THE DEMAND ANALYSIS FOR ELECTRIC AND FUEL-BASED ENGINE VEHICLES IN ASIAN COUNTRIES: A STUDY FROM THE YEAR 2010-2022

Thesis

Submitted to meet the Graduation Requirements of

Master's Degree (M.A. in Economics & Business)

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FACULTY OF ECONOMICS AND BUSINESS

UNIVERSITAS ISLAM INTERNASIONAL INDONESIA

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ABSTRACT

Electric vehicles are gaining popularity as an environmentally beneficial innovation, offering a potential long-term solution to global energy constraints and pollution concerns. Despite their advantages, the demand for EVs in many Asian countries has not experienced substantial growth. Understanding the influential factors behind EV demand in this region is crucial to promote their adoption and addressing environmental challenges effectively. This study aims to examine the demand for electric vehicles in Asian nations as well as its substitution effect on those of fuel-based engine type. This study empirically investigates the factors that influence the demand for EVs. We apply a panel data regression model to analyze the relationships between GDP, inflation, EVs price, gasoline price, and quantity of charging stations from the year 2010 to 2022 in Asia. It is found that the EV market growth in India and ASEAN member countries is negligible. However, fuel-based vehicles are still dominating the vehicle market, especially in India and ASEAN member countries. In addition, the findings also indicate that GDP, EV prices, and the quantity of charging stations have a positive and significant impact on consumer demand in Asian countries. Overall, the study suggests that each country's policies should balance their domestic purchasing power; increase the development of charging infrastructures; and provide a well-designed scheme of incentives to harmonize the transition from conventional vehicles to EVs in the transportation sector.

Keywords: *Electric vehicles Demand, EVs Future Outlook, EVs Price, Gasoline price, Number of charging stations, macro level determinants.*

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LIST OF ABBREVIATIONS

EV	Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
BEV	Battery Electric Vehicle
FCV	Fuel Cell Vehicles
CO2	Carbon di oxide emission
GHG	Green House Gas Emissions
SDG	Sustainable Development Goal
Mt	Million ton
IEA	International Energy Agency

CHAPTER I

INTRODUCTION

1.1 Background

Asian regions form a huge market of vehicle in the global market. Around 48% of global vehicle market was dominated by Asian region in 2019. The expansion of road transport in correlation with economic growth has been substantial, leading to significant emissions of greenhouse gases (GHGs) and air pollutants that have implications for both the environment and public health. According to estimates, Asia will account for the major growth in global transport emissions, and its contribution will continue to rise. Asia is one of the world's areas most impacted by the increase in air pollution emissions and the escalation of air pollutant emissions places Asia among the most impacted regions (He et al., 2021).

In recent years, the environment has faced a serious threat from air pollution prompted by the combustion of fossil fuels in the energy, transportation, and industrial sectors. These sectors which are heavily relied on fossil fuels are intimately contributed to large energy consumption and CO_2 emission in a country (Poornesh, Nivya, & Sireesha, 2020).

The transportation sector is essential for both reducing and producing greenhouse gas emissions. The desire for purchasing vehicles with fuel engines has increased along with the socioeconomic level and living conditions. Oil accounted for 92% of the ultimate energy used in the transportation sector during the last ten years, a mere two percentage points less than in 1973. More oil was required to meet the rise in demand for the transportation of people and commodities, which resulted in additional carbon dioxide (CO_2) emissions. Currently, the transportation industry contributes significantly to air pollution and accounts for over a quarter of all direct CO_2 emissions connected to energy use worldwide. The transport industry has a crucial role to play, as highlighted by global and local goals and promises to enhance the environment and air quality (Fulton, Jaffe, & McDonald, 2019).

The fuel-based engine vehicles were dominating the world’s vehicle market. The demand for fuel-based engine vehicles has been increasing globally, especially in Asian region with the growth in the population and living standard the demand for vehicles has been increasing sine the year 2000. According to the International Energy Agency, until 2010 more than 98% of vehicle market was embedded by fuel-based engine vehicles. Since fuel-based vehicles mainly rely on fossil fuels, issues like excessive oil use, pollution, the CO_2 emission have been getting

worse in this industry (International Energy Agency, 2022). Therefore, countries around the world in response to the Paris climate agreement, the health effects of pollution, and the increasing severity of extreme weather events, are promoting the gradual phase-out of fossil fuel-powered vehicles, which significantly contribute to both air pollution and climate change. To accomplish this purpose, nations worldwide have launched policies to phase out fuel-based engine vehicles and stimulate the use of electric vehicles (EVs) via national-level incentives. Numerous governments have developed laws aiming at ending or drastically decreasing the manufacturing and consumption of vehicle with gasoline combustion by 2035 and 2040 as part of their electrification objectives (Burch & Gilchrist, 2018).

A variety of power trains and alternative fuels have been deployed with increasing speed during the last ten years. The year 2010 marked a turning point in the development of electric cars and the emergence of a potential new market. To minimize air pollution in densely populated places and to help governments achieve their goals of increasing energy diversity and reducing greenhouse gas (GHG) emissions, electrification of transport sector is considered a significant technological approach. Electric vehicles possess notable advantages, including zero exhaust emissions and superior efficiency compared to fuel-based engine vehicles. Moreover, when coupled with a low-carbon energy sector, electric vehicles hold substantial potential for mitigating greenhouse gas emissions (Global EV Outlook, 2020)

The demand for electric cars as a form of transportation has been influenced by growing environmental concerns and the quest for clean energy. Today, several nations worldwide are working to attain specific goals in the field of renewable energy. The electric car is a substitute to satisfy the need for a green source of transportation with lower emissions and improved fuel efficiency to lessen the effects of rising fuel costs and to adopt environmental legislation with higher requirements.

With its appealing potential of greater mileage and lower emissions, electric vehicle technology is a viable answer to the aforementioned problems. With the ultimate goal of eradicating harmful emissions, the contribution of the global transportation industry is also boosting EV popularity day by day. Due to the electrification of key components in the electricity and transportation industries, replacing fuel-based engine vehicle with EVs is a more efficient economic strategy (Habib et al., 2018)

Electric cars do not have fuel-based engine and are thus gas-emission-free since they are powered by electricity and because of this feature of EVs the adoption from fuel engine

vehicles to EVs is considered crucial for preventing climate change and maintaining the ecosystem (W. Li, Long, Chen, & Geng, 2017).

Further, compared to conventional cars, electric vehicles have a better energy transition efficiency, and the power needed to charge them may be produced from sustainable energy sources like wind, water, sun, and other natural resources. Hence, encouraging the use of EVs may help consumers use less fossil fuels overall. Since fuel-based motor cars generate over one-fourth of all carbon dioxide (CO_2) emissions at the global scale, there is rising concern about energy usage, environmental pollution, and the effect that greenhouse gas emissions have on climate change. The rise in global temperature caused by the increase in greenhouse gas emissions has an impact on both biological processes and all aspects of life on Earth. It is vital to cut down on the usage of fossil fuels and non-renewable energy sources to stop the temperature from rising further and lower greenhouse gas emissions. This leads to a greater possibility for electric cars to cut down on overall CO_2 emissions in the context of traffic (Mutavdžija, Kovačić, & Buntak, 2022).

Electric vehicles are widely regarded as the cornerstone of future transportation patterns. Electric vehicles (EVs), such as Plug-in Hybrid Electric Vehicles (PHEVs), Battery Electric Vehicles (BEVs), and Fuel Cell Vehicles (FCVs), use electric motor powertrains and have a large potential to alleviate the environmental problems associated with traditional vehicles. Transport emissions rose by 2.1% (equal to 137 Mt) due to the growth of advanced economies. However, the increased adoption of low-carbon vehicles helped mitigate emissions. Over 10 million electric vehicles were sold in 2022, making up more than 14% of all vehicle sales worldwide. The world's emissions are lower than anticipated because of the rising adoption of zero-emission vehicles. Based on the pre-estimations, If all newly registered electric cars were conventional diesel or gasoline vehicles, global emissions would have been 13 million tons (Mt) higher (IEA, 2022).

Traditional vehicles or fuel-based vehicles, which run on gasoline or diesel, have historically dominated the transportation industry. A fundamental transformation from fuel-based engine to EV is necessary as the transportation industry represents a substantial source of daily oil consumption and a major contributor to global carbon emissions. To prevent irreversible climatic effects, this transformation must take place within the next three decades. EVs, which have zero tailpipe emissions, became a key driver for developing a low-carbon economy and improving air quality (Harrison & Thiel, 2017).

Electric vehicles are the kind of vehicles which solely rely on electricity for power, unlike traditional vehicles that use petrol, diesel, or a combination of electricity and fuel. The electric vehicles operate using an electric motor and a battery that can be recharged. While a conventional vehicle derives its power from a fuel-based engine vehicle which is fueled by gasoline or diesel, making it a gasoline-powered vehicle. A regular electric vehicle can travel 100-200 miles on a full charge, while high-end models can cover up to 300 miles before needing a recharge. EVs fall into several types, and not all of them are entirely electric. The EVs categories are the range of these automobiles, known as pure electric vehicles (EVs), which are normally between 100 and 200 miles. In addition, unlike electric cars, plug-in hybrid vehicles (PHEVs) are powered by a combination of energy and fossil fuel (petrol or diesel). The maximum electric range of PHEVs is between 15 and 30 miles due to their smaller battery than pure electric cars. The vehicle's combustion engine will continue to operate until the battery is recharged. On the other hand, HEVs (hybrid electric vehicles) can only travel a little distance on electricity alone. A hybrid vehicle does not have a plug; instead, it uses the energy it gains from braking to replenish its battery while it is moving (Powell, 2023; EVfriendly, 2021).

Electric vehicles (EVs) are now widely acknowledged as an eco-friendly form of transportation. Along with this, the majority of automakers have begun to create and promote EVs, focusing particularly on the urban market (Sierzchula et al., 2012). EV can reduce local air pollution and also increases the sustainability of the road transportation sector, which accounts for the largest proportion of transportation carbon emissions. Demand for EV is rising, particularly in Asia, as a result of rising urbanization and steady economic growth. The adoption of electric cars can help reduce pollution and thereby improve an area’s quality of life, especially in urban areas (European Environment Agency, 2018; Schickram et al., 2013)

Asian nations are, in many respects, at the forefront of the climate crisis. Six of the top ten nations are most at danger from climate threats and 93 of the 100 most polluted cities are all located in Asia. As many nations continue to experience fast urbanization and economic growth, the area also has a high energy demand. China uses more than three times as much energy as all of Europe makes it more difficult for it to achieve net zero. Progress in the transportation sector will be crucial for Asia's efforts to combat climate change since it is one of the main sources of greenhouse gas (GHG) emissions. According to the calculations, the EVs provide almost 14% of the possible reduction in emissions between 2018 and 2050 (McKinsey, 2022).

Considering Asia, certain nations have declared their plans to transition from traditional fuel-powered vehicles to electric vehicles which highly supports the drastic future growth of EVs in vehicle market . For instance, Japan intends to ban new sales of internal combustion vehicles in the mid-2030s to achieve net carbon neutrality by 2050. China, the world's largest vehicle producer, announced in October 2020 that it will phase out sales of internal combustion vehicles in 2035. In contrast to Japan and South Korea, where traditional vehicles producers dominate EV market, numerous new venture firms such as NIO market are emerging in China's electric vehicle market and competing against traditional manufacturers.

Further, the government of Southeast Asia also launched an EV implementation strategy in 2016 to promote the manufacturing of BEVs and PHEVs, to have 1.2 million of these cars in use by 2036. Thailand unveiled an EV strategy in March 2020 intending to produce 250,000 EVs and creating an ASEAN EV center by 2025. Furthermore, the government of Indonesia under its low-carbon emissions program, has encouraged lower-carbon technology for EV. The nation signed a law encouraging the use of battery-powered road cars in August 2019. Indonesia, which competes with Thailand, wants to create an EV center in the area by offering tax incentives with local content requirements that may include HEVs and PHEVs (Natsuda, 2021).

Taking into account, the market sales and the growth of infrastructure in Asian countries, only three countries China, Japan, and Korea are regarded as the major EV market since the year 2010. While the other targeted countries in this study such as India and (ASEAN) are still in the fancy market and within the years 2010 to 2020 their progress has been inconsiderable, even though some of these countries such as Indonesian and Thailand along with India have shown remarkable growth in the recent years. On the other hand, according to the International Energy Agency and previous empirical studies, these countries have announced zero-carbon emissions by 2050 completing the carbon reduction plan of the Sustainable Development Goal (SDG) by 2030.

According to the International Energy Agency (2022) the adoption of EVs requires adequate investment and, evaluating the current EVs adoption is not projected to achieve zero carbon emission in the transport sector, while the carbon emission by the transport sector is expected to be increased in these countries. Therefore, this study with the main objective of analyzing demand for EVs and fuel-based engine vehicles will study the influencing factors of demand for fuel-based engine vehicles and electric vehicles from the perspective of demand theory.

This study is primarily designed on demand theory to evaluate the consumer choice theory with the impacts of variables such as GDP, inflation, fuel price, electric vehicle price, and number of charging station to achieve the primary purpose and fill the gaps by finding the effects of these components on consumer behavior and demand for EV and fuel-based engine vehicles. Moreover, this study to analyze the EVs demand, opposite to the previous studies conducted a quantitative approach with the combination of mature and emerging EV markets in Asia. While previous studies have studied the EVs demand by individual countries or limited countries in qualitative approach.

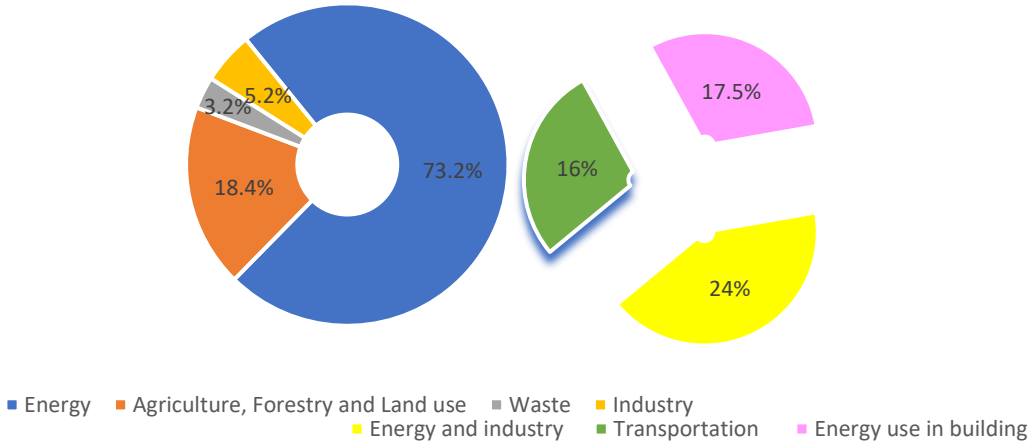

Figure 1. 1: CO_2 emission by sector & CO_2 emission share in energy sector
Source: Our World in Data 2020

1.2 Statement of The Problem

The transportation sector is a significant contributor to global greenhouse gas emissions since they are mainly relied on fossil fuels sources. As Asian countries continue to experience rapid economic growth and urbanization, the demand for transportation has increased, resulting in increased emissions of greenhouse gases. In response to this issue, many countries in Asia have introduced policies and incentives to promote the adoption of electric vehicles as a more sustainable and environmentally friendly alternative to fuel-based engine vehicles. However, the adoption of electric vehicles in the region has been slower than expected, and the factors that influence the demand for electric vehicles are not yet fully understood.

Additionally, despite the increasing global demand for sustainable transportation and the promotion of electric and fuel-based engine vehicles in many countries, the adoption of electric vehicles in Asian countries has been slow and varies across countries. This is even though many Asian countries are facing significant environmental and health challenges due to air

pollution and dependence on fossil fuels as well as the process of electrification in transport industry or the shifting to Electric vehicle from fuel-based engine vehicles is still facing global challenges.

The adoption of electric vehicles in Asian countries specially in China, India, and ASEAN member countries which constitute the high populations of the world needs high investment in the transportation sector in providing adequate source of clean energy such as electricity. While the main sources of energy in these countries are fossil fuels which generate high CO_2 emissions. In the other hand, building electric station requires more electricity, however, based on International Energy Association the demand for electricity consumption in household will increase ,and still more than 20 million of the ASEAN member countries facing a lack of electricity.

One of the most prominent concerns lies in the realm of electric vehicles in the ASEAN EV market. According to the International Energy Agency the market development of EVs excluding China Japan and Korea has been remarkably low in ASEAN countries from 2010 to 2018 and only in recent years these nations are showing progress which is also not aligned with their announcement for zero carbon emission. EV market with the current progress in these countries is still considered fancy and the EVs infrastructure for Electric Vehicles (EVs) is also not sufficiently developed to attract consumer's attention to serve as a viable substitute with fuel-based engine vehicle.

1.3 Research Questions

To conduct a comprehensive analysis of the demand for electric and fuel-based engine vehicles in Asian countries from 2010 to 2022, and to address the problem statement, the following research questions can be formulated:

1. What is the trend of demand for electric and fuel-based engine vehicles in Asian countries from 2010 to 2022?
2. What are the factors that drive the demand for electric and fuel-based engine vehicles in Asian countries?
3. What is the potential for future growth in demand for electric vehicles in Asian countries?
4. How do government's policy incentives effect the demand for EVs in Asian countries?

By answering the research question on the demand analysis of electric and fuel-based engine vehicles in Asian countries from 2010-2022, the study aims to provide insights into the factors that influence the adoption of electric vehicles in the region. This analysis can help to identify the trends and patterns in the demand for electric and fuel-based engine vehicles and the factors that drive these trends. Moreover, this study can help policymakers and industry stakeholders develop effective policies and strategies to promote the adoption of electric vehicles and reduce the use of fuel-based engine vehicles, thereby contributing to sustainable transportation and environmental protection.

1.4 Research Objectives

The objective of this study is to:

1. To determine the current and future trends of demand for electric vehicle in Asian countries from 2010 to 2022.
2. To examine the driving factors that have influenced the demand for electric vehicles in Asia.
3. To identify the current electric and fuel-based engine vehicle demand patterns in Asian countries.
4. To assess the influence of incentive policies on the demand for EVs in the region.

1.5 Research Hypothesis

Based on the research questions and objectives, possible hypothesis for the study could be:

H1: Increase in consumer's GDP per capita Increases the demand for EVs and helps EV adoption.

H2: Inflation has a negative impact on demand for EVs.

