

Factors that Impact Consumers' Expenditure on Electric Vehicles: A Case Study from China

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ABSTRACT

Development of electric vehicles is dynamic all around the world, and so does in China. This is because of the characteristics of electric vehicles, such as powered by green energy, no pollution in functioning, and more convenient in driving. However, the stock of electric vehicles is still relatively small, which is only about one percent of total vehicles in the world. Therefore, it is necessary to continue to stimulate the development of electric vehicles and improve their ownership. The purpose of this paper is to study the factors that will influence consumers' expenditure on electric vehicles in China. This paper implies the model based on Theory of Planned Behavior, Technology Acceptance Model, and Innovation Diffusion Theory, and further develops the model by adding environmental impact as a new factor. The paper utilizes Cronbach alpha score and regression analyze to analyze and validate data. This study concludes that there are eight dimensions that impact consumers' expenditure on electric vehicles in China: Consumer's attitude towards electronic cars, consumer's subjective norm on electronic cars, consumer's self-control ability, consumer's perceived usefulness of electronic cars, consumer's perceived convenience of electronic cars, consumer's adaptability on electronic cars, external information, and perceived environmental effect of electronic cars. The implication of this paper is to help firms and government understand what is required to improve the popularity of electric vehicles in consumers' perspective and increase number of stocks of electric vehicles.

Keywords: *Consumers' Expenditure; Electric Vehicles.*

1. INTRODUCTION

Nowadays, with the development of technologies and economy of the society, people's living quality has a significant improvement. However, the improvements that made by humans are causing environmental issues around the world. The utilization of gasoline powered vehicles provides a more convenient way for people's transportation, but the pollution that those vehicles produce while functioning is one of the largest contributors of causing air population [1]. According to statistics of the International Energy Agency (IEA), the stock of gasoline powered vehicles in the world is about 1 billion, and those vehicles consume approximately 60 million barrels of oil a day [2]. For private vehicles, they consume 36 million barrels of oil a day, and produce 14 million tons of carbon dioxide at the same time [2]. As a result, due to environmental-friendly characteristics, such as no pollution in functioning, electric powered based

vehicles become a great potential option for consumers to unitize and replace traditional gasoline powered vehicles. Currently, the total number of electric vehicles in the world is approximately 7.2 million [3], but in 2010, the number of electric vehicles was merely about 17000. Thus, the growing of market of electric vehicles around the world is rapid. In China, the area studied in this research, the market of electric vehicles develops dynamically. The central government of China has a great positive attitude toward developing electric vehicles. In New energy vehicle industry development plan (2021-2035) published by General Office of the State Council, it indicates that in 2025 the sales volume of new energy vehicles should be about 20% of the total sales volume of new vehicles in China. Moreover, in order to help the development of electric vehicles, government of China give subsidy to firm producing electric vehicles. As a result, the growth of adoption of electric vehicles is promising. According to the data from China Association of Automobile Manufacturers, recently, China produced

approximately 1.24 million electric vehicles. Comparing to the production in 2015, which was 0.38 million electric vehicles, the production now had a significant improve. Moreover, on the demand side, China accounted for 20 percent of global electric vehicles in the past, and this number increased to 50% in 2019.

In past years, some aspects of electric vehicles were investigated by previous researchers, such as the designing of parking lots and charging piles of electric vehicles [4], the effectiveness of incentive policies on sales of electric vehicles [5], impacts of driving range on electric vehicles adoption [6], and trend for development of hybrid and battery electric vehicles [7]. Although many researchers have done investigation on the aspect mentioned, the research about factors influencing consumers' intention to purchase electric vehicles is insufficient. Now, the rate of stock number of electric vehicles increases rapidly, but the uptake of electric vehicles is still at a relatively low level. Thus, a vital content for investigation is to research how to make consumers adopt electric vehicles better and discuss the condition for people to accept electric vehicles. As a result, consumers' purchasing intention plays a significant role in promoting on electric vehicles. The research question this paper is what are the factors that will influence consumers' expenditure on electric vehicles in China, and the hypothesis of the study is that there are eight dimensions, including consumer's attitude towards electronic cars, consumer's subjective norm on electronic cars, consumer's self-control ability, consumer's perceived usefulness of electronic cars, consumer's perceived convenience of electronic cars, consumer's adaptability on electronic cars, external information of electronic cars, and the perceived environmental effect of electronic cars, will have positive impact on consumers' intention for purchasing electric vehicles. The survey in this paper is used for investigating owners of electric vehicles. This paper will review and discuss related literature, provide reasonable amendments according to the previous research results, establishes the theoretical framework of factors influencing consumers' purchase of electric vehicles, and puts forward statistical hypotheses from different dimensions.

