Study of Factors Influencing Consumers to adopt EVs (Electric Vehicles)

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Abstract

Statista market forecast has shown that revenue in the Electric Vehicles market is projected to reach US\$457.60bn in 2023. Revenue is expected to show an annual growth rate (CAGR 2023-2027) of 17.02%, resulting in a projected market volume of US\$858.00bn by 2027. Electric vehicles are gaining popularity and market share. In Q2 2022, EV sales accounted for 5.6% of the total auto market (up from 2.7% in Q2 of 2021). Clean energy and improved performance are driving people to make the switch to electric. Government incentives continue to buttress the future of all things electric. Between today and 2050, the electric vehicle market opportunity is slated to rise to \$53 trillion. Additionally, global electricity demand in that same year is projected to increase by 27% even though KPMG reports in December 2022 that automotive executives are less bullish than they were last year about the adoption of electric vehicles. The survey found 76% are concerned that inflation and high interest rates will adversely affect their business in 2023. For the U.S., the median expectation for EV sales was 35% of the new vehicle market by 2030 — down from 65% a year earlier.

The purpose of this research is to study factors influencing consumer to adopt Electric Vehicles. These factors include seven independent variables: Mileage (ML), Battery (BA), Charge station (CS), Price (PR), Maintenance (MT), At-home charger (HC), Government

policy (GP), Promotion (PM), Brand (BR) and one dependent variable: Consumer Factor (CF). 387 sample were collected using electronic questionnaire through social media. We used Structural Equation Models (SEM) for data analysis. The result shows that since the RMSEA, which is an absolute fit index that assesses how far our hypothesized model is from a perfect model, for this model is .04 (<.05) which strongly indicates a "close fit" and the Goodness of Fit Index (GFI) value is .913 (>.90), the model seems to fit well according to the descriptive measures of fit. More importantly, Battery (BA), Charge station (CS), Price (PR), At-home charger (HC), Government policy (GP), and Brand (BR) are significantly defined as key success factors of electric vehicles (EV) from the consumer's perspective due to their p-values are all less than .05. That means if these significant factors are taken good care of from having branded EV with quality battery at a competitive price offering with more charge stations available both in public and at home, all of which are deeply supported by government policy to encourage people to switch over to EV ASAP, EV will become much more successful and widely adopted from consumer standpoint much faster than what has been happening so far.

Keywords: EV, SEM, Customer Adoption
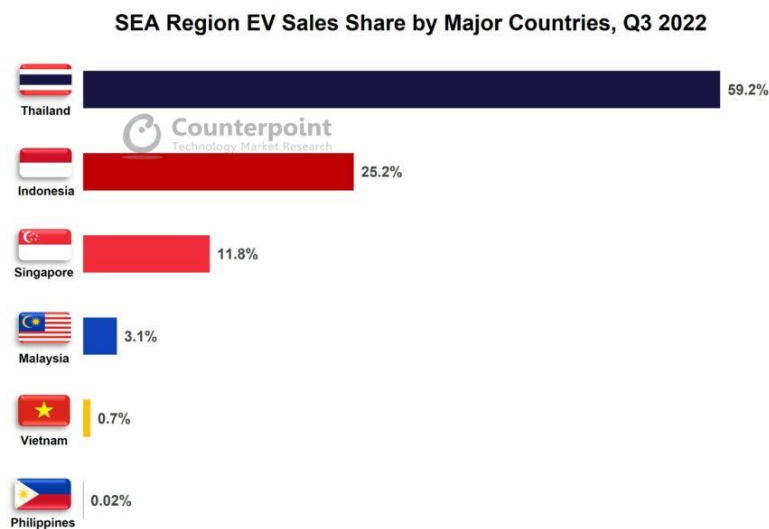
1. Introduction