H3: Th price of fuel has positive effects on electric vehicle demand.

H4: The electric vehicle price has no effect on demand for EVs.

H5: Availability and number of charging points increase the demand for EVs.

1.6 Significance of Study

The importance of this study rests in its contribution to our understanding of Asian nations' demand for fuel- and electricity-powered vehicles between 2010 and 2022. Insights about the demand trend, the variables influencing the demand, and the potential for a future increase in demand for electric cars in Asian nations will be illustrated in this study. Understanding the determinants of EV demand is essential for formulating effective strategies to promote the

widespread adoption of electric vehicles. By identifying the significant factors influencing EV adoption, this study offers valuable guidance for governments and organizations seeking to accelerate the transition to sustainable transportation alternatives.

Additionally, this study is significant since by focusing on Asian countries, this study contributes to the existing body of knowledge on EV adoption in a region that is experiencing rapid economic growth and urbanization. The insights gained from this study inform regional policies and initiatives aimed at reducing carbon emissions and promoting sustainable EV market and transition to zero emission alternative. Further, the combination of mature and emerging countries and lessons learned from major EVs market, and the policies applied by major EV markets offers valuable lessons for emerging nations in the region. This study provides insights from the success of mature markets and uses similar incentive policies to boost EV adoption in emerging countries and address challenges specific to their contexts.

Furthermore, the promotion of electric vehicles (EVs) holds significant potential in mitigating greenhouse gas emissions and reducing the carbon footprint of the transportation sector. This study contributes to this overarching goal by comprehensively analyzing the influential factors that drive EV demand. By doing so, it offers valuable insights into achieving a greener and more sustainable future.

Moreover, this study's uniqueness lies in the implications it holds for the automotive industry and related sectors. Through a thorough examination of EV demand based on demand theory and consumer preferences in EV adoption, the findings offer critical insights. These insights serve as essential guidance for automakers, charging infrastructure providers, and other stakeholders to tailor their strategies and investments to meet the evolving demands of the market effectively.

1.7 Outline of Study

The second chapter of the dissertation will focus on the literature review, aiming to provide a comprehensive understanding of the relevant academic works on the subject of electric and fuel-based vehicle demand in Asia. This chapter will explore key concepts of EV demand in Asian countries under the theory of consumer behavior. Further, in this segment definitions related to EVs, and the factors affecting their demand in the Asian market will be also illustrated. In addition, this chapter will also analyze the literature gaps and conceptual framework to emphasize the significance of the current research.

The third chapter will detail the research methodology employed for data collection and analysis. This chapter will cover the research design, data sources, research instruments used, sampling techniques employed, and data analysis techniques applied to ensure the validity of the results obtained.

The fourth chapter, the results, and discussion section will present the analysis of the data collected. Tables, graphs, and charts will be used to illustrate the trends and patterns observed in the demand for EVs and fuel-based engine vehicles. The discussion will then interpret the results obtained, examine their implications, and relate them to the research questions and hypotheses.

The fifth and final chapter of the dissertation will consist of the conclusion and recommendations. This chapter will summarize the research's main findings, evaluate the research hypotheses, and draw conclusions based on the findings. Further, suggestions for further research in this field will be presented, emphasizing the study's constraints, and proposing opportunities for future studies. On the other hand, implications for policy and practices will be drawn from the research results.

CHAPTER II

LITERATURE REVIEW

This chapter will be centered on the literature review to impart a thorough comprehension concerning the demand for electric and fuel-based vehicles in Asia. The demand theory is regarded as an acceptable guiding theory for the present study's objectives since consumer behavior is a crucial component of involvement, consumption, and adoption as well as establishing market demand. Moreover, the influencing factor chosen as an independent variable in this research will also be illustrated in the body of theory in this section. This segment will also delve into fundamental ideas and definitions of EVs, demand for electric vehicles, the outlook of EVs, historical demand for EVs, demand for fuel-based engine vehicles the rationale for the shift to electrification, and the factors influencing their demand in the Asian region.

2.1 Theoretical Framework

Prior to reviewing the previous empirical findings, this study delves into the economic theories which form underlying reasons for the existence of demand for EVs and fuel-based engine vehicles, particularly in the Asia region. Among the economic theories, the neoclassical economic theory of demand reflects the consumer’s choice preferences, and willingness for demanding goods and services. Neoclassical theory was developed in the late 19th century by William Stanley Jevons to compete with older ideas of classical economics. This theory emphasizes supply and demand as the primary forces influencing the creation, valuation, and consumption of commodities and services. This theory believes that a product's pricing is determined by the consumer's estimation of its worth, as well as the theory affects how organizations, financial institutions, and governments control the market (Kenton, 2023).

In addition, consumer preferences and their desire for products and services are highly valued in neoclassical economics as well as consumer demand may be affected by consumer preferences, resource allocation, and several other variables. In the context of neoclassical theory, goods and services are priced according to the perceived value they have among consumers, which may be greater than their production costs. Further, according to this hypothesis, consumer behavior and tastes strongly influence market demand for a product. Following this idea, consumers have a wide range of options, and their preferences among the items to increase market demand for a particular good (Perloff, 2011).

Furthermore, according to neoclassical economists, there is a law for demand in economic principle that applies to all consumers. Based on the concept of this law, in the condition when all other factors are equal (ceteris paribus), a decrease in the price of a good or service will generally lead to an increase in the quantity demanded, while an increase in price will lead to a decrease in demand. The law of demand reflects the inverse relationship between price and quantity demanded, indicating that consumers tend to buy more of a good when its price is lower and less of it when its price is higher. This concept forms the basis for understanding how changes in price affect consumer behavior and market demand.

The law of demand also contends that consumers' choice and behavior are crucial in shaping the demand for goods. The market's demand for goods and services is directly impacted by consumer preferences, tastes, and selections. Consumers are typically prepared to pay more for a good when they believe it to be more useful or attractive, which increases demand. On the other hand, demand for a given good will fall if consumer preferences change or their willingness to pay declines.

Further, based on this hypothesis, consumers have a free hand in their product preferences, which boosts market demand for a certain product. On the other hand, the concept of this theory, aside from the prices of goods, signifies to the non-price determinants of demand which are influential in shifting consumer willingness from one product to another (Perloff, 2011). These determinants are as follow:

- Interests or tastes of consumers
- The number of consumers in the market
- Consumer budget
- The cost of related items
- Consumers' assumptions regarding future pricing

2.1.1 Demand Theory for Electric Vehicle

Demand theory examines how individuals choose how much money to spend depending on their preferences and financial limitations. Based on the demand theory demonstrates how people's decisions are influenced by their income level, as well as the costs of products and services. Understanding consumer behavior or consumer choice helps merchants forecast which of their goods will sell more, and it helps economists better understand the invisible hand, the hidden factors that influence the economy. Based on this theory's point of view,

people are free to pick between many packages of goods and services, and consumer preference and choice are greatly influenced by how much a product maximizes its utility. Additionally, according to this theory, consumers maximize their utility by shopping strategically and purchasing the goods that will benefit them the most.

According to this theory, the consumer's preference and a change in their decision often call for the following inputs:

- A whole range of consumption possibilities.
- How much usefulness each bundle in the collection of alternatives provides for the consumer.
- A range of prices associated with each bundle.
- Any initial package that the buyer already has.

This study which seeks to analyze the demand for EVs and fuel-based engine vehicles in the Asian countries, lies on the demand theory since this theory in the body encompasses and explains the influential factors particularly consumer preference and ability which form the market demand. Based on this theory consumer preference, their ability, and their utility level from using certain products substantially impacts on rise and fall of demand. Therefore, this study considers it necessary to explain the variables such as EV price, GDP, Inflation, gasoline price and the significance of charging station availability in the body of demand theory because these variables are influential in creating market through price of goods, income of buyers, price of other related goods, and consumer tastes and preferences.

2.1.1.1 EV Price

Analyzing the demand theory and relating them to this study is given that the price of electric vehicles as a significant factor impacts the demand for electric vehicles. According to demand theory, prices have a significant impact on how consumers behave and make decisions, including their preference for electric cars (EVs) over those with fuel-based engine cars. A key factor in determining consumer preferences and the possible switch from fuel-based to electric cars is the pricing of EVs in comparison to that of fuel-based vehicles.

The price elasticity of demand, in accordance with consumer choice theory, gauges how responsive consumers' quantity demands are to price changes. The quantity requested for EVs is anticipated to rise in the context of EVs if the price of EVs lowers, providing all other factors remain constant. Consumers' sensitivity to changes in EV pricing is shown by the size of the

price elasticity of demand for EVs. A decline in EV pricing would cause a substantially bigger rise in the quantity required if EV demand is price elastic (Hashim Haslenda et al., 2021).

Additionally, the cost of EVs affects how affordable and available they are to consumers. Particularly among consumers who are price sensitive, higher EV pricing may operate as a barrier, reducing EV demand. Lower EV costs may make them more appealing and available, which might lead to an increase in demand. Prices for EVs and fuel-based cars vary, which influences consumer choices for EVs. The cost of EVs may become more competitive or equivalent to that of fuel-powered cars, which may raise demand for EVs. As a result, the consumer choice theory may be used since the cost of EVs is a significant determinant of consumer choice and the move to EVs (McKinsey, 2019).

2.1.1.2 Gross Domestic Product (GDP)

According to the Hanžič et al. (2019) government and individual's in production and choosing more form a basket of product is rely on their ability, and GDP growth is signifying to the government's ability and individual's purchasing power relatively in production, creating market demand and willingness in purchasing new and high cost product. In terms of purchasing a vehicle, it can also be inferred from theory when the GDP of a country is growing, the (per capita) increases and consumer confidence is high, people are more willing to buy a car The demand for both electric cars (EVs) and vehicles powered by fuel-based engines may be influenced by GDP, according to consumer choice theory. Therefore, the following are some ways in which consumer choice and their demand for EVs will be impacted by GDP:

- **Income Effect:** According to consumer theory, a person's preferences and choices depend on their ability to meet financial obligations. By using scarce resources wisely, consumers desire to maximize utility. Due to the fact that people base their choices on their preferences, wants, and limits, consumer choice is crucial to this transition. Consumers have more choices as GDP increases and ideal circumstances for EV adoption are created. Consumer preferences and choices are significantly influenced by GDP, since the growth of GDP enhances the purchasing power of consumers, and they would assess their budget and ability prior shifting to a new product. Average salaries among the population often rise as GDP rises.

  The ability to evaluate and purchase more costly solutions, such as EVs, may increase with increased salaries for consumers. An increase in GDP may lead to a boost in demand for EVs and fuel-based automobiles, according to the income effect since

consumers will have more discretionary money to spend on alternative forms of transportation. Although EVs are not quite competitively priced with fuel-based engine cars, the growth in their GDP, which strengthens their buying power, will help people to make a reasonable decision towards switching to EVs. In contrast, a lower GDP will encourage people to stick with fuel-based engine vehicles when there is a significant price disparity between these two distinct products (Boyle, 2018).

- **Consumer Preferences and Perceptions:** As a key factor GDP growth, may affect consumer preferences and perceptions. As GDP increases, it often denotes economic success and advancement, which may enhance consumer confidence and readiness to spend on more modern or environmentally friendly products. The popularity of EVs and the desire for eco-friendly transportation options may both rise in tandem with an expanding GDP.
- **Technological Advancement and Affordability:** GDP growth and innovation are often correlated. Infrastructure investment often increases as economies grow, which may result in advancements in EV technology and lower costs. Increasing GDP may lead to improvements in manufacturing efficiency, charging infrastructure, and battery technology, which will lower the cost and increase consumer interest in EVs.
- **Environmental Concerns and Policies:** A higher GDP is often linked to increased environmental concern and an emphasis on sustainable development. Governments and people could become more environmentally aware as GDP rises, especially the need to cut greenhouse gas emissions and slow down climate change. This increased environmental consciousness may affect consumers' choices towards EVs, which are thought to be more ecologically benign than fuel-based cars. Because consumers place a stronger priority on sustainability, growing GDP may help to fuel a rise in EV demand.
- **Governmental Incentives and Policies:** Economic growth and greater GDP levels may provide governments with the resources they need to put supporting policies and incentives for EV adoption into place. For EVs to be more appealing to consumers, governments may give subsidies, tax credits, and other financial incentives. Because consumers see EVs as more economically advantageous because of government backing, these policy actions may help to increase demand for EVs.

It's crucial to remember that, although GDP may affect demand for both EVs and fuel-based cars, the strength and direction of this effect may differ depending on other variables including

consumer preferences, governmental regulations, the availability of infrastructure, and technical breakthroughs. Hence, the growth and lag in GDP will significantly impact government and individual ability toward preference and investment in EVs. A rise in GDP may influence the switch from fuel-based motor cars to electric vehicles. This change is being driven by consumer choice, as people weigh their alternatives, form opinions based on their preferences, and act on the things that are important to them.

2.1.1.3 Inflation

The desire for electric cars (EVs) may be impacted by inflation in several ways, possibly affecting consumer choice, demand, and the transition toward EVs. When a nation experiences inflation, EV manufacturing costs may rise, pushing up the cost of these cars. It's crucial to keep in mind, too, that inflation also has an impact on the costs of other items and commodities. Consumers' buying power declines when the cost-of-living increases, making them cautious with their money. In these circumstances, consumers often give priority to necessities and goods that meet their urgent demands. In addition, consumers with low buying power could be less likely to invest in EVs during periods of inflation since EVs often cost more than traditional fuel-based cars. Consumers may be discouraged from considering EVs as viable solutions by their greater price, particularly if they are preoccupied with meeting their fundamental wants and managing their limited finances. Instead, consumers could choose less expensive transit solutions that fit their tight budgets (Slowik et al., 2023).

The increased cost of EVs during an inflationary period may reduce consumer demand as they prioritize buying products that meet their immediate requirements and are more reasonably priced. According to the consumer choice theory, consumers' desire to switch from fuel-based engines to EVs would depend on several cofactors in an inflationary environment. Consumers' purchasing power will gradually reduce over time by inflation as the average price of goods and services rises. High inflation may lower consumer purchasing power and make it more challenging to acquire pricey goods like EVs. In such circumstances, the market for EVs may be adversely impacted as buyers choose more necessary or less expensive commodities (Slowik et al., 2023). During inflation consumer willingness and demand for electric vehicles will be adversely affected in the following ways:

1. **Changes in Relative Prices:** As a result of inflation, prices of EVs for other products and services may fluctuate. EVs may become comparatively more appealing and cost-effective for consumers if the rate of inflation for EVs is lower than for other items or

fuel-based cars. Due to the pricing advantage of EVs in terms of decreased fuel prices and future government subsidies, demand may rise despite general inflation due to these factors.

2. **General price of inflation:** A rise in pricing for products and services generally is referred to as general price inflation. Consumers may find it harder to purchase superior or luxury goods when the general price of inflation occurs and causes a decline in purchasing power of buyers. Consumers' discretionary income may be strained when the cost of different products and services rises, which might limit their budget to invest in more expensive things like EVs. The demand for EVs may be negatively impacted by higher overall price inflation, especially if salaries are not keeping up with price increases.

2.1.1.4 Gasoline Price

Gasoline is a combination of volatile, flammable liquid hydrocarbons generated from petroleum that is used as fuel for fuel-based engine vehiclelike those used in motor vehicles (Selin, 2023).

Based on the consumer choice theory, the price of other goods and services impact on consumer demand. In perspective, of this theory it can be interpreted that the cost of gasoline is a complementary good that is consumed together with driving a car with a fuel-based engine. Consumer demand for the product in use typically decreases when the price of a complementary commodity rises. This is because the greater cost of the supplement makes consuming the commodities as a whole more expensive or less desirable. Consumers may prioritize alternatives that do not require the costly complement or lessen their desire for both products (Perloff, 2011).

In addition, the concept of this theory has been emphasized with empirical studies. A study that has investigated consumer behaviors in China in response to variations in the price of gasoline has found that consumers are more sensitive to fluctuations in oil prices. The frequency of vehicle use is influenced by changes in oil prices, and when oil prices rise, consumers tend to drive less. On the other side, it also has an impact on how consumers behave while making purchases. When oil prices rise, potential buyers alter their purchasing expectations and opt for other alternatives and chose lower carbon emission vehicles to stop gasoline expenses (Du & Lin, 2017)

2.1.1.5 Charging Station and Demand for Electric Vehicle

The availability of charging infrastructure as a variable in this study has selected because of its relationship with consumer attitude in purchasing and adoption of electric vehicles as well as the charging infrastructure has been tested a key factor in consumer demand toward electrification. Further, it is mentioned that for every new concept to become a reality, infrastructure is a fundamental prerequisite. A lack of infrastructure causes an idea to fail from the beginning. Roads, recharging stations, battery exchange stations, and service stations make up the infrastructure needed to foster a good view of electric cars and ultimately their acceptance. Consumers are being discouraged from investing in the adoption of electric vehicles by the lack of availability or the poor state of the current infrastructure (Bhalla, Salamah Ali, & Nazneen, 2019).

According to the Perloff (2011) Microeconomic principles, in terms of consumer choice sheds light on how the availability of complementary goods and services draw consumer behavior in demand for certain good and service and relating the concept to the current study, it can be inferred that the EV charging stations affects consumers' decisions to buy electric cars (EVs). Consumer choice theory holds that people make rational choices by taking into account a variety of criteria, such as the accessibility and availability of products and services. In this instance, the availability of EV charging stations plays a significant role in influencing consumer preferences and EV adoption choices.

The idea of utility, a key idea in consumer choice theory, is very important. Utility is the pleasure or advantage that consumers experience as a result of using a certain item or service. When it comes to EVs, buyers want to maximize their usefulness by selecting a car that meets their demands. The perceived usefulness of having an EV is directly impacted by the availability of charging stations. Consumers perceive more accessibility and convenience while charging their cars when there are more charging stations available, which alleviates fears about running out of gas. This higher utility has a beneficial impact on consumer choices and the propensity for purchasing an EV (Hashim Haslenda et al., 2021).

