Adoption of Electric Vehicles (EV) among Millennial through the Diffusion of Innovation (DOI) Framework: The Role of Pro-Environmental Attitude

Faizah Mashahadi[1*], Razmah Mahmod[2], Faizah Mohd Sohid[3]

[1]Department of International Business and Management, Faculty of Business and Management,
Universiti Teknologi MARA Cawangan Selangor,
Kampus Puncak Alam, 42300 Bandar Puncak Alam, Selangor
**faizahmashahadi@uitm.edu.my*

[2]Department of Technology and Supply Chain Management Studies, Faculty of Business and Management,
Universiti Teknologi MARA Cawangan Selangor,
Kampus Puncak Alam, 42300 Bandar Puncak Alam, Selangor
razmah@uitm.edu.my

[3]Department of International Business and Management, Faculty of Business and Management,
Universiti Teknologi MARA Cawangan Selangor,
Kampus Puncak Alam, 42300 Bandar Puncak Alam, Selangor
faiza746@uitm.edu.my

Corresponding author (*)

Received:05072023 Revised from: 18082023 Accepted:24102023
Published: 31102023

Abstract

To encourage sustainable development, the government is now promoting the usage of electric vehicles (EV). Malaysia's present EV market share is still pitiful, nonetheless. At less than 3% of the market in 2021, the adoption rate is much lower than what has been achieved in nearby nations. As millennials are believed to be more environmentally sensitive than previous generations, this study attempts to find out more about their adoption of electric automobiles. This study, which is based on the Diffusion of Innovation (DOI) theory, suggests that pro-environmental sentiments will moderate the significant influence of relative benefits, complexity, compatibility, observability, and trialability on the adoption of electric vehicles. In practice, this study aims to offer thorough details on variables influencing EV adoption from the viewpoints of millennials to policy makers, researchers, and industry players.

Keywords: Electric vehicles, Diffusion of Innovation (DOI), Millennial generation, Pro-environmental behaviour,

1. Introduction

Around the world, rapid economic development and growing population has persistently caused damage to the ecological system. A significant increase in the middle-class group has increased demand for passenger cars. The effect of greenhouse emission from passenger cars has been continuously rising. There are about 1.49 billion cars on the planet earth reported in 2023 including 1.11 billion passenger cars and 380 million commercial vehicles (RFID Tires, 2023). While it creates profitable return to the government and industry players, simultaneously it has elevated global concern about the sustainability of the earth. Every day, the transportation sector consistently emits millions of tons of greenhouse gasses into the atmosphere. A conventional passenger car typically emits 400 grams of carbon dioxide (CO2) per mile and on average 4.6 metric tons of CO2 per year (Center for Climate and Energy Solutions, n.d.). This sector accounts for 20.2 percent of greenhouse gas emission and is positioned as the fourth in the ranking of carbon-polluting sectors

worldwide (Greenly Institute, 2023). Passenger cars are the main cause of greenhouse gas since 80 per cent of the cars are primarily powered from diesel and gasoline. Among the greatest challenges in the transportation industry, designing and implementing strategies in reducing CO2 emission is one of the most complex. Effective sustainability measures in the transportation sector are therefore essential for striking a balance regarding social, economic, and environmental challenges.

Governments and business leaders collaborate globally to promote electric vehicles (EVs) as a means of halting environmental destruction. Strategies aimed at reducing the environmental impact of CO2 from the transportation sector play a key role in reducing the unfavorable effects on the environment. The world's leaders have communicated their commitments to limit global warming to 1.5 degree Celsius at the latest in 2025 as concluded in Paris Agreement, 2015. Malaysia establishes its determination in supporting the agreement such as in the 12th Malaysia Plan 2021-2025, National Automotive Policy 2020, National Determined Contribution 2021, and the Low Carbon Nation Aspiration 2040. So far, electrification of passenger cars is the best course of action in reducing greenhouse gasses (Sharma & Maréchal, 2019). EV adoption together with sustainable hydro, wind, nuclear and solar power plants can contribute to a significant pollution reduction and directly increase air quality (Veza et al., 2022). EV is expected to conquer 30 percent of the transportation industry (excluding two wheelers) in the global market (Krishna, 2021). Given that EV is still in the early phase, appropriate policies and incentives are vital to increase EV adoption from 1 per cent in 2018 to 38 per cent in 2040 (Malaysia Automotive Association, 2023). However, the conversion from combustion engine to EV remains an unpopular option although EV has been in the market since the 19th century (Krishna, 2021).

The expansion of EV is a new opportunity for Malaysia to attract more foreign investment into the country. Of ten ASEAN member states, Malaysia ranks fifth in terms of foreign direct investment (FDI) receiving an average of 4.313 billion per annum between 2009 and 2020. FDI is found to draw positive economic growth, as indicated by rising Gross Domestic Product (GDP) over the past ten years with an average of USD 1.144 trillion (Sijabat et al., 2023). Examining EV diffusion provides future direction in designing EV policies and facilities to provide more opportunities for businesses. A comprehensive understanding of EV diffusion in the market is important to attract more inward FDI from the EV manufacturers.

To highlight some data, Malaysia has a population of 32.7 million in 2022 (Department of Statistic Malaysia, 2023). Statistics from Malaysia Automotive Association, (2023) said the number of passenger vehicles in Malaysia is 641 773 units in 2022 compared to 452 663 units of passenger vehicles in 2021. Since there is no restriction on passenger car ownership, the number of passenger cars is expected to be 725 000 units in 2023. To encourage the adoption of EV that is consistent with the commitment established in the Paris Agreement 2015, Malaysia has introduced a few tax exemptions including a two-year extension of the excise duty, sales tax exemption, and import tax exemption for selected components in locally assembled (CKD) EVs until Dec 2027 (Ministry of Finance, 2023). As a result, Malaysia Automotive Association reported 2 717 units of EV were sold in 2021, compared to 1 642 units sold in 2020. The association optimists that Malaysia is to be the home for 125 000 EVs by 2030 and the EV market is expected to grow steadily in the coming years.