1.1 Background of the Study

Statista market forecast has shown that revenue in the Electric Vehicles market is projected to reach US$457.60bn in 2023. Revenue is expected to show an annual growth rate (CAGR 2023-2027) of 17.02%, resulting in a projected market volume of US$858.00bn by 2027. Electric vehicles are gaining popularity and market share. In Q2 2022, EV sales accounted for 5.6% of the total auto market (up from 2.7% in Q2 of 2021). Clean energy and improved performance are driving people to make the switch to electric. Government incentives continue to buttress the future of all things electric. Between today and 2050, the electric vehicle market opportunity is slated to rise to $53 trillion. Additionally, global electricity demand in that same year is projected to increase by 27% even though KPMG reports in December 2022 that automotive executives are less bullish than they were last year about the adoption of electric vehicles. The survey found 76% are concerned that inflation and high interest rates will adversely affect their business in 2023. For the U.S., the median expectation for EV sales was 35% of the new vehicle market by 2030 — down from 65% a year earlier.

The adoption of electric vehicles (EVs) is increasing due to various factors. Some of the factors that influence consumers to adopt EVs include Environmental concerns, Government policies and incentives, Cost savings, Technological advancements, and social influence. One of the significant factors that drive EV adoption is environmental concerns. People are becoming more aware of the impact of gasoline-powered vehicles on the environment, including air pollution and greenhouse gas emissions. EVs are considered a cleaner alternative, and consumers who are concerned about the environment are more likely to adopt EVs. Government policies and incentives can play a crucial role in encouraging consumers to adopt EVs. For example, tax credits, rebates, and other financial incentives can make EVs

more affordable for consumers. Governments can also provide infrastructure support, such as building more charging stations, to make it easier for consumers to use EVs. EVs can be more expensive than traditional gasoline-powered vehicles, but they can also provide long-term cost savings. EVs have lower fuel and maintenance costs, and they may also have a longer lifespan. Consumers who are looking for long-term cost savings may be more likely to consider EVs. As EV technology continues to improve, consumers may be more willing to adopt them. For example, advancements in battery technology have led to longer driving ranges, making EVs more practical for everyday use. Additionally, the availability of features like self-driving and smart charging can make EVs more convenient for consumers. Consumer behavior can also be influenced by social factors, such as peer pressure and cultural norms. As more people adopt EVs, it can become a social norm, making it more likely that others will follow suit.

1.2 Electronic Vehicles (EV) of Thailand

Thailand's EV market has grown tremendously this year, making it SEA's undisputed EV leader. The country grabbed almost 60% of EV sales in SEA in Q3 2022. It aims to achieve 100% domestic sales from BEVs by 2035. Subsidies, excise duty waivers and import tax reductions have put Thailand on the right path in its EV journey (Gupta, 2022).

SEA Region EV Sales Share by Major Countries, Q3 2022

Country	Share
Thailand	59.2%
Indonesia	25.2%
Singapore	11.8%
Malaysia	3.1%
Vietnam	0.7%
Philippines	0.02%

Source: Counterpoint Global Passenger Electric Vehicle Model Sales Tracker, Q3 2022