The demand theory also acknowledges the significance of restrictions in decision-making. A limitation in complementary goods or services such as a lack of available charging stations make EVs less appealing to certain users. A larger network of charging stations would ease this restriction and provide consumers with more choices, which would increase the chance of EV adoption. Furthermore, the theory acknowledges the importance of market competition and

variety in consumer decision-making. As the number of charging stations increases, it stimulates market expansion and encourages automakers to introduce a wider range of EV models. This variety enhances consumer choice and addresses diverse preferences and needs, making EVs a more appealing option (Schulze-Darup, Guillén, & Lozada-Benavente, 2018)

Meanwhile, the result of some empirical studies also intensifies the importance of EV charging point in elevating consumer demand and EV adoption. Recent research studies have emphasized the crucial role of charging infrastructure availability in shaping consumer attitudes toward purchasing electric vehicles (EVs). These studies have demonstrated that the mode of charging significantly influences consumers' charging habits, and the presence of charging facilities directly impacts consumers' intentions to adopt EVs, as well as their overall attitude and perceived behavioral control (Knez, Zevnik, & Obrecht, 2019).

Furthermore, charging facilities have been identified as a fundamental driver for the advancement of electric vehicles, as they play a pivotal role in influencing consumer attitudes. A specific study conducted in Taiwan examined the relationship between charging infrastructure availability and consumer attitudes. The findings of this study revealed a positive correlation between the charging infrastructure of green vehicles and consumers' attitudinal consumption.

The study highlighted that the availability of charging facilities addresses crucial consumer concerns, such as EV range anxiety, and effectively mitigates worries associated with limited driving range. By providing convenient and accessible charging options, the availability of charging infrastructure helps alleviate consumer apprehensions and promotes positive attitudes toward EV adoption. Overall, these research findings emphasize the significance of charging infrastructure in shaping consumer perceptions and attitudes toward electric vehicles, providing valuable insights into the importance of expanding and improving charging networks to accelerate the widespread adoption of EVs (Dutta & Hwang, 2021)

2.1.2 Electric vs Fuel-based Vehicles

EVs and fuel-based engine vehicles have various significant differences that separate them in the sense of their operation, their environmental effects, performance, and user experience. EVs which do not rely on combustion of diesel and gasoline to run are well known as zero emission and environmentally friendly vehicles. EVs with advantages which have in their power source, environmental effects, cheaper repairing cost is considered an alternative to fuel-

based engine vehicle. The aspects such as inadequate charging station, high initial cost and driving are making the EVs less competitive against the fuel-based vehicles.

On the other hand, fuel-based vehicles which are powered by fossil fuels are regarded as a source of greenhouse gases. The fuel-based engine vehicles for their reliance on gasoline, contributing to climate change and air pollution. Hence, an increase in demand for fuel-based vehicles is complicating the decarbonization in the transportation sector.

EVs are considered the future of mobility global market since these vehicles contributing to the world toward decarbonization of transportation sector. The increasing demand for EVs helps the governments in their announcements for zero carbon emission target through deterring the combustion of fossil fuel energies.

2.1.2.1 EVs Definition

An electric vehicle is a type of vehicle that runs on an electric motor rather than an internal combustion engine. An electric car requires a charging station since its electric motor is powered by a sizable traction battery pack. Batteries like lithium-ion, nickel-metal hydride, and lead-acid batteries are used in electric cars. Due to their superior energy retention, lithium-ion batteries are frequently used in electric cars. Electrified vehicles, both cars, and trucks, can be classified into four distinct categories:

- **Battery Electric cars (BEVs):** which are also famous for “pure electric engines” are powered only by electricity and lack a petrol engine. Battery Electric Vehicles (BEVs), also known as 'all-electric vehicles' or 'pure electric vehicles,' operate solely on electricity and do not have a gasoline engine. BEVs are propelled by one or more motors powered by electricity that are fueled by rechargeable batteries. The majority of BEVs on the road now contain lithium batteries. Because lithium batteries have a high power-to-weight ratio and a tiny physical footprint, they are preferred by automakers that need longer ranges.

  Utilizing electricity provided by an EV charger is used to charge the battery packs. Most BEVs can fast charge using a level 3 charger, which is the quickest form of EV charger (there are multiple types or "levels" of chargers for electric cars, with levels 1 and 2 being the slowest and level 3 being the fastest). BEVs are emissions-free cars that don't emit any hazardous gases or pollute the air, in contrast to gasoline-powered automobiles. Although updated versions with larger ranges are being introduced, the

driving range of today's BEVs is between 50 and 350 miles per charge (Nanaki, 2020; Global EV Outlook, 2021)

- **Plug-in Hybrid Electric Vehicles (PHEVs):** Utilize batteries to power an electric motor alongside a fuel-based engine vehicle, which serves to recharge the batteries and extend the driving range. Typically, a PHEV operates on electricity stored in the battery until it is nearly depleted, covering a distance of around 10 to 50 miles depending on the vehicle model and battery capacity. Afterward, the car smoothly switches to the fuel-based car, enabling it to travel several hundred miles using fuel from the tank. This transition can significantly reduce fuel consumption and emissions, particularly for short trips. In instances where electricity is unavailable, a Plug-in Hybrid can solely rely on fuel for operation. PHEV batteries can be charged using Level 1 or Level 2 EV chargers, although most are not compatible with Level 3 DC fast chargers (Nanaki, 2020; Global EV Outlook, 2021)
- **Hybrid Electric Vehicles (HEVs):** also known as 'self-charging hybrids,' utilize both an internal combustion engine and an electric motor powered by a battery pack. Unlike Plug-in Hybrid Electric Vehicles (PHEVs), HEVs cannot be charged using an EV charger since their batteries are charged through the engine and regenerative braking. The electric motor in an HEV assists the vehicle by generating additional power, which can enable the use of a smaller engine. The battery pack in an HEV also functions as a supplementary battery, reducing idling time and resulting in improved fuel economy and lower emissions compared to conventional engine cars.
- **Fuel Cell Electric Vehicles (FCEVs):** Operate with zero emissions, as they are powered by hydrogen. Like Battery Electric Vehicles, FCEVs utilize a system where energy is converted to electricity to propel the vehicle. In the case of FCEVs, hydrogen serves as the energy source and is converted into electricity through the fuel cell. These vehicles have a hydrogen tank for storing pure hydrogen, which can be refueled in just a few minutes, much like fuel-based engine vehicles that are refueled today. FCEVs can travel approximately 300 miles on a single tank of hydrogen. They also incorporate regenerative braking technology to capture and store energy generated during braking in a battery pack. However, it's important to note that there are currently only a limited number of FCEVs available to the public, and the infrastructure for refueling these vehicles is not yet sufficiently developed to support the widespread adoption of FCEVs (Nanaki, 2020; Global EV Outlook, 2021)

2.1.2.2 Demand for Electric Vehicles

The demand for EVs has surged in developing countries globally. The global demand for electric vehicles has been steadily increasing over the past decade. According to the International Energy Agency (IEA), the number of electric cars on the road exceeded around 27 million in 2022, representing a significant increase compared to previous years. The growth of the EV market has been particularly notable in countries like China, the United States, and Europe. The demand for electric vehicles varies based on factors such as infrastructure development, government policies, and consumer preferences. The main factor for the initiation of EVs relates to the global concern of CO_2 emission and the factors such as increasing the number of charging infrastructure, incentives, and reduction in the EV prices through growth of battery industries have been functioning as supplementary in expanding demand for EVs (Global EV Outlook, 2023).

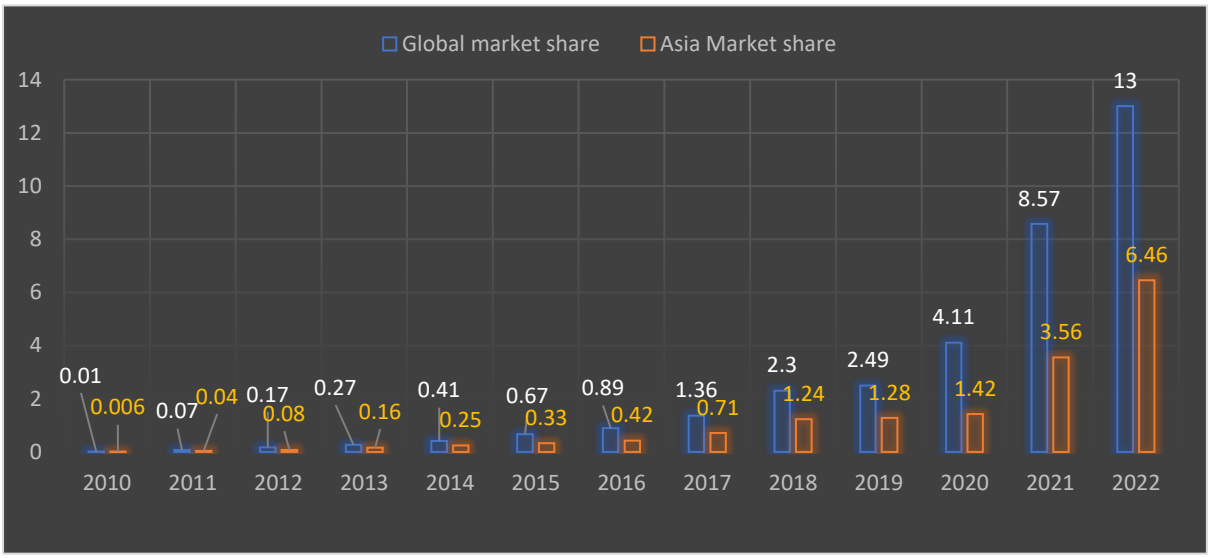

Figure 2 1: EV market sales share in global EV market

Source: (International Energy Agency, 2022)

Figure (2.1) shows the EVs growing market share from its preliminary steps in 2010 until 2022 in Asia region compared to the global market share. Asian developed and emerging economies such as China, Japan, Soth Korea, India, and ASEAN helped Asia to create a substantial market following the global decarbonization target. China dominates the EV market in Asia, accounting for more than 95% of the market share. This makes China a prominent player in both the regional and global EV market. (International Energy Agency, 2022)

According to International Energy Agency (2022) the increasing market share and drastic mowing ridge is implying a remarkable demand for EVs in Asia and the globe. The above

figure shows a clearer image of demand for EVs and fuel-based engine vehicles. The year 2010 shows that the EV market share in Asia combined with the world formed less than 1% of vehicle market. This suggests that the global vehicle market was ruled by fuel-based engine cars. Following the year 2010 the market share of EVs has been booming and finally with involvement of China, Japan, and South Korea in year 2015 could make up 1% percent of the global market. The dramatic growth is taken place from 2019 to 2022, though Covid-19 adversely impacted on both EV and gasoline car by raising the cost in supply chain but by the end 2022 the 13% of global vehicle market share indicates a huge growth of EVs. The growth trend not only shows an increasing demand for EVs, but also it exhibits a gradual decline in gasoline cars.

The global electric vehicle (EV) markets exhibit significant variations today due to factors such as policy support, corporate initiatives, consumer preferences, awareness, driving patterns, and cultural specificities. Policy measures have played a crucial role in influencing corporate strategies toward electric vehicles and stimulating consumer interest. In key EV markets like China, Europe, and the United States, early adoption was propelled by policies aimed at boosting demand, such as incentives for vehicle purchases. China also employed direct incentives for automakers. These markets are now witnessing the maturation of EV markets, particularly in the passenger car segment, where sales shares are rapidly increasing. The increasing sales of electric vehicles indicate a significant surge in demand for these vehicles (Global EV Outlook, 2022).

In addition, more developed markets like China and several European countries are shifting their focus to other sectors like heavy transport and charging infrastructure. Simultaneously, governments in major markets have raised their targets for EV adoption and are addressing various aspects of the EV supply chain, including policy support for vehicle and battery manufacturing and critical mineral supply chains. Additionally, several other countries outside the major markets have recently introduced policies to support EV adoption. Overall, both governments and consumers worldwide have substantially increased their spending on electric cars in recent years to harmonize the transition to vehicle and meet the growing demand for EVs (Global EV Outlook, 2023).

The significant increase in demand for electric vehicles is accompanied by government initiatives aimed at accelerating decarbonization, as seen in the new Five-Year Plan (FYP) from 2021-2025. This builds upon the trend of progressively stronger policy support for EV markets

observed in previous FYP periods. One of the contributing factors of the growth is the availability of new plug-in hybrid electric vehicle (PHEV) models with larger batteries, resulting in lower CO_2 emissions ratings. Consumer considerations such as driving range, EV prices, and access to charging points also play a crucial role.

Additionally, subnational regulations, such as local subsidies, tax breaks, financial incentives, and exemptions, provide preferential treatment to EVs. However, it should be noted that the success of electric cars has varied across different regions over the past decade. China, Europe, and the United States dominate the electric car market, accounting for nearly two-thirds of overall sales and representing 95% of total electric car sales in 2021. In contrast, countries like India, and Indonesia have experienced slower adoption rates, with EVs constituting less than 0.5% of total sales. This can be attributed to higher prices that limit mass-market consumer affordability in emerging markets, as well as the lack of widely accessible charging infrastructure and weaker regulatory support (Global EV Outlook, 2022)

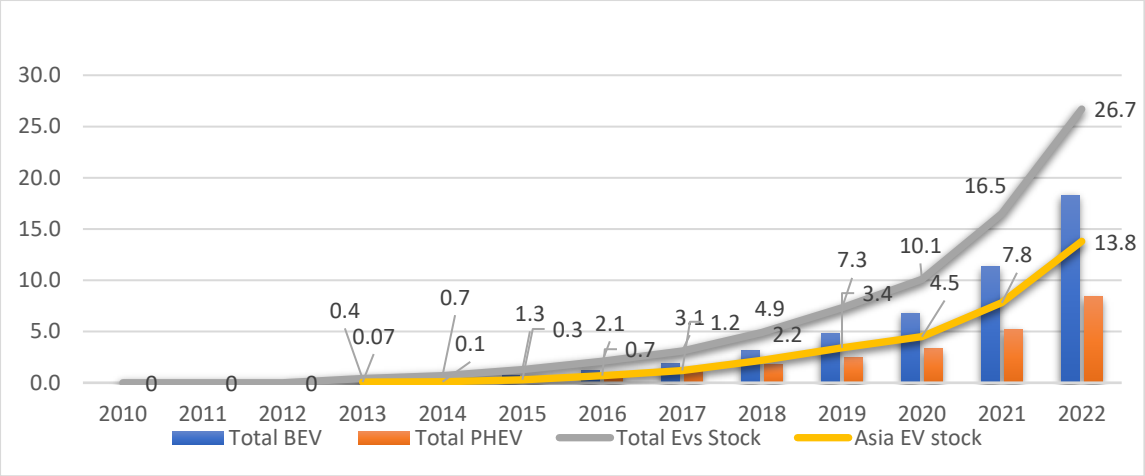

Figure 2.2 *Global electric vehicle stock in million*

Source: *International Energy Agency (2022); Global EV Outlook (2023)*

Figure 2-2 illustrates the gradual growth of Asia's BEVs and PHEVs in the global vehicle stock. Among all types of EVs only BEV and PHEV are developed globally. The figure demonstrates the gradual growth of EVs on the road globally and in Asian region. market share of Asian in the beginning compared to the Asia and worldwide. The data shows that the quantity of EVs in 2013 which is considered the emerging era of EVs, has been 400 thousand EVs on the road globally, while Asia with having 70 thousand EVs were making quite small number of EVs on the road. 2019 to 2022 is considered the remarkable growth of EVs with having more than 10 million EVs on the road (Global EV Outlook, 2023).

Asian EV stock which is leading by China and recently the growth in Japan, South Korea, and participation of India and ASEAN member countries are making the highest EVs market, though the growth in India and southeast Asian countries is considered negligible. In 2022, Asia comprised a substantial portion of the global electric vehicle (EV) stock, with 13.8 million out of the total 26.7 million EVs on the road. This signifies that Asia accounts for more than half of the EVs in circulation worldwide. The significant presence of 13.8 million EVs in the Asian region highlights the region's pivotal role in the transition towards sustainable transportation. Notably, this surge in EV adoption is accompanied by a corresponding decline in the prevalence of conventional fuel-based engine vehicles, both globally and specifically in Asia. (Global EV Outlook, 2023).

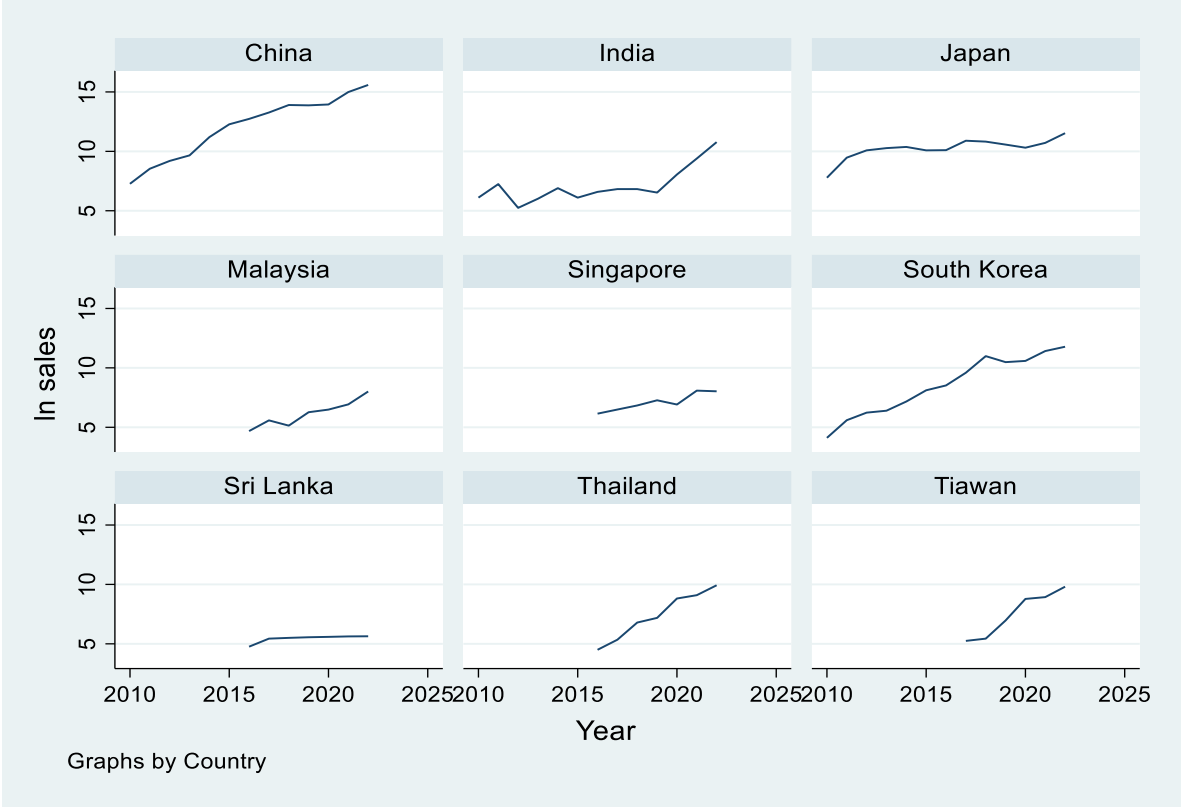

Figure 2.3 *Electrical Vehicle demand trend by country*

Source: *International Energy Agency, IMF*

Figure (2.3) shows the demand trend for EVs in Asian countries. Data in these selected countries of Asia has been big difference, in some of these countries the sales growth which represents the demand for EVs is in millions while in some countries the growth is in small units. Therefore, logarithmic transformation is applied to normalize and make the data to a similar scale. This helps to minimize the influence of extreme values and reduces the impact of outliers that could potentially skew the analysis. It ensures that the variables are comparable

and avoids any biases that may arise due to different magnitude orders. The abovementioned figure shows the overall demand for electric vehicles in Asian minor and major markets. The demand trend for major Asian markets such as China, Japan, and South Korea has been in primary steps but their gradual growth over the years has created potential demand for EVs in these countries where according to International Energy Agency China is leading the global EVs market for having the highest growth and adoption in BEV and PHEV. According to IEA Korea also has formed a huge market of fuel cell electric vehicles in the globe.