Anthropogenic is human-related activities that are greatly accountable for climate instability that causes harmful impact on humans, plants, and animals (Kabir et al., 2023). On average, CO2 from human-related activity accounts for 76 percent of greenhouse gasses. CO2 is the main agent that causes ecological instability which is mostly generated from burning of fossil fuels in the energy, production, and transportation sectors. The level of CO2 indicates an incremental trend since 1960 from 10.9 billion tons per year to approximately 36.6 tons per year in 2022 (National Oceanic and Atmospheric Administration, 2021). Automobiles are the main culprit emitting greenhouse gasses with 25.9 percent shared by China, 13.9 percent contributed by the USA followed by India with 7.5 per cent (Khurana et al., 2020). Across the globe, fossil fuel vehicles contribute 22 percent to the global greenhouse gas emission (Sriram et al., 2022) and 12 percent of the greenhouse gas emissions are shared by private vehicles (Sriram et al., 2022). The earth's temperature keeps on increasing and causes ecological chaos and it has been negatively affecting all living things.

The government sees environmental degradation is at an alarming rate. In addressing this issue, the government is committed to take a great responsibility by promoting EV on a big scale. Unfortunately, the existing EV in the Malaysia market is barely lower than the quantity of EV adopted in neighbouring countries. In 2022, EV of passenger cars in Malaysia was only 2.6 per cent, indicating diffusion towards EV has been stagnant. Indeed, comparing the latest EV adoption with neighbouring countries, Malaysia's achievement in EV adoption is still less encouraging (Veza et al., 2022). In 2022, it is revealed that the EV sales in Thailand

accounted for 58 per cent, followed by Indonesia 19.5 per cent, and Vietnam 15.8 per cent (Counterpoint's Global Passenger Electric Vehicle Model Sales Tracker, 2023).

Cost of the EV, driving distance per charge, charging time, charging infrastructure, battery cost, unqualified dealership (Khurana et al., 2020), poor awareness, lack of understanding, skepticism towards EV and the perception about combustion engine as more convenience than EV (Arora et al., 2022), supply chain of EV components such as batteries, electric motor, inverter and the safety of EV on road, distance range, charging facility (Veza et al., 2022), sales conversion inability, and lack of trust in technology (Krishna, 2021) remain as major barriers that restrain EV adoption. Taking care of these obstacles, it is common to experience low acceptance in the introductory stage of new technology. However, it is important to understand the adoption of EV to meet the EV market share. From this perspective, understanding the diffusion of innovation toward EV is desirable. The diffusion of innovation is related to the process in which a new technology is accepted by a significant number of actors throughout society (Palm, 2022). Understanding the factors related to EV adoption will lead to a better approach and strategy in EV adoption.

Following Rogers (2003), the primary attributes of diffusion of innovation (DOI) are associated with compatibility, complexity, relative advantage, observability, and trialability. Arora et al. (2022) suggested in estimating the diffusion of innovation, study should consider consumer related factors. In essence, environmental damage stems from anthropogenic activity (Kabir et. al., 2023). Therefore, a change in consumer behaviour is needed to improve the damage caused to the environment. Pro-environmental behavior plays a significant role in protecting the environment and improving ecological sustainability (Tian & Liu, 2022). Indeed, pro-environmental behaviour is a practical way to lower pollution emissions and prevent environmental harm. Since EV is introduced to combat ecological damage, understanding diffusion of innovation and consumers' pro-environmental behaviour is expected to establish a higher considerate level of EV adoption through practicing environmentally friendly behavior.

2. Methodology

The purpose of this paper is to examine the diffusion of EV among the millennial generation who are perceived more technologically friendly and sensitive towards environmental perseverance and sustainability. Since this paper aims to identify factors that affect EV adoption, the research question of this paper is what are the factors that influence the millennial generation for EV adoption. A systematic review is conducted using peer-review studies from scientific databases. A systematic literature review is a method in identifying, evaluating, and interpreting all available research related to a particular research topic or question, or phenomenon of interest (Kitchenham, 2007). In this regard, exhaustive reviews were conducted on more than 20 journals relevant to EV using keywords such as diffusion of innovation, pro-environmental behavior, and millennial generations. The study focuses on titles, abstracts, and keywords to facilitate the searching process. Past articles, seminar papers, and additional papers are also considered as important sources. The search was conducted on established scientific databases such as Google Scholar. Article review is such a great help to understand the development of EV and consumers' adoption towards the use of EV. Also, this paper discusses the attributes of millennial generation and electric vehicles, diffusion of innovation framework, and pro-environmental attitude. Finally, this paper proposes a research framework with regards to the adoption of EV from the perspective of diffusion of innovation through the lens of pro-environmental behavior among the millennials.

3. Findings and analysis

3.1 Millennial Generation and Electric Vehicles

DeVaney (2015) identifies generation by age, period, and cohort. While age represents the length of time a person lives, period indicates events or what happens within the lifetime of a person. A person who is living belongs to a group of individuals who share experience and events that could drive a similar attitude and behavior. Applicable globally, there are five generations in the world's population: the silent generation (born between 1930 and 1945), baby boomers (1946-1964), generation X (1965-1979), generation Y (also known as millennial generation born between 1980 and 2000), and alpha generation (2010-2025). The Y generation is as

popular as the millennial generation. This generation is called digital native because they are the first to arrive online and exposed to digital devices while baby boomers and generation X are from the digital immigrant cohort because they substantially life offline before arriving online (DeVaney, 2015). The core values of this generation are based on their community work and intention to initiate changes to the world (Abdul Majid et. al., 2016).