2. LITERATURE REVIEW

In this section, this paper will mainly focus on the review of factors influencing the adoption of electric vehicles in different places in the world.

Although electric vehicles only account one percent of total stock of vehicles in the world, the rate of development of electric vehicles is promising. Electric vehicles had a 40 percent year-on-year increase, and also accounted about 2.7 percent of total sales of global vehicles [8]. As a result, literatures about electric vehicles have also increased. Many researchers investigate social

and economic factors that impact adoption of electric vehicles in 2015, researchers Coffman, Bernstein, and Wee did a review about factors influencing adoption of electric vehicles, and also made a forecast of development of electric vehicles. This research was conducted in Hawaii [9]. Researchers divided factors into two part: the first part was internal factors, and second part was external factors. Internal factors included driving range, charging time, purchase price, and battery costs. External factors include policy incentives, fuel prices, consumer characteristics, travel distance, public visibility, availability of charging stations, and vehicle diversity. According to the result, researchers showed that price of oil was significant incentive for consumers to purchase electric vehicles. Environmental issue also has influence on adoption of electric vehicles. In a research conducted by Guo, Zhang, Gu, Zhang, and Fan, by using empirical analysis, they find that PM2.5 concentration has a significant positive correlation with the sales of electric vehicles [10]. Moreover, researchers also predicted that by the year of 2040, there will be 140000 electric cars on the road in Hawaii, which will account eight percent of vehicles in the road. Moreover, in the research done by Xue, Zhou, Wu, Wu, Xu in 2020, the researchers collected data on market share and promotion policies from 20 different countries in a time of 5 years, and they applied the Random Effects Model Analysis to conduct the research about the incentive factors that may affect the sales of EVs [11]. The finding of this paper was that the tax reduction policies and charger density are having a positive relationship between sales of electric vehicles [11]. The model in this research was effective. However, the data and results in the paper were mainly based on national levels, which means that the data might be differentiate in different places.

Different from above, elements affecting consumers' purchasing intention of electric vehicles is also an aspect of investigating the adoption of electric vehicles. In an investigation conducted by Tu and Yang, researchers studied the factors that may influence consumers' intention of purchasing electric vehicles [12]. This research is based on consumers' behaviors (Purchase Intention, Attitude toward Behavior, and Subjective Norm). Mainly, there are three general aspect of investigating. The first one is Theory of Planned Behavior. This theory, originated from the Theory of Reasoned Action in 1980, is used by researchers to predict people's intention to engage in a behavior in a specific period of time when people have the ability for self-control [13]. The important part of this model is behavioral intent, which measures whether individuals are willing or not in participating in a specific action, and it is impacted by subjective assessment of risk and benefits, and attitude toward whether behaviors will create acceptable outcome [13]. Similarly, an individual's intention of behavior will be impacted by social norm and attitude. Moreover, perceived behavioral control also plays a role in

impacting people's intention of behavior, because it measures the difficulties that people experience in a behavior [13]. For example, if individuals have enough recourse and plenty chances in an activity, they will have higher probability to engage in this activity, vice versa. The second aspect is Technology Acceptance Model [14]. This model indicated that perceived ease of use and perceived usefulness will influence the acceptance of users for a system [14]. Moreover, the third one is Innovation Diffusion Theory, and it was created for researchers to predict how users will adopt to new idea and innovation [15]. In this theory, compatibility is regarded as a factor influencing people's intention of adopting new innovations. In conclusion, according to the result from Cronbach's alpha, and SEM, self-control ability (perceived behavioral control) in behavioral intentions and external influence in subjective norm play vital roles in people's intention of purchasing electric vehicles [12]. In this investigation, it will conduct research on factors influencing consumers' intention for purchasing electric vehicles. This paper will not only implement the method mentioned in Tu and Yang's research, but also add environmental-friendly as a factor that may impact consumer' decision of expenditure on vehicles.