Electric Vehicles, or EVs, are gaining increased interest in Thailand. In the context of transformation in the transportation industry and the push towards decarbonization, EV is a game changer. The movement is being driven by the strong will of all stakeholders – the government, corporates, and consumers – who, as part of their own personal carbon journeys, are increasingly moving towards EVs. As a result, Thailand has developed a favorably evolving policy environment to provide the right push to the EV market and accelerate the development of EV production and related value chain (KPMG, 2021).
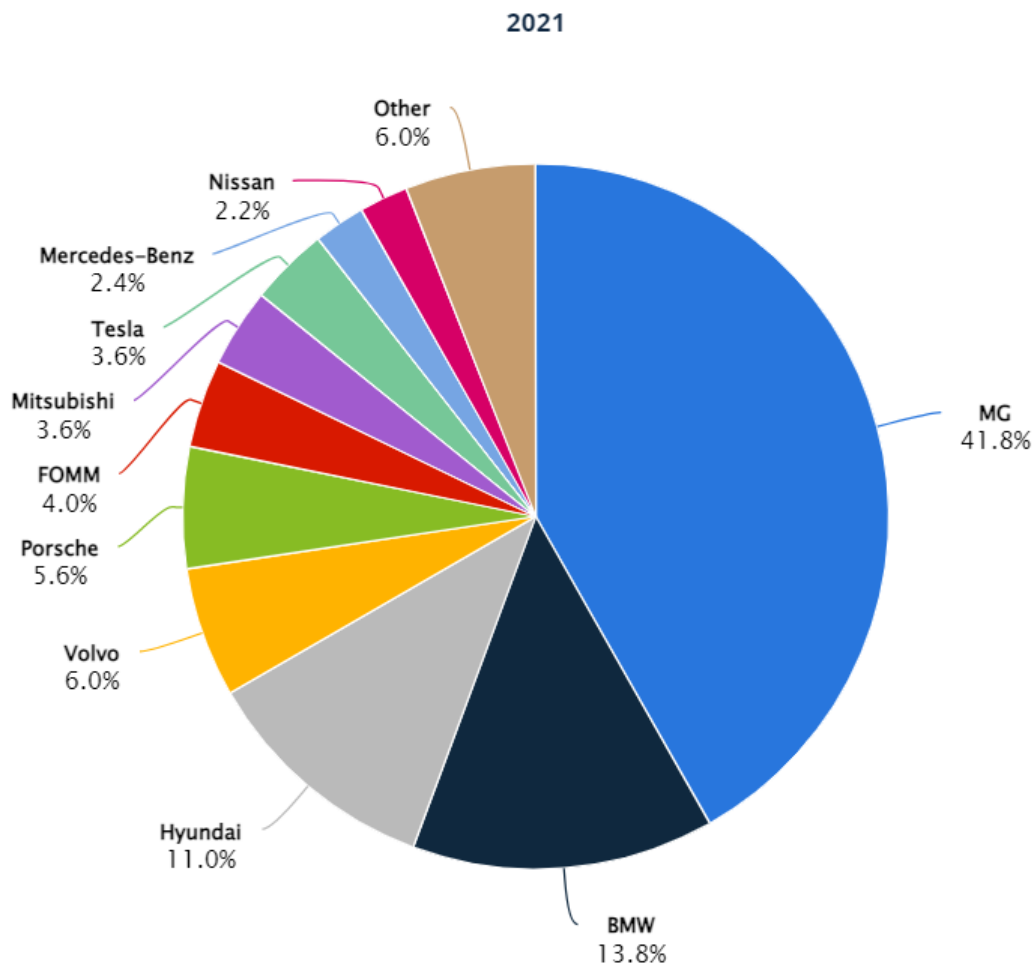
Thailand's EV Production Targets (units)

Thailand's EV Use Targets (units)
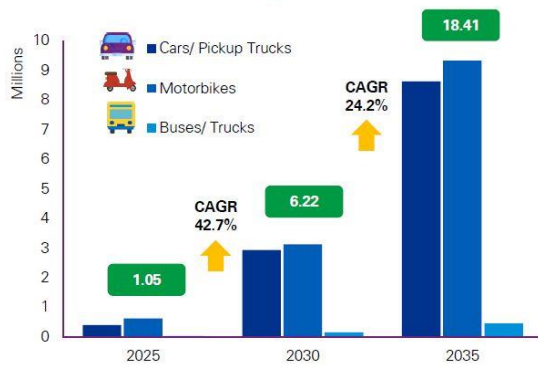
Source: Ministry of Industry, the information released in March 2021
Remark: CAGR = Compound Annual Growth Rate.
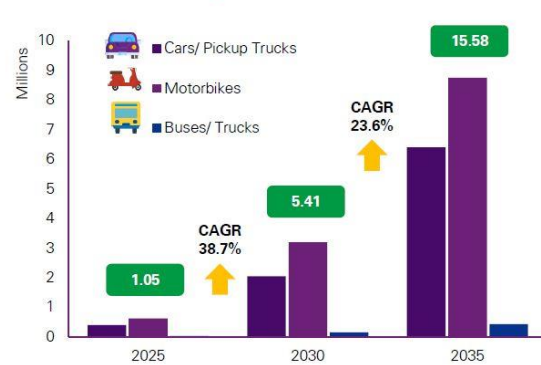
1.2.1 EV Market Share In Thailand

2021

According to the Statista, MG brand is leading the Thailand's EV Market with 41.8%, BMW is in second place with 13.8%, Hyundai is in Third place with 11.0% respectively (Statista, 2022).