On the other hand, the demand for EVs in India and ASEAN member countries has been an idea in the 2010. Even though the EV market in recent years has been growing but their markets are still inconsiderable market because of their tiny growth from 2010 to 2020. The findings and the concept of the above demand chart in Asia entirely agree with the recent findings and concept of Mckinsey company.

Mckinsey (2022) found that different Asian nations had different adoption rates for electric cars (EVs). Emerging Asian markets, notably India and the ASEAN countries, are making slower development than more developed markets like China, Japan, and South Korea. Less than 1% of new car sales in the area in 2021 were electric vehicles. According to McKinsey (2022) findings, scaling up and attaining long-term economic viability are difficult for many businesses throughout the value chain. Because switching to EVs requires a long-term commitment and a sizable upfront expenditure, growing Asian countries have recently been deficient in this area.

The slow expansion of the EV market in developing Asia is caused by a number of problems. One major barrier is the high cost of EVs as a whole to purchase, which has not been addressed in these areas. The significant investment needed to lower the cost of EVs has not been adequately raced for in recent years. These difficulties are especially evident in developing Asian markets where the cost of EVs is higher than that of vehicles powered by gasoline, making them unaffordable for many families. Total cost of ownership parity by 2030, particularly for four-wheelers, looks improbable under the present "business as usual" distribution trajectory in many Southeast Asian nations without further investment in the development of affordable EV models and efficient distribution networks.

Inadequate charging infrastructure is another significant issue. To facilitate the predicted expansion of EVs and mitigate consumer worries about range anxiety, there are often not enough charging stations in ASEAN markets. By 2030, it has been estimated that the ASEAN

markets would need around 95,000 public alternating current (AC) and 40,000 direct current (DC) charging establishments combined (McKinsey, 2022).

2.1.2.3 Demand for Fuel-based Engine Vehicles

According to International Energy Agency (2022), McKinsey (2021), despite the growth of demand for EVs in the global market and mature Asian market such as China, Japan, and South Korea, for the rest of Asian countries the growth has been inconsiderable. This strongly signifies the domination of vehicle market by gasoline cars.

India a country with high population is the huge market of gasoline car users, the EVs development in this country from year 2010 to 2022 has been quite slow in compliance to the country size in population and percentage of vehicle users. Recently, Indian government to meet the CO_2 emission concerns in transportation sector as well as to decarbonize energy sector, has taken measurements to invest in development of EVs market. Indian EVs market for four wheelers (EW4) constitutes 1.5% of vehicle market. India EVs market for two wheelers and three wheelers is regarded growing and considerable market, while the 1.5 % adoption of market to EV four wheelers in compared to the size of country is negligible growth. This suggests that gasoline cars still constitute more than 98 percent of four wheelers in this country.

In addition, the ASEAN member countries which have been experiencing fast economic growth and population expansion, the vehicle market in these nations is led by fuel-based engine vehicles. The ASEAN countries for decarbonizing the transportation sector and meet their CO_2 reduction targets following China and developed countries. The EVs market in the ASEAN is leading by Thailand and Singapore. Thailand and Singapore with adoption rate of 2.3 % and 3.8 % respectively, are forming higher rate of adoption among the other countries in this association.

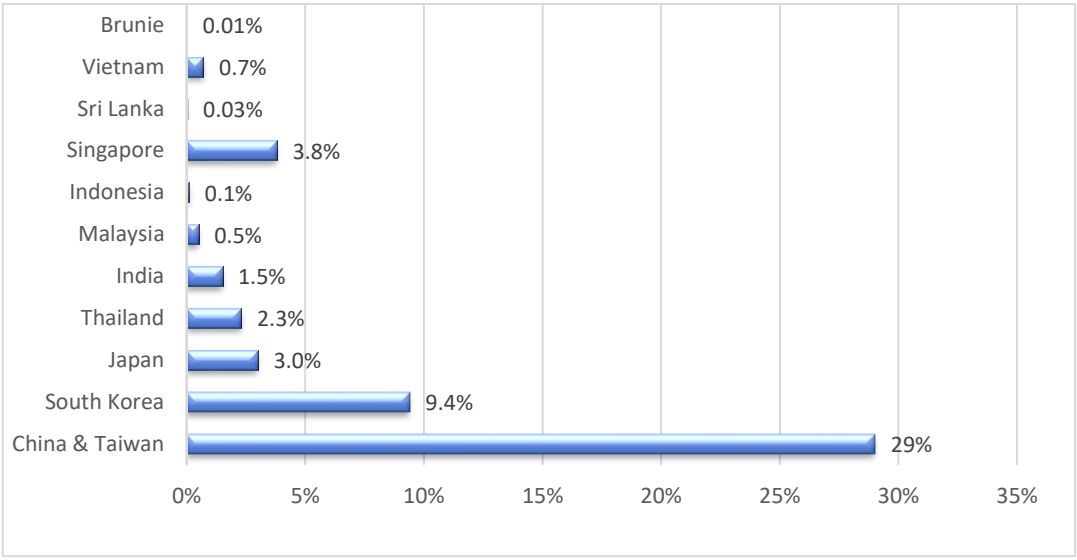

Figure 2 .4 *Market shar of EVs in internal combustion engine vehicles*
Sources: *International Energy Agency, 2022 McKinsey, 2021*

Figure 2.4 illustrates the adoption of EVs and fuel-based engine cars in the year 2022. The figure shows that the adoption of EVs in mature markets, China combined with Taiwan, Japan, and South Korea considerably increased. Due to the unavailability of comprehensive data regarding the total number of fuel-based engine vehicles from 2010 to 2022, this study employs an alternative approach by estimating the demand and market share of fuel-based engine vehicles based on the adoption rates of electric vehicles (EVs) in Asian countries.

The percentage of adoption in these three countries is relatively 29%, 9.4% and 3%. The growth in their adoption indicates an upward slope of demand for EVs and a downward slope of demand for fuel-bases engine vehicles, since the aggregate percentage of adoption in EVs shows the same level of decent in gasoline car in their vehicle market.

Conversely, the figure displays that fuel-based engine vehicles maintain their dominance in the Indian EV market and across most ASEAN member countries. Within the ASEAN region, Singapore and Thailand stand out as the only countries demonstrating a growth rate of more than 2% in the EV market. In stark contrast, the remaining Southeast Asian countries exhibit a growth rate of less than 1%. This finding suggests that the demand for EVs in these countries remains relatively insignificant, with fuel-based engine vehicles continuing to dominate their markets, constituting more than 97% of their overall vehicle sales (International Energy Agency, 2022; McKinsey, 2022).

2.1.2.4 EVs Infrastructure

The word infrastructure in EV mostly indicates the establishment of EV charging stations. Charging infrastructure plays a crucial role in electric vehicle (EV) adoption, serving as both a practical factor for potential EV buyers and a psychological influence on their decision-making (Q. Zhang et al., 2018). Moreover, charging infrastructure is an essential component of the electric mobility system, enhancing the usefulness of EVs to their owners and acting as a significant symbol for existing EV owners. A growing EV charging infrastructure reflects a burgeoning EV market, indicated by visible chargers at various locations and an increasing number of chargers, demonstrating the expanding density and coverage of charging facilities. Third the availability of a single charger and the perception of a growing network of electric vehicle charging points can indicate the commitment of various stakeholders, such as electricity suppliers, infrastructure providers, businesses, and governments, to support for the shift towards electric drive vehicles (Contestabile, & Turrentine, 2020).

Further Burs et al. (2020) regarding the charging time in EV infrastructure and the role of charging stations in EVs adoption pointed out that the availability of charging infrastructure is a critical factor that significantly impacts the adoption of EVs . The time required for recharging plays a crucial role, as the current average of approximately eight hours to recharge BEVs at regular charging points makes long-distance travel uncomfortable or even impractical. Thus, for long-distance trips to be feasible and convenient, the presence of fast chargers is essential, as they can reduce the recharging time to just 30 minutes.

According to IEA (2022) and Tsai-Hsiang et al. (2013), charging stations play a critical role as essential infrastructure for electric vehicles (EVs). These charging stations are categorized into three types based on their charging time, as follows:

Table 2.1 *Types of EVs charging infrastructure.*

Charging level		Charging time	Places
AC	Level 1	8 – 12 hours	Home and Office
	Level 2	4-6 hours	
DC	Level 3	30-40 minutes	Public

Source: *IEA (2022); Tsai-Hsiang et al. (2013)*

Table 2.1 provides an overview of the various types of electric vehicle (EV) charging stations categorized by their charging levels, corresponding charging times, and established locations.

Level 1 and Level 2 chargers fall under the classification of Alternating Current Charging. Level 1 chargers typically require approximately 8 to 12 hours to fully charge an EV, while Level 2 chargers reduce the charging time to around 4 to 6 hours. In contrast, Level 3 chargers, known as fast charging stations, can charge an EV in less than an hour.

Level 1 and Level 2 chargers, categorized as slow charging options, are commonly found in residential areas and office spaces. On the other hand, Level 3 fast charging stations are strategically placed in public areas for convenient access by a wider range of EV users.

As per finding of McKinsey (2022), the EV infrastructure plays a significant role as an incentive and driving force for the adoption of electric vehicles. The lack of charging points emerged as a major obstacle in the widespread adoption of EVs. In mature EV markets like China, Japan, and South Korea, the EV infrastructure, encompassing both slow and fast charging stations, has been growing in parallel with the development of EVs. However, in emerging EV markets, particularly in ASEAN countries, the growth of EV charging stations has been minimal, leading to a negative impact on the demand for EVs.

The inadequate charging stations in many ASEAN markets are critical shortcomings that hinder the projected growth of EVs on the roads and impede consumer confidence, often referred to as "range anxiety." McKinsey's estimation modeling indicates that, collectively, ASEAN markets will require around 95,000 public AC and 40,000 DC charging points by 2030 to support the anticipated number of registered EVs (assuming a combination of laggard, medium, and advanced adoption trends). This estimation is approximately 30 times higher than the current number of charging points available.

2.1.2.5 Outlook of Electric Vehicles

Given the gradual and rapid expansion of electric vehicles (EVs) in the market and the varying demand trends over the years, it is noteworthy that global sales figures represent significant growth in demand. The years 2021 and 2022 witnessed even more remarkable growth, with sales reaching around 6.6 million and over 10 million units, respectively, corresponding to approximately 9% and 13% of car sales worldwide. Asia constitutes nearly more than half of the market share.

These notable surges in demand for EVs in recent years, including the promising performance in the initial quarters of 2023, have further intensified and expanded the market's demand for EVs in the foreseeable future. Projections indicate that electric car sales will continue to thrive

throughout 2023. In the first quarter alone, over 2.3 million electric cars were sold, representing an increase of approximately 25% compared to the same period in 2022. Looking ahead, it is anticipated that sales will reach 14 million units by the end of 2023, reflecting a remarkable year-on-year growth rate of 35%. The second half of this year is expected to witness a significant acceleration in new purchases, which further highlighting EVs potential to capture an 18% share of total car sales for the entire calendar year and their growing prominence in the automotive industry (Global EV Outlook, 2023).

The adoption of EV is rapidly increasing globally, leading to goods transportation companies converting their existing fleets to electric vehicles. It is estimated that by 2040, nearly 54% of new car sales and 33% of global car fleets will be electric, with more than 50% being battery electric. There are several indications suggest that the Asian EVs market will be dramatically developed as a major market. Asia's vehicle market is currently valued at USD 229.39 billion, with an expected reach of USD 777.62 billion by 2027. During the forecast period of 2022-2027, the market is anticipated to grow at a compound annual growth rate (CAGR) of 19.10%. The increasing rate of adoption of Plug-in hybrid electric vehicles worldwide is driving substantial growth in the electric vehicle market. The Asia-Pacific region is experiencing a surge in demand for high-performing, fuel-efficient, and low-emission vehicles due to stricter regulations on vehicle emissions, as well as declining battery costs and increasing fuel prices. All these factors are contributing to the growth of Asia's electric vehicle market.

Further, Asia's market for electric vehicles is divided into several segments based on their propulsion types. In particular, the greater EV market in Asia, including countries like China, Japan, South Korea, and others, is further categorized into four sub-segments, namely Battery Electric Vehicles, Hybrid Electric Vehicles, Plug-in Hybrid Electric Vehicles, and Fuel Cell Electric Vehicles. These electric vehicles can be further classified as passenger cars and commercial cars, which are currently in use in these countries.

Asian nations are aiming to electrify quickly across all sectors in order to reach their ambitious climate objectives; the supply of electric cars (EVs), for example, is expected to rise dramatically over the next ten years. By 2030, China is predicted to sell 60–80 percent of all electric and hybrid vehicles, with penetration rates in other Asian nations varying greatly.

Policymakers and market participants can stimulate consumers and businesses to switch by combining regulatory incentives, investments in infrastructure, and uplifting messaging and campaigns that address consumer concerns in order to support electrification initiatives

throughout transport, infrastructure, and industrial processes. Transport electrification, especially for automobiles and buses, is a critical lever that necessitates investment in EV infrastructure, battery materials, and vehicle manufacture (Dyer, Farmer, Fischer, & Woord, 2022).

Considering the ASEAN region, studies have found and emphasized that the ASEAN region will be a significant market for EV sales and is expected to see substantial growth during the same period. Governments in various countries are offering support to promote EVs to reduce pollution. The factors driving the electrification process include increasing consumer preference for fuel-efficient electric vehicles, self-driving cars, and vehicle-to-vehicle communication technology, which are expected to drive market growth during the forecast period of 2018 to 2028.

In addition, government policies to support the growth of electric vehicles and plans to expand electric vehicle charging infrastructure are expected to be major market drivers during the forecast period. Governments play a crucial role in promoting the expansion of electric vehicle charging infrastructure, and as ASEAN governments encourage further vehicle electrification, incentives for usage and purchase should be provided to reduce the overall cost of ownership or make driving electric vehicles more convenient for consumers. For example, while the Philippine government has implemented limited incentives for electric vehicle purchases or charging infrastructure, the country possesses 5% and 4% of the world's nickel and cobalt reserves, respectively, indicating potential for greater involvement in the electric vehicle battery production value chain (ASEAN Electric Vehicle Market Size & Share, 2023).

Additionally, the report identifies key factors shaping the electric market in Asia, including a shift in consumer preference toward electric vehicles, which is a sign of future decarbonization and is crucial for charging infrastructure. However, EV penetration is subject to various factors, including consumer behavior, infrastructure, and regional clusters. Charging infrastructure is a potential challenge in developing EVs, but governments are investing in it, either directly in public charging stations or indirectly by subsidizing private charging stations at homes and workplaces.

The improvement of charger technology is expected to significantly reduce charging time for EVs and play a role in increasing EV adoption in the coming years. Furthermore, government regulations to phase out fossil fuel-powered vehicles, public investment in EV charging infrastructure, and initiatives like subsidies and tax refunds to promote EV adoption are all

likely to contribute to market growth (APAC Electric Vehicle Market Size & Share Analysis, 2023).

The demand for future electric vehicles (EVs) in major and emerging markets is influenced by various factors that contribute to their growth. National policies and incentives play a crucial role in boosting sales, while the potential resurgence of high oil prices serves as an additional motivation for prospective buyers. Notably, countries like India, Thailand, and Indonesia witnessed substantial progress in their electric car markets in 2022, despite their previous limited involvement. These nations experienced a remarkable surge in electric car sales, exceeding triple the figures of the previous year, with a total of 80,000 units sold. In Thailand, electric cars accounted for slightly over 3% of total sales in 2022, while India and Indonesia averaged around 1.5% each. India's EV and component manufacturing sectors have seen significant development, supported by a government incentive program valued at USD 3.2 billion, which has attracted investments totaling USD 8.3 billion. Thailand and Indonesia are also strengthening their policy support frameworks, offering valuable insights for other emerging economies seeking to promote widespread EV adoption.

China dominates the Pacific Asian electric vehicle market and boasts one of the world's fastest-growing EV marketplaces, with an estimated 500 electric car manufacturers competing in the largest vehicle market. Electric vehicle sales in China rose by 154 percent in 2021 as more consumers opted for cleaner vehicles. In EV manufacturers in China sold a total of 3.3 million units, up from 1.3 million in 2020 and 1.2 million in 2019. This growth is being fueled by increasing demand, rising investments, improved supportive infrastructure and regulations, and advancements in technology. The Chinese government aims to have 20% of all vehicle sales be electric by 2025, with NEVs being embraced as the next generation of government vehicles. Since the beginning of the EV industry in China, government policies, including subsidies, have been a major factor in fostering its expansion (APAC Electric Vehicle Market Size & Share Analysis , 2023).

India is also making significant progress in the electric vehicle market, with sales of 329,190 electric vehicles in 2021, up 168 percent from the previous year, and passenger EV sales increasing threefold to 14,800 units, indicating continued growth. The Indian government is implementing several measures to encourage the production and use of electric vehicles to reduce emissions and develop EVs in response to rapid urbanization. The Indian government has provided tax exemptions and subsidies to electric vehicle manufacturers and consumers to

promote the domestic electric vehicle industry. India's electric vehicle industry is accelerating with various factors contributing to its growth. These include 100% FDI allowance, establishment of new production centers, and efforts to improve charging infrastructure. The industry is also benefitting from government subsidies and policies that support larger discounts for Indian-made electric two-wheelers, as well as a push for localized ACC battery storage manufacturing. Furthermore, regulations and policies set by the Indian government, such as the absence of a license requirement to operate EV charging stations, are providing additional support to the industry's expansion (APAC Electric Vehicle Market Size & Share Analysis, 2023).