3. METHOD

Previous study supports that purchase decision of electric car, as an innovative behavior, is based on seven dimensions of consideration (consumer's attitude towards electronic cars, consumer's subjective norm on electronic cars, consumer's self-control ability, consumer's perceived usefulness of electronic cars,

consumer's perceived convenience of electronic cars, consumer's adaptability on electronic cars, external information of electronic cars) as stated in the literature review [12]. Two year later, Zhou et al conducted a research which indicates the expected social contribution of a certain green product also plays an important role in consumer's purchase decision making [16]. As a result, the main hypothesis that except seven factors that benefit consumer themselves, potential environmental contribution as a result of altruism is an additional factor that influence people's purchase behavior on electronic vehicle. In order to examine effect of the extra factor on purchase decision of electronic cars, this paper conducted a quantitative survey which is similar to previous survey of Tu & Yang. This survey consists of eight dimensions including consumer's attitude towards electronic cars, consumer's subjective norm on electronic cars, consumer's self-control ability, consumer's perceived usefulness of electronic cars, consumer's perceived convenience of electronic cars, consumer's adaptability on electronic cars, external information of electronic cars, and the perceived environmental effect of electronic cars. Among these questions, perceived environmental effect was utilized as an option instead of potential social contribution because some individuals would have vague definition of social contribution. Individuals aging from 19-50 were selected to conduct the survey since they are the major potential buyers of electronic vehicles. In this research, an online survey with 5 points scale with choice from 1 strongly disagree to 5 strongly agree were assigned to the participants of the study. Finally, Cronbach's alpha was used to test the overall usefulness of this survey, and linear regression model was created to find analyze the result of this survey.

Table 1. Cronbach's alpha on different dimension

Dimension	Question	Cronbach's alpha
consumer's attitude towards electronic cars	1	0.864
	2	0.871
	3	0.843
	4	0.866
	5	0.847
consumer's subjective norm on electronic cars	1	0.845
	2	0.896
	3	0.871
	4	0.842
	5	0.826
consumer's self-control ability	1	0.921
	2	0.911
	3	0.934
	4	0.896

	5	0.902
consumer's perceived usefulness of electronic cars	1	0.831
	2	0.834
	3	0.851
	4	0.892
	5	0.875
consumer's perceived convenience of electronic cars	1	0.861
	2	0.852
	3	0.856
	4	0.813
	5	0.845
consumer's adaptability on electronic cars	1	0.815
	2	0.841
	3	0.833
	4	0.846
	5	0.896
external information of electronic cars	1	0.886
	2	0.884
	3	0.853
	4	0.835
	5	0.815
perceived environmental effect of electronic cars	1	0.855
	2	0.826
	3	0.846
	4	0.811
	5	0.827

4. RESULT

The online survey was created in 2021/4/10 and collected in 2021/4/13. To make this research more accurate, a question with requirement of entering 4 was added to the research, and all those did not enter four were removed. At the same time, samples that have four as their answer for all the questions were excluded. At last, 80 samples of different individuals' responses were recorded and analyzed.

Internal consistency is one of the major concerns for the reliability of the survey. In this study, Cronbach alpha score was used to determine the consistency of between the research result and required factors. As shown in the Table 1, each of the questions has Cronbach's alpha that is higher than 0.7, which indicates that the general Cronbach's alpha must be higher than 0.7. According to

the general decision rule, if one set of questions has Cronbach alpha that is higher than 0.7, this set of questions is acceptable. As all eight questions have above 0.7 Cronbach alpha, this survey's internal consistency is proven to be existing.

Since this survey is an online study, the self-selection becomes one of major concern, in the questionnaire, some social data are collected to check the self-selection effect. According to Table 2, female respondents' percentage is abnormally higher than male, using 50 percent as the normal standard, female's percentage is 2.68 standard deviation away from 0.5 see table 3. In addition, married proportion is also a lot higher than single proportion.

