POLITECNICO DI TORINO

Master's Degree Thesis

Competitiveness of Chinese New Energy Vehicle Companies

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Abstract

With the increasing pressure of energy consumption, countries around the world are promoting the development of New Energy Vehicles (NEV). Many developing countries represented by China have also accelerated the pace of the development of New Energy Vehicles (NEV). After more than 20 years of development, the production capacity and the market size of the New Energy Vehicles (NEV) have significantly improved in China. Since 2015, China has ranked first in both sales volume and holding volume of the New Energy Vehicles (NEV) in the world.

In the development process of the New Energy Vehicles (NEV), China has accumulated certain technical achievements, but in the face of competitiveness in the international market, there is still a problem of small export volume. Therefore, there is the great significance to study the development history and current situation of Chinese New Energy Vehicles (NEV) and analyze the competitiveness of Chinese New Energy Vehicles (NEV).

This thesis studies the competitiveness of Chinese New Energy Vehicles (NEV) in the international market through qualitative and quantitative methods. Firstly it analyzes the development history and policies of New Energy Vehicles (NEV) in China and other countries. Then it analyzes the development characteristics of China, EU, the United States and Japan in the New Energy Vehicles (NEV) industry. After that, it analyzes the international competitiveness of China, EU, the United States and Japan by trade index. And according to SWOT, to analyze the competitiveness of Chinese new energy vehicles companies. At the same time, through factor analysis, the competitiveness level of Chinese New Energy Vehicles (NEV) with EU, the United States and Japan is quantitatively analyzed. Finally, the questionnaire is used to understand the current consumers' choice intention and reasons, and analyze the problems and development direction of Chinese New Energy Vehicles (NEV), in order to improve the competitiveness of Chinese new energy vehicle companies.

However, there is also the problem that Chinese New Energy Vehicles (NEV) brands are not well known. Relevant suggestions are put forward for the international competitiveness of Chinese new energy vehicle companies, including optimizing policies to increase the proportion of brand exports and carrying out scientific and technological innovation in advanced and sophisticated fields.

1. Introduction

1.1 Research significance

Since the industrial revolution, the demand for fossil fuels has soared. In the early stage, coal was the main consumables. After the 20th century, especially since the Second World War, the production and consumption of oil and natural gas continued to rise. According to statistics, in 1973, the world energy trading volume was only 5.73 billion tons oil equivalent, while in 2007, the world energy trading volume reached 11.10 billion tons oil equivalent, doubling the total energy consumption in 30 years[1, 2]. Due to a large amount of energy consumption, not only greatly speeds up the exhaustion of traditional fossil energy, but also emits a large amount of carbon dioxide, sulfur dioxide, NOx and a large amount of dust, which causes great damage to the ecological environment[3]. In particular, a large number of greenhouse gases generated in the combustion process lead to global warming and crisis of human living environment[4].

Fine particulate matter PM2.5, means that the pollutant particles which the diameter less than 2.5μm. It is one of the important indicators of air environment, and it is the main reason for the smog. As a pollutant, the particles themselves mainly come from the combustion consumption of traditional energy sources. For example, London is the city of fog, in the early 20th century, coal was the most popular used as household fuel in London, which produced a lot of fog. The reasons as shown combined with London's climate, has generated nickname "the city of fog" for London. In the 21st century, automobile exhaust, especially large vehicles that work by diesel, has become the first source of fine particulate matter.

Smog will bring extremely serious harm. At least 12,000 people died in London in 1952-1953 due to smog. Scientists in Canada and the United States have followed half a million people for a follow-up study, they found that if people exposed to high

levels of PM2.5 for a long time, the incidence of lung cancer is significantly increased after 16 years. And with mortality of lung cancer increased by 8% for every 10μg/m3 increase [5].

According to estimates from the International Energy Information Administration, oil consumption of global passenger vehicle will peak at 23 million barrels per day in 2025. Due to the characteristics of passenger vehicles, although their energy consumption only accounts for 25% of the total global oil consumption[6], their energy utilization efficiency is only 35%-43%, far lower than that of turbine engine, which can reach 60%. That leading to their carbon dioxide emissions have a prominent impact on the environment. Because of this characteristic, its carbon dioxide emissions have a significant impact on the environment. Therefore, it is of great significance to develop new energy as a substitute for automobile energy.

The development of New Energy Vehicles (NEV) as an important way to improve the environment and optimize the energy structure. At the end of 2020, the global holding volume of New Energy Vehicles (NEV) will be about 10 million，4.5 million of them in China, 3.2 million vehicles in Europe, 1.7 million vehicles in the United States. Over the years, China has long been the world's largest automobile market, and among the New Energy Vehicles (NEV) sold, China has the largest number of models, twice that of Europe and three times that of the United States. Therefore, a study on the competitiveness of Chinese New Energy Vehicles (NEV) can help us better understand the difficulties in the development of New Energy Vehicles (NEV) and propose solutions.

1.2 Definition of the New Energy Vehicles (NEV)

The so-called new energy is a kind of generic term of other energy sources excluding traditional energy sources such as coal, oil and natural gas. At present, the new energy mainly includes nuclear energy, solar energy, wind energy, biological energy,

hydrogen energy, geothermal energy and tidal energy. The common feature of new energy is that it does not produce carbon dioxide in the process of generating energy and is cleaner than traditional energy. And that most of the new energy is renewable energy.

The New Energy Vehicles (NEV) is a kind of vehicle, which usually refers to the use of unconventional vehicle fuel as a power source, which integrated vehicle power control and drive advanced technology, and which the formation of a new technology, new structure, technical principle. Specifically, the New Energy Vehicles (NEV) include Plug-in Hybrid Electric Vehicles (PHEV), Pure Electric Vehicles (PEV), Fuel Cell Electric Vehicles (FCEV), Extended Range Electric Vehicle (EREV) and so on.

1.2.1 Plug-in Hybrid Electric Vehicle (PHEV)

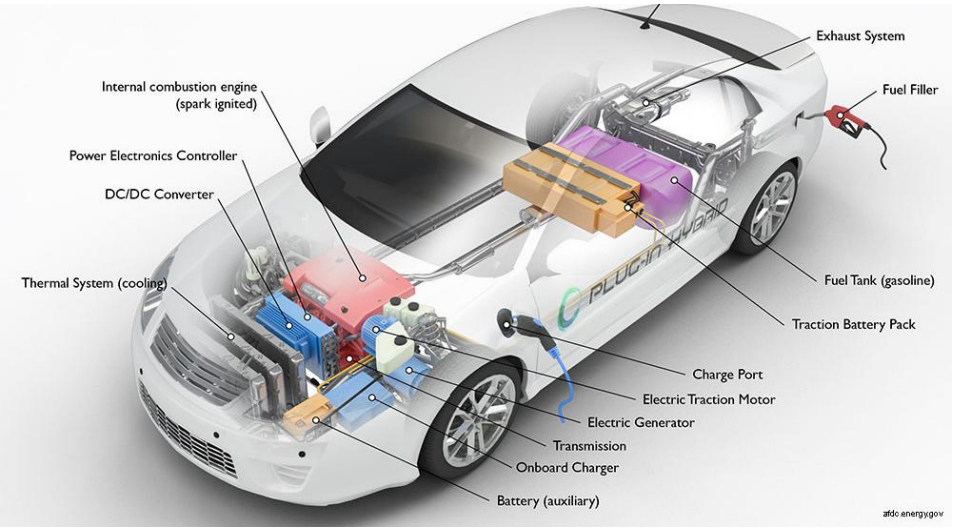

Figure 1. Plug-in Hybrid Electric Vehicle (PHEV)

Plug-in Hybrid Electric Vehicles (PHEV) can work longer distances by batteries alone, and it can also work like a normal hybrid vehicle when needed[7, 8]. Its configuration is shown in Figure 1. Depending on the characteristics of the vehicle's battery changed, Plug-in Hybrid Electric Vehicles (PHEV) can be divided into electricity consumption, battery hold, and regular charging modes. And for electricity consumption, it can be divided into electric mode and hybrid mode. According to the

vehicle's power requirements, the Plug-in Hybrid Electric Vehicles (PHEV) can dynamically adjust its electric and hybrid modes. In electric mode, the engine does not run and the battery acts as the power source, it is same as the electric vehicle. In hybrid mode, the engine and motor work at the same time. On the premise of satisfying the required power, by dynamically balance the power output between electric motor and combustion engine, to achieve the purpose of minimum energy consumption. However, in charging mode, the energy in the braking process can be recovered, in order to achieve the purpose of energy saving.

There are many advantages in Plug-in Hybrid Electric Vehicles (PHEV). In electric mode, it can achieve high efficiency of energy transfer, which is the same as electric vehicles, and it can effectively reduce emissions compared with traditional energy vehicles. However, due to its hybrid characteristics, compared with Pure Electric Vehicles (PEV), the comprehensive energy consumption is still higher than electric vehicles, it is because that the system complexity and extra weight brought by the two power systems in Plug-in Hybrid Electric Vehicles (PHEV). And the battery capacity is small, the range electric mode is short.

1.2.2 Pure Electric Vehicles (PEV)

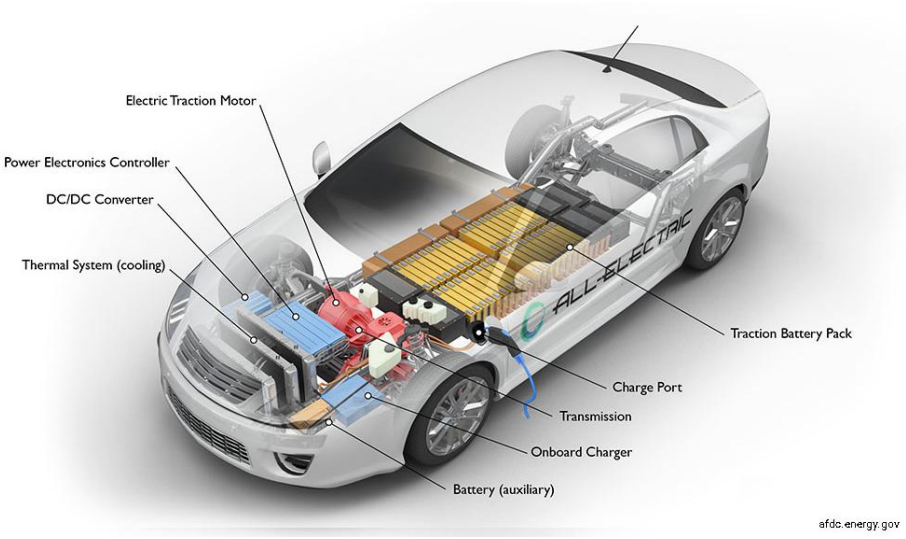

Figure 2. Pure Electric Vehicles (PEV)

As the name suggests, electric motors are the power source for Pure Electric Vehicles (PEV)[9]. Its configuration is shown in Figure 2. Although electricity, as a secondary energy source, is not a new energy source, it can be obtained from a variety of new energy sources, such as nuclear energy, wind energy, tidal energy and so on[10]. Therefore, in the New Energy Vehicles (NEV), Pure Electric Vehicles (PEV) is very important. The energy source of Pure Electric Vehicles (PEV) is battery, which is driven to the tire through the hub motor. This design is characterized by high efficiency, simple structure and low noise. And it does not need axle, gearbox and other mechanical parts to connect, the transmission efficiency is significantly improved compared with traditional energy vehicle. As the New Energy Vehicles, it has the advantage that it does not produce harmful gases to pollute the atmosphere at all. However, as the main factor limiting its performance, the storage capacity of battery still has room for further improvement.

1.2.3 Fuel Cell Electric Vehicles (FCEV)

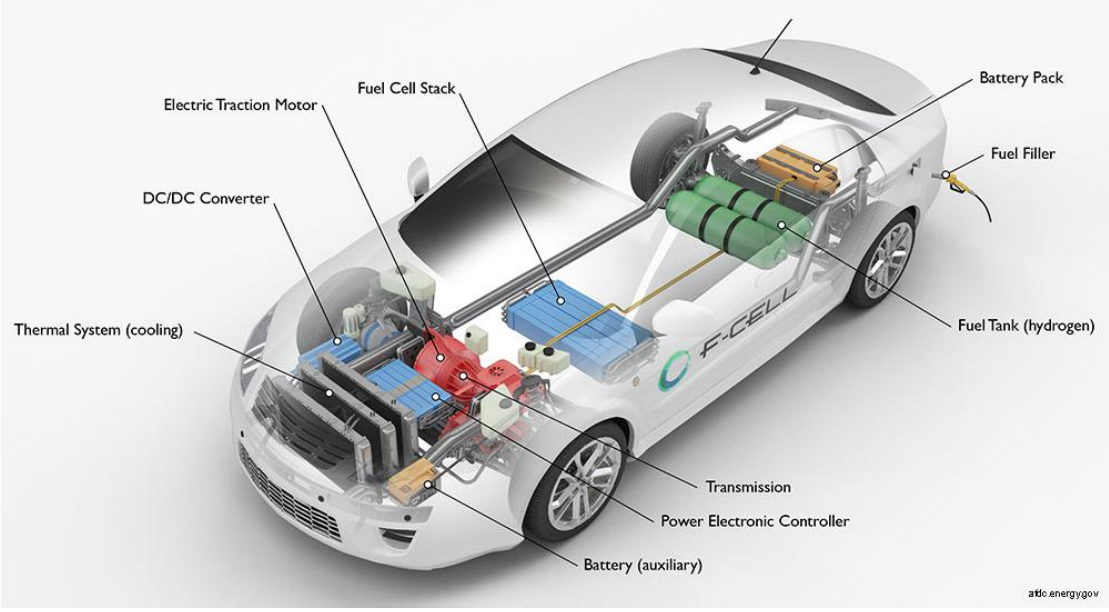

Figure 3. Fuel Cell Electric Vehicles (FCEV)

Fuel Cell Electric Vehicles (FCEV) work in the same way as electric vehicle, but their energy storage is replaced by fuel cells[9]. Its configuration is shown in Figure 3.

Fuel cell is a kind of power generation device that generates electricity through the chemical reaction of fuel. Fuel and air are fed into the fuel cell respectively, and electrochemical reaction is carried out through the proton exchange membrane to generate electricity. At present, fuel cell vehicles are mainly hydrogen cell. Hydrogen, as the lightest molecule in the world, has a high calorific value per unit[11]. The combustion product of hydrogen is water, and there is no pollution at all. Moreover, the main raw material for making hydrogen is water. Thus, hydrogen is renewable. However, hydrogen is rarely found in nature, and the current production process is mainly electrolysis of water, which converts electricity into hydrogen. In a fuel cell, hydrogen and oxygen are fed into the cell together, where a catalyst triggers an electrochemical reaction that passes through a proton exchange membrane to generate water and electricity.

