The Influential Factors on the Total Revenue of Autonomous Cars Using Multiple Regression Model

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Abstract—Since the development of new energy and autonomous cars in the domestic market has attracted the attention of a huge number of consumers. This article conducted a quantitative analysis of consumers' intention to purchase such models to analyze the impact on total sales revenues. Through the questionnaire, this research held multi-faced interviews with 150 participants to collect data. The multiple regression model is established to analyze the factors that affect consumers' purchase intention and how they lead to the decrease in total revenue. The collection feedback demonstrates that those factors could be divided into three categories: environmental performance (environmental sustainability), perceived risk, and perceived benefit. This research found that perceived benefits, such as environmental performance and the satisfaction of brand awareness of ACs, positively affect consumers' purchase intention, which is consistent with hypotheses. The online promotion also has a moderately positive effect on consumers' purchase intention. Besides, consumers' characteristics affect their purchase behavior as well. People with higher education are less inclined to buy an autonomous car. As for limitation, firstly, it is about sample size. The sample size is not big enough, and it cannot comprehensively forecast the intention. The questionnaires' geographical distribution is uneven. These have a big influence on this study, and this research can not reflect all the customers' intentions in different provinces of China.

Keywords-component; Autonomous cars; purchase intention; customer behavior

1. INTRODUCTION

Nowadays, electrification, car sharing, service innovation, and network evolution have rapid development worldwide. While new-energy vehicle sales in China have surged in recent years, the trend in 2019 is lackluster. In the past, the new-energy market of China was mainly driven by supply and policy. Although industry pioneers such as Tesla have made efforts to improve

the awareness of new energy vehicles among Chinese consumers, the demand in the mainstream market is still unmet due to the high price positioning of the products. By 2020, the new energy vehicle market has been changing over the past few years and has gradually become demand-oriented. Nowadays, consumers are more inclined to live a sustainable and environmentally friendly lifestyle. Due to the epidemic, this phenomenon has become more and more significant. Consumers are attaching more and more importance to the environmental sustainability of vehicles at different price levels, which is evident in the Chinese market. Combined with the support of national policies, with multiple efforts, The new energy vehicle market in China and other major automobile countries began to burst into great vitality. In the above context, this survey made a reasonable forecast of the total industry revenue (from the perspective of environmental protection, or various aspects of the performance and cost performance of the car itself) according to the consumer's consumption intention.

Although there are some relevant researches about the customers' intention and behavior about ACs which like Menon & Balakrishnan's research 'Structured Equation Modelling on Consumer Purchase Behavior of Passenger Cars', it used few tools like qualitative and quantitative research methods and questionnaires to get some relative results, however, it did not focus on the newest situation. This area changes quickly with the related policies and technology development, and the newest research about the customers' intention for ACs is significant. Because of the epidemic impact, international political influence, economic effect, and other reasons, the automobile industry has made a big change in China, the foreign suppliers have been a different situation, many national policies like "New Vehicle Industry Development Plan (2021-2035)" which can reduce their research and development cost of Chinese automobile company made them more competitive. The tendency of localization of automobile production in China has been high. Many software and hardware like laser radar, millimeter-wave radar have been adopted by Chinese automobile companies. This paper also wonders whether these changes have been some of the customers' considerations before purchasing a car.

To explore factors affecting consumers' purchase intention for ACs more comprehensively and verify the correctness of previous studies, this research conducted exploratory research based on the perceived benefit-perceived risk framework using data collected from questionnaires and held a multiple regression analysis to demonstrate the relationship between purchase intention and those factors. The perceived benefit-perceived risk framework has been widely applied in the research field of consumer behavior, which can deeply analyze consumers' purchasing psychology. Many scholars have applied it in the research on purchasing intention of innovative products such as new energy vehicles. Based on this model, the measurement scale of consumers' purchase intention to ACs was designed, and the data of target groups were collected through questionnaires. Excel was used for statistics and data analysis, and then the multiple regression model was constructed to explore how those factors influence the public's purchase intention for ACs. This study hypothesized that perceived benefit has a significant positive influence on consumers' purchase intention while perceived risk negatively influences purchase intention. This study enriches the research on influencing consumers' purchase intention to ACs and provides new perspectives for future study. Additionally, this research provides a reference for autonomous car companies to upgrade their products and improve their strategies and has reference value for promoting the commercialization of autonomous driving technology.

