International Journal of Innovative Research and Scientific Studies, 6(4) 2023, pages: 888-902

IJIRSS International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

Unlocking the market potential of electric vehicles in the Philippines: A statistical and neural network approach to customer willingness to purchase electric vehicles

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Abstract

The research aims to identify the key drivers and barriers to EV adoption, inform policymakers and guide future research in the Philippines. The study used a descriptive survey method with 150 Metro Manila car dealership customers as respondents. The research findings indicate that single-family homeowners are willing to invest in EVs if charging infrastructure is available at home. EV safety, dependability, power, performance, design and availability are crucial for increasing EV adoption. Awareness and incentives were identified as hindrances to adoption. The research suggests that technical fixes and policy tools are needed to promote EV adoption and knowledge sharing is necessary to raise customer awareness. A neural network model was created to determine the willingness to purchase an EV. The findings have implications for policymakers, EV manufacturers and stakeholders interested in understanding barriers to EV adoption. The research highlights the importance of safety, reliability and environmental benefits in joint household purchase decisions. The study identifies economic, technological, policy, infrastructure and social barriers to EV adoption and suggests the need for targeted initiatives and information dissemination to overcome these barriers. The report acknowledges limitations and offers avenues for future research to explore additional factors and variables influencing EV adoption.

Keywords: Electric vehicle, EV adoption, EV barriers, EV market attractiveness, Neural network, Willingness to purchase.

DOI: 10.53894/ijirss.v6i4.2088
Funding: This study received no specific financial support.
History: Received: 11 May 2023/**Revised:** 21 July 2023/**Accepted:** 31 August 2023/**Published:** 14 September 2023

Authors' Contributions: Both authors contributed equally to the conception and design of the study. Both authors have read and agreed to the published version of the manuscript.
Competing Interests: The authors declare that they have no competing interests.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Institutional Review Board Statement: The Ethical Committee of the Technological University of the Philippines, Philippines has granted approval for this study on 27 July 2023 (Ref. No. 723 series of 2023).
Publisher: Innovative Research Publishing

1. Introduction

The transport sector has an important role to play in the economic development, population dynamics and urbanization of a country. It enables individuals to reach their destination and to take advantage of resources that meet their individual needs.

Around 40% of the world's CO2 emissions and climate change are caused by the burning of fuel in transport operations which leads to a rise in the costs of transport infrastructure both directly (such as damages) and indirectly (such as reconsidering design concerns) [1]. Decoupling mobility from fossil energy needs is one of the possible solutions to these problems [2, 3].This process greatly benefits from electric mobility [4] and its potential is shown by the rising percentage of electric cars (EVs). It is a growing market worldwide. EVs have significant environmental benefits in comparison to conventional vehicles as they reduce reliance on fossil fuels but they require massive investment in infrastructure charging and their market price is much higher. The use of EVs may help reduce emissions, global climate change and oil dependency. EV market penetration is relatively low despite vigorous marketing strategies being used by various governments.

Many government agencies have designed and executed policies to encourage the production and use of EVs [5]. Increased consumer awareness of EV preferences will make these policies more efficient and successful. Yeh [6] asserts that although e-mobility has experienced significant research and development, consumer adoption has received less focus. The development of new alternative electric vehicles and their long-term success are crucial because they play an important role in the function of EVs in the vehicle technology ensemble.

Despite the numerous advantages of EVs, many barriers to their widespread adoption have been identified. One reason for this slow adoption is consumer perceptions of EVs [7, 8]. Previous research has identified and reported on various barriers, factors and issues related to the diffusion of EVs [9-11]. They did not present a framework for identifying and analyzing these barriers in the case of electric vehicle use based on a review of the literature. Furthermore, the country's economic situation and resource availability prevented all of the barriers from being addressed at the same time, and there was no comprehensive research that emphasised all the impediments within a comprehensive strategy at a specific time [12]. A deeper comprehension of the obstacles to EV use is needed in order to eliminate them and accelerate adaptation. The current study attempts to bridge these gaps.

This paper presents a market assessment with the goal of attracting a larger number of consumers of electric vehicles. It is of great importance to determine which factors are important to consumers when making product and consumer-related purchasing decisions for electric vehicles. Furthermore, the goal of this research is to identify the key drivers and barriers to EV adoption to inform policymakers and guide future research more effectively.

2. Materials and Methods

More information that is accessible to the public is required due to the EV market's development. Consequently, previous research primarily focused on surveys that examined specific contexts of EV purchase by consumers [13, 14] or the consumer characteristics associated with EV buying [15-17]. However, consumers in emerging markets mainly those interested in green innovation products often exhibit an "attitude-action gap" [18]. There is a substantial gap between consumers' "intent to purchase" and actual buying behaviours, despite the fact that they may be inclined to buy environmentally friendly items owing to financial or environmental advantages.

According to the Philippine Electric Vehicle Policy Analysis Report [19], the number of electric vehicles sold globally has experienced rapid growth in recent years. Global sales exceeded one million in 2015, two million in 2016 and three million in 2017 [20, 21] (see Figure 1). In 2018, the global electric vehicle fleet, including light vehicles, reached 5.4 million units with 2.1 million units sold indicating a remarkable increase of 64.150% compared to 2017.

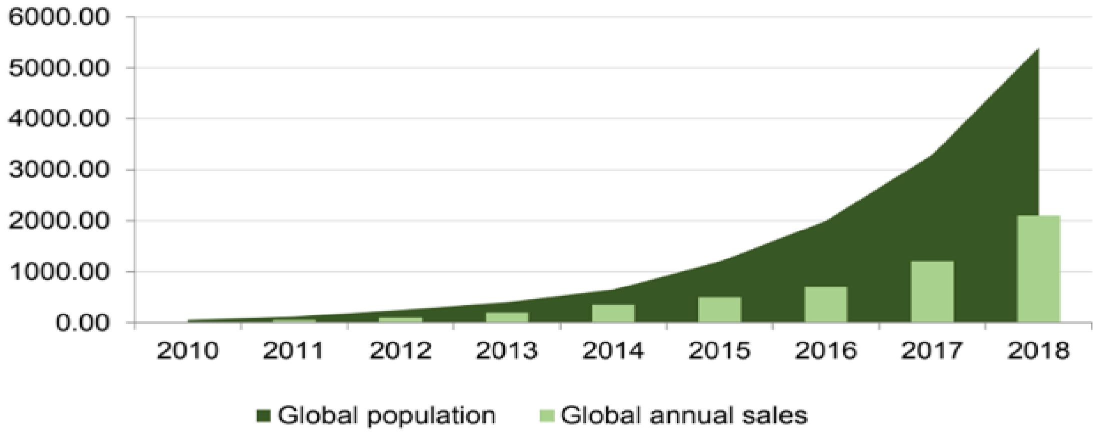


Figure 1.
Global xEV population and sales, 2010-2018.
Source: IEA [20]; EV Volumes [21] and Biona [19].