Compared with internal combustion engines, its energy utilization efficiency can reach 60%, and 5kg of hydrogen can provide a driving range of about 500km, and only water can be produced[12]. The filling process is faster than charging, and the mass of vehicle is significantly lower than Pure Electric Vehicle (PEV). However, due to the characteristics of hydrogen, the 5kg hydrogen storage tank needs a pressure of about 70MPa for storage, which has great potential safety risks.

1.2.4 Extended Range Electric Vehicle (EREV)

Figure 4. Extended Range Electric Vehicle (EREV)

The Extended Range Electric Vehicle (EREV) is a special kind of Plug-in Hybrid Electric Vehicle (PHEV)[13]. Its configuration is shown in Figure 4. The battery is the power source of the Extended Range Electric Vehicle (EREV). With the different from Plug-in Hybrid Electric Vehicle (PHEV), the internal combustion engine in Extended Range Electric Vehicle (EREV) is only used to charge the battery. When the battery runs low, the internal combustion engine starts to charge the battery. Because of the single function of the internal combustion engine, the internal combustion engine does not need to connected with the transmission mechanism, the structure is more simple. So, the internal combustion engine on Extended Range Electric Vehicle (EREV) can always work in the higher thermal efficiency range. Even when the battery is exhausted, the energy consumption and pollution are still significantly lower than traditional energy vehicles.

On the one hand, the Extended Range Electric Vehicle (EREV) has the advantages of electric vehicles, such as lower noise and lower pollution. At the same time, when the battery is exhausted, the internal combustion engine can work to recharge the battery. EREV realize environmental protection and rapid replenishment of energy, it is a

beautiful balance. But because of the chassis design and overall layout of extended-range vehicles, and plus the extra weight of the internal combustion engine, the pure electric range of Extended Range Electric Vehicle (EREV) is shorter.

1.3 The promotion significance of the New Energy Vehicles (NEV)

As an emerging means of transportation, New Energy Vehicles (NEV) not only protect the environment, but also promote the progress of other industries. The promotion of New Energy Vehicles (NEV) not only optimizes the energy structure and improves the environment, but also promotes the industrial chain, internet technology innovation, and so on[14].

From the automotive industry, the development of New Energy Vehicles (NEV) has promoted the progress of the automotive industry. The New Energy Vehicles (NEV) include a large number of technologies than the traditional ones, they combine advanced materials development and application, sophisticated parts manufacturing, batteries, motors and electronic control technologies.

1.3.1 To change the energy configuration

Traditional energy vehicles are powered by diesel or gasoline, which are mostly refined from petroleum. The formation of petroleum is a very complex process. The remains of ancient animals and plants are buried in the ground, and gradually formed after a long period of high temperature and high pressure. With the death of a large number of plants and animals, the organic matter they carried is constantly decomposed and deposited, with the pressure and temperature of the sedimentary layer rising, the sedimentary rock gradually began to the form of waxy oil shale. And then, over a long period of time, it builds up to form what we know as oil, natural gas and so on. So for humans, oil is of great strategic importance as non-renewable resources.

By promoting New Energy Vehicles (NEV), changing the energy structure is crucial to the national energy security[15]. Oil security is particularly important to China. Chinese remaining proven oil reserves are estimated at 25.7 billion barrels (3.7 billion tons), the 13th largest in the world. Therefore, foreign oil imports have become a crucial link, and Chinese degree of dependence on foreign oil is close to 70%. A shortage of imported oil would be extremely dangerous for China.

Therefore, it is very important to promote New Energy Vehicles (NEV) and transform energy at the same time. So as supporting industry of New Energy Vehicles (NEV), wind and solar power generation has also been greatly developed. It is expected that by 2035, wind and solar power generation will account for more than 80% of Chinese installed capacity and more than 40% of its electricity generation[16], and the cost of solar and wind power generation can be further reduced. The current new energy revolution is faced with the low cost of solar and wind power generation, but the fees of the new energy using is still high, among which energy storage is the main bottleneck.

1.3.2 To improve the environment

The source of traditional energy, petroleum is polluted greatly in the process of exploitation, transportation and combustion. For the ocean, once oil enters the ocean, a series of changes occur immediately, including diffusion, evaporation, dissolution, emulsification, photochemical oxidation, microbial degradation and so on. It will interfere with the ability of feeding, reproduction, growth, behavior and chemotaxis of organisms, will also destroy the normal structure and permeability of cell membranes, interfere with the enzyme system of organisms, and then to affect the normal physiological and biochemical processes of organisms, thus resulting the widespread death of marine organisms, seabirds and their populations in a large scale decline.

If oil spills are caused by transportation, use or processing on land, petroleum pollutants can remain underground for a long time and pollute groundwater. Coal burning, oil burning and large-scale infrastructure construction have become one of the three major sources of air pollution. Soot, dust, NOx, CO and hydrocarbon generated in the process of petroleum generation will cause photochemical smog to harm the human body[2, 3]. In addition, the process of petroleum generation will also indirectly cause acid rain, dust and other weather.

However, New Energy Vehicles (NEV) do not use traditional energy, and there will not be a variety of pollution problems brought by traditional energy[17]. The development of New Energy Vehicles (NEV) will help achieve peak carbon dioxide emissions, which is a point at which carbon dioxide emissions stop rising to a peak and then gradually fall back and carbon neutral in advance. As the share of renewable energy in power generation increases, carbon emissions per mile traveled by Pure Electric Vehicles (PEV) are expected to drop to 20g/km by 2035, down more than 70% from 2021. In 2035, New Energy Vehicles (NEV) will achieve carbon emission reduction of about 200 million tons in road transportation, which will have significant carbon reduction benefits[16].

1.3.3 To promote industrial chain

Take the electrification as a starting point, to strongly develop the intelligence. The electrification of vehicles integrate the Research and Development (R&D) of advanced materials and the manufacturing of high precision parts and components, combined with battery, motor, electronic control technology, in order to improve together. Automobile industry is one of the most important application scenarios which include the new generation of information technology, artificial intelligence, 5G, the internet, and so on. In this case, lots of "out of the vehicle" technologies are

applied to automobile industry, on the one hand, achieving the intelligent development of automobile industry; on the other hand, the intelligent development of automobile industry has become the stage of a large number of trans-boundary technologies. From this it seems clear that the automobile industry has become an important force to accelerate innovation in other industries.

The two-way interaction between New Energy Vehicles (NEV) and power grid (V2G) energy and the efficient coordination with renewable energy can reduce the use cost of New Energy Vehicles (NEV), improve the use of clean electricity, and improve the peak efficiency and safety emergency response capacity of the power grid. The energy utilization of automobiles is coordinated with wind power generation and solar power generation to increase the proportion of renewable energy applications. In the area of public services, we will develop integrated smart travel services, build an intelligent and green logistics and transportation system, and promote the construction of intelligent road network facilities. The efficient collaboration of "human-vehicle-road-cloud" with data as the link is integrated with information and communication to achieve a cross-industry and cross-field comprehensive big data platform. Vehicle-road collaboration in the context of AI (Artificial Intelligence), 5G, big data and cloud computing, can not only improve the safety of autonomous driving, but also effectively reduce the cost of sensors. Compared with other countries, China has more resources in the electric vehicle industry chain. China has large reserves of rare earths needed to make batteries and electric motors. At present, China is largest exporter of battery electrolyte and battery in the world, and has a leading advantage in technology.

1.4. Summary

New Energy Vehicles (NEV) are the focus of development in recent years. People are paying more and more attention to the development of New Energy Vehicles (NEV). At present, environmental protection is the main task for everyone, and it is also the key way of modernization. Therefore, green environmental protection stay into everyone's daily life. Pure Electric Vehicles (PEV) can achieve zero pollution in the process of operation, and do not emit harmful gases that pollute the atmosphere[18]. Even when electricity consumption is converted into emissions from power plants, it causes less pollution than the traditional energy vehicles. Because of the higher power plants energy conversion rates, concentrated emissions can more easily be passed off as emission reduction and pollution control equipment[19]. The development of the New Energy Vehicles (NEV) can greatly reduce the dependence of the automobile industry on traditional energy, in order to play the main purpose of saving resources and optimize the energy consumption structure. At the same time, New Energy Vehicles (NEV) can also drive the development of the relevant industrial chain, promote technological innovation and development.

Therefore, promoting the development of New Energy Vehicles (NEV) has an important role for all countries in the world.

2. The current situation of New Energy Vehicles (NEV)

New Energy Vehicles (NEV) as one of the important methods to improve the environment and ensure energy security[20, 21]. At present, there are many types of new energy vehicle companies. From the perspective of R&D point of view, it can be divided into four types: 1. Adding new product lines on traditional energy vehicles brands. 2. Traditional energy vehicle enterprises establish new brands in joint ventures with other enterprises. 3. New brands created by manufacturing enterprises which are out of the automobile industry. 4. New entrepreneurial enterprises. There is the largest category of new energy vehicle brands in China, and most of them in China are fire-new ones created by manufacturers which are out of automobile industry.

The field of New Energy Vehicles (NEV), China stay the first rank in the world in terms of market size, accounting for more than 50% of global ownership and sales in 2019. In addition to China, major players in the global new energy vehicle market are mainly developed countries, including the United States, Japan, Germany, France, the United Kingdom and the Netherlands. Among of them, the United States has the best performance. So that, understanding the development history of New Energy Vehicles (NEV) between countries can better understand their performance in New Energy Vehicles (NEV).

Therefore, this chapter compares the different development histories and policies of Chinese New Energy Vehicles (NEV) with those of the United States, Europe and Japan.

2.1. The New Energy Vehicles in China(NEV)

2.1.1. Development history in China

As an important symbol of a country's comprehensive strength and technological level, the automobile industry has the characteristics of technology-intensive, capital-intensive and high value-added industries. As a developing country, China has been in a catch-up position in the automobile industry. Until 1956, the FAW Jiefang truck was produced, it was the first automobile made in China independently[22]. At the same time, BMW had produced the precursor of the 3-series which is called the 2002. Chinese automobile industry started late and poor technology accumulated. However, through joint ventures, the advanced production lines were introduced in China, in order to learn and accumulate production technology and experience, which greatly promoted the progress of traditional fuel vehicles. In 2021, self-branded passenger cars accounted for 44.4% of domestic sales in China. Among them, the biggest contribution comes from Chinese new energy vehicle brands.

Due to the late start and slow development of Chinese automobile industry, there is a certain gap in the competitiveness of traditional energy vehicles compared with other first-line brands[23]. However, the structure of New Energy Vehicles (NEV) is completely different from traditional energy vehicle, Chinese new energy vehicle companies and traditional energy vehicle companies stand at the same starting point[24]. The development of New Energy Vehicles (NEV) in China mainly includes the following development stages.

2.1.1.1 The initial stage

Chinese New Energy Vehicles (NEV) from 2001 to 2008 began to guide the development of New Energy Vehicles (NEV)[25]. In 2001, the "863 Program" major special project for Electric Vehicles (EV) guided enterprises to carry out the R&D of

electric vehicles and lay out the new energy vehicle industry in advance. In 2006, Pure Electric Vehicles (PEV) and Hybrid Electric Vehicles (HEV) with proprietary intellectual property rights came out successively in China, achieving a breakthrough from zero to one.

2.1.1.2 The industry cultivation stage

Since 2009, China has been improving the front-end and back-end industrial chains of New Energy Vehicles (NEV). The battery, motor and electronic control system of electric vehicles are the most important components of New Energy Vehicles (NEV), and their cost accounts for about 55% of the total vehicle cost[26], which is the most important part of the industrial chain. With continuous invest, a complete industrial chain has been formed in China. At the same time, Pure Electric Vehicles (PEV) have been realized export in batches. The R&D of Fuel Cell Electric Vehicles (FCEV) has reached the advanced level in the world.

2.1.1.3 The product optimization stage

Since 2014, a large number of new energy enterprises have emerged, forming a strong competition in the market. With the emergence of brands, various vehicle enterprises have formed a healthy competition. Enterprises continue to innovate and apply advanced technology to the latest products. Certainly, the entry of internet enterprises has greatly increased the market vitality.

2.1.2. Policies in China

Since 2009, China has launched a wide range of subsidies for New Energy Vehicles (NEV)[27, 28]. As shown is the Figure 5. In 2010, subsidies were introduced for Plug-in Hybrid Electric vehicles (PHEV) and Pure Electric Vehicles (PEV), which

was 3000Yuan/kWh. Plug-in Hybrid Electric vehicles (PHEV) can receive up to 50,000 yuan and Pure Electric Vehicles (PEV) up to 60,000 Yuan.

Since 2014, China has implemented the policy of exempting purchase tax on New Energy Vehicles (NEV), which has been in effect for 8 years[29]. The amount of purchase tax exempted is about 10% of the total price of the vehicle.

As Chinese New Energy Vehicles (NEV) enter the product optimization stage, since 2017, China has launched about 36 policies related to New Energy Vehicles (NEV), including 14 in terms of technological innovation, investment management, fiscal subsidies, infrastructure construction and finance and insurance, accounting for about 50%.

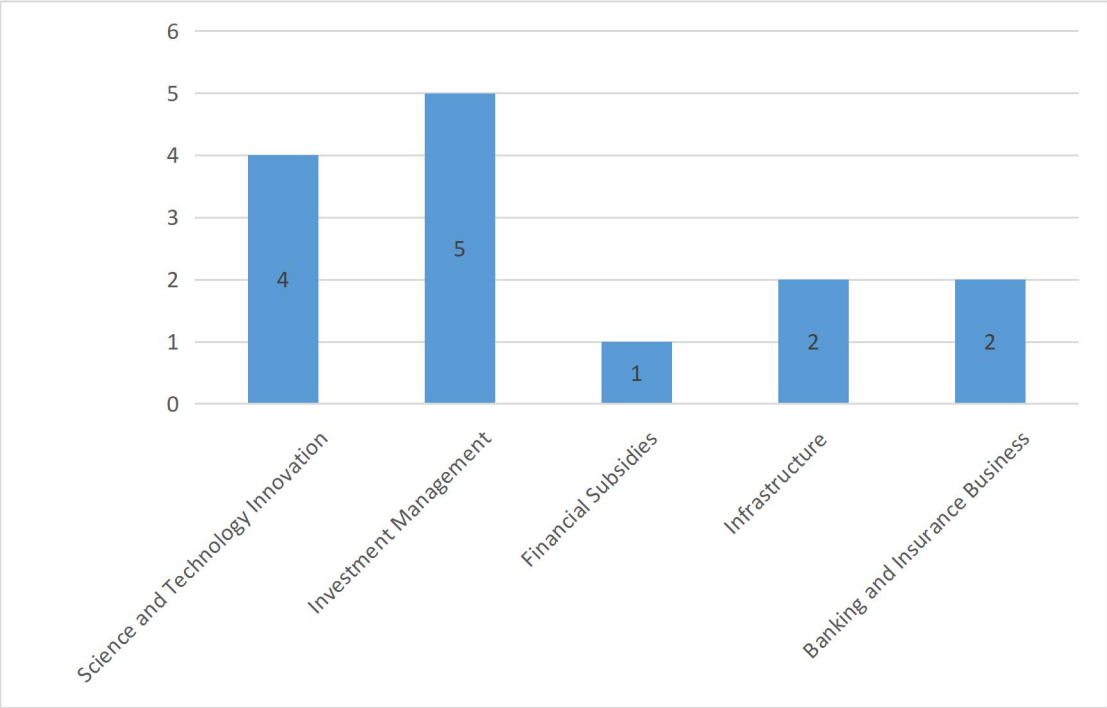

Figure 5. Chinese polices related to NEV

At present, the most important policies are double cumulative score policy and subsidy standard respectively[24, 28]

2.1.2.1 The double cumulative score policy

In 2017, China introduced a double cumulative score policy, mainly aimed at encouraging companies to engage in the production of New Energy Vehicles (NEV)[29].