2. LITERATURE REVIEW

2.1 Perceived Risk and Perceived Benefit Theory

Perceived risk theory is the mainstream framework of consumer behavior research and has been widely used in innovative products research. It was originally a psychological concept including perceived benefit and perceived risk, and then Bauer moved it to the consumer field to analyze consumer purchase behavior in 1960 [1]. Bauer believes that perceived risk is the uncertainty that consumers feel about the outcome of a purchase, which is closely related to consumers' subjective feelings [1]. This article will explore consumer behavior in the industry of new energy cars by this method.

2.2 Influencing Factor for Purchase Intention

Brandon and Michael, in 2014, researched public opinion of ACs and found that most of the public had heard of ACs and had positive expectations. Beyond that, they found Chinese consumers' attitude towards autonomous vehicles is more positive than consumers in other countries, such as the UK, the US, and Australia [2]. In 2018, the study of young consumers' attitudes toward autonomous vehicles was held by Anna Dewalska-Opitek showed that more than half of young consumers are open to autonomous vehicles and are willing to purchase autonomous vehicles [3]. Then, in the discussion of ACs, the following points are the main factors that affect the purchasing tendency of buyers.

Initially, safety is the most serious consideration [2, 3]. According to the research on the influencing factors of consumers' purchase intention to ACs which held by Topolšek et al. in 2020 demonstrated that in addition to the factors related to the automobile product itself, the characteristics of consumers themselves, such as age and education level, will also affect the purchase intention [4]. Secondly, Barry in 2017 found that there was also a significant connection existing between social influence and purchase intention when a product was used publicly [5]. In 2019, Chen and others did a study to provide a logit model and vehicle incentive program design algorithm. And to find the rational match of the deploying autonomous vehicle lanes and subsidy of the purchase autonomous vehicle to the autonomous vehicle under the government budget and purchase price of autonomous vehicle [6]. Then the research found that the proposed incentive program is good for autonomous vehicles. The subsidy of purchase can be regarded as a flexible part of the incentive program, making the system achieve the optimal [6].

2.3 Research Method and Findings

In 2018, Balakrishnan Menon created a customer purchase behavioral model which is with 8 constructive variables: information gathering and customer purchase initiation, preference based on personal need, personal preference based on convenience factors, personal preference based on comfort factors, influence factor based on the car model, external influence, and satisfaction level. And his research filled up the blank of the relative modeling approach of cars study in India. The model was tested to be proved that it is reliable and fit, which can enhance the knowledge and information basement of the passenger car industry [7]. Whereafter, to investigate the status motivation on customers' purchase intention of a green luxury car and the moderation effect by the materialism and horizontal-vertical dualism (collectivism), Ali et al.

used the online survey technique and quantitative method to collect the cross-cultural data from Chinese and German respondents in 2019 [6]. Firstly, the interaction of status motivation and materialism has a prominent effect on customer purchase intention. Secondly, the interaction of status motivation and uniqueness has a significant effect on customer purchase intention. The outcome represented a significant positive link between status motivation and intention to purchase a green-luxury car. The respondents were willing to buy the green-luxury car because this behavior can express that their action was sustainable and can gain more social status and power resources, vertical individualism, horizontal collectivism, and vertical collectivism enhance the positive effects of status motivation on customer purchasing behavior for a green-luxury car [8]. In 2017, this paper presented the effects of electric vehicle promotional policies and customer preferences about alternative fuel vehicles. Knez and Obrecht use the compilation method to gather and study the data and find that different measures are effective for various environments and various customers. Degirmenci and Breitner, in 2017, also stated from an economic point of view, compared with fuel vehicles, the main factors hindering the popularization of electric vehicles are highly high costs and limited mileage due to insufficient battery technology [12]. Furthermore, they predict consumers' attitudes towards new energy vehicles and their purchase intentions on the environmental performance, price value, cruising range, and the number of charging devices of electric vehicles. The analysis results indicate that most consumers consider electric vehicles as a sustainable alternative to burning vehicles [13]. Then, the environmental performance of electric vehicles is a stronger determinant of attitude and purchase intention, rather than price value and range confidence. Since they hold the most and the least important non-financial and financial factors for consideration in low emission vehicle promotional policies, the three most important non-financial factors are overall condition and mileage of the vehicle, safety features (e.g., airbags), and Style or appearance, or color. And then the three least important non-financial factors are followed closely by acceleration, engine type and power, Brand name (e.g., Volkswagen). Besides the non-financial part, there are three most significant financial factors: Total vehicle price, Fuel economy, Maintenance repair costs. Three least important financial factors: Annual Road tax, Trade-in value, Trade-in value [9]. Meanwhile, Kim and others in 2010 have been used a structural equation model to identify the social media marketing activities and examine this relationship among perceived activities, value equity, relationship equity, brand equity, customer equity, and purchase intention. Firstly, luxury fashion brands comprise five constructs; entertainment, interaction, trendiness, customization, and word of mouth. Then find that brand equity has a significant negative effect on customer equity, purchase intention, value equity, and relationship equity had significant positive effects. The relationship between purchase intention and customer equity has significance. Their finding can enable luxury brands to forecast future purchasing behavior and can guide their marketing activities and assets [10].