Millennials are believed to have a higher level of awareness in environmental sustainability (Naan & Seng Hun, 2022). This generation is more environmentally conscious and keen to involve directly to reduce the carbon footprint (Meyer, 2023). Indeed, they are more concerned about the damage caused in anthropogenic activities by the previous generation. This techno-savvy generation is the most appropriate subject for EV adoption since it is predicted that this generation is to be the key market for EV (Naan & Seng Hun, 2022). The millennial generation is portrayed as a generation that grows up with technology. They can adjust effortlessly to technological changes. This generation is the first generation exposed to smart devices such as mobile communication devices, and desktop computers (Mutteti & Nyariki, 2022). They are born between 1980 and 2000. In 2023 their age range is between 23 to 43 years old. Despite being known as the technological-friendly generation, the millennial is also known as the environmentally friendly generation. The millennial generation is characterized as an environmentally conscious generation and keen to reduce ecological destruction done by the previous generations (Dilotsotlhe, 2022). This generation is the most recent to enter the employment market and will take over the market when baby boomers retire (Smith & Nichols, 2015). EV is still an innovation in the Malaysian market. It requires considerable attention in understanding the propensity of the millennial generation toward EV. One of the studies related to EV and millennial generation has reported that attitude, subjective norms, perceived behavioral control, perceived value, and environmental self-image positively affect intention to purchase and perceived risk is negatively affected the intention (Vafaei-Zadeh et al., 2022). The examination about EV among Chinese millennials indicates that green praticed attitude, subjective norms, and perceived behavioral control positively influence intention toward green car purchasing behaviour (Wang et. al. 2022). Despite the long-standing study on EV, most studies examine propensity towards EV from the Theory of Planned Behaviour perspective. There is still a limited study on diffusion towards EV, making studies related to EV adoption from the millennial generation perspective is valuable. This study is performed to gain a comprehensive understanding of the existing literature about factors that influence EV adoption through the lenses of the Diffusion of Innovation (DOI) framework while also implementing pro-environmental behavior to regulate the link.

Globally, EV is an initiative to reduce pollution emitted from passenger and commercial vehicles. Malaysia is on the solid stand and highly committed to increase the number of EV. Such action is vital in combating climate change and ecological damage. So far, EV market share in Malaysia is at an outrageous level with only less than 3 percent of EV on the road. EV is a vehicle that is partially or fully powered on an electrical motor. The United States Environmental Protection Agency (2023) essentially divides EV into three different categories. First, an All-Electric Vehicle (All-EV) is a vehicle that is installed with a battery instead of a petrol tank and uses an electric motor as a substitute for a combustion engine. This type of EV uses electricity generated from the battery to run the motor and power the wheels. All-EV runs on electricity with zero CO2 emission and does not contain liquid fuel components, such as fuel tank and fuel pump. Second, Plug-in Hybrid Electric Vehicle (PHEV) is a type of vehicle that generates energy from a battery and electric motor as well as from petrol tank and combustion engine. PHEV can be charged using a wall outlet or charging equipment and when the battery is almost drained, the petrol is burned in the engine to supply additional electricity to the electric motor. Third, Blended Mode EV (BHV) or Hybrid EV uses both petrol and electricity to power the vehicle. This type of EV cannot be plugged-in to charge the battery. When the battery is drained out, the battery is then charged through regenerative braking and by the combustion engine. In the global market, the blended mode EV or hybrid is dominating in terms of adoption speed, infrastructure preparation, technology maturity and investment by automakers (Trencher & Edianto., 2021)

EV is safer for the environment since the vehicle is powered by an electrical engine or battery. Although this development will improve the ecological system a bit, people are still concerned about battery degradation with time. The degradation could lead to a decline in the performance and range of the battery, indicating it is almost impossible for people to use the EV the same way they experience when the EV is new (Krishna, 2021). People also perceive that EV is not environmentally friendly due to the mining activities needed for manufacturing batteries and other related components. People are also concerned about the existence of blood

diamonds where people are conjecturing about if the mining activities do follow the human rights law (Krishna, 2021). For these reasons, many believe that the EV is still in its early stage of development, and consumers are hesitant to adapt to the technology that they perceive still requires further improvement and development. Few mentioned that EV is indeed an innovation that will bring a positive effect to the environment, but they are not ready to use EV (Krishna, 2021). In addition to the immature technology, people are reluctant to use EV due to the high buying price and limited charging facilities making these factors a barrier for adoption. Henceforth, understanding EV adoption from the millennials perspective may offer some guides for the policy maker and industry players to provide the required facilities as expected by the market.

3.2 EV Adoption and Diffusion of Innovation (DOI)

Fossil fuel depletion and the damaging consequences of fossil fuel vehicles on the environment have spiked awareness of the players in the transportation industry to rethink the conventional mode of transportation. One such effective measure is offering an alternative mode of passenger vehicle that is safer for the environment. EV can be regarded as an innovative product because it brings new experiences to users by using new energy, new systems, and new technologies (Xia et al., 2022). This environmentally friendly innovation is still in early adoption with a slow adoption rate. Creating awareness to adopt EV is an important step to combat environmental issues. Henceforth, it is highly relevant to observe which factors affect the likelihood of adopting EV. Understanding the reasons why some innovation is widely accepted while others are not successful is crucial (Kaminski, 2011). Rational buyers commonly make a thorough assessment upon the features of the product invention before making any purchase (Aurora et al., 2022).