The first type is the Corporate Average Fuel Consumption (CAFC), which is calculated by:
Average fuel consumption score = (average fuel consumption reached standard value - average fuel consumption actual value) * passenger car production.

Positive scores can be used for the deduction of government integral system assessment. If the enterprise has unused negative scores, will receive relevant penalties.

The second is New Energy Vehicles (NEV) scores, which are calculated as follows: NEV New Energy scores = Pure Electric Vehicles (PEV) scores + Plug-in Hybrid Electric Vehicles (PHEV) points + Fuel Cell Electric Vehicles (FCEV) scores.

2.1.2.2 The subsidy standard of the New Energy Vehicles (NEV) in 2018

China has improved its vehicle subsidy standards since they were first proposed in 2010. It can be seen that the mileage of each model has a significant impact on the subsidy amount, that can promote the new energy vehicle companies to continue to upgrade the technology, especially the battery and motor innovation. It is beneficial to promote the further development of the industry.

2.1.3. Current situation in China

2.1.3.1 Sales volume

With The layout of New Energy Vehicles (NEV) in China, the sales volume of New Energy Vehicles (NEV) has exceeded 1 million for three consecutive years since 2018, occupying more than 50% of the global market share. In 2020, holding volume of New Energy Vehicles (NEV) in China was 4.92 million, accounting for 50.5% of the global total. As the world's largest new energy vehicle market, Chinese companies are beginning to occupy a place in the new energy vehicle industry. As shown in Table 1.

Table 1. Sales volume of NEV in China

Year	2018	2019	2020
Sales volume（10 thousands）	125.6	120.6	136.7
Global share of sales volume	60.1%	55.5%	-
Holding volume	260.8	380.9	492
Global share of holding volume	46.0%	48.1%	50.5%

In the New Energy Vehicles (NEV) category, Pure Electric Vehicles (PEV) dominate the Chinese market, followed by Plug-in Hybrids Electric Vehicles (PHEV), and Fuel Cell Electric Vehicles (FCEV) are still in their infancy. In 2020, 1.367 million New Energy Vehicle (NEV) were sold in China, of which 1.115 million were Pure Electric Vehicles (PEV), accounting for 82%. The sales volume of the Plug-in Hybrid Electric Vehicle (PHEV) is 0.24million, accounted for 18.36%. Other kind of New Energy Vehicle (NEV) is accounted for 0.07%. The data is shown in the Figure 6 in below.

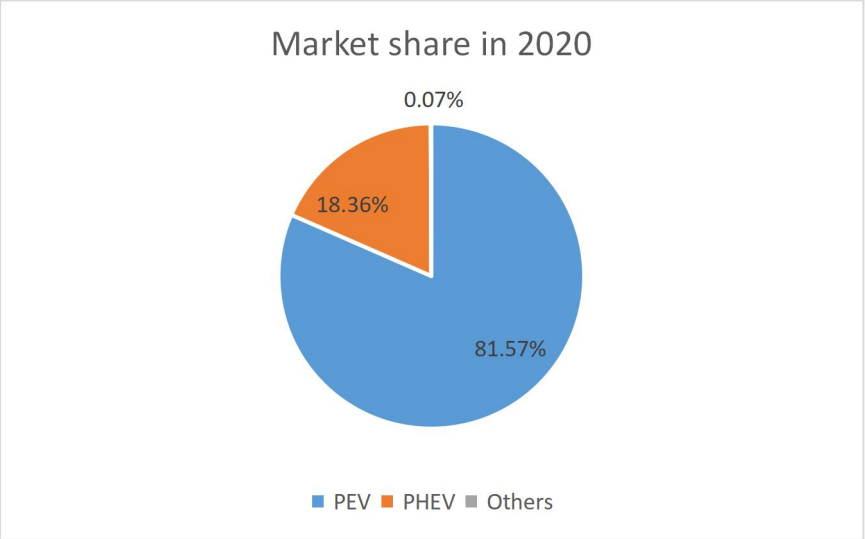

Figure 6. Market share in 2020

2.1.3.2 Industry chain

Under the national guidance, Chinese electric vehicle industry has formed a complete industrial chain[23, 27]. In 2020, Chinese enterprises occupied five slot of the top ten in power battery installations in the world. It accounts for 36% of the global share. Among of them, Contemporary Amperex Technology Company Limited (CATL) ranked first in the world with 34GWh installed capacity and 25% market share.

In terms of battery electrolyte, in 2020, Chinese overall electrolyte production is 250,000 tons, a total of 334,000 tons of battery electrolyte materials were produced in the world, and the proportion of battery electrolyte produced in China was as high as 76%. As the leading manufacturer of battery electrolyte, Tinci Materials Technology Company produced 106,000 tons of battery electrolyte in 2020, accounting for 32% of the world total. In battery-related areas, China has achieved a leading position.

In terms of electric motors, China has basically achieved its own R&D and production. In recent years, the main index of electric motor has caught up with the international advanced level, and the technology in the field of permanent magnet motor has reached the international leading position. At present, domestic electric motors basically meet the demand of the Chinese market, BYD and other Chinese enterprises

have achieved a complete independent supporting. In 2020, the number of domestic electric motors installed in Chinese New energy vehicles has reached 1.24 million.

2.2. The New Energy Vehicles (NEV) in other countries

2.2.1. Development history in other countries

2.2.1.1 The United States

The new energy vehicle industry in the United States has a history of nearly 180 years since its inception in 1834. The new energy vehicle industry in the United States can be roughly divided into three stages: initial stage, slow growth stage and rapid development stage.

The United States is one of the earliest countries in the world to develop and use New Energy Vehicles (NEV). In 1834, the world's first electric car was born in the United States[10]. After that, the United States did not stop the exploration of New Energy Vehicles (NEV), and paid more attention to environmental protection, energy conservation and emission reduction. And urgently developed and used environmentally friendly green vehicles. The United States has issued relevant policies, bills and industry standards to vigorously promote the development of the new energy vehicle industry, which makes the United States has been in a leading position in the world with its supporting policy system and favorable market environment.

The holding volume of vehicles in the United States has ballooned to 100 million, and the exhaust emissions caused serious air pollution such as smog and photochemical smog, which attracted the attention and discussion of the government and academia. The global oil crisis in the 1970s once again alerted the United States to develop low-carbon and energy-saving vehicle, to cope with the energy crisis and

environmental crisis. In 1976 the United States government issued the statement, established a policy to encourage consumers to buy products based on financial subsidies, and through legislative and financial support policies and measures to promote the development of New Energy Vehicles (NEV), marked the formal beginning of the R&D of the new energy vehicle industry in the United States. Subsequently, other states or cities have introduced laws related to the atmosphere, promoting the development process of the new energy vehicle industry.

In the 1990s, Japanese cars dramatically increased their market share in the United States, causing panic among American vehicle enterprise. In the face of serious market losses, President Clinton announced "The Partnership for a New Generation Vehicles" (PNGV) in Washington, mainly developing pure electric vehicles.

The plan has three goals. One is to improve the competitiveness of the car maker, to make car makers more competitive. The second one is to apply new technologies to conventional vehicles to improve fuel efficiency and reduce emissions. The third one is to triple fuel efficiency within a decade. On the whole, the plan accelerates the pace of the upgrading of the automobile industry, promotes the technological innovation of the new energy automobile industry, and carried out an unprecedented automotive technological revolution around the world. The George Walker Bush administration announced the "Freedom CAR Program" to replace "PNGV", and focused on the development of Fuel Cell Electric Vehicles (FCEV). Although the cost is difficult to reduce and the technology is difficult to break through, the R&D of this model is still the long-term R&D goal. In this stage, the United States attaches great importance to the R&D and production of the New Energy Vehicles (NEV), but the new energy vehicle industry is characterized by large investment and long term, and American people lack awareness and acceptance of New Energy Vehicles (NEV), that makes New Energy Vehicles (NEV) unable to achieve great results in the short term. According to various data indicators, New Energy Vehicles (NEV) in the United States are in a slow development stage.

However, the focus of the Obama administration is Pure Electric Vehicles (PEV) and Plug-in Hybrid Electric Vehicles (PHEV), which marks the rapid development of New Energy Vehicles (NEV) in the United States. Driven by fossil energy, environmental protection and energy conservation, the development speed and scale of new energy vehicle industry in the United States are in the forefront of the world. In 2017, the total sales volume of New Energy Vehicles (NEV) in the United States was 477,000, with a growth rate of 5.6%, among which the sales volume of Pure Electric Vehicles (PEV) was 168,000, with a growth rate of 23%.

Originally, the old domestic competitors were General Motors, Ford and Chrysler. In recent years, however, Tesla, represented by Pure Electric Vehicles (PEV), has emerged strongly and is now the leader of the new energy vehicle industry in the United States now.

2.2.1.2 European Union

As a traditional automobile industry powerhouse, European countries have always been in the forefront of automotive development. In terms of New Energy Vehicles (NEV), Europe also got an early start.

1899, A German named Ferdinand Porsche invented a hub motor to replace the chain drive that was common in vehicles at the time. Subsequently, Lohner-Porsche electric car was developed, which used lead-acid battery as power source and was directly driven by the hub motor in the front wheel. It was also the first car to be named after Porsche.

Electric vehicles were in use for a long time before the advent of traditional energy vehicles. In 1900, of the 4,200 vehicles sold in Europe, 40% were steam vehicles, 38% were electric vehicles, and the remaining 22% were traditional energy vehicles.

In the 1960, the oil crisis makes people pay attention to the development of electric vehicles again.

At this stage, Continental Europe was already in the middle of industrialization. During this period, oil crises have been occurring frequently and became a problem that could not be ignored by human beings. People have been aware of this problem, and began to reflect on the increasingly serious environment will bring huge disasters to human beings. So, the electric motor of Pure Electric Vehicles (PEV) is small in size, does not pollute the environment, does not emit exhaust gas, and the noise is very small, these characteristics make people reconsider the Pure Electric Vehicles (PEV).

Driven by capital, the driving technology of electric vehicles has made great progress in that decade, and the electric vehicles have received more and more attention. Small electric vehicles began to occupy fixed markets, such as golf scooter.

As environmental issues become more prominent, Europe is taking the lead in proposing a ban on traditional energy vehicles by 2040. However, compared with the United States and China, European auto enterprises overall start late in the field of New Energy Vehicles (NEV). On the one hand, under environmental group pressure, the EU and European governments promote the development of New Energy Vehicles (NEV) through stringent carbon emission regulations. On the other hand, European automobile companies, especially German ones, are reluctant to choose the development of electrification, due to their advantages in emission reduction technology of traditional energy vehicles[30].

2.2.1.3 Japan

Japanese automobile industry has a good foundation[31], but it lags behind Europe and America in starting New Energy Vehicles (NEV). During the 1970s, when Japanese economy was gradually transitioning to peacetime, it was also affected by the oil crisis, which caused problems for automobile use. On the other hand, due to the economic crisis in the 1970s, the lack of production and use of electric appliances in Japan at that time, many factories closed down and the power supply exceeded the demand for a moment, which also made the Japanese government to encourage the manufacture of electric vehicles, and many emerging electric vehicle manufacturers began to carry out the R&D of electric vehicles.

Although Japan took the lead in the technology of traditional vehicles in the early stage, it was slow down in the high-speed development period of New Energy Vehicles (NEV). At that time, policy support was not as strong as it is now[31], that resulting in the high cost of New Energy Vehicles (NEV) in Japan, which finally led to poor sales.

There are problems in the supply of lithium for batteries, due to the lack of rare earth resources in Japan, Japan has decided to start developing a new energy source, hydrogen. Hydrogen comes from a wider range of sources in comparison with lithium, but the technology is more complicated. After a long time of trying, hydrogen energy is still not widely used in New Energy Vehicles (NEV) due to its production, storage and transportation problems[11].

In the 21st century, Japan resumed the R&D of New Energy Vehicles (NEV). Due to the good sales status of Plug-in Hybrid Electric Vehicles (PHEV), they achieved a good development in Japan. In the field of Pure Electric Vehicles (PEV), Japan, especially Toyota group, did not actively R&D. Therefore, Japan has not achieved good development in the field of Pure Electric Vehicles (PEV). Similar to Europe,

traditional fuel vehicle brands are slow to make decisions in the transition to electric vehicles, which leads to a decline in their competitiveness in the field of New Energy Vehicles (NEV) compared with traditional energy vehicles.

2.2.2. Policies in other countries

2.2.2.1 The United States

On January 24, 2007, the Bush administration proposed the “Alternative Energy and Energy Conservation Policy”. The policy is called for a 20% reduction in gasoline use within 10 years, and 15% would be replaced by renewable energy. The United States government also regards Hybrid Electric Vehicles (HEV) as a key development project, constantly overcoming technical difficulties and expanding the scale of the development of the new energy vehicle industry[32]. In 2011, President Obama proposed that the holding volume of Pure Electric Vehicles (PEV) and Plug-in Hybrid Electric Vehicles (PHEV) should reach 1 million by 2015, and to launch Pure Electric Vehicles (PEV) which is able to be the leading position within 10 years. In 2012, the United States government started the national innovation plan for electric vehicles which is called "EV Everywhere". Taking Pure Electric Vehicles (PEV) as the main target, focusing on the development of Plug-in Hybrid Electric Vehicles (PHEV) in the short term, overcoming difficulties in plug-in technology, battery technology and lightweight technology, and once again clarifying the goals and direction of new energy vehicle R&D. Under the series of powerful policies, in 2014, the sales volume of New Energy Vehicles (NEV) in the United States led the world, passed the 100,000 mark. Nissan Leaf, Volt and Tesla Model S occupied the top three in sales volume.