3. METHODOLOGY

3.1 Research Design

Based on the literature review, a survey, general characteristics of quantitative population study were conducted on consumers' purchase propensity (see Appendix A for a detailed description of our questionnaire), and the sample size of customers participating in this research activity is 150.

3.2 Data Collection

In the questionnaire design, this paper used the Likert scale method as the optional content, and it is the most widely used method of measuring response in survey research either. Thus, the terms are often used interchangeably with a rating scale. After that, the Likert scale is closed, a mandatory choice scale used in a research survey to provide a series of answers from one extreme to the other. Then, this research divided the participants' concern and satisfaction with the various aspects of the intelligent automobiles in the survey into five levels, starting with "strongly disagree" and ending with "strongly agree," etc. The choice of the middle three points is neutral. In a nutshell, the Likert scale is a psychometric and other social science research tool. Furthermore, the questionnaire content was split into four general directions, respectively. For perceived risk, perceived value, environmental awareness, and purchase intention. Perceived risk includes financial, physical, and functional risks. Furthermore, price factors, brand value, emotional value, and quality value are the significant elements that make up the perceived value in the questionnaire. In the sample selection process, this research put the location of the participants in China, and the age subjected is fixed at 18 to 55 years old. Then, according to the standard, the education level and the city scale of the participants were also divided. The findings of the survey feedback suggested three salient beliefs: environmental performance, perceived risk, and perceived benefit. The reasons for this result are: initially, almost 77 percent of participants think that the high efficiency of energy-using of intelligent automobile (new energy vehicles) contribution to the environmental sustainability and the environmental protection is sufficient to affect their purchase intention. Furthermore, for the positive side, the participants' attitude of over 65% demonstrated that brand awareness, satisfaction, and the cost of the vehicle is lower than that of traditional powered one and battery life were also taken into account. Concerning negative aspects, the loss caused by financial risk (95/150), body risk (109/150), and function risk could make them hesitate. Second, most participants' answers refer to the environmental performance, driving safety, infrastructure perfection of ACs (95 answers). In contrast, answers regarding the perfection of relevant laws and the loss of intelligent car function algorithm errors, etc., are evenly distributed. This paper chooses a tree graph to analyze the factors influencing purchase willingness. The figure I. is stated as below.
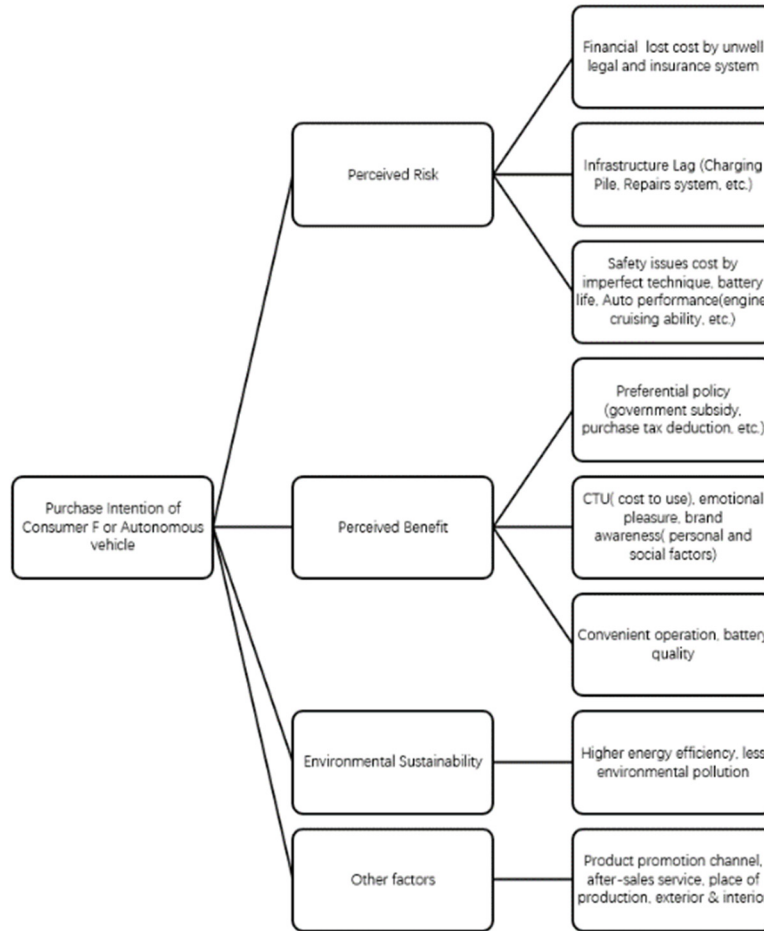
Figure 1. The Composite Indicators Affecting Purchase Intention