Major determinants in EV adoption are demographic, product attributes, supporting conditions, and psychological factors (Hoang et. al. 2022). The current study aims to focus on the effect of innovation characteristics on EV adoption using the DOI model. So far, this model is effectively used to explain the adoption of new products (Kaminski, 2011). The DOI proposed by Rogers (2003) uses five distinct innovation characteristics to explain the scenario including observability, relative advantage, compatibility, trialability, and complexity. Rogers (1962) also highlight the DOI from the social perspective and mapped out the processes into five distinguished categories of innovation adopters: (1) innovators or technology enthusiasts (2) early adopters or visionaries, (3) early majority or pragmatists, (4) late majority or conservatives, and (5) laggards/observability or skeptics. The first two categories play integral roles as opinion leaders as they serve as change agents who can influence others through social media networking, peer communication and role modeling (Kaminski, 2011).

Innovation adoption is initiated from the emergence of new technology to its prosperity. According to Rogers, 1962, innovation adoption consists of, (i) the knowledge stage refers to the exposure process of the innovation but lack complete information; (ii) the persuasion stage where favourable and unfavourable attitudes are developed and people interested in the new idea and seeks for more information; (iii) the decision stage in which people start to engage in adopting or rejecting the technology; (iv) the implementation stage that describes the usage of the innovation; and (v) the confirmation stage where the innovation is reinforced and people makes full use of innovation. The knowledge and the persuasion stage are critical for understanding innovation adoption behaviour because in these two stages attitude toward innovation is asserted (Moon, 2020). These features are particularly important in an assessment for understanding customers' perception towards the adoption of innovative products in the market (Arora et al., 2022).

EV is an innovative technology created for environmental sustainability that is distinctively different from the existing combustion engine car. This study is conducted to understand diffusion towards EV from the perspective of DOI. Many studies have been found to employ DOI in explaining adoption of EV. Considering the above-mentioned point of view, the existing study employs DOI including factors such as relative advantage, complexity, compatibility, trialability, observability in understanding intention for EV adoption. Additionally, as EV is about more than just energy conservation but also environmental protection, the role of the pro-environment consumer is also considered (Khurana et al., 2022). Since DOI is a multi-dimensional concept and must be integrated with other factors to obtain a better explanation for EV adoption (Arora et al., 2022), this study will extend the perspective of DOI by integrating pro-environmental attitudes into the framework.

3.2.1 Compatibility

Rogers (2003) defines compatibility as "the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of the potential adopters". It is assessed whether the innovation is perceived to be consistent with socio-cultural values, previous ideas or perceived needs (Kaminski, 2011). The feature indicates consistency between the customers' needs and the attributes of the innovative technology (Arora et al., 2022). Compatibility explains the extent to which a particular technology fits with individual needs (Xia et al., 2022). It shows the consistency between new technology introduced to the market with values and beliefs of respondents, in which it tests the environmental mindfulness as well as the EV technical attributes that may influence EV intention for adoption (Verma & Khan, 2020). Innovation is deeply important when the new technology is more compatible with consumers' existing behavioral patterns and experience, thus making innovation adoption more established (Moon, 2020).

Specific to the context of EV, a person who believes that EV can meet his or her need and is suitable with their expectation tends to adopt EV, and vice versa. Indeed, high level of compatibility improves the adoption rate among the potential buyers (Arora et al., 2022). Generally, the compatibility of cars is determined by its performance including top speed, acceleration, and handling. Based on the input gathered from Krishna (2021), people state that EV is inferior compared to combustion engine cars due to battery weight, poor handling, and inferior top speed performance. EV is represented by innovations with little compatibility because of low mileage and charging effect (Naan & Seng, 2022). Consumers strongly believe the EV cannot replicate the all-round performance of combustion engine cars unless future innovations are asserted. He also highlights that combustion engine cars from the perspective of the consumers appeared as a symbol of freedom nevertheless EV denied them from freedom due to the nature of EV. Some people like repairing cars as it serves as a sense of satisfaction, and it is seen as a hobby for many. Buying EV increases their dependency on the service centres and they feel inconvenienced with this anti-repair mentality. This situation does not fit well with the needs of some people who believe that they have the right to repair their cars.

Since EV is not well-adopted in the Indian market, this factor has been found to create an insignificant impact on EV intention and adoption (Arora et al., 2022). This may be explained in Verma et al. (2020) who conducted a study in India in which the finding says more than 50 per cent of the respondents are not aware of the cheap fuel cost of EV although majority believes in an upsurge in fossil fuel price in the future. The finding is found contradicting with a study conducted by Xia et al. (2022) where perceived compatibility is positively related to EV intention and adoption and plays the most important role in determining EV intention and adoption. In a different setting, Verma et al. (2020) clearly indicate that EV fuel efficiency is relatively affecting the adoption of EV.

3.2.2 Complexity

Complexity refers to "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 2003; Kaminski, 2011). Complexity suggests the innovation happens together with some difficulty and problems especially in the introductory stage. Increased complexity is a potential barrier that will prevent people from buying new innovations (Arora et al., 2022). Complexity is related to the problem experienced when using the innovative product, hence suggesting that complexity negatively affects the adoption of innovative products (Moon, 2020). Complexity addresses the deterrents that market may consider before switching to EV (Verma & Khan, 2020).