Table 2. Information of people taking survey

Sample	Category	Number	Percentage
Gender	Male	28	0.35
	female	52	0.65
Marital status	single	3	0.0375
	married	77	0.9625
education level	never go to school	3	0.0375
	primary school	12	0.15
	middle school	17	0.2125
	high school	42	0.525
	College	6	0.075

One sample proportion summary hypothesis test:

p stands for proportion of successes

$$\begin{aligned}
 H_0: p &= 0.5 &&) 1 (\\
 H_A: p &\neq 0.5 &&) 2 (
 \end{aligned}$$

Table 3. Hypothesis test results

Proportion	Count	Total	Sample Prop.	Std. Err.	Z-Stat	P-value
<i>p</i>	52	80	0.65	0.055901699	2.6832816	0.0073

Table 4. Impact of all coefficients on purchase decision of electronic vehicles

	Co-efficient	Standard error		t-ratio	p-value
Intercept	-56721	11040.586		-5.1375	<0.0001
consumer's attitude towards electronic cars	45031	11464.432	79	3.927888	0.0002
consumer's subjective norm on electronic cars	13756	6308.1714	79	2.180664	0.0322
consumer's self-control ability	6002	3076.0469	79	1.951206	0.0546
consumer's perceived usefulness of electronic cars	37569	10693.101	79	3.513387	0.0007
consumer's perceived convenience of electronic cars	21562	7294.1655	79	2.956061	0.0041
consumer's adaptability on electronic cars	14752	3970.8095	79	3.715112	0.0004
external information of electronic cars	23541	6113.1862	79	3.850856	0.0002
perceived environmental effect of electronic cars	27975	8558.9974	79	3.26849	0.0016
					Adjusted r-squared=0.934

For simple linear regression model in this study, *t* value gives how likely one coefficient is significant. In this study, any coefficient that has a *p*-value less than 0.05 is going to be rejected. Table 4 indicates that except self-control ability, all coefficient included has impact on purchase decision of electronic vehicles and *p*-values less than 0.05. That is to say, all estimated coefficient is significant except for self-control ability. Besides, *r*-squared is also an important tool for examining the reliability of the regression model. In this study, the *r*-squared calculated was 0.934, which means that the model account for 93.4% of the total variation. For social study, a *r*-squared which is more than 0.3 is generally acceptable. In this study, the calculated *r*-squared is far beyond current normal standard. So. This model is reliable as a whole. The coefficient of each factor in the regression model are used to determine which factor has relative high contribution for spending of consumers on electronic vehicles, except self-control ability which was proven to be not significant, all coefficients have positive impact on money spent on electronic vehicles for consumers. For attitudes of consumers toward electronic cars, it has the highest co-efficient of 45031. This indicates that for every one-point increase in consumer's attitude toward electronic vehicles, the consumer's spending toward electronic vehicles increase by 45031 on average. Namely, among eight factors, consumer's attitude toward electronic vehicles has the greatest impact on spending of the buyers on electronic vehicles. For perceived environmental effect of electronic cars, the main target of our, it has a coefficient of 27975. Particularity, holding everything else constant, for one unit increase in perceived environmental effect of electronic cars points, money spent on electronic vehicles by consumers will increase 27975 by average.

5. DISCUSSION

The research was conducted in China and two years after study of Tu & Yang in 2019 [2]. So, the demographic situation is similar in both of the cases. The result of this research is significant, perceived environmental effect of electronic cars of consumers do play an important role on consumer spending on electronic vehicles. However, unlike the population distribution of survey conducted by Tu & Yang in 2019[12], the female respondents have a percentage much higher than normal basis. This could be a result of the way of assigning the survey. To be more specific, as the survey was spread in an online platform in WeChat, female relatives and friends are more active in answering the survey. Besides, there is nothing unusual in other social economic data. All of the coefficients except self-control ability are proven to be useful, which complies with most of the results of Tu & Yang in 2019 [12]. The low p-value of self-control shows that self-control does not play as much important role as other factors, which is the only contradiction with the study of Tu & Yang. Consequently, the regression analysis validated the hypothesis that except from the seven factors mentioned, potential environmental effect is also a driven force of spending more money on electronic vehicles. Finally, this research was conducted during covid-19 pandemic in 2021. Therefore, unpredictable influence could have in people's mind. The result of the study fails to include the potential effect of covid-19.