Hence, the paper presents the following hypothesis:

H0: perceived risk has a negative impact on purchase intention.

H1: perceived benefit is positively correlated with the purchase intention of consumers.

When the data was collected after the questionnaire releasing, to test the correctness of the hypothesis, the paper measured the participation rate for each of the 22 questions and the percentage of choice for each option. This research adopted the Excel tool in the whole testing process and chose to use the multiple regression model to analyze the existing data. Multiple regression is simply the name of Multiple linear regression, a statistical technique that uses multiple explanatory variables to predict the outcome of a response variable. The target of multiple linear regression is to model the linear relationship between the independent variables and the response variables.

4. RESULTS

The demographic characteristics of the 113 respondents were recorded, as shown in Table 1.

Characteristic		percentage
Gender		
	male	39.82%
	female	60.81%
Age		
	<18	1.77%
	18-24	23.89%
	25-34	55.75%
	35-55	35.66%
	>55	0%
Education level		
	Junior high school degree or below	0.88%
	Senior high school degree	4.42%
	Bachelor's degree or junior college degree	84.96%
	Master's degree or above	9.73%
Living city		
	First-tier and new first-tier cities	49.56%
	Second-tier and third-tier cities	38.05
	Fourth-tier and fifth-tier cities and below	12.39%

As can be seen from Table 1, which shows the characteristics of respondents, the majority of respondents are female, accounting for 60.81%. Most of the participants are young, and more than half of the respondents are between the ages of 25 and 35. As for respondents' education level, nearly 85 percent of them have a bachelor's or college degree. Concerning the level of living city, it can be observed that about 50% of respondents were living in first-tier and new first-tier cities which tend to be more economically developed and culturally open, such as Beijing, Shanghai, Guangzhou, and Shenzhen.

Through multiple regression analysis, the R square is 0.37, which means 37% of the variation in purchase intention can be explained by variation in these explanatory variables. For the 0.1 significant level, by doing F-test for the overall regression model, the significant F is 0.00003, which is much less than the critical value of 0.1. Therefore it can be said that the model is significant. The significance test is also done for individual explanatory variables. The result shows that p-values of five explanatory variables are less than the set significance level of 0.1. The critical values of the confidence interval are both negative or both positive, 0 is not included in the interval which represents these five explanatory variables significantly influence consumers' purchase behavior. VIF is calculated to check whether there is collinearity existing among those explanatory variables. The results of VIF checking are shown in table 2. It demonstrates that VIF values of all X variables are much less than 5, which means there is just a

moderate correlation between a specific explanatory variable and other explanatory variables in the model. However, it is not severe enough to require attention.