As a newly introduced product, several imperfections of EV have created hesitation among the potential buyers. Verma et al. (2020) highlight seven possible deterrents like recharging time, recharging inconvenience, initial cost of purchase, limited choice, style, limited charging stations and power delivery. Since EV depends on the battery for its operation, EV must be recharged at the battery charging facility. To this end, the limited number of charging stations, extensive time taken to recharge the battery, lifespan of the battery, battery replacement scheme, and the price of battery has prevented people from buying EV. Battery capacity and the cost are the most influential factors for EV acceptance (Zhuge et al., 2021). Consequently, these factors have increased perception in people about EV in which EV is more complex compared to combustion engine car. Additionally, people find technology involving Lithium-Ion batteries to be hazardous due to the nature of the

battery that can explode during an accident or when it is generating a lot of heat if the battery is damaged (Krishna, 2021).

Complexity in using the new technology will increase the level of perceived risk. Perceived risk (anxiety) explains the perceived apprehensions and uncertainties when using EV (Bhat et al., 2021). People are only ready to purchase a new technological-related product if the product requires simple operation. Some innovations can be accepted easily by the market but there are some innovations that take a longer time before commercialization (Arorra et al., 2022). If adopting EV causes too many complications, consumers will perceive EV as a complicated technology and tend to show less likelihood to adopt EV. Khurana et al. (2020) in their findings mentioned that consumers perceive combustion engines to be more convenient compared to EV. EV is less favourable due to time taken for charging and limited charging infrastructure. Negative perception is also reported on battery degradation over the period of usage time (Krishna, 2021). Complexity in EV has been reported to negatively affect intention and adoption of EV in the Indian Market. The ultimate reason for this finding according to Arora et al., (2022) is due to consumer perception of difficulty to drive or use EV. When Xia et al. (2022) empirically conduct similar analysis in a different context; a consistent finding is learned in which people tend not to adopt EV that they perceive difficult in using. Bhat et al. (2021) found perceived risk to have influence on EV adoption among the potential buyers.

3.2.3 Relative Advantage

Relative Advantage is defined by Rogers (2003) as "the degree to which an innovation is perceived as being better than the idea it supersedes". It shows the extent to which the technology is perceived to be superior to existing technology (Kaminski, 2011). It can be seen as economic benefits, cost saving, value and cost compared to conventional products (Naan & Seng Hun, 2022). Relative advantage is significant to spark interest and intention among the potential buyer for EV adoption. EV is still an emerging technology and the results of this technology aspect is not yet evident; thereby increase in perceived benefits may create awareness for EV adoption (Verma et al., 2020). The value-added embedded in EV is determined by its relative economic, social, and technical advantage compared to the combustion vehicle (Moon, 2020).

From the economic benefits, EV offers special advantages compared to combustion engine car such as lower price, and lower operating cost (Xia et al., 2022). Although the high cost of EV has been found to discourage EV adoption, the relative advantage of using EV can be created in lower energy consumption and maintenance costs compared to combustion vehicles. Khurana et al. (2020) explain that the energy cost of other fuel vehicles was eight times higher than that of EVs. Rate of adoption improves provided there are improvements in relative advantages of new technology and financial incentives such as government subsidies, tax exemption, cheap road-tax, low cost of ownership and high resale value (Verma & Khan, 2020).

From the technical perspective, consumers are not sure of the superiority of EV over combustion engine cars because many are still ambiguous towards its style, size, brand, and performance (Verma & Khan, 2020). In the case of social benefits, EV is anticipated to motivate innovators, early adopters, and the early majority for using EV (Moon, 2020). The environmental advantage can be interpreted in terms of environmental benefits such as reducing air pollution and being safer to the environment. The motivation to purchase EV lies in the perceived reduction of carbon emitted from EV (Verma & Khan, 2020) and offers special advantages compared to combustion engine cars such as energy efficiency, and relatively loose license issuance (Xia et al., 2022). An empirical finding shows that relative advantage does serve as a significant determinant for EV intention and adoption in India (Arora et al., 2022). This study is also supported in China when Xia et al. (2022) concluded that relative advantage plays a positive role in determining EV adoption. The relative advantages offered for EV adopters such as tax exemption, cheap road tax, etc., are found to significantly explain propensity towards EV adoption (Verma & Khan, 2020).

3.2.4 Trialability

Trialability is defined as "the degree to which an innovation may be experimented with on a limited basis" (Rogers, 2003; Kaminski, 2011). It signifies whether the product is in stock before the customers decide to make

an actual purchase (Arora et al., 2022). In short, trialability is the ease with which potential buyers can test an innovative product (Moon, 2020). Trialability can be in the form of sharing new innovations with potential customers, friends, and families. Innovation with a high degree of trialability is more rapidly adopted in the market (Moon, 2020). Sharing of knowledge and experience is a measure to influence more EV adoption in the future.

Trialability can be improved by providing potential buyers with information for verification and providing EV test-driving opportunities thereby enhancing EV adoption (Moon, 2020). The role of dealers in test-driving opportunities is important to create interest for EV adoption. However, dealers show no interest in promoting EV since they are unable to make a substantial amount of profit in EV compared to combustion engine cars (Krishna, 2021). To overcome this issue, EV manufacturers engage in online dealerships and offer online booking facilities, sharing experiences and product knowledge. Although online platforms are acceptable globally, people perceive EV online distribution as a strange option. The online method of distribution may not be appropriate for EV that requires high consumer involvement in the buying decision process. With the limited number of EV in the market, it makes people have limited experience towards EV (Arora et al., 2022). However, trialability has been observed not to play any significant impact in determining adoption of EV (Arora et al., 2022).