6. CONCLUSION

This study mainly examines the effect of perceived environmental effect of electronic vehicles other than seven factors proven in the study of Tu & Yang in 2021. The effect of perceived environmental effect of electronic vehicles is proven to be significant and positively related to the money spent on electronic vehicles, holding seven other factors constant. This indicates that as people, now days, become more than more concerned on the environment, the potential environmental contribution of the electronic vehicles has become an important factor which associates with consumer's spending on electronic cars. As a result, for producer of electronic vehicles, they should promote the eco-friendly effect of their product in the future; for government, they should apply tax benefit on electronic car companies that have done high environmental effort in order to increase the competitiveness of local electronic vehicles industry; for retailer of electronic vehicles they should procure more electronic cars that are claimed to be good for environment. Such action is necessary, because when the qualities of different electronic vehicles reach the bottle neck, consumer's perceived environmental effect will be the factor that makes the product needle. Nonetheless, the research is conducted during the Covid-19 pandemic in 2021 as mentioned. It is hard to conclude that pandemic

has nothing to do with the result of the study. A repeat study could be conducted to further justify the result of the study after Covid-19 is over. Besides, this study was conducted online, and who ever clicked that link was able to answer. The self-selection effect and randomness are, as a result, questionable. A random sample survey could be applied in the future to address this issue. Finally, the effect of five-points scale regression is also a problem of this study. To be more specific, it is not clear that whether the consumer's attitude toward electronic vehicles is properly reflected by the point between strongly disagree and strongly agree. In future study, better measurement is required.

REFERENCES

- [1] Mayer, Helmut. *Atmos. Environ.* **33**, 24-25 (1999)
- [2] Sang, Yew-Ngin, and Hussain Ali Bekhet. *J. Clean. Prod* **92**, 75-83 (2015)
- [3] Meena Bibra Ekta, Connelly Elizabeth, Gerner Marine, Lowans Christopher, Paoli Leonardo, Tattini Jacopo and Teter Jacob. *Global EV Outlook 2021* (2021)
- [4] Bonges III, Henry A., and Anne C. Lusk. *Transp Res Part A Policy Pract* **83**, 63-73 (2016)
- [5] Jenn, Alan, Katalin Springel, and Anand R. Gopal. *Energy Policy* **119**, 349-356 (2018)
- [6] Lim, Michael K., Ho-Yin Mak, and Ying Rong. *MSOM* **17.1**, 101-119 (2015)
- [7] Thomas, C. E. *Int. J. Hydrog. Energy* **34**, 6005-6020 (2009)
- [8] Abergel Thibaut, Bunsen Till, Gerner Marine, Leduc Pierre, Pal Sarbojit, Paoli,Leonardo Raghavan Seshadri, Tattini Jacopo, Teter Jacob, Wachche Sadanand and Widell Per-Anders *Global EV Outlook 2020* (2020)
- [9] Coffman, Makena, Paul Bernstein, and Sherilyn Wee. *EVTC* 1-36 (2015)
- [10] Guo, Jianfeng, et al. *J. Clean. Prod* **249** (2020)
- [11] Xue, Chenlei, et al. *Sustainability* **13.5** (2021)
- [12] Tu, Jui-Che, and Chun Yang. *Sustainability* **11.14** (2019)
- [13] Ajzen, Icek. *Action control*. 11-39 (1985)
- [14] Azjen, Icek. *Understanding Attitudes and Predicting Social Behavior* (1980)
- [15] Rogers, Everett M. *Diffusion of innovations* (2010).
- [16] Zhou, Z., Zheng, F., Lin, J., & Zhou, N. *Corp. Soc. Responsib. Environ. Manag.* **28.2**, 630-639 (2021)