Electric motorcycles and electric tricycles (E-trikes) dominate the EV market in the Philippines with electric cars and electric utility vehicles (i.e., e-jeepneys) accounting for a minor share. Figure 2 depicts the most recent actual statistics on the national summary of electric vehicles. It should be noted that the registration of light electric vehicles was recently established. As a result, the data represents officially registered units which are assumed to be fewer than the actual EVs currently operating on the route. The coverage of hybrid electric vehicles in registration data is also unclear as is the breakdown of electric car variants (e.g., sports utility vehicles and sedan).

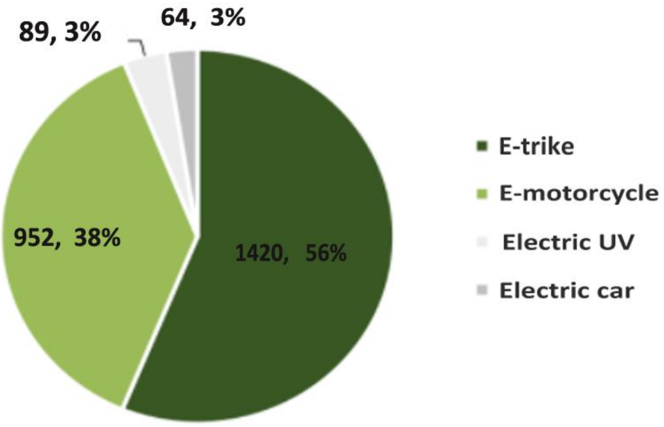


Figure 2.
EV registrations in the Philippines, 2017.
Source: Land Transportation Office (LTO) Biona [19].

3. Drivers and Barriers to EV Adoption

An electric vehicle (EV) is a type of vehicle that uses an electric motor to power its wheels [22]. It is not only considered a modern vehicle but also has the best engine efficiency of all currently used propulsion systems and emits no exhaust emissions. Additionally, Anderson and Anderson [23] argue that EVs are less polluting and more energy-efficient compared to conventional fuel-powered cars. They are also more cost-effective and capable of covering nearly double the distance of a regular fuel car. Studies indicate that the adoption of electric vehicles is primarily influenced by economic, technical, social, infrastructure and policy factors that serve as both drivers and barriers to adoption.

3.1. Economic Attributes

The cost of purchase is a common aspect addressed in the reviewed studies. Many studies adopt a pivotal design to analyze this attribute wherein market prices are customized and centered on the price of a reference vehicle specified by each respondent. The usefulness of electric vehicles (EVs) was found to be negatively and significantly impacted by the purchase price across all studies. Most studies examine this relationship linearly except for a few exceptions. For instance, Ziegler [24] attempted to capture the non-linear effect using price logarithms. Rasouli and Timmermans [25] discovered that when the price of an EV significantly exceeds that of a conventional vehicle (CV), the variability is notably high. According to Achtnicht, et al., some studies indicate that individuals with higher incomes are less sensitive to price than those with lower incomes. At the same time, Jensen, et al. [27] found this effect insignificant.

Vehicle size also plays a role in price sensitivity. Jensen, et al. [27] found that buyers of smaller vehicles exhibit a higher marginal utility of price. Price is a primary consideration for car buyers. Moreover, individuals who prioritize a car's practicality over its design are less influenced by price [28]. The strategic value associated with conventional vehicles (CVs) which are generally cheaper contributes to buyer reluctance to adopt EVs [29]. This relative advantage of lower purchase prices for internal combustion vehicles is recognized as a significant hindrance to EV adoption [30].

Other economic indicators such as battery replacement costs, fuel expenses and credit availability can also impact the distribution of EVs. Many countries now offer various financial incentives to foster a competitive market for EVs and experience has shown that such incentives can partially address economic barriers.

3.1.1. Purchase Price Increase

Consumers are concerned about the higher cost of purchasing EVs. EVs have a higher market price than CVs due to higher manufacturing costs [30]. Subsidizing the purchase of electric vehicles has become a significant option in several countries to market the product. Plug-in Hybrid Electric Vehicles (PHEV) are even more expensive due to the complexity of their dual operations [31].

3.1.2. Battery Price

The battery life of an EV is limited to eight to ten years [13] and the cost of replacement is borne by the consumer. This is a significant barrier to EV adoption. Prior studies have also shown that the cost of the battery accounts for a sizable portion of the total cost of an EV purchase [32].

3.2. Technical Barriers

Vehicle industry technological advancements can have a substantial impact on reducing emissions and vehicle fuel efficiency [33]. EV adoption is hampered by a lack of interoperability, limited supply, a lack of model options and performance or technical concerns [8]. EVs are still in their early stages when compared to conventional vehicles (CVs) and their quality can be undermined by financial constraints during the production process.

3.2.1. Limited Range (One-Time Travel Distance at Full Charge)

EV batteries must be charged for the vehicle to operate and their storage capacities define how far the vehicle could travel on a single charge. Range anxiety is one of the most common user concerns with EVs [27, 34]. Customers who do not frequently travel long distances are more likely to be interested in EVs [35]. As a result, a limited range can be considered a significant technological barrier.

3.2.2. Reliability and Performance

Prospective consumers are usually concerned about EVs' technological performance since they are less innovative than CVs which affects their willingness to use EVs[35]. User perceptions of battery electric vehicles (BEVs) are known to be affected by poor performance [36] whereas system stability is a significant barrier to increased EV deployment [37]. As a result, a lack of data on reliability and efficiency is another technological impediment. Electric vehicles (EVs) are propelled by charged batteries. However, the standard EV battery warranty that has recently been developed will last between eight and ten years. After this time span of battery life, the user is responsible for battery replacement. The batteries are also prone to overcharging which is an issue for EV owners [13]. Battery life is limited necessitating recurrent replacement parts which is a substantial challenge for EV owners [38, 39].

3.2.3. Fewer Electric Vehicle Models

The limited variety of design models influences EV adoption. A larger selection of automobile models can attract a larger consumer base [40]. Thus, the limited availability of EV models displays another challenging problem that restricts users' options [35]. EV research, development and production are the responsibility of the EV manufacturing industry. However, the production of different EV models is typically limited [37].

3.2.4. Branding and Variety

Valeri and Danielis [41] included the car model in the label of the choice experiment. However, the effect was not separated by fuel type. Customers would prefer brands from selected countries [42]. According to Hoen and Koetse [43], more EV models on the market increase the likelihood of buying an EV. It could be interpreted as a measure of the EV market's maturity, influencing customers' perspectives of uncertainty because there are currently only a few other brands offering EVs. This could potentially reduce EV sales and some prospective EV purchasers may dislike the specific brands or favor more viable alternatives.

3.2.5. Recharging Time

Charging time is one of the important factors. The significance of charging time was consistently highlighted across these studies with the exception of the research conducted by Bockarjova, et al. [44]. However, none of the study findings differentiated between slow and fast charging methods. The duration of charging is influenced by the power of the charging station and the capacity of the vehicle's battery. At home or work, EVs undergo slow charging, requiring 6-8 hours for a full charge. On the other hand, fast chargers can replenish the battery up to 80% within 15-30 minutes making them suitable for long journeys. It is important to note that the definition of "charging time" varies significantly depending on the specific circumstances and charging infrastructure available.