3.2.5 Observability

Observability refers to "the degree to which the results of an innovation are visible to others" (Rogers, 2003; Kaminski, 2011). It is about the visibility of EV on road (Arora et al., 2022). People tend to observe both tangible and intangible aspects of EV such as EV convenience, physical aspect, economic benefits, and environmental benefits. Repeated exposure of an innovative product to potential buyers grows familiarity, spreads word-of-mouth, and speeds up the adoption and diffusion process (Moon, 2020). People observe the effectiveness of EV, perceived value, and charging facilities in making their decision to buy EV. When combustion cars still outweigh EV, people will have a higher inclination toward combustion engine cars compared to EV. Observability is not concluded as an important determinant for EV adoption (Arora et al., 2022). A study conducted by Verma et al. (2020) is in line with the rest of the studies where there is no significant relationship in EV awareness and willingness to buy EV.

3.3 Pro-environmental attitude

Environmental degradation, climate change, and greenhouse gasses are global issues that increase stress to the earth and its inhabitants. Since the industrial revolution, human activities have released large amounts of carbon dioxide and other greenhouse gasses to the atmosphere and caused great damage to the environment (United State Environmental Protection Agency, 2020). Human activity (also known as anthropogenic activity) is the main reason for increased greenhouse gasses especially from burning fossil-fuel. The only ways and means to mitigate environmental risk is by transforming people's behavior and values to be more environmentally concerned (Ouariachi et. al., 2020). Environmental concern refers to awareness of environmental damage and people's willingness to address these problems (Khurana et al., 2022). Environmental consideration captures the concerns about continuous environmental damage among the potential consumers (Bhat et al., 2021). Environmental concern is then extended to and reflected on pro-environmental behavior that determinedly protects the environment and improves its sustainability (Tian & Liu, 2022). Pro-environmental consumers commonly display a higher degree of adoption for any environmental sustainability measures. Nonetheless this behaviour is encumbered not by negative attitude but rather weak positive attitudes together with lack of perceived behavioural control (Staats, 2004). In EV adoption for example, most people are in favour of EV to protect mother nature but are discouraged by the complexity related to the use of EV. Pro-environmental attitudes can be seen from at least three different perspectives, including psychological theory, social theory, and economic theory. Different theories apply different pro-environmental attitudes, thereby the extension of pro-environmental attitude towards EV as environmental protection practice offers a perspective from psychological theory (Tian & Liu, 2022).

It becomes imperative that many different players take substantial action to reduce the environmental problems. When society strongly perceives the negative impact of not sustaining the environment, they express higher environmental concern (Hoang et al., 2022). All parties including industry players, governments and consumers must play a significant role in reducing environmental damage. While organizations must minimize their environmental impacts, governments at the same time must implement pro-environmental policies and consumers, on the other hand, must shift their preference to EV and use them in a sustainable way, and adopt pro-environmental behaviour (van de Werff et al., 2021). EV is perceived to create great benefits to the environment (Verma et. al., 2020).

Therefore, in examining the extent to which pro-environmental perspectives affect EV adoption in Vietnam, consumers are found to adopt EV when consumers realize the negative impact of combustion engine car on the environment (Hoang et al., 2021). The existing empirical analyses show that pro-environmental behaviour is found to have a positive relation with intention for EV adoption, which confirms some of the existing conclusions. Perceived environmental responsibility is a significant determinant and strongly related to a stronger willingness to use the EV (van de Werff et al., 2021). Environmental attributes are found related positively to adopt innovation in sustainability technology as reported by Noppers et al. (2019). Yet, a contradictory finding is reported by Verma et al. (2020), where environmental consciousness has no significant association with willingness to adopt EV. Although pro-environmental research has been receiving great attention, there is still insufficient evidence and inconsistent findings from the existing theoretical perspective, thereby calling for a more comprehensive pro-environmental behavior determination model.

4. Discussion

Rapid economic development and rising populations have permanently harmed the biological system throughout the planet. The number of middle-class people has significantly increased, which has raised demand for passenger cars. Since 80% of passenger automobiles are primarily fueled by diesel and gasoline, they constitute the largest source of greenhouse gases. Designing and putting into practice CO2 emission reduction plans is one of the most difficult issues facing the transportation sector. Because of this, effective sustainability action in the transportation industry is essential for achieving a balance between environmental, social, and economic challenges.

Governments and business leaders from around the world are currently collaborating to promote electric vehicles (EV) as a way to slow down ecological destruction. Adoption of EVs in conjunction with environmentally friendly hydro, wind, nuclear, and solar power facilities can significantly reduce pollutants and improve air quality (Veza et al., 2022). According to Krishna (2021), EVs are predicted to control 30% of the global market for transportation (excluding two-wheelers). Given that EV adoption is still in its infancy, effective rules and incentives are essential to boosting it from 1% in 2018 to 38% in 2040 (Malaysia Automotive Association, 2023). Although EVs have been available since the 19th century, switching from a combustion engine to one remains an unattractive alternative (Krishna, 2021).

Cost of the EV, range on a single charge, charging time, charging infrastructure, battery cost, unqualified dealership (Khurana et al., 2020), lack of knowledge, skepticism toward EV, and belief that combustion engines provide more convenience than EVs (Arora et al., 2022). Also considered are the supply chain for EV components like batteries, electric motors, and inverters, as well as the safety of EVs while operating on the road remain as major barriers that restrain EV adoption. In spite of these challenges, it is typical for new technologies to first meet with low acceptability. To meet the EV market share, it is crucial to comprehend EV adoption. This viewpoint makes it desirable to comprehend the diffusion of innovation toward EV. A better method and plan for EV adoption will result understanding on the forerunner to EV adoption.