1.3 Statement of the Problem

The world climate has been rapidly changing into bad conditions (air pollution, high temperature) in these years because of carbon emissions from factories and vehicles. Vehicles are the most matter for these weather changes. So that the governments, environmentalists, vehicle manufacturers are finding ways to reduce the pollution from the carbon emissions of vehicles, Electronic Vehicles is the answer. However, there are some restrictions and limitations for the consumer to think to use the Electric Vehicles.

Research question:

To sure the background and statement of problems, with the aim of conduct

the research study, the researcher creates the research question as follow:

Main question:

The main research question is "What is the structural relationship among all the variables and how Mileage factor, Battery factor, Charge Station factor, Price factor, Maintenance factor, At-home charger Factor, Government policy factor, Promotion factor, and Brand factor will effect on the consumers to adopt Electric Vehicles". Hence, the researcher is interested in the factors influencing consumers to adopt Electric Vehicles.

1.4 Literature Review

1.4.1 Rational Choice Theory

The Rational choice theory, also called rational action theory or choice theory, is a framework used to comprehend the social model and behavior of economics (Durlauf & Blume, 2008). It assumes that social behavior is a result of individual actors making their own choices, and it aims to identify the factors that influence these choices.

According to this theory, individuals must have complete and transitive preferences among all available options. This means that they can always choose their preferred option out of two or neither, and if they prefer option A to option B and option B to option C, then they prefer option A to option C. Rational agents are expected to consider costs, benefits, available information, and probabilities in their decision-making process, and their behavior should be consistent with their choices (Amadae, 2021).

The study of rational theory encompasses both the abstract principles that govern human rationality and the rules that can explain and predict the outcomes of rational choices. There are two main perspectives on rational choice theory: one sees it as a descriptive method to forecast human behavior and decision-making patterns, while the other argues that it explains the guidelines for human decision-making.

1.4.2 Choice Behavior

In the constantly evolving and dynamic world of business, it's important for companies to understand and anticipate how different types of customers make purchasing decisions for various goods and services in order to meet their needs. Many businesses focus on creating

positive perceptions of their brand to influence customer behavior and gain an edge in the marketplace (Shamsher, 2016). Therefore, it's crucial to identify customer choice behavior for successful service management and marketing. By consistently exceeding both the cognitive and emotional needs of customers, businesses can achieve customer satisfaction and create a sustainable competitive advantage (Shaw & Ivens, 2002). For hospitality firms, it's essential to offer unique products and services that differentiate their brand from competitors in terms of experiential features. To fully grasp customer choice behavior in the hospitality industry, it's necessary to have a detailed understanding of the interplay between a consumer's cognitive decision-making traits and their emotional preferences based on their experiential perspective (Kim & Park, 2017).

1.5 Effect on Consumer Adoption of EV

1.5.1 Brand

Using a brand is a powerful tool for promoting a product. It allows companies to focus their marketing efforts and achieve quick, memorable results that increase product sales by making consumers more familiar with the product and increasing their desire to purchase it. The brand also helps consumers to identify and choose goods. The effectiveness of a brand is demonstrated through product advertising. In fact, consumers usually base their purchasing decisions on the brand's image rather than on product trials. Even if consumers haven't personally used a product, they may still choose to purchase it based on the strength of its brand recognition. The brand's reputation can be built through the company's own advertising efforts or through the approval of other consumers.