In order to achieve the energy emission reduction target quickly, the United States government has actively implemented policy and financial support in technology R&D, industrialization and promotion. At that time, the government procurement was the main way of supporting. This is precisely because the United States regards

technological innovation and product R&D of New Energy Vehicles (NEV) as the core of industrial success. In June 2008, the United States government invested $30 million in General Motors, General Electric and Ford Companies, in order to boost Plug-in Hybrid Electric Vehicle (PHEV) development. In August 2009, the Obama administration invested $2.4 billion in support of technology development and production in the New Energy Vehicles (NEV). In addition, the United States also attached great importance to supporting infrastructure. California paid more attention to the project most seriously, according to its plan, to establish charging systems that could accommodate 1,000,000 electric vehicles by 2020, and to install 300,000 charging piles in commercial locations across Southern California by 2030

2.2.2.2 European Union

The guidance and promotion policies of European Union and European governments for New Energy Vehicles (NEV) are mainly reflected in three aspects. The first is setting automobile emission regulations of EU, especially the CO_2 emission regulations[33, 34]. The second one is that setting targets for banning the traditional energy vehicles selling, or zero-emission vehicles. The last one is that to implement high subsidies and other preferential policies for New Energy Vehicles (NEV) in a specific period of time.

In the end of 2013, ahead of the Climate Conference in Paris, the European Commission and the European Parliament agreed to impose new mandatory CO2 targets for passenger vehicles and light commercial vehicles from 2020. The average CO2 emission of passenger vehicles should not exceed 95 g/km. From 2020, Europe will have the most stringent CO2 emission requirements for vehicles in the world[33]. By 2021, if the car makers are not able to meet the standards, they will be fined 95€ for each extra 1g/km per vehicle. On 17 December 2018, the European Commission, the European Parliament and the European Council reached a new agreement, they set

emission targets for passenger vehicles and light commercial vehicles[30]. Under this target, to compare with the emission level in 2021, average CO2 emissions for new passenger vehicles in the EU must be reduced by 15% in 2025 and 37.5% by 2030; and for light commercial vehicles in the EU must be reduced 15% by 2025 and 31% by 2030[28].

European governments got an early start on subsidies because of their relative advance in environmental awareness. Take Norway as an example. Since 2001, the government has taken a series of incentive measures for New Energy Vehicles (NEV)[34]. Firstly, people who purchase the electric vehicles with plug-in are able to exempt from the 25% value-added tax as well as registration fees, annual fees and so on. With these tax reduction, the price of a traditional energy vehicles is now the almost same as the electric vehicles for Norwegian consumers. Secondly, people do not need to pay express way tolls and public parking fees for electric vehicles with plug-in. Since 2008, France has implemented an incentive and fine policies for the new automobile market. After adjusting several times, the general trend is to impose more and more penalties on high-emission vehicles. Other European countries have adopted similar policies of incentives and fines.

2.2.2.3 Japan

In March 2016, The Japanese Economy and Industry released the "PEV and PHEV Development Trend Chart", and the government set the popularization target of various models[8]. By 2020, the holding volume of Pure Electric Vehicles (PEV) and Plug-in Hybrid Electric Vehicles (PHEV) should be 1 million (the cumulative sales volume at the end of 2016 was about 140,000). By 2030, the sales volume of Pure Electric Vehicles (PEV) and Plug-in Hybrid Electric Vehicles (PHEV) will account for 20% to 30% of the new car sales, and about 16% of the total holding volume. As a proposal to promote the popularity of New Energy Vehicles (NEV), it proposed a proposal on charging facilities based for electric vehicles. In order to eliminate the

range anxiety caused by low battery, charging facilities should be widely deployed in gas stations, expressway parking, service areas, shopping mall and other public places. It is essential for expanding the potential market of Pure Electric Vehicles (PEV) and Plug-in Hybrid Electric Vehicles (PHEV).

In addition, according to the regulation of subsidies which set up by Japanese Ministry of International Trade and Industry (MITI), 13.7 billion Yen budgeted for subsidies for environment-friendly models and 2.5 billion Yen is budgeted for subsidies to improve the charging infrastructure of New Energy Vehicles (NEV). This two financial subsidy policies are aimed at increasing the range of electric vehicle, and driving the purchase of electric vehicles, while supporting the construction of charging infrastructure. According to the regulations of the Japanese Land Ministry, through the implementation of local transportation environmental protection plan, the 400 million Yen subsidies budget is provided. In order to promote the popularity of electric vehicles, it is necessary to provide relevant services for electric vehicles according to their regional application conditions.

In order to increase the market share of New Energy Vehicles (NEV), the Japanese government intends to double the subsidy for people who buy New Energy Vehicles (NEV) from spring 2022, with a maximum subsidy of 2.5 million Yen. Starting in spring 2022, Japanese citizens can get a subsidy of up to 800,000 Yen to buy a new electric vehicle. If you buy a Pure Electric Vehicles (PHEV), you can get up to 500,000 Yen, 2.5 times more than the current amount. For the "light electric vehicles" that car makers plan to produce, buyers can also receive a subsidy up to 500,000 Yen. And for the Fuel Cell Electric Vehicles (FCEV), buyers can also receive a subsidy up to 500,000 Yen.

2.3. Summary (Comparison between China and other countries)

2.3.1 Comparison of development history

Chinese New Energy Vehicles (NEV) are limited by the backwardness of the Chinese automobile industry, which starts relatively late compared with other countries. Because of the backwardness of the traditional automobile industry, Chinese New Energy Vehicles (NEV) are more active in terms of strategy[25, 26]. Most of the new energy vehicle brands in other countries are based on hybrid technology, and there are just few Pure Electric Vehicles (PEV), so the market expansion of New Energy Vehicles (NEV) is conservative. On the contrary, Chinese New Energy Vehicles (NEV) companies mainly develop Pure Electric Vehicles (PEV), and the market expansion of New Energy Vehicles (NEV) is more active. Other new energy vehicle companies in other countries, except Tesla and other newly established New Energy Vehicle (NEV) companies are more aggressive in product layout, traditional vehicle companies are more conservative in their New Energy Vehicles (NEV) strategies. For traditional vehicle companies, take Toyota as an example. Toyota's Leiling, Camry and other models are all gas-electric hybrid or plug-in hybrid models. As you can see, with the development of Pure Electric Vehicles (PEV), they entered this field later.

At the same time, internet companies as the parent company of emerging new energy vehicle brands, there is much more in China obviously. In other countries, only one emerging new energy vehicle brand Tesla, has become the main force. As for Tesla, Nio and other emerging new energy vehicle companies, they are constantly reforming and innovating their business models, integrating and utilizing advantageous resources in the industry, and actively expanding brand marketing and sales channels by using the thinking of "Internet +" ("Internet +" means that combine the internet and the traditional industries). For example, as a global leader in New Energy Vehicles (NEV), Tesla has created value alliances and integrated industry resources. Learn from Apple's marketing model, through Musk's, the CEO of Tesla, various active

publicity, publishing books and so on, to establish the "offline experience store + online ordering" sales model. In contrast, the representative of the Chinese new energy vehicle company, NIO tries community marketing. In the community, users can obtain points through novice tasks, daily check-in, submission of comments, publishing pictures and texts, and 100 points =10 Yuan. Moreover, the NIO owner can get points by using the car, inviting friends to test drive and picking up the car. Thus it can be seen that NIO pays more attention to the contribution degree of users to the community. Users can obtain NIO points through community interaction, community development, efficiency improvement, special contribution and other ways. Users with higher NIO value will have a greater say in major events of NIO, including the voting bonus of major community events. So that the product update faster, more to meet the needs of the majority of users.

2.3.2. Comparison of policies

Governments of different countries have established clear policy to give the development direction. The government has not only made provisions of the R&D and promotion priorities for the current automotive industry, but also made policy guidelines and development plans for the development direction of the automotive industry in the next few years. Guide enterprises to take the development of New Energy Vehicles (NEV) as the future development direction. The government has adopted the government-led, enterprises and scientific research institutions to jointly promote the R&D mode of New Energy Vehicles (NEV). Chinese system concentrates resources from all sides to develop important new energy vehicles projects, and has a greater advantage in the organization aspect of technology R&D alliances compared with other countries. And giving priority to the improvement of supporting facilities is obviously. Therefore, China, Japan and the United States all know clearly that in order to popularize New Energy Vehicles (NEV), charging stations and other supporting facilities should go first, which is the most basic and crucial step in the development of New Energy Vehicles (NEV). And both adopt

fiscal subsidies and tax reduction and other measures to expand and develop their own markets. To gradually replace ordinary cars, consumers need to get a higher cost performance ratio than ordinary cars. At present, when the technological development is not perfect, financial subsidies and tax incentives are effective means to encourage consumers to choose New Energy Vehicles (NEV).

However, with the exception of China, the subsidy policies of other countries have gradually increased the subsidy amount. But starting in 2022, China has been gradually reducing the amount of subsidies. At present, New Energy Vehicles (NEV) have formed a large-scale market in China, and there are still a large number of consumers choosing New Energy Vehicles (NEV) even when the reduced subsidy.

Therefore, it is of great significance to study Chinese new energy vehicle market, as the largest single market of New Energy Vehicles (NEV). Research on the competitiveness of Chinese New Energy Vehicles (NEV) in China and the world can better understand the development of New Energy Vehicles (NEV).

3. Analysis of competitiveness of Chinese new energy vehicle companies

As an important link in international trade, the proportion of New Energy Vehicles (NEV) in international trade can show the competitiveness of Chinese new energy vehicle companies. Through the international trade data of China, Europe, the United States and Japan in the international market, the competitiveness of Chinese new energy vehicle companies can be analyzed. At the same time, SWOT model is used to analyze and understand competitiveness of Chinese new energy vehicle companies.

Then, the factor is used to calculate the total productivity of representative enterprises in China[35], the United States, Europe and Japan in the field of New Energy Vehicles (NEV) for analysis. Finally, by comparing the number of patents for technological innovation in each country, in order to analyze the scientific and technological innovation capacity of each country.

3.1. Analysis of World Trade

During this part, we use the internationally universal six-digit code -- The Harmonization System Code (HS code) to classify the New Energy Vehicles (NEV). The New Energy Vehicles (NEV) for passengers include plug-in gasoline hybrid vehicles for passengers (870360), plug-in diesel hybrid vehicles for passengers (870370) and Pure Electric Vehicles (PEV) (870380). New energy commercial vehicles include diesel hybrid bus (870220), gasoline hybrid bus (870230) and pure electric bus (870240). Since the HS code has a separate code for New Energy Vehicles (NEV) in 2017, and the data of 2021 are not statistically collected in China. Therefore, this paper analyzes international trade data from 2017 to 2019. Using the data provided by UN Comtrade database, to analyze the market share and the trade competitiveness index for China, the United States, the European and Japan of New Energy Vehicles (NEV) separately.

3.1.1. The international market share

3.1.1.1 The IMS of New Energy Vehicles

The international market share (IMS) means that the share of sales of a country's products in the international market. The formula is $IMS_{ij}=X_{ij}/X_{wj}$. In this formula, IMS_{ij} represents the international market share of product 'j' in country 'i', X_{ij} is the export value of product 'j' in country 'i', X_{wj} is the total export value of product 'j' in the world[36].

$$IMS_{ij}=X_{ij}/X_{wj}$$

As shown in Figure 7, in the field of New Energy Vehicles (NEV), the IMS index of China is relative lower, although it is only 1.66% in China in 2017, in 2019 it reaches at 5.94% and in 2020 it reaches at 5.70%. The increment is about 70% with an obvious improvement, it shows an overall upward trend. In the overall field of the New Energy Vehicles (NEV), the United States and the European Union are in a leading position. The European Union's performance is relatively stable, with its IMS index holding at 23%. However, there is a sharp decline of IMS index in United States in 2019, from 24.20% in 2017 to 7.50% in 2019, only a little improvement in 2020 reaches at 12.67%. In contrast, IMS in Japan shows an overall downward trend, from 12.92% in 2017 to 7.79% in 2020, only a little bounce in 2019 reaches at top 16.96%.

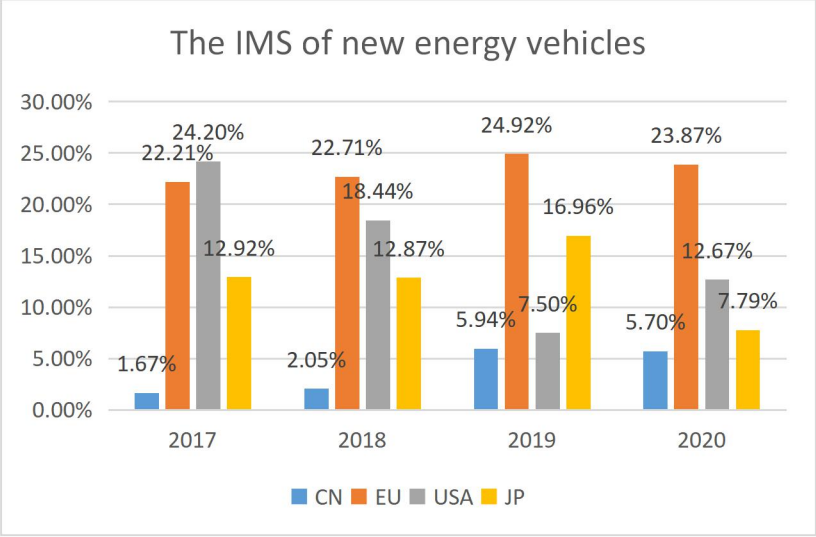

Figure 7. The IMS of New Energy Vehicles (NEV)

3.1.1.2 The IMS of new energy passenger vehicle

As shown in Figure 8, in the new energy passenger vehicle, the trade share account for about 95% of the overall trade share. In the New Energy Vehicles (NEV) for passengers IMS, the trend of the share of each country is almost same as the New Energy Vehicles (NEV) IMS. But the New Energy Vehicles (NEV) for passengers in China still maintain a good growth, from 1.27% in 2017 to 3.64% in 2020, the increment is about 70% with an obvious improvement. In the overall field of the New Energy Vehicles (NEV), the United States and the European Union are in a leading position, and the European Union's performance is relatively stable, both at about 23%. However, there is a sharp decline in United States in 2019, from 24.65% in 2017 to 7.41% in 2019, only a little improvement in 2020 reaches at 12.88%. In contrast, the IMS in Japan shows an overall downward trend, from 13.20% in 2017 to 8.18% in 2020, only a little bounce in 2019 reaches at the top 18.38%.