In addition to this, several ASEAN member countries have made public declarations to introduce a certain proportion of electric vehicles in their new vehicle sales over the next few years. The ASEAN region is a major hub for the sale of automotive vehicles and is projected to experience rapid growth during the forecasted period of 2018 to 2028. The electric vehicle market in these countries is segmented by the type of vehicle, the type of technology used to power the vehicle, and the country in which it is sold.

The market is divided into passenger and commercial vehicles based on the type of vehicle, and into battery, plug-in hybrid, and fuel-cell electric vehicles based on the technology used to power them. The automotive industry in ASEAN countries has witnessed significant growth in terms of production in 2021, which is expected to increase the demand for electric vehicles in the region. As a result, the market for electric vehicles in ASEAN countries is projected to grow at a compound annual growth rate (CAGR) of 32.73% between 2018 and 2028, reaching a market share of USD 2,665.3 million (APAC Electric Vehicle Market Size & Share Analysis, 2023)

Additionally, the popularity of electric vehicles in Indonesia is increasing, with ride-hailing firms like Grab collaborating with local power suppliers to expand fleet charging infrastructure. In the coming years, public transportation operators such as Transjakarta aim to increase their electric bus fleet to 10,000 units, indicating the growth of the electric vehicle market in the region. Furthermore, Indonesia has set a goal of electrifying 20% of its new vehicles by 2025, and to have electric vehicles account for 20% of total exports by 2025. In March 2022, Thailand's government introduced new incentives to speed up the transition to electric vehicles, aiming to convert half of the country's total car production to electric vehicles by 2030. Taking into account the above factors, it is expected that the ASEAN electric vehicle market will be

driven by increasing investments in electric vehicle manufacturing and the government's supportive EV policies during the forecast period (ASEAN Electric Vehicle Market Size & Share Analysis - Industry Research Report - Growth Trends, 2023).

Moreover, Singapore has taken the lead in the ASEAN region in developing EV charging infrastructure with more than 1,800 public charging points available. The Singaporean government plans to add 60,000 more charging points by the end of 2030 and has set a new target of USD 22 million between 2021 and 2025 to encourage EV adoption among consumers. The government aims to strengthen the charging infrastructure by increasing the number of chargers on private properties. Singapore has established itself as a prominent research and development hub for the EV industry, attracting investment from multinationals and start-ups to build a robust local EV ecosystem.

The Singaporean government is committed to reducing pollution by promoting EVs. The increase in EV is expected to boost electric vehicle sales, and Singapore plans to phase out fuel-based engine vehicle by 2040. The newly established National Electric Vehicle Centre (NEVC) is leading the campaign to promote wider EV adoption, with the goal of running vehicles on green energy by 2040. This initiative will allow Singapore to develop new EV-related technologies safely and innovatively (ASEAN Electric Vehicle Market Size & Share Analysis - Industry Research Report - Growth Trends, 2023).

On top of that, according to the (McKinsey, 2022; Global EV Outlook, 2022) there are some indications which show potential growth of electric vehicles (EVs) in Asia and globally. To speed consumer adoption and meet their climate objectives, ASEAN nations have strategies in place to build strong EV ecosystems. To do this, the EV value chain will be significantly developed, driving both the supply and demand sides. In addition to accelerating the deployment of inexpensive EV models with an overall cost of ownership on par with or better than internal combustion engines, this calls for more investment in partnerships, infrastructure, and technology development. Additionally necessary are integrated finance, government incentives to encourage the adoption of EVs and discourage the use of internal combustion engines, and a supporting green investment environment.

The adoption model predicts that emerging Asian economies will continue to experience strong growth in the uptake of four-wheeled electric vehicles (E4W). This is due to the government's plans to support EV markets through robust policy measures in four key areas: official EV targets, restrictions on the production and sale of Fuel engine vehicles, consumer incentives,

and support for EV charging infrastructure. With a projected adoption rate of 60% by 2030 and over 40% of all new EV sales, China is expected to overtake the rest of the world as the largest EV market.

In emerging Asian market which is embedded mostly by ASEAN member countries and India, the E4W output is anticipated to increase significantly. With E4W production scaling up from low levels to a significant market share, Thailand, and Indonesia, two countries that are already important centers for the region's automobile industry, will experience tremendous development. By 2030, the sum of these markets could generate over two million E4W units yearly. Furthermore, the level of commitment to electrification shown by Asian nations varies and these measurements by Asian governments considered a drastic positive change in future EV' markets. Comprehensive policy frameworks for EV adoption have been built in China, Japan, and South Korea. Thailand launched its production policy in emerging Asia with the goal of having 30 percent of domestic vehicle production run on electricity by 2030. While Malaysia is reevaluating its EV policy and has announced tax reductions for locally produced and imported EVs, Indonesia has put a ban on sales of fossil fuel motorbikes by 2040 and fossil fuel automobiles by 2050. By 2025, Malaysia also intends to significantly expand its network of EV charging stations.

On the other hand, battery in EVs which has been considered one of the major reasons in making high up-font cost, is expected to be made remarkably cheaper by Asian nations. Based on Global EV Outlook (2022) reports the battery in EVs has been producing from more costly elements such as Lithium-ion, Nickle and Cobalt. The combination of these components makes the price high for electric vehicles. The future for battery production is expected be Asian countries. China established regulations to improve the management of its rapidly expanding lithium-ion battery sector. These regulations covered minimum production standards before increasing capacity, minimal technical battery performance standards, plant operating conditions, and land development restrictions. Additionally, given its access to raw materials like nickel, Indonesia has the potential to emerge as a significant regional battery provider. These future outlooks signify remarkable growth in EV adoption since the price of EVs will be more compatible with internal combusting engine vehicles as well as it supports the concept that the Asian a huge hub of electric vehicles.

2.2 Incentive Policy for EV Adoption

In recent years, researchers have acknowledged EVs as a promising solution to reduce carbon emissions in the transportation sector. However, the immaturity of battery technologies has resulted in EVs lacking price competitiveness and limited driving range, despite their excellent energy conservation capacity.

Various empirical studies have evaluated the effectiveness of EV policy incentives worldwide, including regions like the United States, Europe, and other countries. These studies have revealed that financial incentives have a positive impact on promoting EV adoption. Specifically, a sales tax waiver has been found to be more cost-effective than an income tax credit (Liu, Sun, Zheng, & Huang, 2021).

Similarly, Langbroek et al. (2016) in their assessment of EV uptake, observed that many European countries have implemented policy incentives to stimulate electric vehicle purchases due to the high investment cost associated with batteries. These policy measures to enhance EV attractiveness can be categorized as purchase-based or use-based incentives. Examples of purchase-based incentives include subsidies or tax rebates when buying or registering an EV. On the other hand, use-based measures include providing free parking for EVs, granting access to bus lanes, or offering exemptions for congestion charging for EV users. Purchase-based incentives aim to reduce the fixed cost of EV use, while use-based incentives aim to decrease the marginal cost of EV use.

Studies demonstrated that policy incentives aimed at electric vehicles (EVs) generally result in a favorable impact on the adoption of EVs. These policy incentives, designed to encourage the utilization of electric vehicles, affect various attributes of the EV, primarily influencing the overall costs associated with EV use. As a consequence, these incentives can be viewed as influencing individuals' extrinsic motivation to transition to EV use. Measures such as subsidies, tax rebates, and exemptions from congestion charges directly impact the pricing aspect of electric vehicles (Y. Zhang et al., 2011; Langbroek et al., 2016).

In Asia countries such as China, Japan and South Korea were growing in EV market steadily, while other regions, such as Southeast Asia, have been slower in their shift towards EVs. In ASEAN countries, the primary concern for owning an EV is the cost price, which is a common issue in new adopter nations. The transition to EVs is often perceived as expensive due to higher battery costs, leading to elevated purchase prices for these vehicles. Alongside the price factor, factors such as infrastructure availability, charging time, and driving range also

contribute to consumer reluctance in purchasing EVs. McKinsey's 2019 consumer survey report highlights that higher costs compared to conventional vehicles serve as a barrier to EV adoption (Hashim Haslenda et al., 2021).

To address this challenge, it would be beneficial to consider the total cost of ownership, which encompasses all expenses incurred throughout a vehicle's lifecycle when comparing EVs to fuel-based engine vehicles. The up-front purchase price is only a part of the overall cost that consumers bear when owning an EV.

In contrast to traditional vehicles, EVs face drawbacks related to their price, driving range, and charging duration, which damps consumers' interest in adopting them. To address these limitations and boost the appeal of EVs, policy incentives have been introduced. Chinese government implemented a range of measures to encourage EV purchases. These measures include purchasing subsidies, tax exemption policies, subsidies for charging infrastructure construction, and various convenience-related initiatives aimed at stimulating consumer interest in EVs. The Chines government in order to increase the demand or the adoption of EVs implement 10%, 20% and 30% incentive based on the types of EVs to make EVs compatible in the market.

On the other hand, Southeast Asian countries, with less developed automotive manufacturing capabilities, see the transition to EVs as an opportunity to reduce carbon emissions and allow their economies to achieve greater social inclusivity. Southeast Asian governments are pushing for increased vehicle electrification, there needs to be usage and purchase incentives that either reduce the total cost of ownership or increase the convenience of using EVs for consumers. Governments in Southeast Asia are actively encouraging vehicle electrification, but for successful adoption, there is a need for incentives that either reduce the overall cost of EV ownership or enhance the convenience of using EVs for consumers. By offering such usage and purchase incentives, these countries can further accelerate the transition towards sustainable transportation and contribute to the global effort in mitigating climate change (Zahid, 2021 & Jamaludin et al., 2021).

The swift progress of well-established EVs markets is propelled by robust policy initiatives in four key areas: setting official EV targets, implementing restrictions on fuel-based engine vehicles production and sales, providing consumer incentives, and bolstering EV charging infrastructure. In Asia, governments demonstrate varying degrees of dedication to electrification. Countries such as China, Japan, and South Korea, as well as emerging nations

like India and ASEAN member countries, have put in place comprehensive policy frameworks to encourage EV adoption.

Table 2.2 *Asian countries incentive polices to increase EVs adoption.*

Country	Types of incentive policy
China	• Policy of banning Fuel-based engine vehicle production by 2035 • 10% to 30% reduction in initial EV price by 2023
Japan	• Banning fuel-based engine vehicle by 2035 • Electrify all passenger car by mid of 2030
South Korea	• Banning fuel-based engine vehicle by 2035 • Increase 30% of EV sales in the market by 2028
Taiwan	• Phase out fuel-based vehicle by 2040
India	• Providing tax exemptions and subsidies to electric vehicle manufacturers and consumers. • Removed license requirement to operate EV charging stations to support charging infrastructure.
Indonesia	• Increase 20% of EV sales in the market by 2025. • Banning production of fuel-based cars by 2050
Malaysia	• Plans to build 25,000 public charging points and 100,000 private charging points by 2030. • 100% reduction in import duties on completely built-up EVs lasting up to end of 2023 • 100% tax exemption on statutory income for the assessment year 2023 until 2032 for manufacturers of EV charging equipment. • Tax relief for owning an electric vehicle.
Singapore	• Plans to install 60,000 charging points by 2030. • Allocating financial incentive until 2025 to promote EV adoption and increase the number of chargers at private properties. • Banning fuel-based vehicles by 2030
Thailand	• Increase 30 % percent domestic production by 2030. • Bann on fuel-based cars production by 2035.
Sri Lanka	• Banning fuel-based cars by 2040
Philippines	• Banning fuel-based engine vehicle production by 2040 • Providing fiscal incentives, such as tax exemption in purchasing EVs

Sources: *Policies to Promote Electric Vehicle Deployment – Global EV Outlook (2021), McKinsey (2022); APAC (2022).*

Table 2.6 provides a comprehensive overview of the incentive policies being implemented by governments across the Asian region to promote the adoption of electric vehicles (EVs). The presence of such policies underscores the commitment of these countries towards gradually

phasing out fuel-based engine vehicles in upcoming years. These proactive measures taken by Asian governments highlight their recognition of the importance of transitioning towards sustainable transportation alternatives.

Moreover, the collective efforts and commitments exhibited by Asian countries indicate that the region is poised to become a future hub for EVs. The increasing emphasis on decarbonizing the transport sector through the widespread adoption of EVs is a significant step towards achieving environmental sustainability and mitigating the adverse effects of greenhouse gas emissions.

2.3 Previous Studies

Adoption of EVs is considered vital in reducing CO_2 emissions around the world. The marked demand for EVs and fuel-based engine vehicles are made by consumer choice and preference. Previous studies have utilized different methods which resulted to find the affecting factors for electric vehicles adoption as well as the contributing factors which influence consumer perspectives in purchasing EVs or staying in using the fuel-based engine vehicles.

Li et al. (2017) Using panel data from 2010 to 2015, the study investigates EV demand in fourteen different nations. The research discovers that the demand for EVs is positively influenced by four factors, including the proportion of renewable energy sources in overall power generation, the density of chargers, the proportion of persons with college degrees, and population density. However, factors like GDP and urbanization don't seem to be significantly affecting the situation. In contrast, the demand for battery electric cars (BEVs) is positively and visibly impacted by the price of gasoline.

A study used Partial Least Squares Structural Equation Modelling (PLS-SEM) to measure the demand for purchasing electric vehicles in the case of Thailand. The study strived to find the relationships between five factors (financial factors, infrastructure, performance, environmental concern, and price-premium) and the intention to purchase electric vehicles (EVs) in Thailand. According to their research, Thai car buyers are more concerned with EV performance factors like driving range, speed, and safety than they are with EV infrastructure like charging stations and financial factors like purchase price, operation and maintenance costs, and resale value. Additionally, owning an EV is influenced by people's environmental concerns, and Thai consumers are willing to pay a premium for EVs. However, the association between environmental concern and intention to purchase EVs may be adversely moderated by the price-premium issue. In other words, those who have an environmental mindset may be

less likely to adopt EVs if the price premium for EVs rises too high (Thananusak, Rakthin, Tavewatanaphan, & Punnakitikashem, 2017).

Schulze-Darup et al. (2018) conducted research on German consumers' preferences for electric vehicle. Binary and multinomial choice logit models were used in the study. The paper examines German consumers' choice for battery electric vehicles (BEVs) over hybrid electric vehicles (HEVs) or conventionally fueled vehicles (NCVs). The authors surveyed 400 people who indicated which of the three vehicles they preferred, taking into account factors such as purchase price, driving range, fuel prices, emissions, refueling accessibility, refueling time, acceleration, and policy incentives. The authors discovered compelling evidence that prior BEV driving experience and car sharing are important factors when deciding whether to declare a preference for electric vehicles. The choice is also influenced by additional elements like driving range, purchasing price, gender, ecological consciousness, and incentives like tax exemptions.

Cui et al. (2021) conducted research using multiple regression analysis as well as applied Maslow's Hierarchy of Needs model to forecast the factors that influence consumer intention to purchase electric vehicles. The findings of data collection on 550 Chinese citizens indicate that environmental concern is the most important predictor of EV purchasing motive, followed by price awareness, openness to experience, social influence, and self-esteem.

Sierzchula et al. (2014) has used multiple linear regression analysis to link between consumer financial incentives and other socioeconomic characteristics and the adoption of electric vehicles (EVs) across different nations. The study lists a few variables that are anticipated to affect EV adoption rates, including charging infrastructure, environmental consciousness, fuel costs, urban density, educational attainment, per capita vehicle ownership, the number of models offered, the location of manufacturing facilities, the date of introduction, the cost of the vehicles, and the price of electricity.

According to the research, a nation's market share for EVs is significantly and positively associated to its financial incentives, charging infrastructure, and local manufacturing facility presence. Additionally, it implies that the best environment for EV adoption is one with a robust charging infrastructure. Further, according to the results the study has added that in addition to the critical role of number of charging stations, consumer preferences and knowledge, in addition to financial incentives, are important variables in achieving high EV adoption rates.

Bhalla et al. (2019) have studied the consumer perception and purchasing intentions for electric cars discovered that consumer faith in technology and environmental concerns are contributing factors in purchasing electric vehicles. Cost, infrastructure, and societal approval are the elements that cause barriers in adoption. Therefore, the study suggests that government must take the lead in promoting the sales of electric cars by developing environmental legislation, infrastructure, and subsidizing the cost of the vehicle or lowering the bank rate of interest.

This research also shows that buyers often follow a logical approach when choosing a car to buy, looking for the best value possible. Additionally, this research discovered that despite the long-term advantages of fuel savings and efficiency, which marginally increase the favorable attitude towards EVs, the initial high cost of EVs tends to produce a negative view among consumers. The government might put in place measures like giving free or heavily discounted financing, free insurance, and free parking in order to increase sales and strengthen the adoption process. The adoption of EVs would increase as a result of these activities, which would stimulate a new viewpoint on buying intentions (Bhalla et al., 2019).

Yong et al. (2017) have comparatively examined the factors affecting the deployment of EVs, identified that the adoption of electric vehicles (EVs) is influenced by a number of major variables. On EV spread, policy assistance, including tax advantages and subsidies, has a big effect. Environmental factors including the state of the economy and the accessibility of charging infrastructure also matter.

Effective public policies, such tax exemptions and purchase incentives, together with enabling public policies, may promote the dissemination of EVs. Further, the study demonstrated that financial incentives for EV adoption should be combined with the construction of charging infrastructure. Countries must take into account a variety of policies that are adapted to their unique situation.

The adoption of EVs cannot be fueled by having a high economic position and a charging infrastructure alone. When paired with two more policies, financial subsidies, and tax exemptions their efficacy is fulfilled. Additionally, the study provides proof in a number of instances. For instance, Luxembourg is a prime example; despite having the greatest GDP per capita, the country lacks tax exemption and subsidy laws, which contributes to its low rate of EV penetration. Iceland, in comparison, obtains a greater EV penetration rate despite having a lower GDP per capita and using tax exemptions and purchase incentives. Conversely, Malta's

EV penetration rate is still low because of unavailability of tax breaks, despite the country has high density of EV charging stations.