Some scholars have studied brand strategy selection and branding related strategies ((Loken & John, 1993), (Keller, 2012)); Josang, Ismail, & Boyd (2007) conducted a credit research on e-commerce services; Dean and others believe that low price brands provide price incentives, can change brand preference and market share, and have the strategic advantage of establishing new brand names (Journal of Marketing Management2012); However, DAE Ryun Chang and Se bum park (2013) found that technological uncertainty will lead to greater brand preference; Nuria villagra1, Belén lópez (2013) believe that corporate social responsibility is increasingly important, especially the brand values and communication, which is directly related to the sustainable development of the brand; Mahabubur Rahman (2014) found that the differentiated brand experience strategy is helpful to establish the enterprise's own brand and strengthen the brand equity; Vanessa quintal and Ian Phau (2014) studied the influence of brand familiarity, external attributes, self-confidence and perceived quality on brand perceived risk; Adam and Kirk Plangger (2015) believe that social media, as a set of online communication channels, helps to promote consumer relations and trust, and is conducive to the development and cultivation of brands; Vasileios Ddavvetas, Adamantios diamantooulos (2016) studied the impact of product categories on consumers' choice of global brands and local brands, and believed that global brands were better than local brands in powerful product categories.

1.5.2 The Concept of Government

The government is responsible for managing the national economy and its operations, particularly the central government. Its role is to regulate the overall social economy to encourage market activity and regulate market operations. This involves the economic concept of achieving a balanced perspective by reporting on the country's market, maintaining consistent and steady growth, and adjusting mainstream views, fiscal expenditure, revenue and expenditure, income and expenditure, and life supply and demand control. By using means and mechanisms to adjust, the government aims to achieve optimal resource allocation and provide a favorable macro environment for economic operations. Ultimately, this leads to a healthy and balanced development process for the market economy.

1.5.3 Concept of EV Charging Station

A study by the International Council on Clean Transportation (ICCT) found that the availability of charging infrastructure is critical to the success of EVs. The study concluded that a "strong correlation exists between public charging infrastructure and the sales of plug-in vehicles (ICCT, 2016).

Another study by the National Renewable Energy Laboratory (NREL) found that the availability of charging infrastructure was a major factor in determining whether consumers would consider purchasing an EV. The study found that "consumers were much more likely to consider purchasing an EV if they had access to charging infrastructure" (NREL, 2016).

A survey conducted by the Electric Power Research Institute (EPRI) found that the availability of charging infrastructure was the second most important factor influencing consumer adoption of EVs, after vehicle cost. The survey found that "nearly 60% of respondents indicated that a lack of charging infrastructure was a barrier to purchasing an EV" (EPRI, 2015). Overall, these studies suggest that the availability of charging infrastructure is a key factor in promoting the adoption of EVs among consumers. As more charging stations are installed, consumers are likely to become more comfortable with the idea of owning an EV and may be more likely to purchase one.

1.5.4 Concept of Battery

A survey conducted by Deloitte in 2021 found that 66% of consumers would consider buying an EV if it had a battery range of at least 300 miles, while only 39% would consider buying an EV with a range of 200 miles or less. This indicates that battery range is a key factor in consumer adoption of EVs (Deloitte, 2021).

Another survey by the International Council on Clean Transportation (ICCT) in 2019 found that the most common reason for consumers not to consider buying an EV was concern about range anxiety, which is the fear of running out of battery power before reaching a charging station. The study found that consumers were more likely to consider buying an EV if they had access to a reliable charging infrastructure and if the vehicle had a longer battery range.

A study by the University of California, Davis in 2019 found that the performance and durability of EV batteries were critical factors in consumer adoption of EVs. The study found

that consumers were more likely to buy an EV if the battery had a long lifespan, fast charging capability, and low degradation over time.

A report by the National Renewable Energy Laboratory (NREL) in 2020 found that the cost of EV batteries has declined significantly in recent years, making EVs more affordable for consumers. The report found that the cost of lithium-ion batteries had decreased by 87% between 2010 and 2019, and projected that the cost would continue to decline in the coming years. This trend could further increase consumer adoption of EVs (Feldman, et al., 2021).