3.2.6. Performance

Engine power, acceleration time and top speed are commonly used indicators of performance and consumers generally prefer better performance. However, the significance of acceleration time can vary due to diverse preferences within the population. According to Potoglou and Kanaroglou, males tend to prioritize faster acceleration; females may have a preference for slower acceleration [45]. Furthermore, Potoglou and Kanaroglou [45] observed that shorter acceleration times are of greater importance to individuals who are single. Hackbarth and Madlener [46] also found that environmentally conscious individuals experience greater disutility from the same level of emissions.

3.3. Infrastructure Barriers

Infrastructure attributes play a crucial role in addressing the availability of charging infrastructure. Different researchers have adopted various approaches including assessing the density of charging stations compared to gas stations considering the proximity of the nearest charging station to one's home or examining the presence of charging facilities in different locations such as homes, workplaces and shopping centers. In most studies, the availability of charging infrastructure has shown a significant positive impact. Additional charging facilities reduce range anxiety worries and can help consumers save time and money. Achtnicht, et al. [26] identified a non-linear relationship with diminishing marginal utility. Additionally, specific groups may exhibit preferences for charging stations in different locations. For instance, Jensen, et al. [27] observed that long-distance travelers place a higher value on chargers at work sites than others and favor a greater density of charging stations.

EV owners can depend on home charging if their regular distance is within the range of the EV which is true for many people [47]. According to Bunce, et al. [48], after a testing period, customers tend to prefer recharging at home to refueling at gas stations because of the convenience [48]. In contrast, using an EV on a regular schedule is nearly impossible if there is no charging station at home or work as EVs rely primarily on slow charging. There are only a few charging stations. Many charging stations are required for the spread of EVs. The unavailability of charging stations has been recognized as a barrier to consumer adoption of electric vehicles [32, 49]. Since the number of EV users is still low and has potential, EV users are apprehensive about investing in E-vehicles. The government and industry are reticent to make investments in charging stations.

3.4. Social Barriers

A social factor particularly consumer understanding of EV attributes has been deemed to be a significant influencing variable in users' decision to buy EVs rather than CVs. In this regard, the communication of relevant information is critical [50]. According to Egbue and Long [32], social barriers to adoption may be as important as technical factors. Consumer knowledge, experience, environmental concerns and perceived EV quality all influence a consumer's decision to buy an EV.

3.4.1. Lack of Knowledge on EVs

Market failures can occur when customers have insufficient information about a product. Precise data dissemination is critical to ease the transition to products like electric vehicles [51]. Awareness of the value of an EV among potential users, government subsidies, infrastructure and potential fuel-related savings are all most likely to be factors in EV adoption [52]. This barrier can provide potential users with the necessary general information about EVs. It takes no account of EV users' perceptions of product quality.

3.4.2. Insufficient Environmental Awareness Regarding EVs

According to Sierzchula, et al. [5], one of the prime advantages of using EVs is lower emissions. Potential buyers are frequently unsure about the potential reductions in emissions from EVs and they are sometimes uninformed about the environmental harm caused by greenhouse gas emissions from CV use. Increased environmental awareness about EVs has accelerated the rate of EV adaptation.

3.4.3. Lack of Consumer Understanding of EV Product Quality

Customer perceptions about the quality of EV products may influence their decision to invest in EVs. Consumers who are poorly informed or misinformed are more likely to be reluctant to buy EVs. Actual versus perceived product quality constraints such as those related to performance and reliability, range capacity and other technical issues may cause a perception gap among potential EV users [36]. Therefore, customers need to be educated about the quality of EVs as this social factor is considered necessary for their acceptance. EVs are still a relatively new technology on the market. This barrier is limited to concerns about product quality.

3.5. Policy Attributes

Policy attributes include various policy instruments for encouraging EV adoption. If a specific policy attribute's preference parameter in the final choice model is significant, the policy can be deemed highly effective. Annual tax reduction would seem to be the only significant policy in terms of usage cost reduction policies while free parking and toll reduction would not seem to be significant in any of the studies that investigated their impacts. The effectiveness of various types of tax reductions demonstrates the disparity between people's perceptions of taxes and other expenditures. Indifference is mostly caused by high accessibility to parking spaces as well as cheap or free parking [44].

Granting electric vehicles special privileges, such as limiting the entry of gasoline-powered two-wheelers in urban areas of China has the potential to enhance the acceptance of electric vehicles [53]. Another feasible option could involve permitting electric vehicles to use high-occupancy vehicle or bus lanes [54]. Several local or national government policies aim at subsidizing EV purchases [55]. This resulted in a significant increase in EV market penetration in certain parts of the world such as Norway and the Netherlands. Moreover, both governments and businesses (such as parking lots and automobile manufacturers) continuously promote EVs by providing subsidized (free) charging [56].

4. Method

This descriptive type of research aims to provide a market assessment to attract a greater number of electric vehicle buyers. It is of great interest to find out which factors are important to customers when buying products and making consumer-related purchasing decisions for electric vehicles. Furthermore, the purpose of this research is to determine the key drivers and barriers to EV adoption. The descriptive survey method is used to achieve the objective of the study. Focus groups validated the quantitative survey and provided the researcher with a solid foundation and in-depth knowledge of electric vehicles. Cronbach's alpha was used to assess the scale's reliability by measuring the consistency between questionnaire respondents and dimensions. The Cronbach's alpha for each dimension is greater than 0.7 indicating that all dimensions are highly reliable.

150 potential purchasers of electric vehicles were purposefully and randomly selected to participate in this research study as respondents. Data was collected from prospective vehicle sales clients in Metro Manila and surrounding areas. The respondents were also provided with additional information and elements to think about before being questioned about their

views towards EVs. The researcher used graphic descriptions of EV technologies and charging. In order to provide responders with enough information about EVs, we need to consider their prices, prospective government purchase incentives and environmental effects.

5. Results and Discussion

This section presents, analyzes and interprets the collected data from the study.

The ability to install EV charging equipment at home differs for those who live in single-family houses versus multifamily dwellings as well as for people who rent versus own their homes; therefore, it is crucial to compare home ownership trends. Renters and residents of multifamily housing may face more challenges in installing EV charging equipment because they will most likely need additional approval and coordination with landlords and Homeowners Associations (HOAs). Figures 3(a) and 3(b) demonstrate that 60% of respondents live in single-family houses and 82% of home owners said they would buy an EV if charging was available at home.