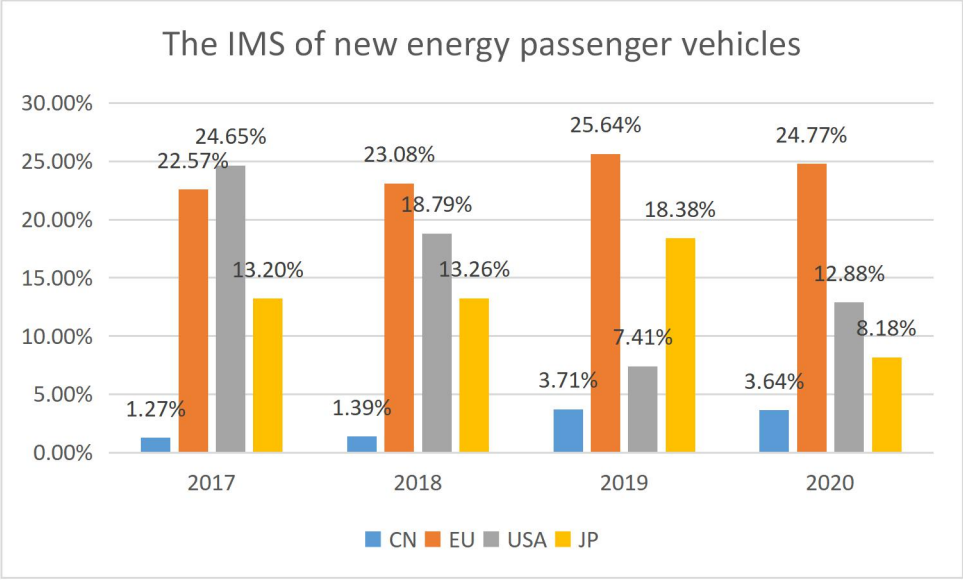

Figure 8. The IMS of new energy passenger vehicle

3.1.1.3 The IMS of new energy commercial vehicles

As shown in Figure 9, in the new energy commercial vehicles, China has been in an absolute leading position in the international market. In china, the IMS indexes of new energy commercial vehicles from 2017 to 2020 are 19.75%, 23.89%, 32.53% and 46.85% respectively. There is a large and steady increasing every year, with an average annual growth rate of up to 28%. In 2020, the new energy commercial vehicles in China have occupied nearly 50% of the export market, especially BYD, as an important brand of Chinese new energy vehicle company, has occupied the position of ferries in various international airports, and also public transportation in some cities (ex. Buses in Turin). Of course, the IMS indexes of new energy commercial vehicles is also a steady increasing every year in the United States, but generally it is relatively low and its growth is not obvious, and the market shares are 3.85%, 6.98%, 8.58% and 8.68% from 2017 to 2020. For the European Union, the IMS indexes of new energy commercial vehicles is a obvious growth from 2017 to 2019, from 5.81% to 16.33%, but decreases back 6.09% in 2020. But, the new energy commercial vehicles in Japan represent not so well, the market share is almost zero for every year.

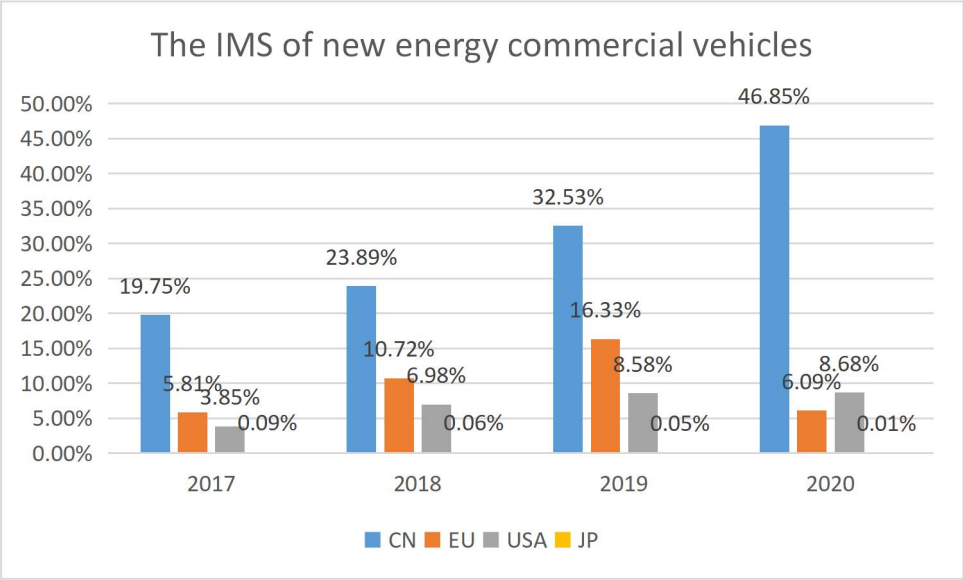

Figure 9. The IMS of new energy commercial vehicles

3.1.2. Trade Competitiveness index

The Trade Competitiveness Index (TC) represents the proportion of a country's import and export trade balance in total import and export trade, to indicate whether a product in a country is an import or export and its relative size[36, 37]. It is one of the commonly used measurement indexes in the analysis of international competitiveness[38]. The formula is $\boldsymbol{TC_{ij}=(X_{ij}-I_{ij})/(X_{ij}+I_{ij})}$. TC_{ij} is the trade index of product 'j' in country 'i', X_{ij} and I_{ij} are the total amount of export and import of product 'j' in country 'i' respectively. If $TC_{ij}=-1$, it means that the kind of product is pure import. If $-1<TC_{ij}<0$, it means that the kind of product is a net import. If $TC_{ij}=0$, it means that the import and export of the kind of product are the same. If $0<TC_{ij}<1$, it means that the kind of product is a net export. If $TC_{ij}=1$, it means the kind of product is pure export. So we can find the TC_{ij} is much closer to 0, the competitiveness is much closer to the average level. As the same, the TC_{ij} is much closer to -1, the export competitiveness of the kind of product is much weaker; the TC_{ij} is much closer to 1, the export competitiveness of the kind of product is much stronger.

$$\boldsymbol{TC_{ij}=(X_{ij}-I_{ij})/(X_{ij}+I_{ij})}$$

3.1.2.1 The TC of New Energy Vehicles (NEV)

As shown in Figure 10, in general, China has been relatively dependent on imports, but the trend of the difference between the exports and imports are more and more small. From -0.73 in 2017 to -0.09 in 2020. At the same time, it should be considered that China as the world's largest single market for New Energy Vehicles (NEV), the output of New Energy Vehicles (NEV) usually cannot fully meet domestic demand, so the long-term imports are needed. And lots of new energy vehicle companies are established by the internet business companies. Due to their international visibility is not well, resulting the export volume of New Energy Vehicles (NEV) is small. The TC_{ij} of European Union and the United States are smaller than 0 from 2019, it means

that the European Union and the United States began to import a large number of foreign New Energy Vehicles (NEV) in 2019, which is related to their local policies. Japan has the strongest export competitiveness due to its low demand for automobiles, from 2017 to 2019, the TC_{ij} are about 0.80. Only a little decrease in 2020 reaches at 0.44, but still as a export status.

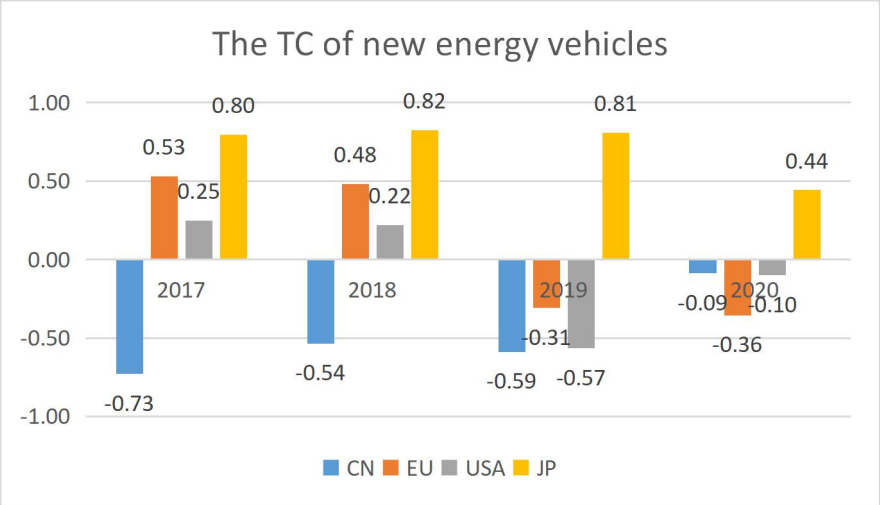

Figure 10. The TC of New Energy Vehicles (NEV)

3.1.2.2 The TC of new energy passenger vehicles

From the new energy passenger vehicle point of view, the tendency is similar with the total new energy vehicle. As shown in the Figure 11. China has been also relatively dependent on imports. And Japan remains the most competitive country.

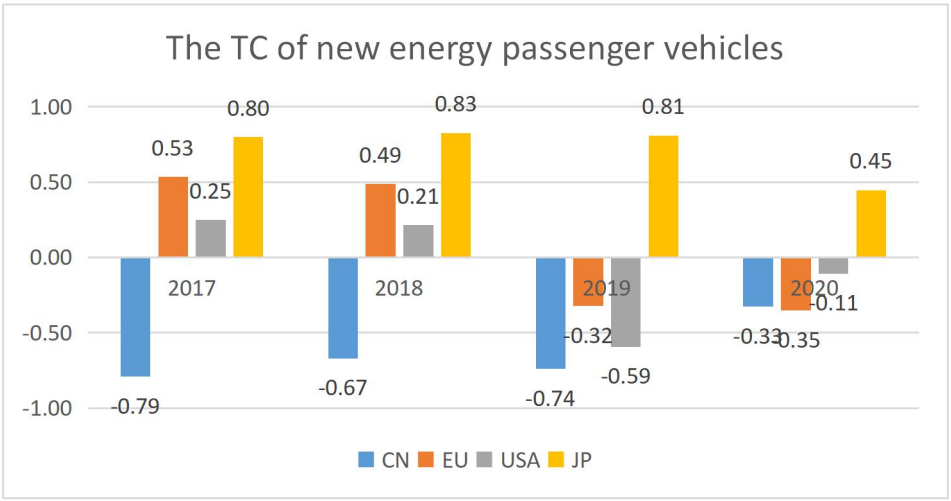

Figure 11. The TC of new energy passenger vehicles

3.1.2.3 The TC of new energy commercial vehicles

As shown in the Figure 12. In terms of the new energy commercial vehicles, China is unique. From 2017 to 2020, the TC_{ij} is almost equal to 1 every year. The export in China occupies an absolute advantage. Due to the leading advantage of Chinese new energy commercial vehicles in the world, almost all of the new energy commercial vehicles are made in China. However, from 2017 to 2020, the TC_{ij} are about -0.80 every year in Japan, it means that Japan has not made a significant breakthrough in development of the new energy commercial vehicles, and should imports to balance the demand for a long time. For the European Union, we can find from 2017 to 2019, the TC_{ij} is closer to 0 every year, the exports and imports are a balanced status. Due to the environmental pollution and other reasons, the EU imported a large number of new energy commercial vehicles, the TC_{ij} reaches at -0.50. For the United states, TC_{ij} is 0.68 and 0.85 in 2017 and 2018 separately, it means that the exports are predominance in these two years. However there is a sharp decrease in 2019, TC_{ij} reaches at 0.24, and reaches at 0.16 in 2020, the exports and imports are a balanced status. The demand for new energy commercial vehicles in the United States is obviously lower than that in other countries due to its large national territorial area and sparse population and high per capita vehicle ownership.

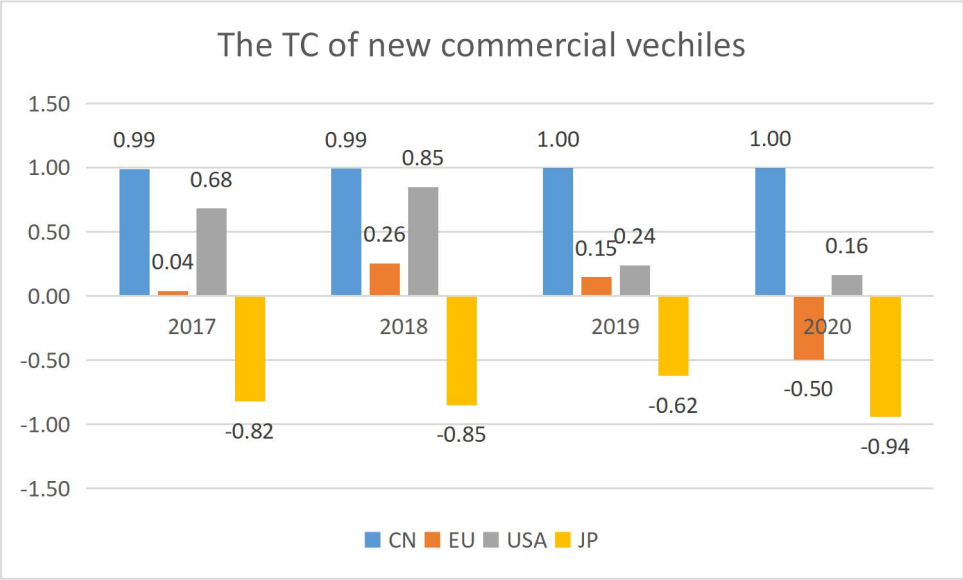

Figure 12. The TC of new energy commercial vehicles

It can be seen that the New Energy Vehicles (NEV) in China have absolute leading advantages in the field of commercial vehicles, while new energy passenger vehicles still have certain disadvantages in the export. The main reason is the low brand awareness of New Energy Vehicles (NEV). Although they have strong product strength, most of them are established by internet business companies, so they are not known in detail internationally. For exports, the most important thing for Chinese New Energy Vehicles (NEV) is to carry out publicity.

3.2. SWOT analysis

SWOT analysis approach is based on the situation analysis of internal and external competitive environment and conditions[39, 40]. It is to list the main internal Strengths, Weaknesses and external Opportunities and Threats which are closely related to the research object through investigation, and according to matrix form, to analyze in a systematic way, then the various factors are matched and analyzed, from which a series of corresponding conclusions can be drawn, and the conclusions are usually decisive effect. By using this approach, it can conduct comprehensive, systematic and accurate research on the situation of the research object, so as to formulate corresponding development strategies, plans and countermeasures according to the research results.

SWOT analysis approach, in a sense, belongs to the internal analysis method of the company, that is, according to the company’s own conditions within the given analysis. Of course, there is the foundation of SWOT analysis[41, 42]. A kind of competition theory proposed by Michael Porter, a famous competitive strategy expert, makes a thorough analysis and explanation of what a company "can do" from the perspective of industrial structure, however, competency-based management scientist use value chain to deconstruct the value creation process of enterprises and pay attention to the analysis of the company's resources and capabilities.

As the same, for the New Energy Vehicles (NEV), SWOT analysis can effectively analyze and study the existing state, so as to formulate the corresponding development strategy according to the research decision.

According to the SWOT method, we first identified several factors that are most important to Chinese New Energy Vehicles (NEV), and proposed different development modes based on SO (Strength-Opportunity), ST (Strength-Threats), WO (Weak-Opportunity) and WT (Weak-Threats) respectively. As shown in the Figure 13.