In conclusion, the performance and durability of EV batteries, including battery range, lifespan, fast charging capability, and cost, are critical factors in consumer adoption of EVs. Improvements in these areas could further increase the popularity of EVs among consumers.

1.6 Hypothesis

H1: Mileage (ML) will have the effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H2: Battery (BA) will have the effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H3: Charge station (CS) will have the effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H4: Price (PR) will have the effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H5: Maintenance (MT) will have the effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H6: At-home charger (HC) will have the effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.
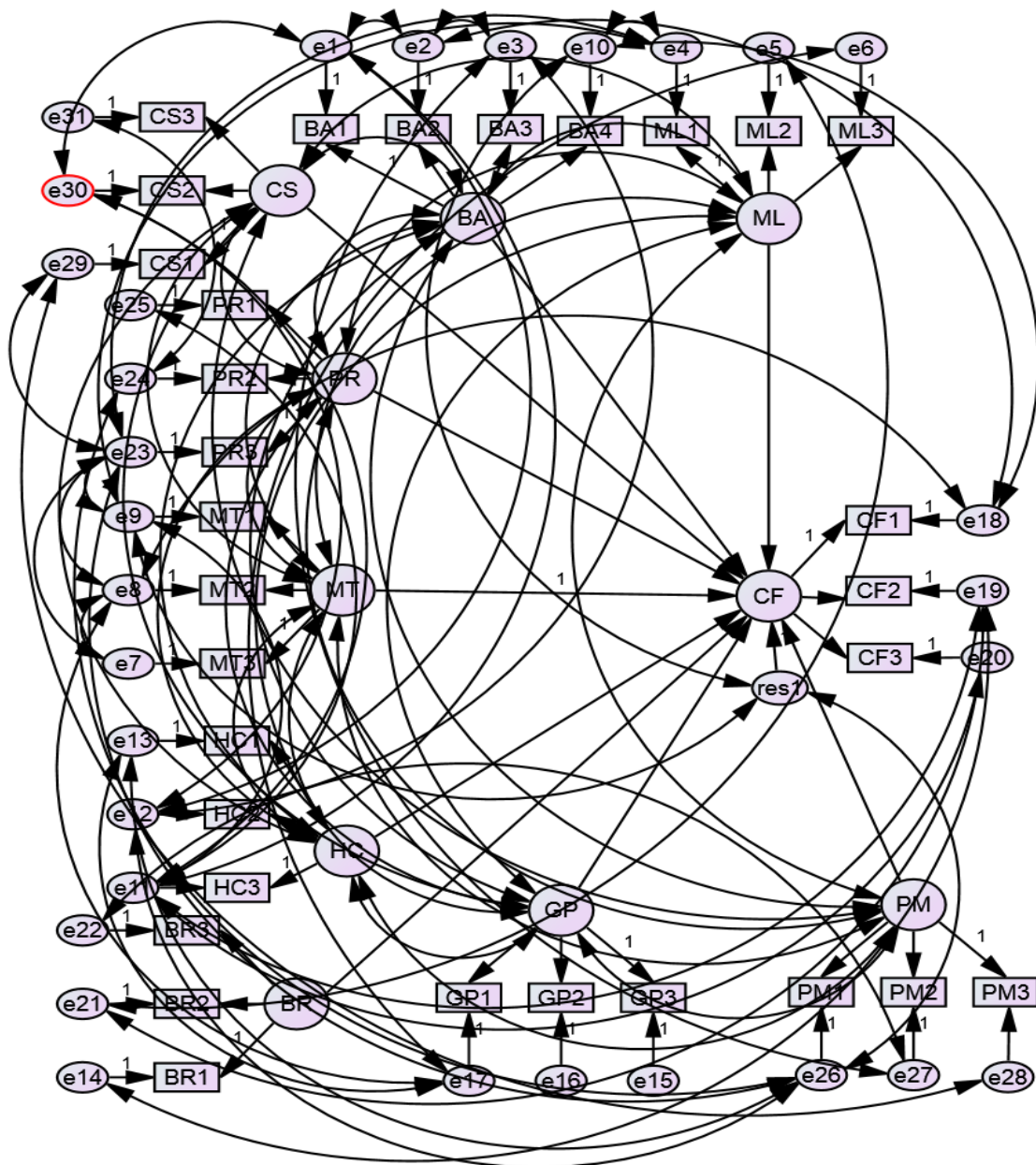
H7: Government policy (GP) will have the effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H8: Promotion (PM) will have the effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H9: Brand (BR) will have the effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