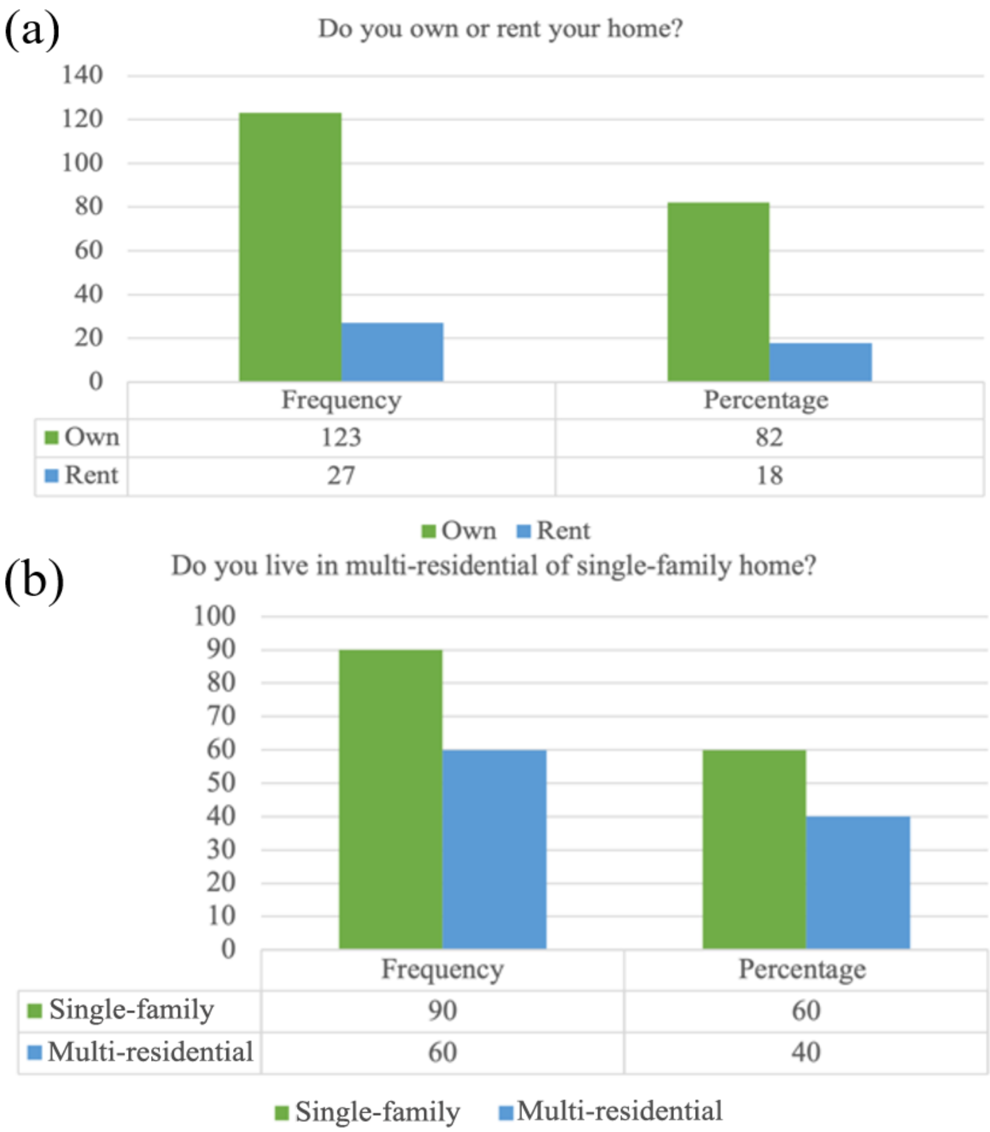


Figure 3.
Home ownership statistics. (a) Owning or renting a house, (b) Living in single-family or multi-residential house.

According to Liao, et al. [57], the categories of individual-related variables most commonly included in preferred studies are socioeconomic and demographic characteristics. It is unclear whether the effects of all important socioeconomic and demographic variables such as gender, age, income, education level and household composition are positive, negative or non-significant at all.

5.1. Vehicle Purchase Decision, Ownership and Preferences

Many households will make the decision to buy an EV together. Almost half of the sample population is married and 48% of those who buy a vehicle do so with their spouse or significant other as shown in Figures 4(a) and 4(b) respectively. Single-family homeowners are more likely to purchase a new car as shown in Figure 5(a) because new car sales will drive the primary market for EVs over the next five years. It is critical to understand the likelihood of each segment purchasing a new vehicle. The majority of respondents are willing to spend one million to two million pesos on a new car referring to Figure 5(b).

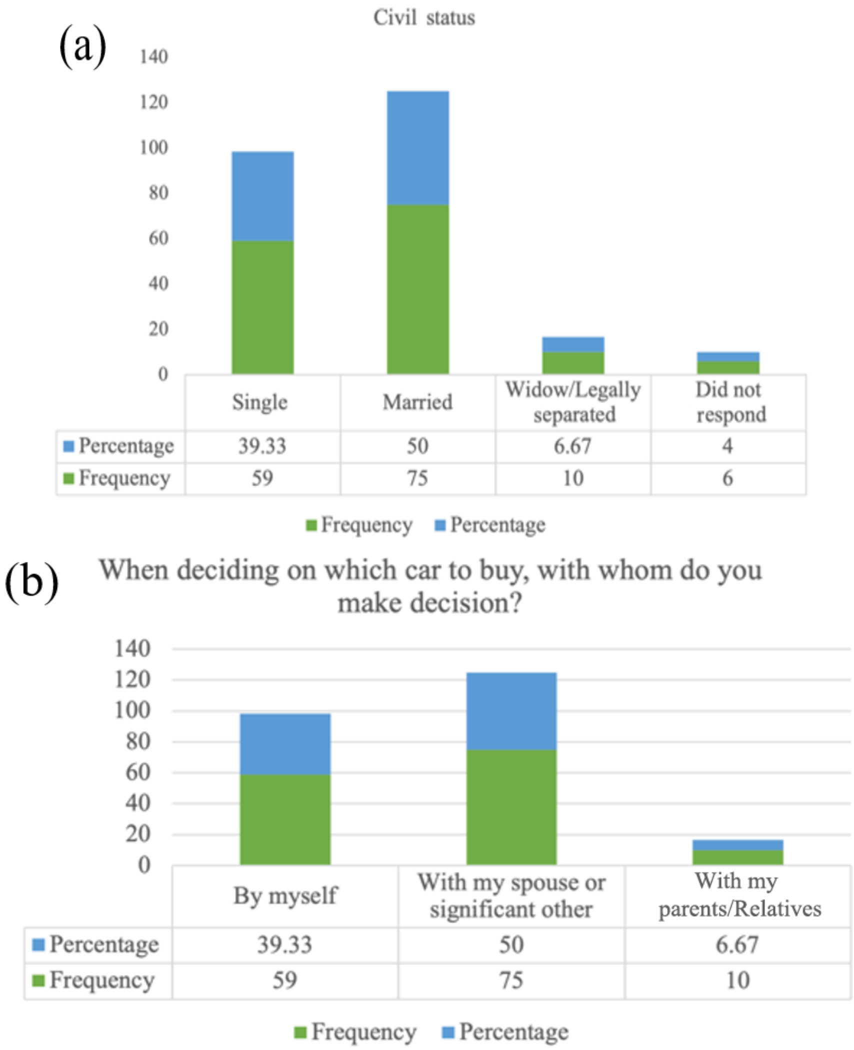
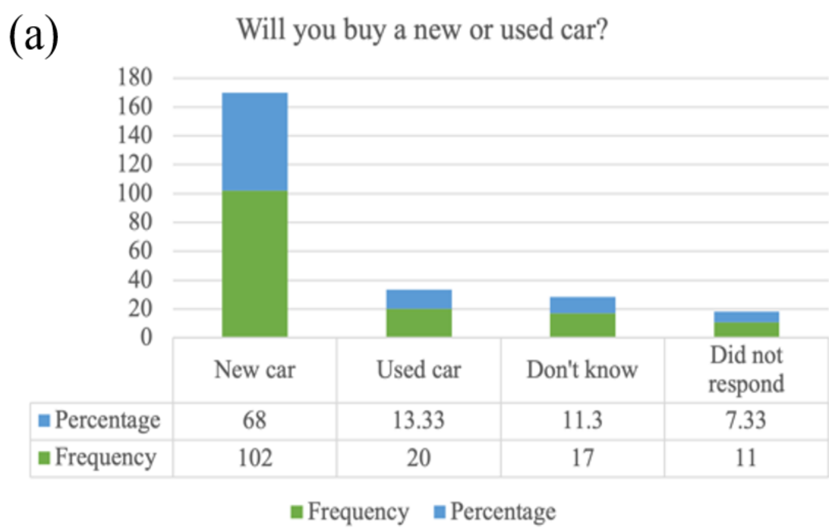