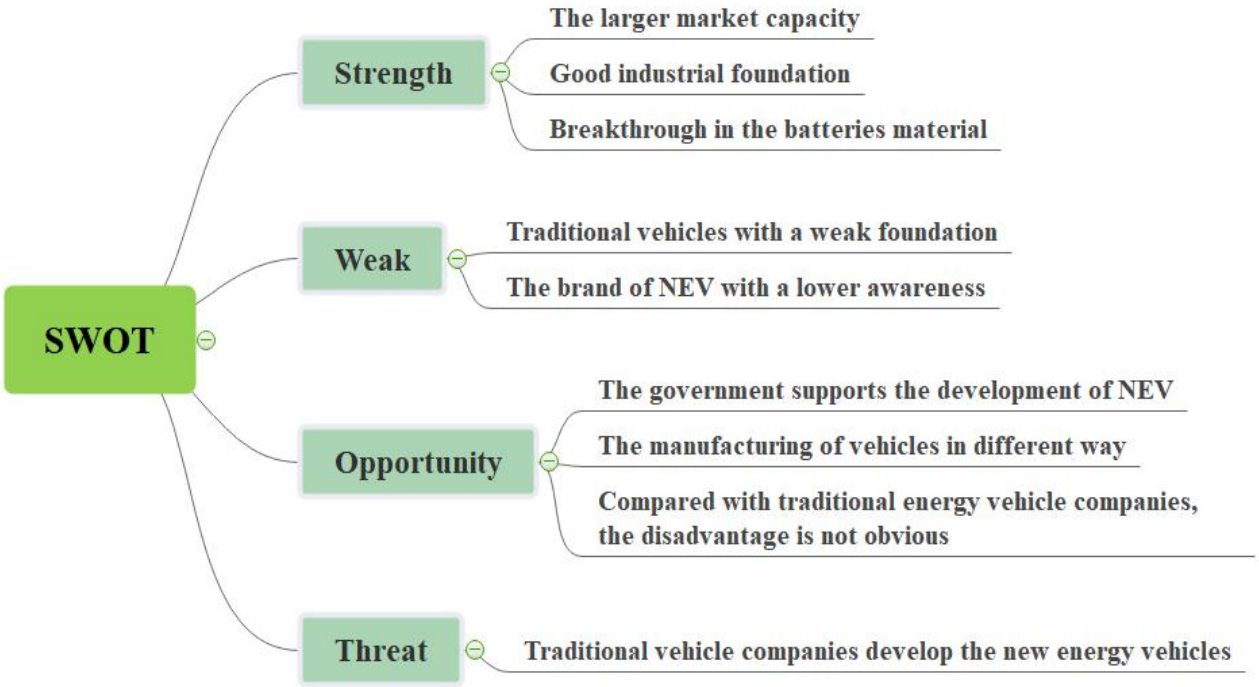

Figure 13. SWOT

In this case, we analyse each aspect below.

3.2.1. Strength

3.2.1.1 The larger market capacity

As one of the largest single economies in the world, China has the advantage of vast geographical areas. Due to the improvement of residents' living standards, the demand for vehicles has been on the rise in recent years. Since 2018, more than 1 million vehicles have been sold annually for three consecutive years in China. By 2020, the holding volume of the New Energy Vehicles (NEV) in China has reached 4.92 million, accounting for 50.5% of the global holding volume. In this case, there was the largest number of the New Energy Vehicles (NEV) in China. In 2021, 26.08 million vehicles were sold in China, with a 169% increase from 2020. The huge market means the huge demand in China, which will effectively promote the development of Chinese new energy vehicle companies.

3.2.1.2 Good industrial foundation

As the largest industrial producer in the world, China stay a very important position in the industry chain of the New Energy Vehicles (NEV). Thanks to the excellent industrial base in China, there was more than 550,000 public charging piles in China by 2021, including 200,000 super charging piles. In the world, there is the largest number of charging piles in China.

In terms of batteries, China has a leading position thanks to an excellent upstream and downstream industrial chain. Lithium-ion batteries mainly include positive pole, negative pole, battery electrolyte and battery additives and so on, and China has all the manufacturers related to batteries. And there are all kinds of manufacturers in China. Lithium hexafluorophosphate, as one of the most important electrolyte materials in lithium ion batteries, it is already mass production. Tinci new material phosphoric acid and Anhydrous Hydrogen Fluoride (AHF) direct reaction synthesis

method as the world's most advanced process, it has helped Tinci complete the breakthrough from the catch-up to the leader. Dimethyl Carbonate (DMC), Ethylene Carbonate (EC) and Vinyl Carbonate (VC) as solvents and additives for electrolytes have been produced on a large scale in China. In the field of battery materials, there is the advantages in cost and quality in China which we compared with other countries.

In terms of the electric driving motors, China has achieved independent R&D of electric driving motors. Among the electric driving motors, permanent magnet motors are the main R&D direction of Chinese companies, of course thanks to the abundant rare earth resources in China. As one of the earliest new energy vehicle company in China, BYD has invested heavily in electric motor R&D. Its independent R&D of permanent magnet synchronous motor, performance has reached the international advanced level in which the volume is smaller than the AC asynchronous motor obviously. At present, the efficiency of the third generation permanent magnet synchronous motor has reached 96%, and it is significantly improved compared with of AC asynchronous motor which the efficiency is 80% to 90%.

3.2.1.3 Breakthrough in the batteries material

At present, there are two main types of batteries used in New Energy Vehicles (NEV), ternary lithium batteries and lithium iron phosphate batteries. Ternary lithium battery occupies a major position in New Energy Vehicles (NEV) due to its advantages of wide temperature range and high energy density. The lithium iron phosphate battery still has a place in the automotive field which pays attention to safety due to its strong stability. With the development of science and technology, Chinese enterprises have achieved mass production of graphene batteries. In July 2016, Dongxu launched the world's first graphene-based lithium ion battery. Graphene batteries have attracted the attention of the new energy vehicle industry due to their characteristics of fast charging speed, wide temperature tolerance range and high battery cycle life. In 2021, GAC Group announced that the whole vehicle of graphene battery had entered the test

run and mass production test. However, due to its high cost, it has not been put on the market. As the first country with graphene battery production capacity, China is still in the lead in graphene battery R&D.

3.2.2. Weakness

3.2.2.1 Traditional vehicles with a weak foundation

There is no denying that in the field of traditional fuel vehicles, western countries with first-mover advantage and technological accumulation have created an advantage that China cannot surpass. Although Chinese major vehicle manufacturers are struggling to catch up, they still needs a period of time to catch up with western countries in the foreseeable future. Specifically reflected in the vehicle suspension tuning, Chinese enterprises are still unable to achieve a higher level.

3.2.2.2 The brand of new energy vehicle with a lower popularity

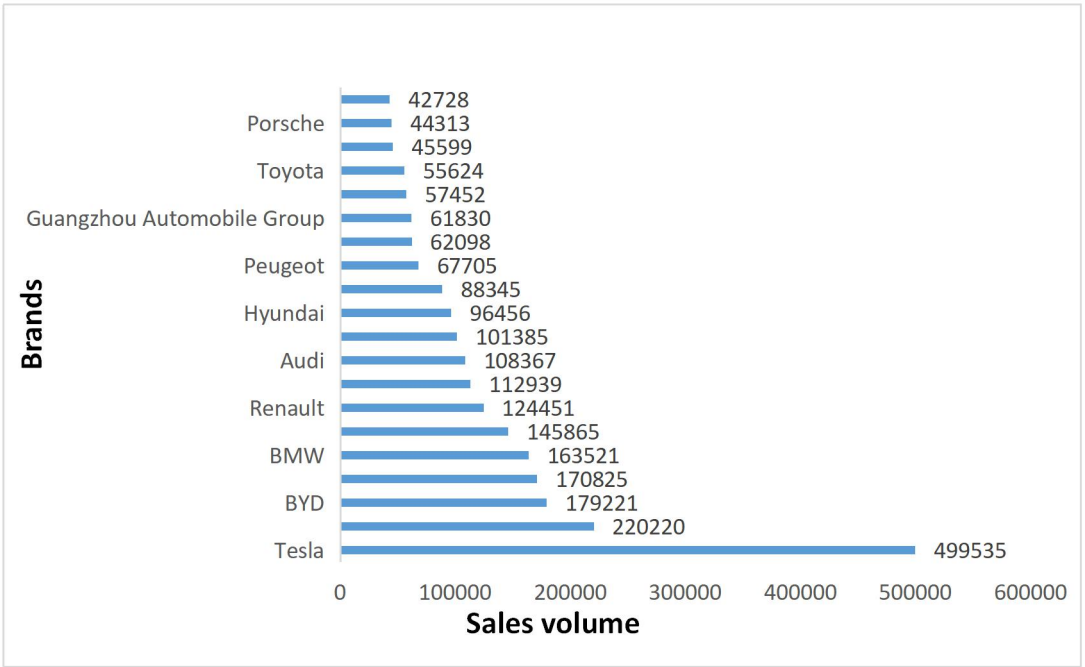

Figure 14. The top 20 global sales volume of New Energy Vehicles (NEV) in 2020

Figure 14 shows the top 20 global sales volume of New Energy Vehicles (NEV) in 2020, among which six are Chinese independent brands. But with the exception of BYD, most of the other brands' sales come from China. In the world, Chinese new energy brands are not well known. As the largest new energy vehicle market in the world, domestic competition is the most intense. In this competition, four Chinese independent brands in New Energy Vehicles (NEV) have surpassed Toyota, which once had the highest sales volume of traditional vehicles. Even NiO, a new company founded in 2014, has jumped into the top 20 global sales volume in the world. In July 2021, NIO passed the European Whole Vehicle Type Approval (EWVTA) and began to enter the European market. It indicates that the product of Chinese New Energy Vehicles (NEV). However, in terms of popularity, Chinese New Energy Vehicles (NEV) still need time to settle and good feedback from customers.

Chinese New Energy Vehicles (NEV) have low brand influence in the international market. Due to a large number of buses with BYD New Energy Vehicles, so only BYD has a certain influence in the world. Although the sales of other brands have reached a high level, but their sales are mainly concentrated in China and they are not well known in the world.

3.2.3. Opportunity

3.2.3.1 The government supports the development of New Energy Vehicles (NEV)

The government in China has been providing financial subsidies for the sales and production of New Energy Vehicles (NEV), but with the development of New Energy Vehicles (NEV), the amount of subsidies has decreased. The purchase tax deduction will be reduced from 10% to 5%. While subsidies will continue in 2022, the standard of subsidy for New Energy Vehicles (NEV) in this year was lowered by 30% from 2021. That is to say, the Pure Electric Vehicles (PEV) with subsidies before which according to the New Vehicles Driving Cycle (NEDC), will get 3,900 yuan or 5,400

yuan less subsidies. For ordinary the Pure Electric Vehicles (PEV) which the price less than 300,000 yuan and New Vehicles Driving Cycle (NEDC) less than 400 kilometers, for example, the maximum amount of new energy subsidies will be 18,000 yuan in 2021, while the amount will be reduced to 12,600 yuan in 2022. And in this year, when the New Vehicles Driving Cycle (NEDC) between 300km and 400km, the maximum of subsidy is 9100 yuan for the Pure Electric Vehicles (PEV) and 4800 yuan for the Plug-in Hybride Electric Vehicles (PHEV). But compared with traditional fuel vehicles, which cannot enjoy subsidies, the New Energy Vehicles (NEV) still have the opportunity to continue to develop.

3.2.3.2 The manufacturing of vehicles in different way

Because of the New Energy Vehicles (NEV), especially Pure Electric Vehicles (PEV), the driving form is different from that of traditional energy vehicles. Since the motor's torque output can reach high levels at low speeds, and that the speeds can reach 20,000 RPM, and another important thing is that the motor can be directly connected to the wheels, so we are able to eliminating the gearbox. While the torque output of traditional energy vehicles increases with the increase of speed. Even many turbo combustion engines can reach peak torque at around 1500-2000 RPM, but the overall peak speed is low, so the existence of a gearbox is necessary. (Ex. W264 in Mercedes E300L, maximum torque output 370Nm in 1800-4000rpm. EA888 in Audi A6L 45TFSI, maximum torque output 350Nm in 1600-4500rpm. B48B20D in BMW 530Li, maximum torque output 350Nm in 1400-5000rpm). Therefore, there is a big gap between New Energy Vehicles (NEV) and traditional energy vehicles.

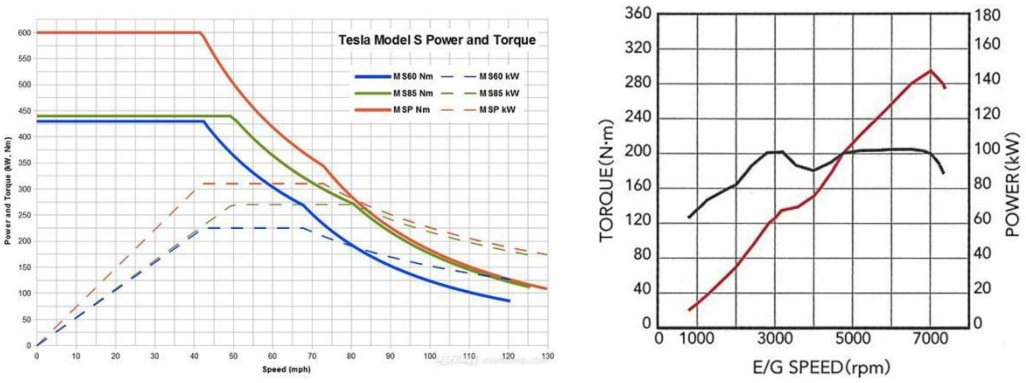

Figure 15. The different power and torque curve of Electronic and traditional motor

As the left of the Figure 15 shown, for Tesla model S, the maximum torque output from beginning, after 40 mph, the torque output decreases. From the right of Figure 15, it is shown that the torque output of tradition energy vehicles are increases with the increase of speed. It also confirms the previous point.

So for the New Energy Vehicles (NEV), we can adopt more radical chassis design, such as skateboard chassis. It is shown in the Figure 16 in below. The skateboard chassis features that the body and the chassis are separated. And the chassis is basically flat, which can apply the telex technology originally belonging to the aviation field to turn the steering, braking and acceleration of traditional energy vehicles into telex signals, it is strongly saving space. Of course the exterior design of the vehicles can be more flexible, and the design of aerodynamic can be further improved, in order to improving the vehicle performance and saving energy.

Figure 16. The skateboard chassis

Nio, which was founded in 2014, has been developing new technologies. In order to realize its proposed battery replacement scheme, the chassis has been completely new design. As shown in the Figure 17.