The Hypothesized Model

Independent variables: Mileage (ML), Battery (BA), Charge station (CS), Price (PR), Maintenance (MT), At-home charger (HC), Government policy (GP), Promotion (PM), Brand (BR)

Dependent variable: Consumer factor (CF)

2. Research Methodology

2.1 Research Strategy

In this study, a quantitative research method was employed to achieve the research objectives, which was to investigate the factors that influence consumers' adoption of Electric Vehicles. The researcher utilized questionnaires as a survey tool to collect and analyze data. The questionnaire was constructed based on relevant theories and approved by experts.

Quantitative research methods can be categorized into three types: descriptive, experimental, and casual comparative. This study adopted a casual comparative approach, which focuses on examining how the independent variables affect the dependent variable as part of cause-and-effect relationships, with a particular emphasis on the interaction between independent variables and the dependent variable (Williams, 2007).

The research sample was carefully selected from the population using a combination of convenient and purposive sampling methods. Inferential statistics, descriptive statistics, and Structural Equation Modelling (SEM) for Factor Analysis were the statistical techniques used for data analysis and interpretation.

2.2 Reliability

The value of Cronbach's alpha coefficient is using by the researcher to measure the reliability of the Questionnaire. The researcher was performed 30 peoples as a sample for the pilot test and afterward enter the data into IBM SPSS 24 statistical software. The value of Cronbach's alpha coefficient of the questionnaire must be greater than 0.70 for all parts, therefore the questionnaire is considered as reliable (Taber, 2018).

Criteria of Cronbach's alpha coefficient

Cronbach's alpha coefficient	Reliability Level	Desirability Level
0.80 – 1.00	Very High	Excellent
0.70 – 0.79	High	Good
0.50 – 0.69	Medium	Fair
0.30 – 0.49	Low	Poor
Less than 0.30	Very Low	Unacceptable

The result of Cronbach's Alpha Test from 30 samples: All Factors

Statement of each part	Alpha Coefficient	Accepted/ Not
Mileage	0.925	Accepted
Battery	0.902	Accepted
Charge Station	0.864	Accepted
Price	0.857	Accepted
Maintenance	0.875	Accepted
At-home Charger	0.915	Accepted
Government policy	0.827	Accepted
Promotion	0.893	Accepted
Brand	0.814	Accepted
Consumer	0.806	Accepted
All Factors	0.89	Accepted

2.3 Population and Sample Size

2.3.1 Population

Population can be described as the people who lived in Bangkok, Thailand. The target population including the native and foreigners who live, work and study in Bangkok not

lower than 1 year.

2.3.2 Sample Size

Structural Equation Modeling (SEM) is a powerful and versatile technique that extends the generic linear model. Like other statistical methods, SEM has a set of assumptions that must be met or approximated to ensure accurate results. One of the main challenges in SEM is determining the appropriate sample size, which unfortunately has no general method for selection.

Bentler and Chou (1987) suggest that researchers use at least 5 examples for each parameter estimate in SEM analysis, assuming that the data is well-behaved (e.g., no missing data, normally distributed, etc.). Additionally, they recommend that researchers use 5 cases per parameter estimate instead of every observed variable. Since measured variables usually have at least one path coefficient related to another variable in the analysis, as well as a residual term or variance estimate, it is important to follow the recommendations of Bentler, Chou, and Stevens and have a minimum of 15 cases per measured variable.