Figure 4.
(a) Marital status and (b) Purchase decision of respondents.



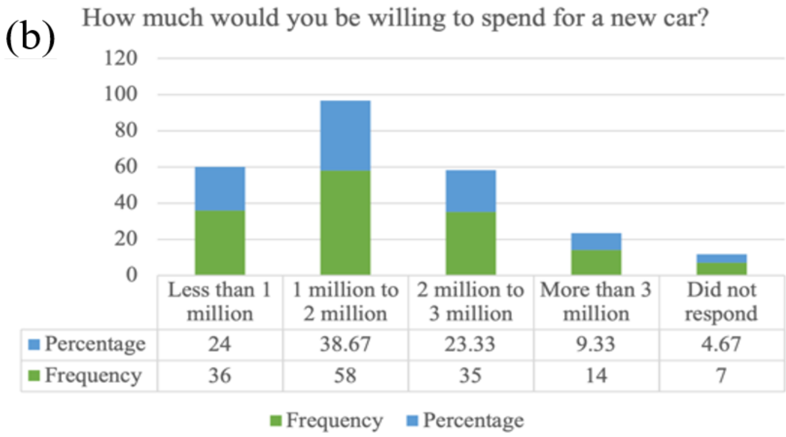


Figure 5.
Purchase of vehicle. (a) Buying a new or used car and (b) Willingness to spend for a new car.

According to Greene [58], the purchase price is the most crucial component in the purchasing decision-making process because it determines the parameters of all other factors mentioned due to the desire of customers to achieve maximum marginal value which is associated with a higher purchase price. The preference of respondents for a type of vehicle explains their values, interests and lifestyle choices. Many respondents prefer gas compact vehicles and sport utility vehicles (SUVs). The respondents are more likely to drive hybrids indicating a preference for environmentally friendly vehicles and fuel efficiency. Others prefer luxury cars, minivans and other vehicles. Respondents who have owned a vehicle for 3 to 5 years would like their car to be replaced (see Figure 6(b)). Hence, in exchange for the dependability of the automobile, this market is not reluctant to pay up front.

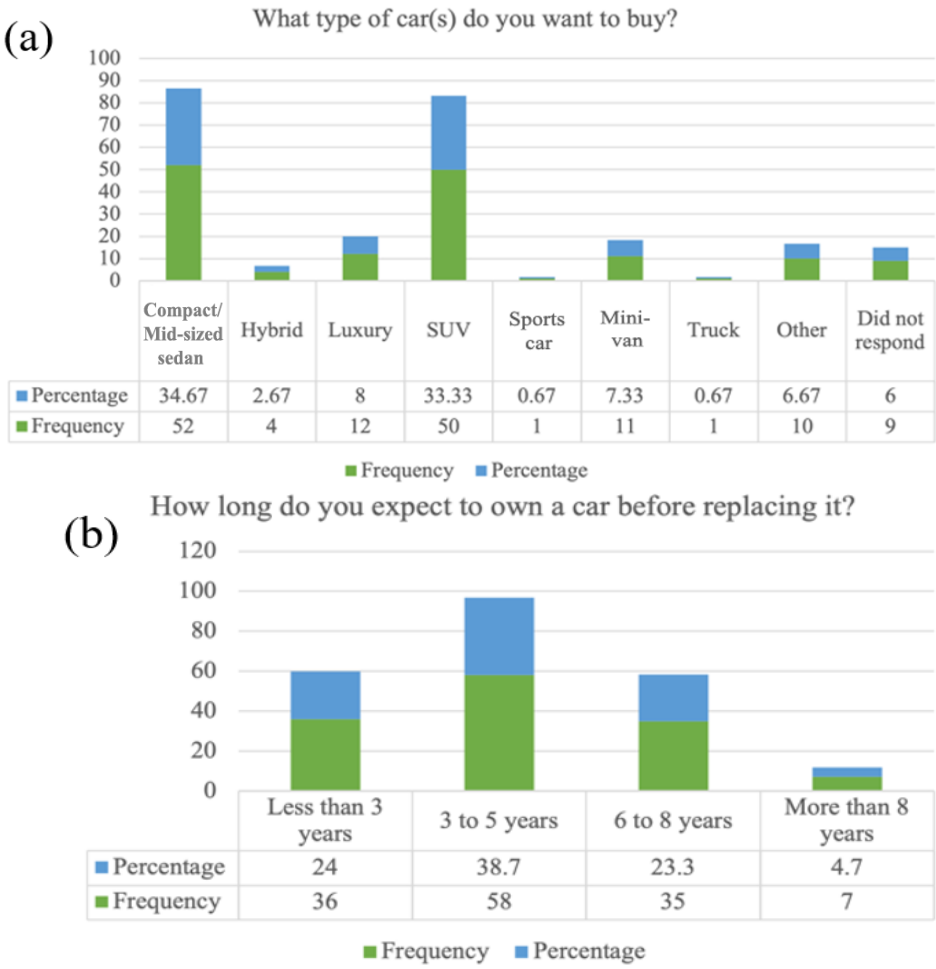


Figure 6.
Purchase of vehicle. (a) Type of car and (b) Time to replace the old car.

Consumer interest in buying a new car will be encouraged by a better understanding of EV power and performance as well as safety and dependability. According to Table 1, most respondents agree that safety and dependability are important considerations when purchasing a vehicle. In comparison to exterior and interior design, more than half of respondents are concerned with power and performance. The study's participants expressed a need for more modern EV designs and model availability. To gain attraction, EVs must compete on more traditional vehicle quality metrics. According to Greene [58], consumers place a high value on the brand and model variety of a vehicle. Other factors that contribute to electric vehicle market penetration include protection of the environment, reduced noise emission levels and the appeal of technological innovation. A willingness to pay extra allows for the inclusion of these advantageous features in the model for private customers. Experience has shown that admitting a willingness to pay a higher price in a questionnaire does not correspond to actual observed purchasing behavior [59]. Nonetheless, it provides preliminary indications of the value placed on new technologies and the approximate extent to which people to pay more for them. The willingness to pay a higher price is common in market diffusion models of electric mobility [60].