Singh et al. (2020) evaluated the validity and reliability of variables impacting EV adoption using a variety of data techniques, including RA, SEM, and FA, as well as theoretical frameworks including TPB, DOI, and VBN. Accordingly, it was shown that consumers' intentions to use electric vehicles are indirectly tied to environmental considerations, which are impacted by individual moral standards and attitudes.

Environmental awareness influences non-EV purchasers' buying intentions as well as indirectly influencing EV buyers' post-purchase contentment. The low driving range and expensive cost of purchase are cited as the two main obstacles to EV adoption. Although the majority of study is centered on early adopters and those with little understanding of EVs, consumer variables like age, gender, and education all significantly influence purchase intention. The study also makes the case that while socio-demographic and psychological variables can help predict consumer EV adoption, contextual variables like policy and charging infrastructure have a direct impact on consumers' intent to buy EVs, making them the most important predictors of EV adoption rates.

Nian et al. (2019) in a study which has considered 30 countries in his observation, he found that financial incentives and charging infrastructure were the main factors contributing to their adoption. Surprisingly, sociodemographic factors like income, education, and environmental concern did not play a significant role in the adoption of EVs. In addition, this study has mentioned the EV's price or the upfront cost of EVs as crucial challenge to become a more demanding and const competitive option from the perspective of consumer.

Nourinejad (2015) investigated the influence of GDP and increase in income on the adoption of electric vehicles (EVs) across 20 European countries between 2010 and 2016. Employing panel data analysis, the study reveals a positive and significant relationship between income and EV adoption, particularly for battery electric vehicles (BEVs). Furthermore, the analysis identifies additional factors such as fuel prices, charging infrastructure, and environmental awareness that impact the diffusion of EVs. Based on the findings, the study proposes that policies aimed at promoting EV adoption in Europe should address both income-related barriers and other non-income factors.

On the other hand, a study has examined the impact of GDP on the demand for purchasing vehicles, and it has found a relationship between economic growth and car sales. The study

indicates that when the GDP of a country is growing, the (per capita) increases and consumer confidence is high, people are more willing to purchase a car. However, during periods of economic uncertainty, when there is a slow expansion and reduced optimism or pessimism about future personal financial situations, people tend to delay buying relatively expensive items like a car (Indonesia Investments, 2018).

Zhuge & Shao (2019) employed Multinomial Logit (MNL) model to analyze the weights of various factors, a measure of global spatial autocorrelation, to examine the spatial perspective of the analysis. The objective was to determine the influential factors affecting electric vehicle (EV) demand. The results revealed that among the factors tested in the study, vehicle price had the highest impact on EV demand. Specifically, it accounted for 32.3% of the overall influence on EV demand, based on the statistical analysis. This indicates that changes in vehicle price significantly affect the demand for electric vehicles.

Pappas & Woodside (2021) The study employed fuzzy set qualitative comparative analysis (fsQCA) to examine the factors influencing EV deployment across countries. Results showed that GDP, charging station availability, and incentives collectively influence EV demand. For example, India's low EV penetration is attributed to insufficient charging infrastructure and low GDP per capita, despite tax exemptions. In China, relatively popular EV adoption is due to better charging infrastructure. Iceland and Sweden demonstrate high EV adoption levels due to their high economic status, despite poor charging infrastructure. Effective policies combining tax exemptions, purchase subsidies, and charging infrastructure are crucial for promoting EV adoption.

CHAPTER III

METHODOLOGY

3.1 Data and Variables

The data for this study is collected from secondary sources such as the World Bank, IMF, Trade Economy, Macrotrend, and International Energy Agency (IEA). The study will focus on analysis of demand and factors affecting the demand trend for EVs and fuel-based engine vehicles in Asian major EV market such as China, Japan, South Korea and the emerging and yet negligible EV market such as India and ASEAN member countries which contains countries such as, Malaysia, Singapore, Thailand, Taiwan and Sri Lanka. The data sources for this study will be national-level data on GDP growth rate, Inflation, fuel price, EVs price, charging stations in the mentioned countries. The data will be collected for a period of the years 2010 to 2022, to capture long-term trends to demand for fuel-based engine vehicles and EVs. More importantly, due to the lack of data from all types of electric vehicle this study only focuses on passenger and commercial electric vehicles or electric vehicle four-wheelers (EV4W).

Th reason for selecting these variables has already been mentioned in line with theoretical framework in line with the demand theory and previous empirical studies. These variables are selected because they have been observed in the different studies which have shown impactful in EVs purchase and consumer behavior. The choice of the specific time period, from 2010 to 2022, is motivated by advent of EVs as an acute topic globally. While the specific countries have been selected because of their market share and their plan for reduction of emissions in the Transport sector. China, Japan, and Korea are selected because of their remarkable market share in the Asia and their growth since the yar 2010, while India and countries from ASEAN member group such Malaysia, Singapore, Thailand, Taiwan and Sri Lanka are chosen because of data availability within this period of time and their future outlook in reduction of emission in transport sector in line to their announcement for zero-carbon emission.

The selected variables with their data sources are as follows:

Table 3.1 *Description of operational variables*

No.	Variable	Period	Description	Reference	Note
1	Sales	2010 -2022	• The EVs sales is used as proxy to represent the demand of EVs.	International Energy Agency, IMF, Statista	Data for sales in major Asian EV market (China, Japan, South Korea) is available from year 2012 to 2022. While the data for emerging markets (India, ASEAN) can be found from 2014.
2	GDP per capita	2010 -2022	• The Gross Domestic Product (GDP) per capita is a measure that illustrates how economically secure a nation's citizens are. • It is often used as a gauge of economic progress and living standards and measures the average income or production per person in a certain nation. • The infrastructure and general economic progress of a nation are also reflected in the GDP per capita.	World Bank, IMF	
3	Inflation	2010 -2022	• The overall rise in prices of goods and services over time in an economy is referred to as inflation. • The percentage change in the average price level of a basket of goods and services	World Bank, IMF	
4	Gasoline price	2010 -2022	• Gasoline prices represent the price level of fuel that shows how much consumer spends while using fuel-based engine vehicles.	International Energy Agency, Our world in data, ASEAN center for Energy, Trade Economy.	Due to data limitations regarding fuel-based engine vehicles and their diverse pricing range, our analysis assumes the price of gasoline cars based on the prevailing gasoline prices.
5	EVs price	2010 -2022	• Electric vehicle prices represent the price of commercial and passenger cars.	Statista, IMF	Data for EVs price in mature Asian EV market (China, Japan, South Korea) is available from year 2012 to 2022. While the data for emerging markets (India, ASEAN) is available 2014 to 2022.
6	Charging Station	2010 -2022	• This variable represents the number of charging points in these selected countries. • Contains fast and slow charging infrastructure.	Global Energy outlook, ASEAN energy outlook, International Energy Agency, IMF, and Statista.	…….

Source: *IMF, The World Bank, and International Energy Agency.*

3.2 Model Specifications

This study analyzes the demand for EVs and affecting components of demand incompliance with the neoclassical theory of demand. Utility plays a crucial role in demand theory as it represents the underlying satisfaction or benefit that consumers derive from consuming goods and services. Consumers make choices based on their preferences and the utility they expect to gain from consuming different quantities of goods.

Through theory of demand and consumer behavior and their total satisfaction this study assumes demand function for EVs and the utility function to quantify the utility or consumer's enjoyment. Therefore, according to this theory and demand function, the demand for EVs and other selected variables of this study can be formulated as follow:

$$EVD = F(GDP, IN, GP, PEVC, CS)$$

Where EVD is the demand for electric vehicles, GDP represents the GDP per capita of the selected countries, IN is the inflation rate, GP is the gasoline price, PEVC is the price of EVs, and CS is the number of charging stations.

The equation for utility maximization, also known as the consumer's optimization problem, can be expressed as follows:

An implicit function of maximizing utility is :

$$U = f(X_1, X_2, .., X_i)$$

Where U represents the consumer's utility function, which measures the satisfaction derived from consuming good X1……Xi. Consumer utility is constraint to the income of consumer. It means a consumer's total expenditure on goods cannot exceed their income and the equation utility constraint to income is :

$$I = P_1X_1 + P_2X_2 + P_3X_3$$

Where:

I = Represents the consumer's total income or budget

P_1, P_2, P_3 = Are the price of different goods

X_1, X_2, X_3 = Are the quantity of different goods

In addition, for quantifying consumer's enjoyment we need an explicit function. On of the function to explain that goods are mostly substitutable is Cobb-Douglas. Cobb-Douglas function aims to explain that consumptions of goods are mostly substitutable homogenously. Or another function to explain that consumption of goods can be complementarity. The Cobb-Douglas function is as follow:

$$U = X_1^{\alpha} X_2^{\beta} X_3^{\gamma}$$

U = Represents the utility derived from consuming goods X_1, X_2, ..., X_3

X_1, X_2, ..., X_3 = Are the quantities of goods consumed

α, β, γ = Are positive constants that represent the marginal utility or importance of each good.

Through Cobb-Douglas function we can get an optimized equation of utility which is:

$$lnX_1 = \alpha lnP_1 + \beta lnI$$

In the optimized equation we apply logarithm function since we have our variables in logarithmic form. In the optimized function X_1 is the quantity of goods; P_1 is the price for this good and I is the income or budget. Through the process of deriving equation from the above functions this study found the following function as utility model:

$$lnEVD = \alpha_1 lnP_{EVC} + \alpha_2 lnGDP + \alpha_3 lnGP + \alpha_4 lnInf + \beta_1 lnCS + \epsilon \ldots\ldots 1$$

Where in equation 1:

lnEVD: Denotes the natural logarithm of Electric Vehicle Demand (EVD).

lnP_{EVC}: The natural logarithm of the price of Electric Vehicle Cars (EVC). It captures the impact of EVC prices on the demand for electric vehicles. The coefficient α_1 represents the elasticity of EVC demand with respect to its price.

lnGDP: The natural logarithm of Gross Domestic Product (GDP). It represents the economic activity or income level of a country or region. The coefficient α_2 indicates the elasticity of EVC demand with respect to changes in GDP.

lnGP: Represents the natural logarithm of the gasoline price (GP) in the utility model equation.

lnInf: The natural logarithm of Inflation (Inf). It represents the general increase in prices over time. The coefficient 'a' captures the impact of inflation on EVC demand.

$\beta_1$lnCS: Represents the natural logarithm of charging station availability. It is a linear term that captures the impact of charging station availability on electric vehicle demand.

ϵ: The error term, representing unobserved factors or random variations that affect the EVD but are not explicitly accounted for in the equation.

The coefficients (α_1, α_2, α_3, α_5, a, β_1) in the equation determine the sensitivity or responsiveness of EVD to changes in the corresponding independent variables.

Further, the study uses panel data model to estimate the Asian countries GDP, Inflation rate, price of fuel, price of EVs and charging station's impact on demand for EVs and fuel-based engine vehicle can be expressed as follow:

$$lnEVS_{it} = \beta_0 + \beta_1 lnGDP_{it} + \beta_2 Inf_{it} + \beta_3 lnGP_{it} + \beta_4 lnPEV_{it} + \beta_5 lnCS_{it} + \varepsilon \ldots\ldots\ldots 2$$

EVS = EV sales as a proxy to demand for EVs, represents the demand for EVs in country i at time t.

β_0 = Is the intercept in each unit of cross section.

GDP = Represents GDP per capita in country i at t time.

Inf = Represents is the inflation rate in country i at time t

GP = Is the gasoline price in country i at time t.

PEV = Represents the price of EV in country i at time t

CS = Is the number of charging station in country i at time t

β_1- β_5 = Are the coefficients of independent variables that the effects of independent variables on dependent variables

U_{it} = Is the error term that captures all other unobserved factors that affect the demand for electric vehicle in country i at time t

it = The letter i is the observation and t denote the time period.

This study uses Panel data regression because panel data combines data from multiple units (countries) over time, which enables the researcher to capture the variation across units as well as over time. This study analyzes demand for electric and fuel-based vehicles both in cross-sectional and time-series dimensions of the data in Asian countries from 2010-2022. With respect to the forms and data collection across counties and multiple years in this study it demonstrates more variability, less collinearity across variables, increased degrees of freedom, and enhanced efficiency.

It also enables the investigation of changing patterns and trends by looking at repeated cross-sectional data. Further, effects that are difficult to see in pure cross-sectional or time series data may be captured and measured using panel data. Panel data reduces biases that may result from grouping people or businesses into more general groups by giving data for a lot of different individual units. Furthermore, using panel data for empirical analysis improves it in ways that may not be possible when using just cross-sectional or time-series data. It enables a greater comprehension of interactions, dynamics, and the long-term impacts of diverse elements (Gujarati & Porter, 2009).

Moreover, considering the variables and the time frame of this study, panel data can allow for the estimation of dynamic relationships between the variables, and their lagged effects on the demand for electric vehicles. Therefore, panel data is an appropriate method for this study as it can provide a more comprehensive and detailed analysis of the factors that affect the demand for electric and fuel-based engine vehicles in Asian countries from 2010-2022.

3.3 Estimation

This study which analysis the demand for EVs and fuel-based engine vehicles across various Asian countries. Employing a panel data estimation model, this study meets the complexities of data by combining both cross-sectional and time-series dimensions. The panel data estimation encompasses three distinct approaches Pooled Ordinary Least Square (OLS) model (POLS), Random Effect Model (REM), Fixed Effect Model (FEM). Each of these models has distinct features and presumptions, so choosing the one that fits the estimation most effectively requires thoughtful consideration. These models are as follows:

3.3.1 Pooled Ordinary Least Squares (POLS) model

Pooled Least Square, which is also known as the Common Effect Model in the panel data model method, is the most straightforward since it basically mixes time series and cross section data. A statistical technique for estimating the associations between independent variables and a dependent variable is the Pooled/Panel Ordinary Least Squares (OLS) method. It creates a single regression model using cross-sectional and time series data. The individual-specific and time-specific impacts are ignored when using the POLS technique, which treats the panel data as a single, massive dataset.

Using the ordinary least squares method, a regression analysis is performed on the independent and dependent variables. This strategy assumes that the independent variable coefficients are consistent across people and throughout time. In other words, the Pooled/Panel OLS approach offers a clear and easy way to estimate the relationship between the variables in the panel data. The fact that it does not take into account individual- and time-specific effects, however, might result in estimates being skewed and inconsistent if the dependent variable is influenced by unobserved heterogeneity or time-varying variables. When there is no concern about the individual- and time-specific effects, and when it is assumed that variation across people and over time is random and uncorrelated with the independent variables, the POLS technique may be a fitting strategy.

The (POLS) model is formulated as:

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it}$$

Where:

Y= Is the dependent variable which indicates the country i at time t

α = indicates the common impact or intercept that is applied to all entities or observations in the panel data.

X= represents the independent variables for country i at time t

β = is the independent variable coefficients.

ε = is the error term.

it = The letter (i) represents individual observation and (t) shows the number of time period in data.

3.3.2 Fixed Effect Model

This Fixed effect model is also often referred to as the Least Squares Dummy Variable (LSDV) method. Although it varies from the common effect model, the fixed effect model nevertheless applies the conventional least squares concept. To account for the time-invariant variation among individuals, the Fixed Effects (FE) model integrates fixed effects in panel data regression models. The individual-specific traits that are unique to each person in the panel and do not vary over time are captured by the fixed effects.

Further, individual-specific fixed effects are included as dummy variables in the regression equation to estimate the Fixed Effects model. To estimate the influence of the independent variables on the dependent variable within each person, these fixed effects absorb the time-invariant heterogeneity. The Fixed Effects model is especially helpful when there are time-invariant unobservable traits that might influence the dependent variable and cause bias from missing variables. The model incorporates fixed effects to account for these unforeseen variables and provides more accurate estimates of the influence of the independent variables. The Fixed Effect Model equation can be formulated as follow:

$$Y_{it} = \alpha_i + \beta X_{it} + \varepsilon_{it}$$

Where:

Y = Is the dependent variable

α = represents the individual-specific fixed effects for each individual i, capturing the time-invariant heterogeneity.

it = The letter (i) represents individual observation and (t) shows the number of time period in data. The i takes value from 1 to n and t takes value from year 1 to year n.

3.3.3 Random Effect Model

In panel data analysis, time-invariant heterogeneity and unobserved individual-specific effects are both taken into account using the Random Effects (RE) model. It is predicated on the idea that individual differences have no impact on the independent variables. By taking into consideration interrelated factors across time and people, this approach estimates panel data. Through error terms for each entity, it accommodates variations in intercepts, aiding in the handling of heteroscedasticity. Instead of using traditional least square, the Random Effects model use maximum likelihood or generalized least squares. A combined residual across cross-sections and time series as well as an individual-specific residual that doesn't change over time are the two sorts of residuals that are presumed. Further, the random effects model efficiently resolves problems by utilizing residual variables. It assumes two types of residuals: a combined residual that considers variations across cross-sections and time series, and an individual-specific residual that remains consistent over time.

In situations where the main explanatory variable remains constant throughout the time, fixed effects cannot be utilized to assess its influence on the dependent variable. In such cases, alternative approaches like random effects should be considered to tackle this particular challenge. The equation for the (RE) model of panel regression is as follows:

$$Y_{it} = \alpha + \beta X_{it} + u_i + \varepsilon_{it}$$

Where:

α = is the intercept term, representing the average effect of variables not included in the model.

β = Is the coefficients of the independent variables which represent the effects of independent variables on the dependent variable

u_i = is the individual-specific random effects, capturing time-invariant heterogeneity and unobserved individual-specific factors that are assumed to be normally distributed and uncorrelated with the independent variables.

ε_{it} = is the error term capturing random factors.

3.4 Model Selection

Implementing panel data estimation are there some crucial tests that must be run to make a proper model selection, discover data problems, ensure model validity, compare, and locate the best-fitting model, evaluate result robustness, and improve the reliability and significance of

the analysis. This study referring to Gujarati (1987) suggested steps in panel data estimation and data evaluation employs some tests which are necessary since making the findings reliability is greatly dependent on these tests. This study conducts Breusch Pagan or (LM) test and Hausman test in finding accurate model of estimation. These tests are common in selection between (POLS) model and Random Effect Model (REM) and between Fixed and Random Effect respectively.