Most researchers are advised to use a sample size of at least 200 or 5-10 cases per parameter estimate to ensure reliable results (Kline, 2005). Based on the Kline (2005) recommendations, the researcher is using 10 cases per parameter. The total parameter on this research is 31 parameters. So that the population size is as follow:

$$31 \times 10 = 310$$

The total sample size is 310. However, the researcher is using 400 samples. The 400-sample size is often considered as the most "cost effective" sample size and it gives the statistical accuracy of ±5%.

3. Research Findings

3.1 Correlation of Variables

This section reviews the various goodness-of-fit criteria for testing the model in the following manner. Model evaluation uses root mean square residuals (RMR) as one of the review criteria, and a model is considered good or satisfactory if the RMR value is low. RMR is the root mean square of the residuals. RMR is the sum of the squares of the sample variances and covariances minus the corresponding estimated variances and covariances, and the square root of the mean. RMR is acceptable if it is less than 0.08. The smaller the RMR, the better the fit the smaller the RMR, the higher the goodness of fit. The goodness-of-fit index (GFI) is a measure of goodness-of-fit that ranges from 0 to 1 but can theoretically be a negative number with no significance. By convention, the GFI should be equal to or greater than 0.90 for the model to be considered acceptable. The adjusted goodness-of-fit index (AGFI) is the adjusted GFI value and should be greater than 0.9 or more for the model to be considered acceptable. Parsimonious normed fit index (PGFI) determines whether the research model is too complex, and the same sample information but similar models are better with a larger parsimonious index. Usually PGFI >0.50, the model is considered satisfactory.

Result of SEM

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.072	.913		

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	**.040**	.041	.053	.769
Independence model	.178	.174	.183	.000

Since the RMSEA, which is an absolute fit index that assesses how far our hypothesized model is from a perfect model, for this model is .040 (<.05) which strongly indicates a "close fit" and the Goodness of Fit Index (GFI) value is .913 (>.90), the model seems to fit well according to the descriptive measures of fit.

3.2 Hypothesis Result

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
CF	<---	ML	.087	.084	1.039	.299	
CF	<---	BA	-.296	.083	-3.575	***	
CF	<---	PR	-.266	.067	-3.945	***	
CF	<---	MT	1.000				
CF	<---	HC	.754	.392	1.920	.050	
CF	<---	GP	.212	.052	4.076	***	
CF	<---	PM	.006	.059	.110	.913	
CF	<---	CS	-1.215	.546	-2.227	.026	
CF	<---	BR	.176	.062	2.840	.005	

4. Conclusion and Discussion

4.1 Hypothesis Result

According to the SEM Result,

H1: Mileage (ML) do not have the significant effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H2: Battery (BA) have the significant effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H3: Charge station (CS) have the significant effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H4: Price (PR) have the significant effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H5: Maintenance (MT) do not have the significant effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H6: At-home charger (HC) have the significant effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H7: Government policy (GP) have the significant effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H8: Promotion (PM) do not have the significant effect on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

H9: Brand (BR) have the significant on influencing the Consumer factor (CF) of Electronic Vehicle Adoption.

4.2 Discussion

According to our SEM result showed that Battery (BA), Charge station (CS), Price (PR), At-home charger (HC), Government policy (GP), and Brand (BR) are significantly defined as key success factors of electric vehicles (EV) from the consumer's perspective due to their p-values are all less than .05. That means if these significant factors are taken good care of from having branded EV with quality battery at a competitive price offering with more charge stations available both in public and at home, all of which are deeply supported by government policy to encourage people to switch over to EV ASAP, EV will become much more successful and widely adopted from consumer standpoint much faster than what has been happening so far.

4.3 Recommendations for Future Research

The generalizability of the findings are the limitations of this study. The sample used in this research was targeted on all age groups. So that future research should be choosing the certain age groups. The different viewpoints of confirmatory factor analysis (CFA) can also be applied on the factors which were reviewed in this research to find further inside on the Study of Factors Influencing Consumer to Adopt Electric Vehicles (EV) Adoption. Moreover, the different Structural construct and model can be used based on the factors discussed in the paper.

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