Table 1.
Mean and standard deviation of the EV attributes.

Attributes	5	4	3	2	1	Arithmetic weighted mean	Standard deviation	Interpretation
Reliability	84	45	15	5	1	4.37	0.85	Agree
Safety	67	40	33	6	4	4.07	1.03	Agree
Power and performance	79	44	16	7	4	4.25	1.00	Agree
Exterior and interior design	66	51	19	9	5	4.09	1.05	Agree
Availability of EV model	64	37	42	1	6	4.01	1.05	Agree
General weighted mean						4.16	1.00	Agree

5.2. Drivers of EV Adoption

According to Table 2, the majority of the respondents agreed that "EVs were good for the environment". Respondents were also asked which priority they thought was more important: environmental protection or economic growth or if both were equally important. Protecting the environment is more or equally important to 56% of respondents as economic growth. Meanwhile, over 80% of those who responded to the survey thought global warming was a serious problem. Finally, respondents agree on the importance of reducing dependence on foreign oil. Many respondents are impressed by new technologies and are prepared to spend more for a car with modern technology. Increased gas prices will motivate more individuals to purchase EVs. They are the most price- sensitive but they are also concerned with lowering ongoing fuel costs. According to respondents, current gas prices are an important factor to consider when purchasing an EV.

Increasing respondents' perceptions of the value of EVs will require a competitive price structure that is well communicated. Many respondents were concerned about battery recharge costs because of a competitive rate structure that reduces charging costs. Reserved EV parking spaces, subsidized parking fees, free charger installation and number coding exemptions all prove to be effective incentives for attracting additional EV demand. Another way to add value to the consumer's experience is to provide parking spaces exclusively for EV drivers.

Table 2.
Drivers of electric vehicle adoption

Attributes	5	4	3	2	1	AWM	SD	Interpretation
Environment	83	31	24	12	0	4.23	0.85	Agree
Reduce dependence on foreign oil	84	45	15	5	1	4.37	1.01	Agree
Interest in new technology	67	40	33	6	4	4.07	0.87	Agree
Willingness to pay more for technology	79	44	16	7	4	4.25	1.07	Agree
Purchase price	66	51	19	9	5	4.09	0.81	Agree
Cost to recharge battery	64	37	42	1	6	4.01	0.94	Agree
Reserved parking slot for EV	83	31	24	12	0	4.23	1.01	Agree
Subsidized parking fee	72	39	31	3	5	4.13	1.03	Agree
Free charger installation	75	38	35	1	1	4.23	0.88	Agree
Number coding exemption	68	50	26	5	1	4.19	0.89	Agree
General weighted mean						4.16	1.00	Agree

5.3. Potential Barriers to EV Adoption

In general, there is a lack of knowledge about EVs and EV incentives as evidenced in Figure 7. Only 4% of respondents said they were very knowledgeable about EVs and only 0.7% was aware of available EV incentives (see Figure 7(b)). A lack of understanding about EVs and EV subsidies could discourage many potential adopters. Greater education and information about EV incentives would be most beneficial to EV adopters as 36.67% stated that a lack of knowledge was an impediment to purchasing an EV (see Figure 7(a)). Adoption is hampered by a lack of knowledge about EVs and available incentives.

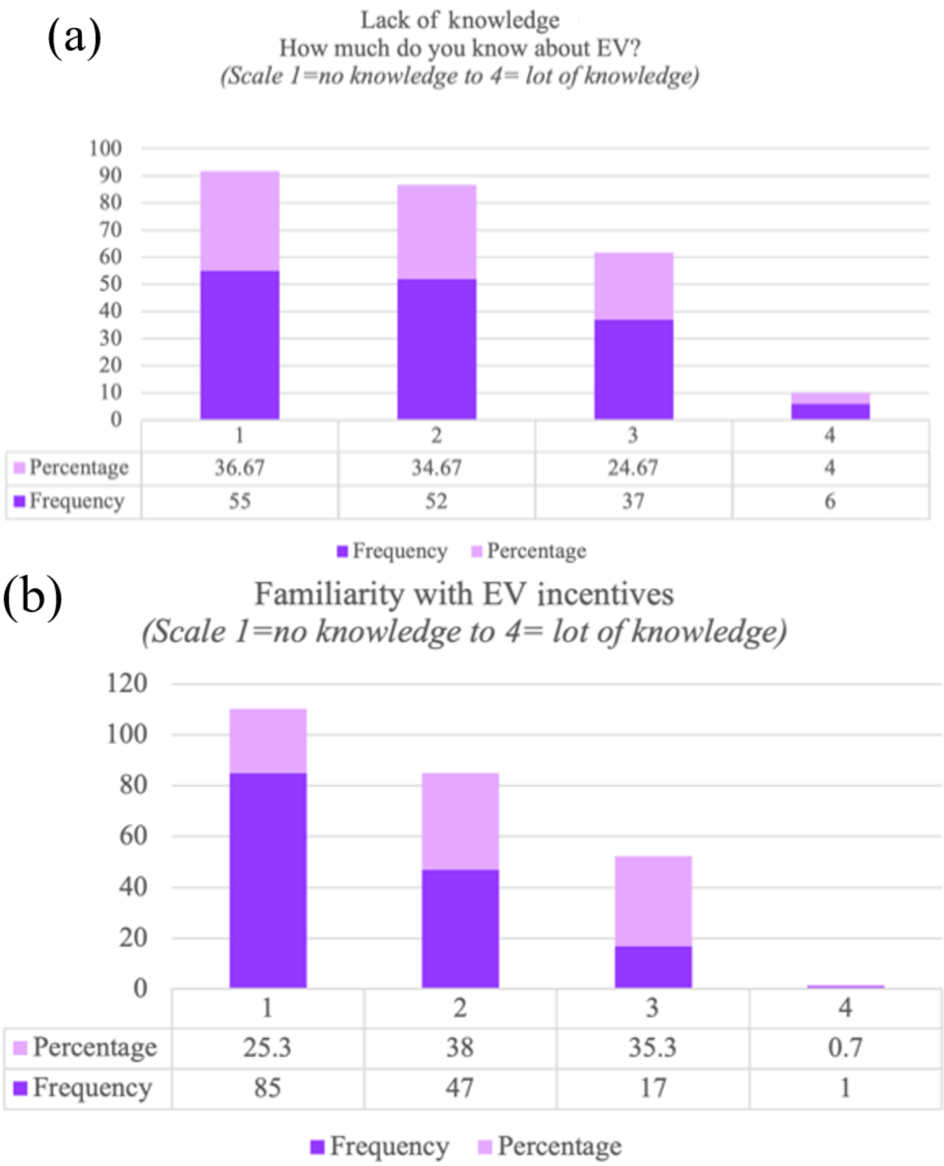


Figure 7.
Knowledge on (a) EV and (b) EV incentive.