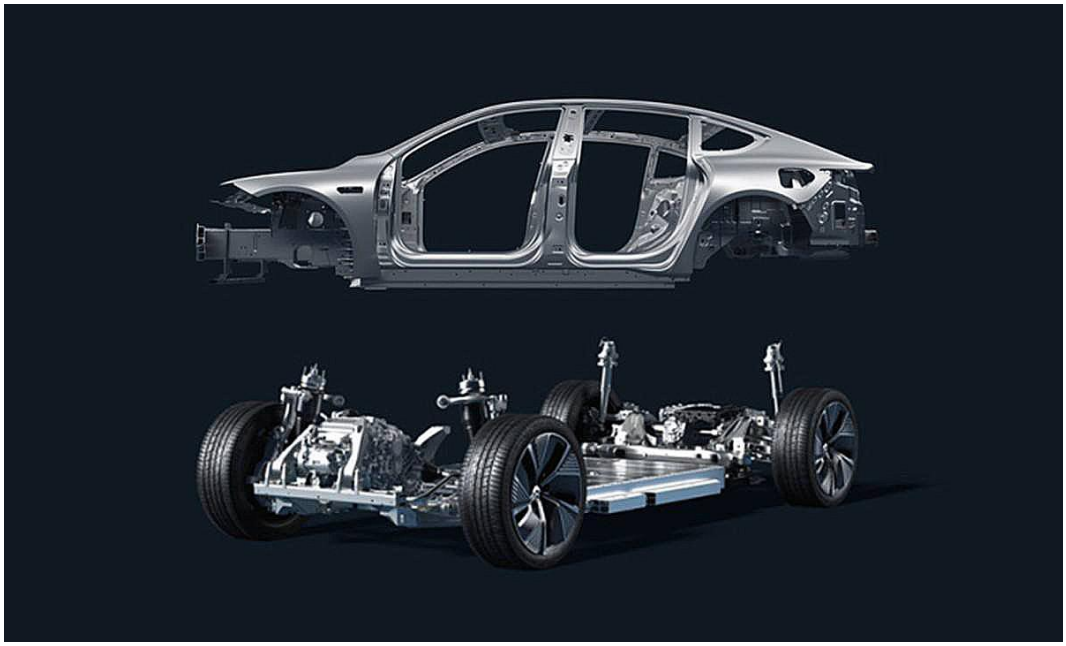

Figure 17. The replacement chassis by Nio

In general, the way that the New Energy Vehicles (NEV) are manufacturing is completely different from traditional ones, in addition to the chassis, there is much more room in cabin for driver and passengers. This allows for more luxurious features and configurations, such as the bigger screen for operating, front or rear seats with massage, air suspension and so on. It is a huge opportunity for Chinese new energy vehicle companies to innovate and gain advantages in various fields.

3.2.3.3 Compared with traditional energy vehicle companies, the disadvantage is not obvious.

Due to the different ways of building the New Energy Vehicles (NEV), traditional energy vehicles companies and new vehicle companies are at the same level in the design and production of New Energy Vehicles (NEV), but there is a big gap in the suspension tuning and some other aspects. At present, traditional energy vehicles companies still keep the design concept of traditional energy vehicles in the manufacturing process of the New Energy Vehicles (NEV). And so, a large number of New Energy Vehicles (NEV) manufactured by traditional vehicle companies are reformed on the basis of traditional energy vehicles. For this kind of the traditional vehicle companies, the manufacturing concept of the vehicles generally lags behind the emerging new energy vehicle companies. In the field of traditional energy vehicles companies in China, the lag behind is obviously, but now, in the field of the new energy vehicles companies, the R&D are almost same level.

3.2.4. Threats

3.2.4.1 Traditional energy vehicles companies develop the New Energy Vehicles.

There are a large amount of data and experience in the traditional energy companies which are gained by technology accumulation and practice. This is still a huge challenge for the emerging Chinese new energy vehicle companies. As we know,

there are hundreds of years for traditional vehicles companies, it is more stable than new energy vehicle companies which with only a few years of development background. Once the traditional vehicles companies begin to change the design concept and redesign the body structure for the New Energy Vehicles (NEV), it will be both a challenge and an opportunity for emerging Chinese new energy vehicle companies. Whether the New Energy Vehicles (NEV) verified in the Chinese market can break through the New Energy Vehicles (NEV) manufactured by traditional car companies will be an important contradiction in the future.

3.3. Factor analysis

After SWOT analysis, the indicators are classified and factor analysis is carried out [33], which can better quantify the competitiveness of Chinese New Energy Vehicles (NEV). The index of NEV is shown in the Table 2.

Table 2. The index of NEV

1st index	2nd index		Unit
Strength	Sales volume of the New Energy Vehicles (NEV)	S1	10 thousands vehicles
	Production level of supporting industries	S2	10 thousands dollars/person
	Vehicles ownership per thousand people	S3	vehicles
	Transaction size of auto parts	S4	A hundred million dollars
	Supporting facilities of public charging piles	S5	/10 thousands people
	labor resources	S6	10 million people

Weak	Value of trade of vehicles	W1	10 thousands dollars
	The new energy vehicle share	W2	%
Opportunity	Governments supports	O1	
	Ability of independent innovation	O2	%
Threat	Average rate of profit of New Energy Vehicles (NEV)	T1	%
	Economic scale of companies	T2	10 thousands vehicles

3.3.1. The factor meaning and data sources

S1: Sales volume of New Energy Vehicles (NEV). According to the market conditions of each country, the unit is ten thousand. The data source is from the country data released by China Association of Automobile Manufacturers in 2021.

S2: Supporting industrial production level. The national labor productivity is able to calculate by the GDP in each country divided by the number of labor force. For the automobile industry, because of its strong correlation, the report uses average labor productivity. The data comes from country data published by the World Bank in 2019.

S3: Vehicles ownership per thousand people. The data is from China Industry Information Network in 2020.

S4: The transaction size of auto parts, data is from all goods export data starting with 8703 in UN Comtrade HS code.

S5: Supporting facilities of public charging piles. It is calculated by the total number of public charging piles in China divided by the number of working population in China. The data is from the World Bank database.

S6: Labor resource refers to the total labor force of each country. The data source is data released by the World Bank in each country in 2019.

W1: Auto trade volume, data from all goods export data starting with 8703 in UN Comtrade HS code.

W2: The new energy vehicle share, for the international market share mentioned above. Here, it is shown the HS code from UN comtrade again. The New Energy Vehicles (NEV) for passengers include plug-in gasoline hybrid vehicles for passengers (870360), plug-in diesel hybrid vehicles for passengers (870370) and Pure Electric Vehicles (PEV) (870380). New energy commercial vehicles include diesel hybrid bus (870220), gasoline hybrid bus (870230) and battery electric bus (870240).

O1: Governments supports. It is a qualitative indicator, and the data comes from the fixed value of this direction in different papers and the discussion within the group.

O2: Ability of independent innovation. In sales volume, the share of the R&D investment. In sales, the investment of R&D is accounted in percentage (%). The data selected for this thesis are: BYD, Geely and SAIC are Chinese manufacturers; Tesla, Ford and GM are American manufacturers; Toyota, Nissan and Honda are Japanese manufacturers; BMW, Volkswagen and Daimler are European manufacturers. The data is from the internet, and using in each company in 2019.

T1: Average rate of profit of the New Energy Vehicles (NEV). It adopts the average profit margin of different New Energy Vehicles (NEV) in various countries. The data selected for this thesis are: BYD, Geely and SAIC are Chinese manufacturers; Tesla,

Ford and GM are American manufacturers; Toyota, Nissan and Honda are Japanese manufacturers; BMW, Volkswagen and Daimler are European manufacturers. The data is from the internet, and using in each company in 2019.

T2: Economic scale of companies. It is the economy scale that vehicle companies have when they produce. In this thesis, BYD is selected as a Chinese manufacturer; Tesla as an American manufacturer; BMW as a European manufacturer; Toyota as a Japanese manufacturer.

Table 3. The score of each index

	S1	S2	S3	S4	S5	S6	W1	W2	O1	O2	T1	T2
China	2148	1.6	201	455.6	4.7	99.2	243.1	5.70	8.1	7.74	4.0	22.3
US	1494	10.0	818	356.4	2.8	21.4	546.8	12.67	8.1	9.2	4.2	22.4
EU	769	8.2	631	638.3	7.1	5.3	1496	23.87	8.6	9.1	4.0	14.2
Japan	444	7.1	625	325.3	4.2	7.6	855.4	7.79	8.7	8.7	4.0	5.0

3.3.2. Test the applicability of factor analysis

Table 4. Test the applicability of factor analysis

			Pearson										
	M	SD	1	2	3	4	5	6	7	8	9	10	11	12
S1(1)	1213.75	761.945	1											
S2(2)	6.725	3.62	-0.582	1										
S3(3)	568.75	261.027	-0.578	0.993**	1									
S4(4)	443.9	141.009	-0.027	-0.068	-0.187	1								
S5(5)	4.7	1.791	-0.297	-0.148	-0.251	0.914	1							
S6(6)	33.375	44.456	0.89	-0.886	-0.873	-0.031	-0.133	1						
W1(7)	785.325	535.684	-0.77	0.528	0.448	0.637	0.738	-0.764	1					
W2(8)	12.508	8.118	-0.417	0.572	0.47	0.779	0.672	-0.598	0.874	1				
O1(9)	8.375	0.32	-0.935	0.277	0.259	0.192	0.523	-0.691	0.772	0.366	1			
O2(10)	8.685	0.666	-0.614	0.988*	0.964*	0.081	0.003	-0.905	0.641	0.688	0.338	1		
T1(11)	4.05	0.1	0.245	0.603	0.637	-0.414	-0.707	-0.18	-0.297	0.013	-0.573	0.516	1	
T2(12)	15.975	8.264	0.897	-0.202	-0.224	0.134	-0.247	0.61	-0.527	-0.052	-0.941	-0.216	0.518	1

* $p<0.05$ ** $p<0.01$

From the Table 4 as we can see, to analyse the correlation between S1 and S2, S3, S4, S5, S6, W1, W2, O1, O2, T1 and T2. Pearson correlation coefficient is used to indicate the strength of the correlation[43]. Specific analysis shows that: There is no significant difference between S1 and S2, S3, S4, S5, S6, W1, W2, O1, O2, T1 and T2. The correlation values are -0.582, -0.578, -0.027, -0.297, 0.890, -0.770, -0.417, -0.935, -0.614, 0.245, 0.897, all close to 0, and all P values are greater than 0.05. It means that S1 has no correlation with S2, S3, S4, S5, S6, W1, W2, O1, O2, T1 and T2. Therefore, factor analysis can be carried out to meet the requirements of factor analysis[44, 45].

3.3.3. Test of commonness

Table 5. Test of commonness

Factor	The percentage of explained variance (before the rotation)			The percentage of explained variance (after the rotation)		
	Value	%	Accumulation (%)	Value	%	Accumulation (%)
1	6.23	51.918	51.918	4.804	40.033	40.033
2	3.612	47.583	99.501	3.818	31.818	71.851
3	2.158	30.099	129.601	3.378	28.149	100
4	0	17.983	147.583	-	-	-

Factor extraction focuses on solving factors and matrices, it is based on sample data. This study uses the component model to extract the number of factors based on the cumulative variance and variance contribution rate of the original variable and common factor. In Table 5, it shows the analysis of the factor extraction and the information amount of factor extraction. It can be seen: factor analysis extracts a total of 3 factors with characteristic root values greater than 1. The variance explanation rate of these 3 factors after rotation is 40.033%,31.818% and 28.149% respectively, and the cumulative variance explanation rate after rotation is 100.0%.

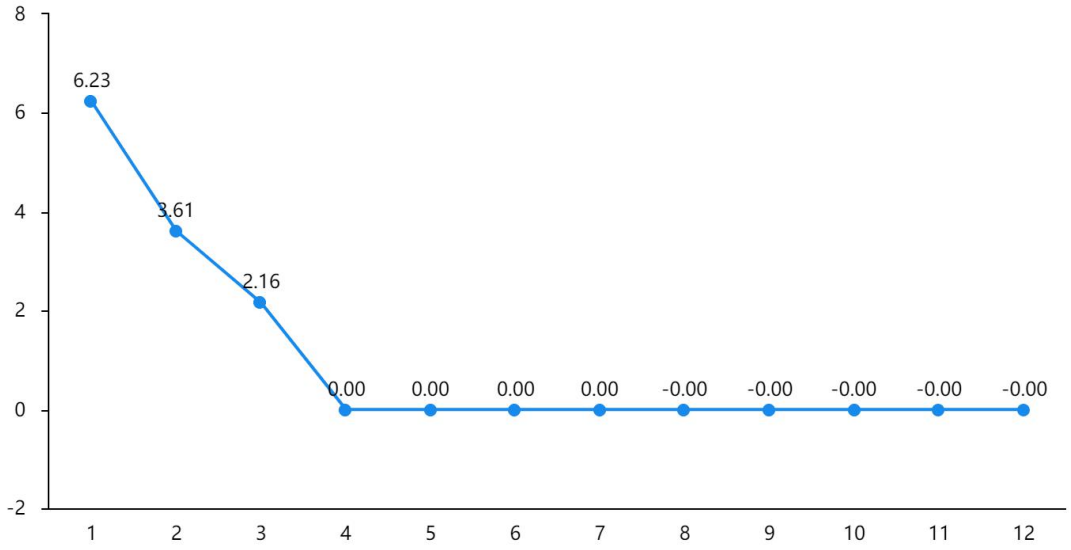

Figure 18. Scree map

Scree map is used to assist in judging the number of extracted factors. It is shown in Figure 18. When the broken line changes from steep to smooth suddenly, the number of factors corresponding to steep to smooth is the number of extracted reference factors. It can be seen from the analysis that the extraction of the three factors in this thesis is reasonable and scientific.

As shown in the Table 6, the data in this thesis are rotated using the maximum variance rotation method (VARImax) in order to find the corresponding relationship between factors and study items[46, 47]. The above tables show that the information extraction of factors for research items, as well as the corresponding relationship between factors and research items. And the common degree values corresponding to all research items are higher than 0.4, which means that there is a strong correlation between research items and factors, and information can be effectively extracted from factors.

Table 6. Factor loading (Rotated) Communality

Factor loading (Rotated) Communality

Coefficients

	Factor 1	Factor 2	Factor 3	Communality
S1	-0.456	0.88	-0.134	1
S2	0.989	-0.144	0.033	1
S3	0.983	-0.16	-0.087	1
S4	-0.091	0.074	0.993	1
S5	-0.225	-0.313	0.923	1
S6	-0.808	0.571	-0.147	1
W1	0.431	-0.542	0.721	1
W2	0.541	-0.066	0.838	1
O1	0.132	-0.952	0.276	1
O2	0.969	-0.168	0.182	1
T1	0.708	0.585	-0.395	1
T2	-0.061	0.997	0.055	1

3.3.4. Explanation of the meaning of extracted factors

Explanation of the first common factor: The first common factor includes S2 (Supporting industrial production level), S3 (Vehicles ownership per thousand people), and O2 (Ability of independent innovation). Their loads on the first common factor are 0.989, 0.983 and 0.969 respectively. It comprehensively reflects the driving force of the new energy vehicle market and defines it as a market factor.

