which one will you prefer to buy or purchase on i... = I will buy other motorcycle

Q89 Do you propose a minimum cost that will motivate you to purchase an Electric Two-wheeler?

- ◯ Yes (1)
- ◯ No, I would continue using petrol based motorcycle (2)

Display This Question:

If Do you propose a minimum cost that will motivate you to purchase an Electric Two-wheeler? = Yes

Q90 Why did you choose an electric two wheeler?

- ◯ Operational cost is low (1)
- ◯ Environmental benefits (2)
- ◯ Low maintenance cost (3)
- ◯ Other (4) ____

Display This Question:

If Do you propose a minimum cost that will motivate you to purchase an Electric Two-wheeler? = Yes

Q91 What is the maximum price are you willing to pay to consider buying above Electric two wheeler?

▼ 20000 (1) ... More than 150000 (15)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 20000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 30000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 40000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 50000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 60000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 70000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 80000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 90000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 100000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 110000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 120000-

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 130000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 140000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 150000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = More than 150000

Q92 Which type of Electric two wheeler will you buy?

- ◯ Electric motorcycles (1)
- ◯ Electric scooters (2)
- ◯ Electric bicycle (3)

Display This Question:

If Which type of Electric two wheeler will you buy? = Electric motorcycles

Or Which type of Electric two wheeler will you buy? = Electric scooters

Or Which type of Electric two wheeler will you buy? = Electric bicycle

Q93 Will you pay the full price of Electric Two Wheeler or in instalments?

- ◯ Pay full price (1)
- ◯ Installments (2)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 20000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q94 What type of business models, you would select for installments ?

◯ 12 months (1)

◯ 24 months (2)

◯ 36 months (3)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 30000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q95 What type of business models, you would select for installments?

◯ 12 months (5)

◯ 24 months (6)

◯ 36 months (7)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 40000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q96 What type of business models, you would select for installments?

- ○ 12 months (4)
- ○ 24 months (5)
- ○ 36 months (6)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 50000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q97

What type of business models, you would select for installments?

◯ 12 months (4)

◯ 24 months (5)

◯ 36 months (6)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 60000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q98

What type of business models, you would select for installments?

◯ 12 months (4)

◯ 24 months (7)

◯ 36 months (8)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 70000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q99

What type of business models, you would select for installments?

- ◯ 12 months (4)
- ◯ 24 months (5)
- ◯ 36 months (6)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 80000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q100

What type of business models, you would select for installments?

○ 12 months (4)

○ 24 months (5)

○ 36 months (7)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 90000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q101

What type of business models, you would select for installments?

○ 12 months (4)

○ 24 months (5)

○ 36 months (6)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 100000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q102

What type of business models, you would select for installments?

- 12 months (4)
- 24 months (5)
- 36 months (6)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 110000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q103

What type of business models, you would select for installments?

◯ 12 months (4)

◯ 24 months (5)

◯ 36 months (6)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 120000-

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q104 What type of business models, you would select for installments?

◯ 12 months (2)

◯ 24 months (3)

◯ 36 months (4)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 130000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q105

What type of business models, you would select for installments?

- 12 months (4)
- 24 months (5)
- 36 months (6)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 140000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q106

What type of business models, you would select for installments?

◯ 12 months (4)

◯ 24 months (5)

◯ 36 months (8)

Display This Question:

If What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = 150000

Or What is the maximum price are you willing to pay to consider buying above Electric two wheeler? = More than 150000

And Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q107

What type of business models, you would select for installments?

○ 12 months (4)

○ 24 months (6)

○ 36 months (7)

Display This Question:

If Which type of Electric two wheeler will you buy? = Electric motorcycles

Or Which type of Electric two wheeler will you buy? = Electric scooters

Or Which type of Electric two wheeler will you buy? = Electric bicycle

Q108 Would you require any financial assistance to purchase an Electric Motorcycle?

○ Subsidy by the government (1)

○ Bank Loan (4)

○ Other Loan from Private Financial Institution (5)

○ I would not require any financial assistance (6)

○ Other (7) ____

Display This Question:

If Will you pay the full price of Electric Two Wheeler or in instalments? = Installments

Q109 Which type of monthly installment do you prefer?

- ○ Private installment (Motorcycle showrooms) (1)
- ○ Bank installment (3)

Q110 Do you suggest a solution, so that electric two-wheelers could be adopted in Pakistan?

____

____

____

____

____

Q111 What is the full name of the interviewer **(Do not write if you are filling the online form yourself)**?

____

Q112 In which city, this survey has been conducted?

End of Block: Default Question Block

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