In addition, this study utilizes Multicollinearity test and Heteroscedasticity test to check auto correlation and variation of data. Tests for model selection and data evaluation are as follows:

3.4.1 Breusch and Pagan Lagrange Multiplier Test (BP/LM)

A statistical technique called the Breusch-Pagan or LM test is used to identify heteroscedasticity in a regression model. The assumption that the error component has a constant variance across observations is violated by heteroscedasticity. In other words, it shows that the error term's variability varies depending on the level of the independent variables. Additionally, the test suggests there may be considerable evidence of heteroscedasticity in the regression model if the p-value for the Breusch-Pagan test is less than the level of significance (0.05). However, if the p-value exceeds the significance level (0.05), it means that there is insufficient evidence to refute the homoscedasticity (constant variance) assumption. In estimating panel data, the implementation of the Breusch-Pagan test is crucial to take into account, particularly when analyzing the assumption of constant variance of the error factor. As a result, the reliability of statistical inferences and the validity of the regression results are improved and based on the result the test suggests the following hypothesis:

H_0: The selected model of POLS is appropriate if the P- value is > (0.05)

H_1: REM will be applied due to existing randomness if the P-value is < (0.05)

The mathematic equation for this (BP/LM) test is :

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon$$

3.4.2 Hausman Specification Test

To assess whether the fixed effects (FE) or random effects (RE) model is better suitable for panel data analysis, the Hausman test is a statistical test. The test aids in determining if there is endogeneity or correlation between the independent factors and the effects that are unique to each person. The Hausman test implies that the random effects model is the appropriate specification, and the null hypothesis (H_0) states that the individual-specific effects are

uncorrelated with the independent variables. The alternative hypothesis (H_1) asserts that the fixed effects model is preferable since it shows a relationship between the independent variables and the individual-specific effects.

The hypothesis for the Hausman test is as follows:

H0: $\beta 1 = 0$, indicating that a random effects model is suitable.

H1: $\beta 1 \neq 0$, suggesting that a fixed effects model is preferable.

The following suggestions may be made in light of the Hausman test's findings:

a) We fail to reject the null hypothesis (H0) if the p-value is higher than the selected significance threshold, which is commonly read as $p > 0.05$. The fact that there is no statistically significant difference in the coefficients between the random effects and fixed effects models implies that the random effects model should be used instead.

b) We reject the null hypothesis (H0) if the p-value is less than the selected significance threshold, which is commonly understood as p 0.05. Given that there is a statistically significant difference in the coefficients between the random effects and fixed effects models, it may be concluded that the fixed effects model should be used.

3.4.3 Multicollinearity Test

Multicollinearity is a condition that happens when there is a strong connection between two or more independent variables in a regression model. Multicollinearity can cause problem in statistical analysis since it might result in unstable and incorrect estimations of the regression coefficients. The test determines how much multicollinearity is present in the model. This test's objective is to find out whether there is multicollinearity between the independent variables and how severe it is. We may address or lessen multicollinearity's consequences by detecting it and taking the necessary action.

The variance inflation factor (VIF), which quantifies how much the variance of each coefficient is inflated as a result of multicollinearity, is the most often used technique to test for multicollinearity. According to a general rule, there is a major multicollinearity issue if the VIF is higher than 10.

3.4.4 Heteroscedasticity Test

A heteroscedasticity test is used to determine whether the variance of the residuals among the observations is unbalanced. When the variance of the residuals is the same across data, it is

said to be homoscedastic, however when the variance differs across observations, it is said to be heteroscedastic. It is preferable to use a model for regression analysis that displays homoscedasticity and stays away from heteroscedasticity.

The test evaluates the significance of the association between one or more independent variables and the absolute values of the residuals. The following assumption is made after running the test:

H_0: The null hypothesis is accepted if the probability value (p-value) is higher than the selected significance level. This suggests that the heteroscedasticity issue is not present in the regression model.

H_1: The null hypothesis can be rejected if the probability value is smaller than the significant level because it indicates that the regression model exhibits heteroscedasticity.

CHAPTER IV

4.1 Model Estimation Result

In this chapter the study focuses on the findings of estimation as well as the result of the estimation will be interpreted align with the objectives of this study. This study is conducted with the purpose of finding demand trend for electric vehicles, or to find the driving factors of demand for EVs in Asian countries. To fulfil these objectives the study uses panel data analysis and statical program (Stata) is use for estimation of demand for EVs from 2010 to 2022.

In addition, the collected data has been set abnormal in terms of estimation. Therefore, logarithmic or LAN (natural logarithm) transformation is applied to solve concerns with heteroscedasticity, nonlinearity, and changing variables with skewed distributions. Data conversion to LAN could help in establishing linear correlations between variables that display nonlinear patterns in the initial form. Converting data to LAN could be useful to normalize variables with skewed or non-normal distributions. This may increase the reliability of statistical tests and assist in upholding the panel data model's assumptions, such as the normality of residuals.

Further, the outcome of the LAN is going to be interpreted as approximative percentage changes. This offers a useful and simple-to-understand measure of the connection between variables.

The study has implemented some required tests during and after doing the estimation in terms of choosing appropriate model and figure out the fitting of data and model which are as follow:

4.1.1 Breusch and Pagan Lagrange Multiplier Test (BP/LM)

The Breusch pagan test which is also called (LM) test not only a test to identify heteroscedasticity in an estimation model but the result of this test also helps to select proper model between (POLS) and Random Effect model (REM) in panel data estimation. The test is further detailed in the model selection segment of this study. The result of probability value in this test signifies choosing one of the models between (REM) and POLS. If the p-value in this test is less than the significant level (0.05) indicates the Random Effect Model is the fitted model and conversely if the p-value is greater than (0.05), it points out that the POLS model is proper model for this study.

Table 4.1 *Result of LM or Breusch Pagan test.*

Breusch and Pagan Lagrange Multiplier Test for Random Effects (LM) test:

lnsales[cid,t] = Xb + u[cid] + e[cid,t]

Estimation Results:	Var	SD=sqrt(Var)
Lnsales	8.654593	2.941869
e	.4182149	.6466953
u	.6089779	.7803703
Test: Var(u) = 0		
	chibar2(01) =	55.45
	Prob > chibar2 =	0.0000

Table 4.1 demonstrates the result of LM test. The LM test is more common in selection between two models, random effect, and POLS model. Based on the result of this test we can decide to go with random effect model or POLS model. The decision can be taken based on the result of P-value. If the probability value is greater than (0.05), it means the test suggests going with POLS model, while the probability value of greater than (0.05) indicates that the random effect model is the best model. Therefore, the result of this test suggests going with random effect model which is more appropriate for this study.

4.1.2 Hausman Specification Test

The Hausman test is used to choose between Random Effect Model (REM) and Fixed Effect Model (FEM). This test, which is also described in model selection segment, the p-value level in the result of this test indicates which estimation model is proper for our study. If the p-value is greater than (0.05), it suggests a Random Effect Model as an appropriate model. While the p-value of smaller than (0.05) indicates Fixed Effect Model as an appropriate model for our estimation.

Table 4. 2 *Result of Hausman Specification Test*

	Coefficients			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	re	fe	Difference	Std. err.
lninf	.0013846	.0259329	-.0245483	.013494
lnpev	-.2056076	1.151204	-1.356812	.
lngdp	.0442839	3.938858	-3.894574	.
lngp	.3821876	-.461886	.8440736	.
lncs	.8460702	.6495984	.1964719	.

b = Consistent under H0 and Ha; obtained from regress.
B = Inconsistent under Ha, efficient under H0; obtained from xtreg.
Test of H0: Difference in coefficients not systematic
chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 904.08
Prob > chi2 = 0.0000
(V_b-V_B is not positive definite)

Table 4.2 is the result of Hausman specification test which is implemented to choose the model between fixed and random effect model. According to this test the decision to select an appropriate model estimation can be taken based on the result of p-value. Therefore, based on the result of the Hausman test which is (0.00), we can take the final decision in selecting model. The result suggests going with a fixed effect model.

4.1.3 Heteroscedasticity Test

The Heteroscedasticity test is employed to identify the variation of residuals across data. Heteroscedasticity occurs when a variable's standard errors are observed over a certain amount of time and are not constant. The desired result is to have homogenous relationships between data. As much as the data is close to the normality level, the data is homogenous and as much as the data is dispersed from normality line, the data is inconstant or heteroscedastic. After conducting the test, the p-value indicates if the data is constant or not. If the p-value is greater than significance level (0.05), it points out that the selected data has constant variation and the value of less than (0.05) indicates that the data is in inconstant variation or the data is heteroscedastic.

The existence of heteroscedasticity violates the assumption of constant error variance and impacts the overall fit and prediction ability of model.

Table 4.3 *Result of Heteroscedasticity Test*

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity	
Assumption:	Normal error terms
Variable:	Fitted values of lnsales
H0:	Constant variance
chi2(1) =	3.55
Prob > chi2 =	0.0597

The above table (4.3), which is the heteroscedasticity result, demonstrates that the data is not dispersed from the standard line, i.e., the error variation in this model is constant. Since the p-value is larger than (0.05) it indicates that the data are not heteroscedastic, and this is a solid model.

4.1.4 Multicollinearity test

The Variance Inflation Factor (VIF) is a measure used to detect and quantify multicollinearity among the predictor variables. Multicollinearity occurs when independent variables in a regression model are highly correlated with each other. The VIF value indicates the extent of multicollinearity. A VIF of 1 suggests no multicollinearity, as there is no correlation between the predictor variable and other variables. Generally, a VIF value of less than 5 or 10 is considered acceptable, indicating a relatively low level of multicollinearity.

The existence of multicollinearity indicates that there is a serious autocorrelation among the variables, which results in unstable and incorrect estimations of the coefficients.

Table 4.4 *VIF Test*

Variable	VIF	1/VIF
lnevp	1.55	0.644480
lngdp	1.37	0.728577
lngasp	1.18	0.843899
lnnch	1.10	0.907577
Mean VIF	1.30	

Table 4.4 demonstrates the result of VIF test which shows that the values for each variable and overall, the mean of VIF is less than 5. Therefore, it supports the assumption that there is no multicollinearity in our model.

4.2 Finding and Discussion

Table (4.5) below demonstrates the result of estimation in three possible methods of panel data estimation. To find an appropriate model of estimation, this study with limited available data utilized the required tests such as LM test and Hausman test which the results suggest the fixed effect model as appropriate model for this study. The result of our estimation in fixed effect model shows that only three variables, GDP, EV price and number of charging station have significant and positive impact on demand for electric vehicles in the selected countries and in time frame 2010 to 2022. The rest of variables such as gasoline price and inflation have insignificant effects on demand. The coefficients and standard error in the table below indicate that these variables are significant in 1% and 5%.

Table 4.5 *The result of Estimation*
*Denotes 10%, **denotes 5%, ***denotes 1%

Variables	OLS	RE	FE
lninf	0.0013846	0.0021521	0.0259329
	(0.021)	(0.017)	(0.016)
lngp	0.3821876	0.0771091	-0.461886
	(0.279)	(0.362)	(0.353)
lngdp	0.0442839	0.7505613	3.938858
	(0.655)	(0.288) ***	(0.624) ***
lnpev	-0.2056076	-1.650196	-1.151204
	(0.707)	(1.223)	(0.5994) **
lncs	0.8460702	0.8408385	0.6495984
	(0.027) ***	(0.047) ***	(0.058) ***
Cons	3.567837	13.05652	-45.81135

GDP in this study is considered as consumer purchase power parity and the result of estimation for GDP's effects on the demand for EVs is concluding with coefficient (3.93) and P-value (0.000). Based on this result we reject null hypothesis because GDP per capita has significant impact on demand for electric vehicles, which denotes a 1 percent increase in consumers GDP per capita the demand for electric vehicles will increase (3.93) percent. The outcome implies that the growth in GDP per capita has a beneficial influence on the adoption of electric vehicles (EVs) in a variety of ways. The analysis' conclusions are in line with the consumer choice in demand theory, which holds that an increase in GDP per capita turns into more disposable income and purchasing power. As a result, it is anticipated that consumer choices and behavior associated with EVs would change depending on their financial situation. Therefore, using the demand theory as a guide, the hypothesis and data support the idea that as much as consumer ability increases consumer's willingness will change in paying more for superior goods. Since EVs are more expensive than fuel-based engine vehicles, people may be more likely to consider and buy EVs in an environment with a higher GDP per capita.

Additionally, it implies that the rise in GDP per capita will alter consumer behavior, particularly that of people who are price sensitive. This suggests that people with higher GDP per capita may be less price sensitive and more likely to invest in environmentally friendly and sustainable solutions like EVs, even if they have a higher price tag. This also signifies that the EVs will be prioritized over fuel-based engine vehicle even if their initial costs are much higher

than those of fuel-based engine vehicles when GDP per capita rises and consumers consider the long-term benefits of EVs which save more budget and the operating expenses of EVs which is cheaper than fuel-based engine vehicles.

Furthermore, based on the study's findings about the GDP's effects on EVs deployment, it is believed that greater environmental consciousness and concerns about climate change are linked to higher GDP per capita. Consumers with higher incomes are more likely to prioritize electric vehicles (EVs) due to their eco-friendly features, specifically their reduced carbon emissions. In essence, individuals with greater financial capacity tend to make more informed decisions when purchasing EVs, considering the environmental benefits.

On the other hand, with respect to the positive effects of GDP per capita this study presumes that the GDP per capita is an indicator of a nation's overall economic development and progress is the growth of its GDP per capita. It represents the nation's average per-person income and purchasing power and a country's economy is said to be growing, productivity is rising, and people generally have more money to spend when the GDP per capita of the nation rises. Hence, this study holds that increasing GDP per capita not only motivates people to embrace EVs but also aids governments in a variety of ways to harmonize EV adoption. Governments with higher GDP per capita frequently make larger investments in the establishment of infrastructure, which includes the construction of EV charging networks. Range anxiety issues can be reduced, and EV owners' convenience and accessibility can be improved with a well-developed charging infrastructure. The confidence of consumers and their choice to buy an EV may be favorably impacted as a result.

Additionally, the findings of numerous empirical research show that the governments' use of incentives and tax breaks has significantly contributed to lowering the cost of EVs compared to fuel-powered vehicles. The adoption of EVs therefore necessitates significant investments and tax-free policies, and nations with higher GDP per capita may have more resources available to implement such incentives, tax credits or reduced registration costs. Consumers may prefer electric vehicles over conventional vehicles because of these incentives, which can lower the upfront cost of purchasing an EV.

The result of this study is also aligned with the previous empirical results which they found significant relationship between GDP and EV adoption. Harrison and Thiel (2017) examined the effects of macroeconomic variables, such as changes in the gross domestic product (GDP), and policy incentives on the uptake of EVs. International Energy Agency (2022) based on the

annual evaluation of EVs growth emphasized that the economic ability is crucial in EV adoption, countries with high economic ability is more able to invest for the growth and adoption of EVs. According to these empirical findings, households, and individuals' willingness to embrace EVs relies on their financial situation, and those with greater GDP are more likely to purchase EVs. Furthermore, this analysis suggests that the GDP accurately reflects economic expansion in a particular nation. In other words, the percentage change in GDP represents the change in the ability to generate goods and services over a certain period of time. The model used in this research was evaluated on a few European nations, and the results showed that the deployment of EVs occurs more quickly in nations with greater GDP per capita levels.

However, nations with smaller GDP per capita show a slower adoption of EVs and seem to be affected at a lower stock share than 5%. Further, the research noted that the results are not unexpected given that EV adoption is accelerated or delayed as a result of greater GDP per capita, since EVs initially cost is higher to purchase than conventional cars when they first hit the market.

Moreover, the result in terms of charging infrastructure or the availability of charging stations resulted with P-value of (0.000) and coefficient of (0.649). The result indicates that the availability of charging infrastructure is significant in (1%) with positive effects, it means the existence of charging station or the growth in the number of charging infrastructure has significant and positive impact on demand for EVs. The result denotes that an increase of 1 percent in charging station the demand for electric vehicles will be increased (0.649) percent. The result of this study is in line with the previous theories. Numerous studies found the same effects such as (Clinton et al. 2019; Sierzchula et al. 2014; Zhou et al. 2016; Lutsey et al. 2016) in their studies have found significant effects of charging infrastructure on adoption of EVs. These studies, which looked at how the availability of charging points affected the adoption of EVs both locally and worldwide, revealed that the existence of incentives and the accessibility of charging infrastructure had the most impact on the uptake of BEV and PHEV.

Additionally, this research determined the effect of charging stations on other EV incentives. Based on their research, it has been shown that financial incentives have only a limited impact on PEV adoption in the absence of adequate charging infrastructure. Their results utilizing various models also imply that the availability of public charging infrastructure has a substantial influence on the purchase of both PHEV and BEVs and relatively elevates EV's

market share and demand. The findings suggest that increasing the number of EV charging stations might lessen concerns about running out of gas and thus boost PHEV and BEV demand and market share.

Therefore, this study after evaluating the result of estimation in Asia and studying the previous empirical results and theories as well as relating them to the theory of demand, believes that the accessibility of charging stations is essential for driving consumer behavior toward EV purchases and advancing the adoption of EVs as a whole. Additionally, based on findings and analysis of the trend in EVs establishment in major EVs market (China, Japan, and South Korea), and emerging market in Asia (India and ASEAN members) during the years 2010 to 2022 have discovered the positive influence of charging points on growth of demand for EVs.

The availability of convincing number of charging station or the growth in number of charging point incompliance with the growth of EVs in major market represents a potential effects of charging station on EVs demand. In contrast the inexistence of adequate charging infrastructure has been the basis of lower growth and adoption of EVs. Considering the gradually growth and expectation for future growth of charging infrastructure, this study believes that the increase in the number of charging points will assist the EV adoption and demand for electric vehicles in perception support, consumer confidence range and market confidence.

The availability of charging stations helps EV owners to increase their driving range and discover new locations without worrying about running out of battery life. Consumers can schedule longer trips, such as intercity or cross-country travel, and recharge their automobiles enroute with the help of a dependable network of charging infrastructure. EVs are now more enticing to consumers who need flexibility in their travel demands because of their increased driving range. On the other hand, consumers find it more practical and handier to possess an EV when charging facilities are easily accessible. Because of their convenience, EVs are more appealing as a choice for buyers.

Furthermore, the presence of charging stations in public areas conveys to consumers that EV adoption is supported and promoted. It demonstrates a dedication to environmentally friendly transportation and promotes EV use. Consumer behavior may be affected by this perception of support since people are more likely to pick EVs when they believe that the necessary infrastructure is in place to meet their demands. Likewise, a strong infrastructure for charging stations boosts consumer confidence in the EV sector. It illustrates that there has been investment in the development of EV market and that there are charging solutions available to

fulfil the rising demand. This in turn promotes market expansion by encouraging more consumers to consider EVs and increasing EV sales and adoption rates.