TABLE II. ANALYSIS RESULT OF SIGNIFICANT VARIABLES

	P-value	VIF	coefficients
Education level	0.0819	1.3818	-0.2969
Brand awareness	0.0067	1.2756	0.2126
Energy consumption	0.0474	1.3832	0.1656
Environmental performance	0.0477	1.2029	0.2530
Online promotion	0.0002	1.2020	0.1393

The results of multiple regression analysis show the relationship between influencing factors and consumers' purchase intention for ACs. The coefficient of brand awareness is 0.2126, meaning that consumers' purchase intention will increase by 0.2126 when perceived brand awareness increases by 1. There is a positive relationship between the satisfaction brought by brand awareness included in perceived benefit and consumers' purchase intention, which is consistent with hypothesis 0. However, there is a moderate positive relationship between worries about energy consumption and purchase intention, which is different from hypothesis 1. A positive relationship is also existing between environmental performance and purchase intention. The coefficient of environmental performance is 0.2530, which shows the highest correlation among these factors. Besides, consumers' characteristics affect their purchase behavior as well. People with higher education are less inclined to buy an autonomous car.

In the preliminary survey before the questionnaire survey, several participants stated that they hated the active brake system of ACs braking too frequently and had obvious frustration when releasing the accelerator. Therefore they would not buy ACs. Therefore, the research considers the comfort of ACs. However, the analysis results show that its p-value is greater than 0.1, which is not significant. The strong correlation between safety and consumers' purchase intention of ACs was verified in several past works of literature. Most of the respondents in this survey are also very careful about the safety of the ACs, worried about its possible algorithm error, hacker attacks, and so on. The average score of the safety item is 4.45, which is the highest one. However, the results of multiple regression analysis show that its p-value is higher than 0.1, which is not significant. This study also explores whether the imperfection of relevant laws, preferential policies and subsidies, and other factors will affect consumers' purchasing decisions. Yet, the results show that they are not significant.

5. DISCUSSION

To sum up, this report has explained the relationship between customers' purchase intention of autonomous vehicles and perceived benefits. And find the positive factors like brand awareness or worries about energy consumption or environmental performance or consumers' education level. And this paper could help the manufactures to change their strategic plan and marketing orientation. For example, the manufacturers pay attention to car safety, relevant subsidies, and

relevant policies. However, this paper finds that the safety, relevant laws, and subsidies do not have a strong significant relationship with purchase intention.

When comparing with previous results of theories. Topolšek in 2020 finds the purchase intention related to car safety, and buyer age, Ro, Y in 2017 found in the analysis of consumer expectations for ACs that customers purchase intention related to safety, and this paper finds that safety and buyer age have not a significant relationship with autonomous car purchase intention [1, 2]. Matjaz Knez, in his research of policies for promotion policies and factors influencing consumers purchasing decisions, finds that even the promotional policies that try to impact the customers' preferences will not be effective [5]. It is the same as this research about customers' intention of government policies and subsidies.

In addition, consumers' purchase intention is also related to their characteristics. For instance, people with higher education incline not to buy an autonomous car. In this research, the influence of several factors on consumers' purchase intention has not been verified due to several limitations. Firstly it is about sample size. The conduction is not big and diversified makes a limitation of the study because of research time limitation and the Covid-19 impact. The sample size is not enough, which only includes 113 questionnaires. Therefore it may not be comprehensively to forecast the intention. The geographical distribution is not at an average level. The biggest one is 16.81% people from Guangdong. The second is 8.85% in Henan, the third is 7.96% in Sichuan, the fourth is 7.08% in Hebei, the fifth is 7.08% in Fujian, the sixth is 4.42% in Jiangsu, the seventh is 0.42% in Shanghai, eighth is 3.54% in Shandong, ninth is 3.54% in Shanxi, the tenth is 3.54% in Hubei, the eleventh is 3.54% in Anhui, twelfth is 2.65% in Shanxi…the smallest is Chongqing only 0.88%. This condition also has a big impact on this study, that it can't reflect all the customers' intentions in China.

6. CONCLUSION

To explore the potential influence factors and how they affect consumers' purchase intention of ACs, this research was conducted to analyze perspectives from consumers. Through the analysis of the obtained data, the paper found that perceived benefits positively impact the purchase intention of consumers, which is consistent with the hypothesis, and the online promotion and marketing of the product are also positively correlated with the purchase intention.

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