People of the millennial generation are portrayed as having grown up with technology. They can easily adapt to technological advancements. Millennials are regarded as the environmentally conscious generation in addition to being renowned as the technologically savvy age. The millennial generation are more capable of quickly adjusting to technological change and are more concerned with ecological sustainability. Studies relating to EV adoption from the technologically savvy and environmentally conscious age are important since, despite

the long-standing study on EV, there is little empirical research on diffusion towards EV. Through the lenses of pro-environmental attitude, this study aims to identify the variables that affect future adoption of EVs based on the Diffusion of Innovation (DOI) framework.

Based on Diffusion of Innovation theory (Rogers, 2003), this study proposed that relative advantage, compatibility, trialability and observability positively explain EV adoption while complexity is negatively related to EV adoption. This study integrates pro-environmental attitudes into the framework since it plays an important role in reducing environmental damage and in preserving the environment. Consumers who are more favourable towards environmental sustainability have higher propensity towards EV adoption. They are expected to consistently act in environmentally friendly ways, in which when it is applied in EV, the pro-environmental consumers have higher propensity in adopting EV. The higher the pro-environment attitude, the more likely the consumers are to adopt EV. On the other hand, consumers with less pro-environmental attitudes tend to act in environmentally friendly ways when they experience positive effects from the use of EV. These presumptions imply that pro-environmental attitude has a moderating influence on the relationship between relative advantage, compatibility, trialability, observability and complexity towards EV adoption.

5. Conclusion

This study is undertaken to explore EV adoption in the Malaysian market that is characterized by poor EV diffusion. Despite the available long-standing research, there is a dearth of observation on understanding factors that influence customer EV adoption from diffusion of innovation perspective. This study contributes to the existing body of knowledge related to EV adoption by testing the DOI and pro-environmental behavior. It will provide valuable information and thought for researchers, government, and industry players who are analyzing factors that will make people adopt EV.

References

Abd Majid, F., & Syed Mustafa, S.M. & Jais, I., Shahril, W., & Subramaniam, K., & Halim, M. (2016). A Preliminary Study on Selected Malaysian Millennials: Their Characteristics and Its Implications on Teaching Innovation. 10.1007/978-981-287-664-5_54.

Anderson, K. (Aug, 2023). Greenhouse gases by sector: who is polluting the most? Greenly Institute. https://greenly.earth/en-us/blog/ecology-news/greenhouse-gases-by-sector-in-2022-who-is-polluting-the-most#anchor-21

Arora, S.C., Sharma, M. & Singh, V.K. (2022). Using diffusion of innovation framework with attitudinal factor to predict the future of mobility in the Indian market. *Environ Sci Pollut Res*. https://doi.org/10.1007/s11356-022-23149-8

Bhat, F. A., Verma, M., & Verma, A. (2022). Measuring and modelling electric vehicle adoption of Indian consumers. *Transportation in Developing Economies*, *8*(1), 6.

Center for Climate and Energy Solutions, Global Emissions. (n.d.) https://www.c2es.org/content/internationalmissions/#:~:text=CO2%20accounts%20for%20about%2076,6%20percent%20to%20global%20emissions.

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Counterpoint's Global Passenger Electric Vehicle Model Sales Tracker, 2023. Southeast Asia Passenger Electric Vehicle Model Sales Tracker: Q1 2018 – Q2. (2023). https://www.counterpointresearch.com/research_portal/southeast-asia-passenger-electric-vehicle-model-sales-tracker-q1-2018-q2-2023/

Department of Statistics Malaysia, current population estimates Malaysia, 2022. https://www.dosm.gov.my/portal-main/release-content/current-population-estimates-malaysia-2022

DeVaney, S. A. (2015). Understanding the millennial generation. *Journal of financial service professionals*, *69*(6).

Dilotsotlhe, N. (2022). Factors Influencing Consumers' Intentions towards the Adoption of Environmentally Friendly Cars. *Multidisciplinary Business Review*, *15*(1), 63-76.

Faul, F., Erdfelder, E., Lang, AG. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods* **39**, 175–191. https://doi.org/10.3758/BF03193146

Hoang, T. T., Pham, T. H., & Vu, T. M. H. (2022). Examining customer purchase decision towards battery electric vehicles in Vietnam market: A combination of self-interested and pro-environmental approach. *Cogent Business & Management*, *9*(1), 2141671.

Kabir et al. (2023) Climate change due to increasing concentration of carbon dioxide and its impacts on environment in 21st century; a mini review

Kaminski, J. (Spring 2011). Diffusion of Innovation Theory. *Canadian Journal of Nursing Informatics, 6*(2). Theory in Nursing Informatics Column. https://cjni.net/journal/?p=1444

Keizer, K. K., Steg, L. S., Milovanovic, M. M., & Noppers, E. H. N. (2019). The role of adoption norms and perceived product attributes in the adoption of Dutch electric vehicles and smart energy systems.

Khurana, A., Kumar, V. V. R., & Sidhpuria, M. (2020). A Study on the Adoption of Electric Vehicles in India: The Mediating Role of Attitude. *Vision*, *24*(1), 23–34. https://doi.org/10.1177/0972262919875548

Kitchenham, Barbara. (2007). Kitchenham, B.: Guidelines for performing Systematic Literature Reviews in software engineering. EBSE Technical Report EBSE-2007-01.

Krishna, G. (2021). Understanding and identifying barriers to electric vehicle adoption through thematic analysis. Transportation Research Interdisciplinary Perspectives. 10. 100364. 10.1016/j.trip.2021.100364.