5.4. Validity and Reliability Testing

In this study, testing the validity and reliability of measuring instruments is also considered. The usefulness of additional analysis and statistics is only accessible when the credibility of the data is within an acceptable range and the findings of the questionnaires are reasonable and credible.

Cronbach's alpha reliability coefficient is used to assess the reliability of the data. The greater the value, the more reliable the data. A reliability coefficient greater than 0.7 is generally considered acceptable while a coefficient less than 0.7 denotes that the scale item must be modified. As a result, the Cronbach's alpha must be greater than 0.7. Cronbach's alpha for the five constructs is all greater than the recommended criterion of 0.70 indicating that the measures are reliable and internally consistent (see Table 3).

Infrastructures, economical, technological and social hurdles all provide substantial obstacles with social barriers being the least significant. Adhikari, et al. [61] identified poor social acceptance of EVs as the main barrier. Economic barriers to EV adoption should be addressed first and foremost. Previous studies have cited the higher purchase price as a critical factor and it has been proposed that purchase subsidies may give EVs an advantage over CVs [37].

Technical barriers were ranked as the second most important barrier in this study. The availability of charging stations can help alleviate the issue of limited range [62]. The findings also showed that limited battery life and a lack of evidence regarding EV reliability and performance were the second and third technical barriers with weights comparable to the issue of limited range. The findings show that these technical issues must be addressed to promote the use of EVs.

Table 3.
Drivers of electric vehicle adoption.

Construct	Item	Cronbach's alpha	Mean	Rank
Economic	E1	0.836	4.16	1st
	E2	0.836		
	E3	0.837		
	E4	0.838		
	E5	0.836		
	E6	0.837		
Technical	T1	0.841	3.81	2nd
	T2	0.842		
	T3	0.836		
	T4	0.836		
	T5	0.836		
	T6	0.838		
	T7	0.838		
	T8	0.839		
Policy	P1	0.956	3.77	3rd
	P2	0.837		
	P3	0.837		
	P4	0.838		
	P5	0.837		
Infrastructure	I1	0.841	3.51	4th
	I2	0.843		
	I3	0.799		
	I4	0.784		
	I5	0.796		
	I6	0.838		
Social	S1	0.848	3.11	5th
	S2	0.843		
	S3	0.839		
	S4	0.837		
	S5	0.841		
	S6	0.837		

Policy barriers came in third because electric vehicles are new to the country. Various policy instruments adapted to certain government objectives and goals would very probably be needed to encourage the use of EVs. Subsidized parking fees, number coding and free charger installation are examples of government incentives. According to our findings, the most important policy-related factor influencing EV use is the government's long-term strategic planning [61]. Consumers are unlikely to invest in EVs unless the necessary infrastructure is in place because they are a newer technology than CVs. As a result, policymakers and electric vehicle manufacturers should collaborate to develop and maintain the necessary infrastructure [52]. Among the barriers, infrastructure was ranked fourth. Consequently, government involvement and intervention in infrastructure development with the private sector are critical to meeting any EV adoption targets [62].

The experts considered social barriers to be the least important as they did not believe they were as important as the other challenges. The most significant social barrier was consumer understanding of quality followed by a lack of knowledge about EVs and a lack of environmental awareness [61]. As a result of the findings, the average customer is likely to be unaware of the advantages of using EVs as well as their quality and actual performance. Hence, it is critical to disseminate information about EVs widely to increase consumer understanding and awareness.

5.5. Analysis Using Pattern Recognition Neural Network

According to Figure 8, this study used MATLAB to build the neural network (NN) model using a Pattern Recognition Neural Network (PRNN) to determine the willingness to purchase EV. It is possible to use PRNN to recognize patterns and categorize data into predetermined classes. Vectors with all zeros except for a 1 in element i where i is the class they are to represent are ideal target data for PRNNs.

A typical NN has many nested layers including an input layer, a hidden layer(s) and an output layer(s). In addition, this study's input layer included 28 important factors (such as respondent profiles, EV attributes, drivers and barriers) whereas the study's output layer only included an output variable, i.e., willingness to purchase which represents 3 classes, namely, yes (class 1), maybe (class 2) and no (class 3). The activation function of the hidden layer and the output layer were both set to a sigmoid function and the number of nodes in the hidden layer was set to 10.

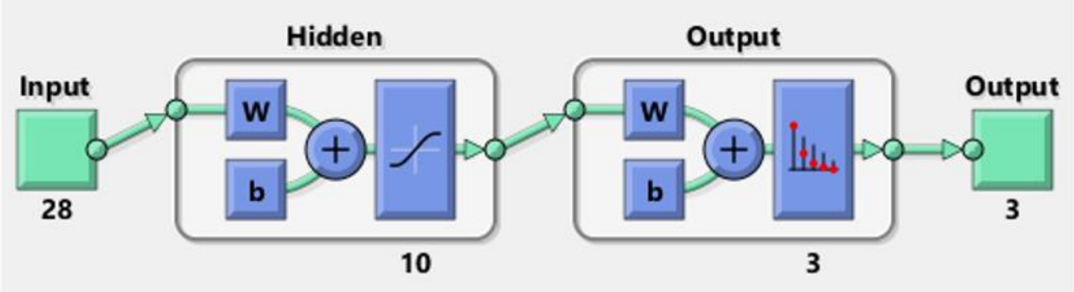


Figure 8.
PRNN model for this study.

70 % of the data were used for training, 15% for testing and 15% for validating the NN to determine its accuracy. According to Figure 9, 21 epochs were used and the best validation performance is 0.026941 at epoch 15. As shown in the generated confusion matrix in Figure 10, the training accuracy is 99.0%, the test accuracy is 96.7%, the validation accuracy is 96.7% and the overall accuracy is 98.0%. An NN model to determine the willingness of an individual to purchase EV was successfully built.