Overall, this study believes that consumers are more likely to adopt electric vehicles when charging facilities are readily available It addresses concerns related to range anxiety, offers convenience and accessibility, and promotes confidence in the market. Charging stations promote consumer behavior that supports the purchase and adoption of EVs by facilitating charging and expanding driving range.

The estimation results in this study indicate an insignificant impact of gasoline price on EV demand. Several factors contribute to the lack of significance between gasoline price and EV demand. Firstly, it is noteworthy that the price of gasoline, crude oil, and automotive diesel experienced minimal changes per liter from the year 2010, as reported by the International Energy Agency IEA (2021). Second, based on the Regional Economic Outlook for Asia and Pacific (2023) highlights the rapid economic growth in Asian countries, particularly in ASEAN member nations, where the economy doubled since the year 2000.

Considering these observations, the concept of price elasticity of demand becomes relevant in understanding consumer behavior. The relatively less fluctuation in gasoline prices, coupled with the robust economic growth in Asia, may result in an inelastic response from consumers towards changes in gasoline prices. In other words, consumers in these regions may be less sensitive to fluctuations in gasoline prices when making their purchasing decisions, since the EV price is in huge gap which these little changes in the price of gasoline cannot convince consumer to stop purchasing fuel-based engine vehicles. Instead, they may prioritize other crucial factors such as the initial cost of EVs, availability of charging infrastructure, and environmental considerations when choosing between EVs and traditional internal combustion engine vehicles.

This analysis suggests that the gasoline price's limited variations during the study period did not hold substantial significance compared to other decisive factors that profoundly influence EV demand. Consequently, this study contends that the minor changes in gasoline price and the high economic growth in Asia contribute to a relatively inelastic market. As a result, the impact of gasoline prices on EV demand is overshadowed by the weight of other pivotal factors. These insights lend support to the notion that the gasoline price's significance is negligible in this context.

In conclusion, the combination of stable gasoline prices and robust economic growth in Asian countries leads to an inelastic market, where consumers' demand for EVs remains influenced by other significant factors. The findings of this study shed light on the complexities of consumer behavior in the context of EV adoption and emphasize the need to consider multiple factors beyond gasoline prices in promoting the transition towards electric and fuel-based engine vehicles in Asian countries.

Additionally, the estimation and findings of this study indicate that inflation has no significant effect on EV demand. Inflation is a phenomenon that influences the general prices of commodities within a country. However, several compelling reasons suggest that the impact of inflation on EV demand may be insignificant in this study. Firstly, during the period from 2010 to 2022, the selected Asian countries in this study, especially the ASEAN member countries, have undergone rapid economic growth. Consequently, these countries have not experienced substantial inflation, and the available data on inflation rates for these nations show normal variance.

Moreover, the Covid-19 period provides a clear illustration of the relatively limited effects of inflation on EVs compared to fuel-based engine vehicles. According to reputable sources like the IEA (2020) and Global Electric Vehicle Outlook (2022), the electric vehicle market has shown resilience and remarkable and immediate growth in Covid-19 recovery time pandemic, despite inflationary pressures affecting other sectors. This suggests that factors like government incentives, charging infrastructure development, and consumer preferences are more influential in driving EV demand than short-term fluctuations in prices caused by inflation.
This study contends that inflation's impact on EV demand in the selected Asian nations during this period is negligible. The substantial increase in EV sales despite the challenges posed by the Covid-19 pandemic and supply chain disruptions, coupled with the increasing focus on climate and environmental concerns, demonstrate a positive trend towards zero-emission vehicles. In this context, the direct influence of inflation on EV demand may be overshadowed by more significant factors and the implementation of supportive government policies.

Moreover, the result for the price of electric vehicles also shows significant and positive effects with probability value of (0.041) and coefficient of (-1.151). The result shows a positive relationship or positive impact of Ev price on EV demand at (5%). According to the result we reject null hypothesis, and the result denotes that 1 percent increase in price of electric vehicle the demand for EVs will fall at (1.15 %). The result coincides with earlier research and

assumptions. The previous studies such as (Gyimesi and Viswanathan, 2011; Rapson and Muehlegger, 2021; Global EV Outlook, 2022) have constantly emphasized how important EV pricing is in influencing consumer attitudes and adoption trends. The results of the abovementioned studies highlight the enormous impact that pricing has on consumers' decisions to purchase electric cars. It becomes clear that the high cost of EVs continues to be a significant obstacle, preventing their mainstream adoption. The analyses show that without strong incentives and government initiatives to lower the cost of electric cars, demand for this environmentally friendly form of transportation remains disappointingly low in several countries.

Further, these studies have stressed the need to acknowledge that several variables contribute to the high cost of electric cars (EVs), further compounding the difficulty of adoption. Due to the complex technology and components needed, such as the battery system, battery manufacture, and elements utilized in creating batteries, EVs are often much more expensive than fuel-based engine vehicles. Potential buyers find EVs less financially tempting because of the high cost of producing and obtaining these specialized components, which greatly increases the price of EVs overall.

Therefore, this study considering the current findings as well as with respect to the previous findings agrees to the consumer choice of demand theory and consumer’s behavior in preferring between EVs and fuel-based engine vehicles. According to the demand theory, the price of electric vehicles (EVs) plays a crucial role in shaping consumer demand and adoption. The theory suggests consumers weigh the advantages and disadvantages of several possibilities before making a choice. As a result, this study perceives that there are a few different ways that EV pricing affects consumer demand. Consumers frequently consider price while making purchases and frequently compare the costs of various goods. Some people may be discouraged from considering EVs as feasible solutions by their higher price tags, particularly if they believe there to be a large price gap between EVs and conventional automobiles. Consumers with cost-conscious will choose less expensive options, which might slow down the adoption of EVs. Since consumers decide based on their budget and affordability, higher-priced EVs may be out of reach for some consumers, particularly those with limited financial resources. As EV prices decrease or become more competitive with conventional vehicles, consumers with different income levels may find EVs more affordable and be more willing to consider them as a viable choice.

Overall, after estimating the affecting components on EVs demand in Asian countries within the years 2010 to 2022, this study suggest that consumers make rational decisions based on their preferences, budget constraints, and the perceived value of the available options and the high price of EVs in compared to the fuel-based engine vehicles has been a serous hurdle in minor and major markets of Asia. Based on findings of this study it can be predicted that the price of EVs is significant in adoption of EVs, the high price of EVs has been the main reason of low demand for EVs in most of Asian countries. Only limited developed counties in Asia were making the EVs market major by gradual growth since the year 2010, while the rest were creating minor growth in last few years and demand for EVs in these countries has been making mere growth.

Furthermore, this study through evaluation of previous studies and government incentive polices for EVs adoption believes that Incentive policies play a pivotal role in shaping the trajectory of electric vehicle adoption in Asian countries. These policies serve as powerful tools in influencing consumer behavior and promoting the transition to sustainable transportation alternatives. One of the key benefits of incentive policies is their ability to address the price barrier associated with EVs. As electric vehicles have higher upfront costs compared to their conventional counterparts, financial incentives such as subsidies, tax credits, and rebates help offset these higher costs, making EVs more affordable and accessible to a broader segment of the population.

Moreover, incentive policies not only encourage individual consumers to embrace EVs but also foster an environment conducive to industry growth and innovation. Governments can provide several types of incentive to elevate the growth of EVs in the market. Incentives to manufacturers and businesses involved in the production and distribution of EVs and charging infrastructure stimulate investments and spur technological advancements. This, in turn, leads to increased economies of scale and cost reductions in EV production, making them more competitive with traditional internal combustion engine vehicles.

Beyond addressing the cost barrier, incentive policies also serve to create a supportive ecosystem for EV adoption. For instance, policies that provide subsidies for the installation of charging infrastructure help alleviate range anxiety among consumers. Additionally, policies that grant EV owners free parking, free tax in using EVs on the road or exemption of purchasing tax as well as providing incentives in reducing upfront cost EVs further enhancing their adoption.

4.3 Hypothesis Testing

Hypothesis testing is a statistical method used to assess the validity of proposed statements or hypotheses about a population based on sample data. In this case, the study formulated five hypotheses and conducted hypothesis testing to determine if there is enough evidence to support or reject each hypothesis. Further, we conduct hypothesis testing to make decisions based on the data evidence which allows us to draw meaningful conclusions.

Table 4. 4 *Test of Hypothesis*

Hypothesis Testing	Coefficient	P-value	Result
H1: Increase in consumer's GDP per capita Increases the demand for EVs and helps EV adoption.	3.938858	0.000	Reject the null hypothesis
H2: Inflation has a negative impact on demand for EVs.	0.0259329	0.113	Reject alternatives
H3: Th gasoline price has positive effects on electric vehicle demand.	-0.461886	0.194	Reject alternatives
H4: The electric vehicle price has no effect on demand for EVs.	-1.151204	0.0413	Reject the null hypothesis
H5: Availability of charging station significantly increases the demand for EVs.	0.6495984	0.000	Reject the null hypothesis

Table 4.4 demonstrating the result of hypotheses testing. Testing hypotheses as a significant test is utilized to assess which of two competing hypotheses, the null hypothesis (H_0) and the alternative hypothesis (H_1) is more likely to be accurate. The alternative hypothesis contends that there is substantial relationship between the variables, while the null hypothesis (H_0) states that there is no such a relationship or effects between variables. Therefore, the result for each hypothesis based on the finding of this study are as follow:

H_1: Increase in consumer's GDP per capita Increases the demand for EVs and helps EV adoption. Based on the result the coefficient for GDP is 3.938858 with p-value: 0.000 indicates that there is strong evidence to reject the null hypothesis, suggesting that an increase in consumer's GDP per capita significantly increases the demand for EVs

H_2: Inflation has a negative impact on demand for EVs. The result of this study regarding the effects of inflation on EV demand found that the coefficient for inflation is 0.0259329 and p-value is 0.113. This denotes that the relatively high p-value 0.113 supports the insignificant

effects of inflation in this case. Or the result suggests that there is insufficient evidence to reject the null hypothesis. Therefore, we cannot conclude that inflation has a significant negative impact on the demand for EVs based on the available data.

H_3: The gasoline price has positive effects on electric vehicle demand. The result of estimation in this study found coefficient (-0.461886) and p-value 0.194 for gasoline price. The p-value 0.194 is greater than the conventional significance level (e.g., 0.05), indicating a lack of sufficient evidence to reject the null hypothesis. Therefore, we cannot conclude that gasoline prices have a significant positive effect on electric vehicle demand based on the given data.

H_4: The electric vehicle price has no effect on demand for EVs. Coefficient -1.151204 and p-value 0.0413 which is less than the significance level (e.g., 0.05), indicating that there is enough evidence to reject the null hypothesis. Therefore, we can conclude that the electric vehicle price has a significant effect on demand for EVs.

H_5: Availability of charging station significantly increases the demand for EVs. The result of our estimation shows quite the same designed hypothesis of this study. The study found that the coefficient for charging stations in this study is 0.6495984, while the p-value is 0.000 and less than the significant level. The finding suggests that the charging station is highly significant. Hence, there is strong evidence to reject the null hypothesis, indicating that the availability of charging stations significantly increases the demand for EVs.

In conclusion, the study conducted hypothesis testing for five different hypotheses related to factors influencing the demand for EVs. Based on the results, some hypotheses are supported by strong evidence, while others show insignificant relationship with EVs demand in this study.

CHAPTER V

5.1 Summary and Conclusion

In conclusion, this study examined the market for fuel-based and electric vehicles in Asian nations. The research aimed to determine the elements that influence the demand for the purchase of electric cars in major and emerging Asian markets, guided by the demand theory. The estimation's results provide insight into the major factors influencing demand for electric vehicles in Asia. Notably, the results indicate that among the other variables examined in this study, GDP, electric vehicle price, and the availability of charging stations were the main factors influencing EVs demand in Asian nations, and their absence has been identified as a significant barrier to electrifying the transportation sector.

The demand for electric vehicles and GDP per capita is positively correlated, which is consistent with the core ideas of consumer choice in demand theory. People tend to prefer sustainable transportation solutions more when their disposable income and purchasing power improve. Because of the potential long-term advantages for the environment and personal transportation requirements of electric cars, a greater GDP per capita encourages consumers to think about and invest in them.

The study also emphasizes the large and advantageous influence that people's economic well-being, as determined by GDP per capita, has on consumer demand in purchasing electric cars (EVs). Additionally, a government's general economic expansion gives it more financial resources to spend on critical EV ecosystem components. In order to lower the initial cost of EVs and increase their market competitiveness versus conventional internal combustion vehicles, this includes the creation of a strong EV infrastructure as well as the introduction of supportive policies like tax breaks and incentive programs.

The outcome further highlights the importance of price sensitivity in the uptake of electric vehicles by demonstrating the major impact of EV price on demand. Even though EVs have benefits including lower running expenses, the greater initial cost may put off some consumers. The initial cost of EVs in Asian countries, especially in the minor market, was posing a bigger barrier and, comparatively, lowering consumer interest in demanding EVs or choosing EVs over fuel-based engine vehicles.

Additionally, the correlation between the availability of charging stations and the demand for electric vehicles emphasizes the importance of the infrastructure for charging stations in influencing consumer behavior. Concerns about range anxiety and the practicality of owning an electric vehicle are directly addressed by the accessibility and availability of charging stations. Potential EV consumers are more assured that they can conveniently charge their vehicles as the number of charging stations rises, which has a beneficial effect on their adoption choices. Investigations of the charging point as a barrier to generate demand have also been conducted.

On the other hand, this study based on the finding over the impact of incentive policy on EVs demand concludes that government intervention in driving demand for EVs is necessary. Without such intervention, the relationship between EV demand and the establishment of electric vehicle charging infrastructure becomes a challenging chicken-and-egg dilemma. Our findings underscore the crucial importance of incentive policies implemented by governments, which include the establishment of EV charging infrastructure, tax exemptions, and subsidies to reduce the initial cost of EVs. The absence of these incentives could hinder the widespread adoption of EVs, making them less competitive in the market. Moreover, this study demonstrates that relying solely on other factors without the support of government incentive policies may not be sufficient to boost EV demand.

In summary, the study of the demand for electric vehicles in Asian nations via the perspective of consumer choice in demand theory underlines the significance of economic considerations, pricing strategies, and charging infrastructure. The results of this study can be used to create targeted policies and initiatives that will increase the use of electric vehicles, hasten the transition to sustainable transportation, and tackle today's most urgent environmental issues.

5.2 Policy Recommendation

The findings primarily point out the need for governments and policymakers in Asia to take initiative in lowering the cost of EVs for consumers. For policymakers, industry stakeholders, and researchers wishing to advance sustainable transportation practices in Asian nations, this study, which examined the demand for EVs based on consumer choice in demand theory, offers invaluable insights. Policymakers can create complete programs to encourage higher use of electric vehicles by considering the interaction between economic variables, pricing methods, and charging infrastructure. These initiatives can help achieve the region's overall sustainability

goals, cut carbon emissions, and accelerate the transition to a greener and more ecologically friendly transportation system in Asia.

Further, this study suggests that governments and other industry stakeholders must therefore immediately put in place efficient laws and incentives to close the price gap between fuel-based engine vehicles and electric vehicles. Such programs can increase consumer interest and encourage the wide adoption of electric vehicles by solving affordability issues.

In addition, the analysis of government incentive policies in this study reveals that incentives incorporating tax reduction and government subsidies play a significant role in addressing the high upfront cost of EVs in the vehicle market. By reducing the financial burden on consumers, these incentive policies make EVs more financially viable and competitive in price compared to fuel-based engine vehicles. The findings of this study highlight the effectiveness of government incentives in China and several European countries, where the implementation of such policies has resulted in a substantial reduction in the primary cost of EVs. This reduction in cost has contributed to enhancing the affordability and attractiveness of EVs to potential buyers, ultimately driving the adoption and market penetration of EVs.

According to the analysis and findings from the incentive policies implemented by governments, this study suggests that governments should design and implement comprehensive incentive policies that address the key barriers to EV adoption. These policies include financial incentives, tax benefits, and subsidies to make EVs more affordable and compatible in the market. Further, this study believes that there is a need for substantial investments in EVs infrastructure. Hence this study recommends that government should in invest in establishing enough charging station to alleviate range anxiety and enhance the convenience of using electric vehicles.

5.3 Study Limitation and Future Direction

The study aimed to cover a broad spectrum of major and small EV markets in Asia, including China, Japan, South Korea, India, and all ASEAN members, which have all seen considerable EV growth in the recent year. The study appeared to have several limitations that must be noted.

- Data accessibility is the main limitation to this study's potential. Regular data from 2010 to 2022 were only accessible for a limited number of these nations, while others lacked full data for the years 2010 to 2022. The reliability and accuracy of the estimating model

applied to the research may be negatively impacted by the disparity in the data availability from 2010.

- Additionally, financial constraints limited the ability to purchase data from commercial sources that could have provided more extensive and robust datasets. Consequently, the study relied on available public sources, which might not fully capture the complexity of the EV markets in the selected countries.
- Financial limitations prohibited the collection of specific data sets, potentially compromising the analysis's accuracy and completeness. These restrictions prevented the study from including a number of nations, potentially affecting the results. As a result of these limitations, several countries were not included in the study, leading to a potential negative effect in the findings. The exclusion of these countries may have implications for the generalizability and representativeness of the results, as the study's focus was narrowed to the available data.
- In addition, data for the fuel-base engine vehicle and its price for Asian countries are missing. Hence data for the fuel-based engine vehicle is not regressed in econometric model of this study. Further, in equation model also due to lack of data the price of gasoline care is whip out and the demand for EVs figure out based on the gasoline price.

This study suggests that financial assistance or grants be made available to academics to help them get through the cost obstacles related to data collecting and purchase to alleviate these restrictions. With this help, data restrictions would be reduced, and a more thorough study would be possible. Future research should also try to increase the sample size by analyzing a larger variety of nations. The results would be more comprehensive and inclusive of the whole of Asia if they included more different nations and markets. Future research may contribute to a more robust and thorough knowledge of EV markets in Asia by addressing these shortcomings and putting the offered solutions into practice, which will eventually help the transition to sustainable transportation systems.

Finally, future research should strive to include more current and extensive information, allowing a longitudinal analysis of the EV industry in Asian nations. This will help us assess EV demand and uptake more thoroughly and provide policymakers and industry stakeholders with the most recent information.

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