Malaysian Automotive Association. (2023). Sales & production statistics. http://www.maa.org.my/statistics.html

Meyer, S. 2023 https://www.thezebra.com/resources/research/how-do-different-generations-feel-about-electric-cars/

Ministry of Finance. (2023). Speech Budget 2023 https://budget.mof.gov.my/en/budget2023/

Moon, S. (2020). Integrating Diffusion of Innovations and Theory of Planned Behavior to Predict Intention to Adopt Electric Vehicles. International Journal of Business and Management. 15. 88. 10.5539/ijbm.v15n11p88.

Mutteti, M. & Nyariki, K. (2022). Influence of Mulltigenerational Teamwork on Employee Performance: Understanding The Millennial. International Research Journal Publishers. Vol. 4, Issue 3, pp 270-278.

Naan. J., and Seong Hun, K. Will Millennials Be a Major Market for Evs?. Available at SSRN: https://ssrn.com/abstract=4141287 or http://dx.doi.org/10.2139/ssrn.4141287

National Oceanic and Atmospheric Administration (2021). https://www.noaa.gov/news-release/greenhouse-gases-continued-to-increase-rapidly-in

Ouariachi, T., Li, C. Y., & Elving, W. J. (2020). Gamification approaches for education and engagement on pro-environmental behaviors: Searching for best practices. *Sustainability*, *12*(11), 4565.

Palm, A. (2022). Innovation systems for technology diffusion: An analytical framework and two case studies. Technological Forecasting and Social Change. Volume 182. https://doi.org/10.1016/j.techfore.2022.121821.

RFID Tires. (2022). How many cars are there in the world today? https://www.rfidtires.com/how-many-cars-world.html

Rogers, E. M. (1962). Diffusion of Innovations; The Free Press: New York, NY, USA, 1962.

Rogers, E.M. (2003). Diffusion of Innovations; Simon and Schuster: New York, NY, USA, 2003.

Sharma, S., & Maréchal, F. (2019). Carbon Dioxide Capture from Internal Combustion Engine Exhaust Using Temperature Swing Adsorption. *Frontiers in Energy Research, 7*.

Sijabat, R. (2023). The Association between Foreign Investment and Gross Domestic Product in Ten ASEAN Countries. *Economies*, *11*(7), 188.

Smith, T. & Nichols, T. (2015). Understanding the Millennial Generation. Journal of Business Diversity Vol. 15(1).

Sriram, K. V., Lidwin Kenneth Michael, L. K., Hungund, S.S., & Fernandes, M., Cameselle C., (Reviewing editor) (2022). Factors influencing adoption of electric vehicles – A case in India, Cogent Engineering, 9:1, DOI: 10.1080/23311916.2022.2085375

Staats, H., Harland, P., & Wilke, H. A. M. (2004). Effecting Durable Change: A Team Approach to Improve Environmental Behavior in the Household. *Environment and Behavior*, *36*(3), 341–367. https://doi.org/10.1177/0013916503260163

The United States Environmental Protection Agency. (2023). Causes of climate change. https://www.epa.gov/climatechange-science/causes-climate-change

Tian H, and Liu X. Pro-Environmental Behavior Research: Theoretical Progress and Future Directions. (2022) Int J Environ Res Public Health. doi: 10.3390/ijerph19116721.

Trencher G, and Edianto A. (2021) Drivers and Barriers to the Adoption of Fuel Cell Passenger Vehicles and Buses in Germany. *Energies*. 2021; 14(4):833. https://doi.org/10.3390/en14040833

United States Environmental Protection Agency. (2023). Electric & Plug-in hybrid electric vehicles. https://www.epa.gov/greenvehicles/explaining-electric-plug-hybrid-electric-vehicles

Vafaei-Zadeh, A., Wong, T.K., Hanifah., H., Teoh, A.P., & Nawaser, K. (2022). Modelling electric vehicle purchase intention among generation Y consumers in Malaysia. Research in Transportation Business & Management. Vol. 43. https://doi.org/10.1016/j.rtbm.2022.100784.

van der Werff, E., Steg, L., & Ruepert, A. (2021). My company is green, so am I: the relationship between perceived environmental responsibility of organisations and government, environmental self-identity, and pro-environmental behaviours. Energy Efficiency, 14(5), [50]. https://doi.org/10.1007/s12053-021-09958-9.

Verma, M., & Verma, A., & Khan, M. (2020). Factors Influencing the Adoption of Electric Vehicles in Bengaluru. Transportation in Developing Economies. 6. 17. 10.1007/s40890-020-0100-x.

Veza et al., 2022 Electric Vehicles in Malaysia and Indonesia: Opportunities and Challenges

Wang, L., Zhang, Qi., Wong, P.P.W. Purchase Intention for Green Cars Among Chinese Millennials: Merging the Value–Attitude–Behavior Theory and Theory of Planned Behavior. (2022). Front. Psychol. Sec. Environmental Psychology Volume 13. https://doi.org/10.3389/fpsyg.2022.786292

Xia, Z., Wu, D., & Zhang, L. (2022). Economic, Functional, and Social Factors Influencing Electric Vehicles' Adoption: An Empirical Study Based on the Diffusion of Innovation Theory. Sustainability, 14(10), 6283. MDPI AG. Retrieved from http://dx.doi.org/10.3390/su14106283.

Zhuge, C., Dong, C., Wei, B., & Shao, C. (2021). Exploring the role of technology innovations in the diffusion of electric vehicle with an agent-based spatial integrated model, Resources, Conservation and Recycling; 174. https://doi.org/10.1016/j.resconrec.2021.105806.