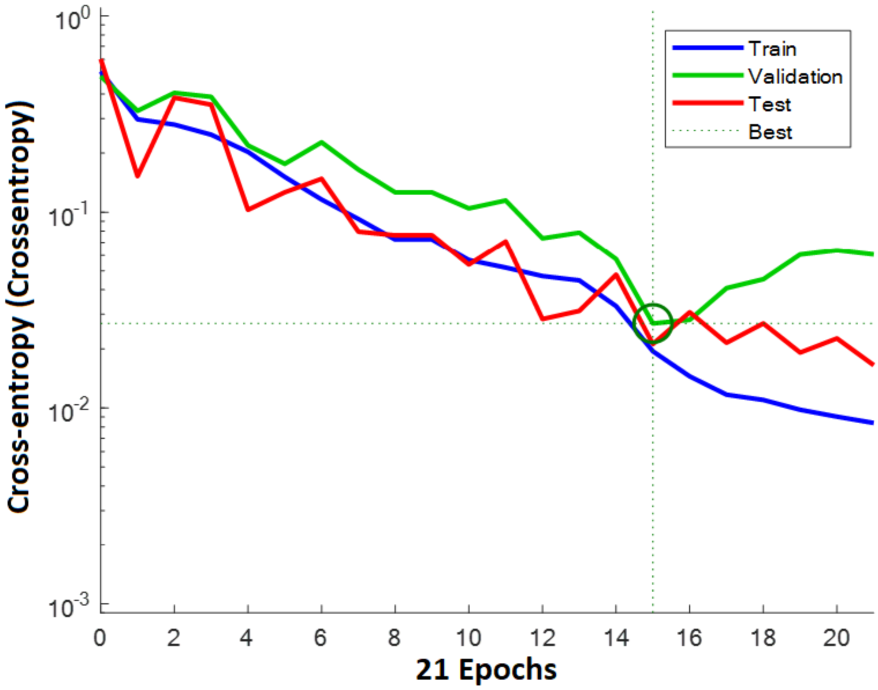
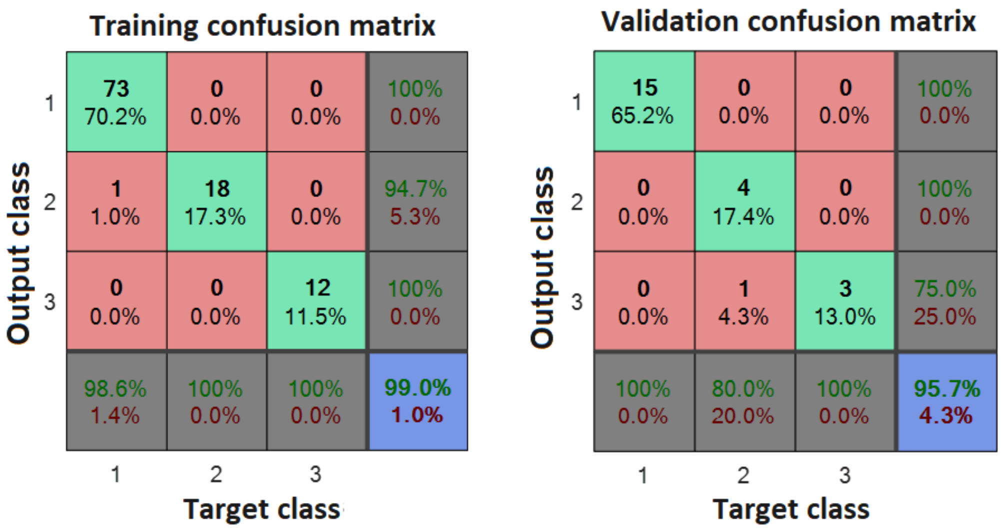


Figure 9.
Neural network training performance for this study. Best performance is 0.0269 at epoch 15.



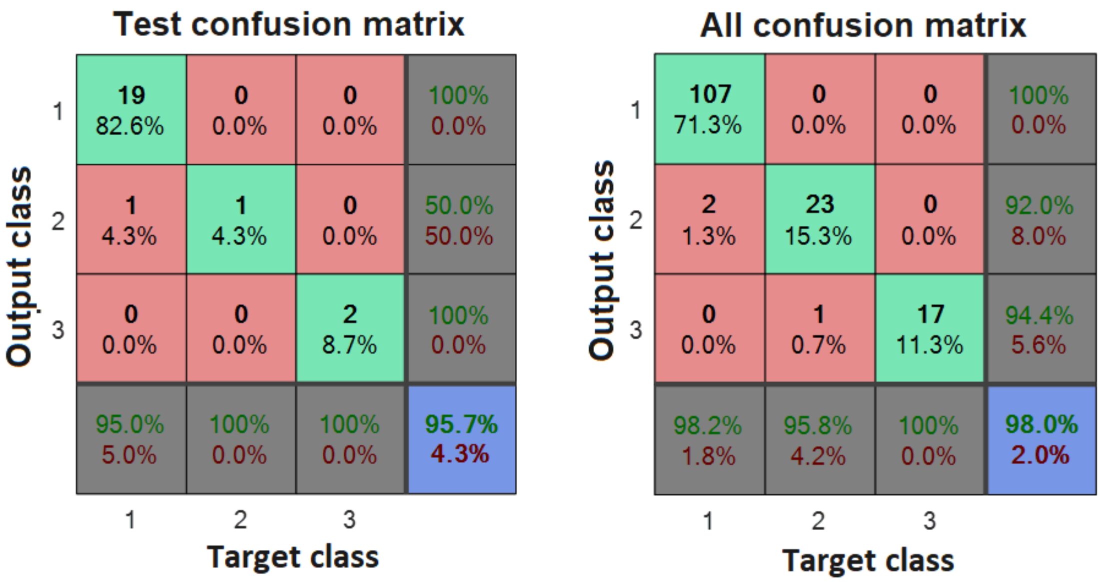


Figure 10.
Confusion matrix to determine willingness to purchase EV

6. Conclusion and Future Work

The findings of the study have significant implications for government decision-makers, EV manufacturers and other interested stakeholders seeking to understand the barriers to EV use and their relative importance. Respondents who live in single-family homes and own their homes said they would buy an EV if charging was available at home. Many respondents will make the decision to buy an EV in collaboration with their spouses or significant others. It is critical to emphasize important factors in a joint household purchase decision such as safety and reliability. They are almost certain and likely to buy a new vehicle and would be willing to pay 1-2 million pesos for one. For EVs to gain attraction, they must compete on more traditional vehicle quality metrics. More awareness of electric vehicle safety and reliability as well as their power and performance, exterior and interior design and EV model availability will help attract more electric vehicle adopters. The majority of respondents are more concerned with the environment and new technology. Furthermore, respondents stated that environmental protection is more important than economic growth. Respondents said they would be more interested in EVs if one of two things happened: the purchase price dropped or the perceived value increased. Increase the perceived value of EVs through public-private education campaigns and initiatives. They can emphasize the environmental benefits, reduced dependence on foreign oil, EV safety and reliability and other benefits. Adoption is hampered by a lack of knowledge about EVs and available incentives.

The findings indicate that significant economic, technical infrastructure, policy and social barriers exist. Economic barriers are the first to be included in the list of EV adoption barriers followed by technological barriers. The findings suggest that these technical issues must be addressed to promote the adoption of EVs. The third most significant barrier group was identified as policy barriers. Various policy instruments may be required to encourage the use of EVs depending on specific government plans and priorities. Government benefits such as subsidized parking rates, number coding and free charger installation are examples of such initiatives. Infrastructure is ranked fourth while social barriers are regarded as the least significant. However, information on EVs has to be extensively communicated in order to raise consumer knowledge and awareness of them.

This report has some limitations that should be considered for future research. The field of market acceptance research for electric vehicles is still in its early stages because of the small and relatively undiversified sample size, the empirical analysis cannot be generalized. Future research studies may include additional factors and variables such as the area of residence on customer purchase requirements, i.e., socio-demographic variables to determine the extent to which this aspect has an impact on electric vehicle adoption.

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