Explanation of the second common factor: The second common factor includes S1 (Sales volume of New Energy Vehicles (NEV)),T2 (Economic scale of companies). Their loads on the second common factor are 0.88 and 0.997 respectively. This thesis mainly reflects the production scale of the industry and defines it as the size factor of the development of the industry.

Explanation of the third common factor: The third common factor includes S4 (The transaction size of auto parts), S5(Supporting facilities of public charging piles), and W2 (Auto trade volume). Their loads on the third factor are 0.993, 0.923 and 0.838, respectively. This thesis comprehensively reflects the supporting factors of New Energy Vehicles (NEV) and defines them as supporting factors

3.3.5. The score of each factor

SPSS is used to calculate the fraction of each sample of each common factor, to determine the competitiveness of New Energy Vehicles (NEV) in each country represented by the original sample of each common factor, in order to provide reasons for further analysis. The score of each factor is shown in the Table 7.

Table 7. The score of each factor

Matrix

Name	Market factor	Scale factor	Infrastructure factor
S1	-1.188	2	-3.125
S2	-6.5	0	-1.063
S3	-0.922	0.5	0.047
S4	3.063	-2.5	1.719
S5	-1.125	1	-1.219
S6	1.469	2.5	-0.063
W1	-0.625	-0.75	1.109
W2	0.656	-0.25	0
O1	3.438	0	-0.75
O2	-2.25	0	-1.5
T1	6.625	2	-1.375
T2	-1.5	-1	2.031

Market factor

=-1.188*S1-6.500*S2-0.922*S3+3.062*S4-1.125*S5+1.469*S6-0.625*W1+0.656*W2+3.438*O1-2.250*O2+6.625*T1-1.500*T2

Scale factor

=2.000*S10.000*S2+0.500*S3-2.500*S4+1.000*S5+2.500*S6-0.750*W1-0.250*W2 0.000*O10.000*O2+2.000*T1-1.000*T2

Infrastructure factor

=-3.125*S1-1.062*S2+0.047*S3+1.719*S4-1.219*S5-0.062*S6+1.109*W10.000*W2-0.750*O1-1.500*O2-1.375*T1+2.031*T2

And the synthesis score is calculated by summing which the product of the variance interpretation rate after rotation (normalization) and factor score. As shown in Table 8.

Table 8. The synthesis score of each factor

Country	Market factor	Scale factor	Infrastructure factor
China	1.55	4.45	7.34
US	-3.32	3.58	-3.93
EU	2.44	-6.86	-2.28
Japan	-0.67	-1.16	-1.13

the formula of aggregate score is

(40.033* score of factor 1 + 31.818*score of factor 2 + 28.149* score of factor 3)/100.000

finally is：0.400* score of factor 1 + 0.318* score of factor 2 + 0.281* score of factor3

Table 9. The total score of each country

Country	Score
China	4.79
US	-1.37
EU	-2.41
Japan	-1.01

As can be seen from the Table 9, China is the number one with the score 4.79, it indicates that under the current environment, Chinese New Energy Vehicles (NEV) have certain competitiveness in the international arena, and the main scoring item is the supporting factor. China has made great efforts in policy implementation and the number of charging piles. At the same time, the excellent industrial chain system provides greater development space for Chinese New Energy Vehicles (NEV).

3.4. Scientific and technological innovation

3.4.1. Connected car

Connected car is also called "car on the internet", it is the new definition of a car, powered by an intelligent operating system, this system provides the car with a second engine. It allows cars to run on the road and the internet at the same time. For this kind of vehicles, the internet becomes the infrastructure, the intelligent operating system cover whole vehicle, and data can be exchanged in the cloud[48, 49]. The car on the internet includes intelligent vehicles, electric vehicles and autonomous vehicles. At present, lots of internet companies become a member in the automotive field based on their own advantages[50]. In the whole new energy vehicle industry from 2011 to 2020, there were 897 investment and financing events of new energy vehicle brands, and the amount of investment and financing was disclosed as 384.11 billion yuan. According to incomplete statistics, from 2014 to 2020, NIO has financing exceeded 5 billion dollars; Xiaopeng financing exceeded 35 billion yuan; Leading Ideal financing exceeded 22 billion yuan. The car on the internet companies get huge financing.

Figure 19. The operated system in Tesla

The system is operated by a large screen in Tesla on the Figure 19 as we can see. It is the first time which appear on the connected car. After that, the operating system with large screen appears on the Chinese New Energy Vehicles (NEV), and it becomes a kind of standard. The large touch screen provides more interactive ways and functions, it allows which with the large screen to perform much more functions that traditional energy vehicles cannot, such as watching videos and playing games.

On the basis of the existing large screen interaction, Chinese new energy vehicle companies are the first time to put forward connecting-screen, it increases the possibility of human-computer interaction. It is more easily to operate and set for driver, and other passengers are able to enjoy the time by connecting-screen especially the front passenger. At present, the most commonly distribution mode of the connecting-screen is three parts. As shown in the Figure 20. The first one which in the front of the driver shows the conventional information, such as speed, total mileages, fuel consumption and so on. It is similar with the dash board of the traditional vehicles. The middle part is used to show some functions of the vehicles, driver is able to operate and set up the vehicle here, such as the air conditioning system, seat ventilation and heating. The another one is in the front of the front passenger, it mainly used as an entertainment screen, providing video, games and other functions. It can be seen that the connecting-screen design has realized the diversity of functions

and the readability of information. Compared with single middle screen on Tesla, the connecting-screen size is greatly increased and the function partition is more reasonable. At the same time, the important information such as speed is displayed as a separate screen which in the front of the driver, it can effectively avoid distraction caused by the driver looking for useful information in numerous information.

Figure 20. The operated system in Chinese NEV

At the same time, the addition of the internet has developed more ways of interaction. HiPhi X, as a new energy vehicle manufactured by an internet company, has added social attributes to the vehicle in a breakthrough and can communicate with other drivers on the central control screen of the vehicle.

As connected cars development in China, traditional energy vehicle companies in other countries are making improvements. The flagship models of Mercedes and BMW are the most obvious.

Figure 21. The operated system in Mercedes EQS

Until 2021, the connecting-screen is used on the Chinese New Energy Vehicles (NEV) in the global car market. In 2021, Mercedes EQS has been officially launched, which will be the first vehicle with a connecting-screen design in addition to Chinese New Energy Vehicles (NEV). It is shown in the Figure 21. However, on the part the internet service, it is not possible to watch videos. Compared with Chinese New Energy Vehicles (NEV), the technology, convenience and diversification of functions is significantly lower. Connecting to a screen doesn't make for a better internet interaction experience.

Figure 22. The backseat of BMW 7 Series

For BMW, as shown in the Figure 22, the 7 Series is a kind of flagship product, puts innovation in the rear part of the room, with a huge screen for the rear passengers. However, BMW is same as Mercedes, as a traditional vehicle company, it is too conservative in internet access, their screen with large size provide more of the information showing rather than an improvement in interaction.

Traditional energy vehicle companies and internet vehicle companies in the sense of the screen, understanding is not absolutely the same. Traditional energy vehicle companies see screens as more of showing the information. Internet vehicle companies see the screen as more of realizing the interaction and internet services.

3.4.2. Autonomous vehicle

Autonomous vehicle is also called driverless vehicles, computer-driven vehicles, or wheeled mobile robots. It is an intelligent vehicle that realizes driverless driving through a computer system. It has a history of several years in the 20th century, and appears to be close to practical trend in the early 21st century[51].

In this thesis, it shows the analyzes in two parts. One is the level of autonomous, another is technosphere.

3.4.2.1 Level of autonomous

Autonomous vehicles is often categorized in six levels, according to a system developed by SAE International (SAE J3016, revised periodically).We could roughly understand by SAE scale as Level 0 - level 5. As shown in the Figure 23.

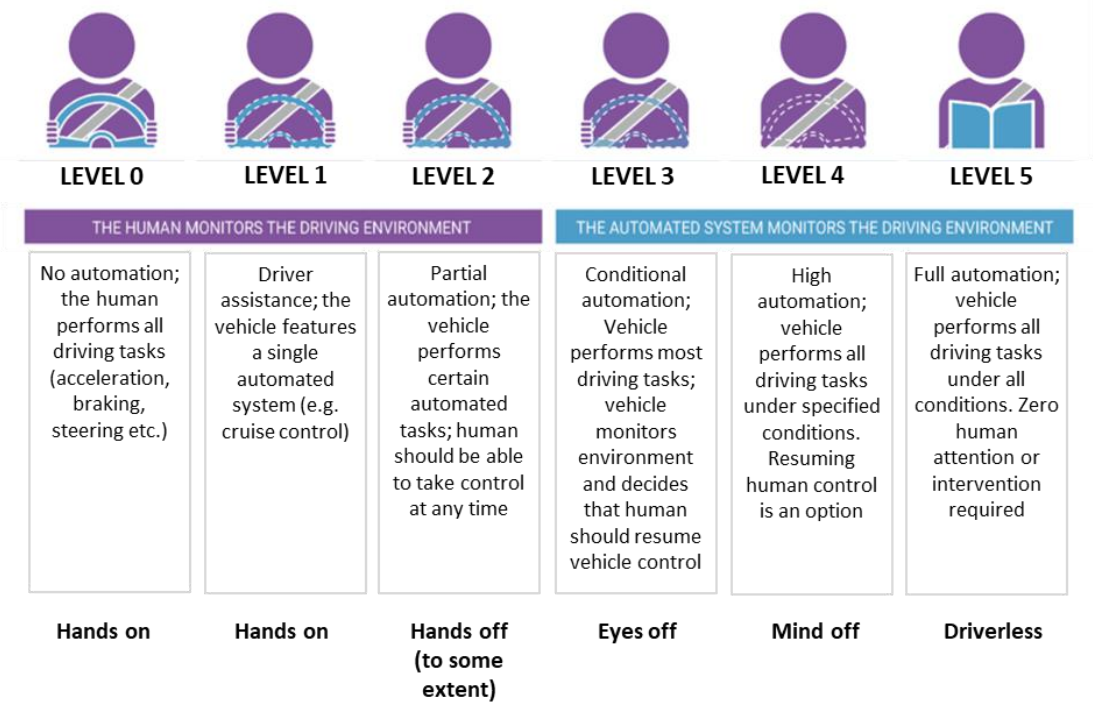

Figure 23. Autonomous vehicles levels

Level 0: No automation. The driver is always in control of all the mechanical and physical functions of the vehicle.

Level 1: Hands on/shared control. the driver operates the vehicle, but individual devices, such as Electronic Stability Program (ESP) or Anti-lock Brake System (ABS), can sometimes play a role.

Level 2: Hands off. The driver primarily controls the vehicle, but the system is progressively automated, so that the operating burden is significantly reduced. For Examples, Active Cruise Control (ACC) and Automatic Emergency Braking (AEB).

Level 3: Eyes off. The driver must be ready to take control of the vehicle at any time. During the automatic driving assistance control period, although the driver can temporarily avoid operation while following the vehicle, when the car detects that the driver is needed, the car will immediately return and let the driver take over the subsequent control. The driver must take over the situation that the system is unable to handle.

Level 4: The driver can allow the vehicle to drive itself completely when conditions permit. After automatic driving is started, it is generally not necessary to intervene in the control. The vehicle can follow the set road rules by itself. (Examples. The vehicle to drive itself completely in smooth traffic flow, standardized road signs and obvious warning lines on expressways).

Level 5: Steering wheel optional. The driver is able to out of the vehicle or does not control the vehicle at any time. Such a vehicle can activate the driving device by itself and perform all important safety-related functions, It means that the vehicle can make its own decisions.(Automatic car without steering wheel).

In this thesis, the main categories of technology and patents are presented.

3.4.2.2 Technosphere

Autonomous driving is one of the most complex computation technologies in the automotive industry[52]. It need to collect the data of the vehicle sensor, and carry out algorithms and identification, in order to certify the customers needs.

The main technologies has the following points:

3.4.2.2.1 Environmental perception

Visual sensor equipment and vehicle radar and other intelligent technology is that the main way of data collection such as vehicle environment perception and traffic operation environment[53, 54]. Network technologies such as 5G and V2X can be used to perception data exchange between vehicle environment and traffic operation environment which in vehicle-vehicle, vehicle-road and vehicle-cloud[55, 56]. In autonomous driving field, algorithm training cloud platform and other sharing technology are able to collect, stores and shares AI road conditions data (i.e., vehicle environment and traffic environment data), in order to train autonomous driving algorithms.

3.4.2.2.2 Environment Identification

Visual identification and radar (sense the objects distance and direction) and other intelligent technology can be used to identify road targets and road infrastructure. Through the environment identification, to collect the information and analyse the object meaning, distance and direction, which includes vehicles, traffic signs and traffic signals and other traffic operating environments. V2X collaborative communication network technology can realize the exchange of vehicle data, pedestrian location data, vehicle environment data, traffic operation environment data and other identification data in vehicle-vehicle or vehicle-road. Sharing technologies

which includes traffic management cloud platform or map cloud platform can realize the sharing of traffic operation data such as the phase of traffic signs and traffic lights.

3.4.2.2.3 Vehicle positioning

The vehicle location function is used to determine the exact position of the vehicle in the lane and on the map, which is the basis of map creation, driving behavior decision and driving trajectory planning. Intelligent technologies includes the Global Positioning System (GPS), the Inertial Navigation System (INS), and the Simultaneous Localization And Mapping (SLAM)[57]. These intelligent technologies are the key and basis technologies for obtaining vehicle location data.

3.4.2.2.4 Simultaneous Localization And Mapping (SLAM)

The environmental perception based on vehicle sensor equipment, and the environment recognition and various vehicle Simultaneous Localization And Mapping (SLAM) technologies based on rule algorithm or artificial intelligence algorithm[58, 59]. These can be used to create a real-time and high-resolution maps of vehicle environment perception.

Sharing technology such as map cloud platform can share static data (road infrastructure), quasi-static data (permanent traffic signs) and quasi-dynamic data (traffic conditions, signal phase, etc.) of real-time and high-precision map. V2X collaborative communication, as a networked technologies, can exchange highly dynamic data (vehicle position, vehicle movement, vehicle operation, pedestrian position, etc.) with high-precision maps in vehicle-vehicle and vehicle-road.

3.4.2.2.5 Route planning

There are some intelligent technology which are the key technology to realize route

planning function. Such as high-precision maps, vehicle positioning technology, route planning algorithms, artificial intelligence chips and vehicle algorithms platforms and so on. Autonomous driving route planning is essentially different from vehicles navigation. The former mainly uses high-precision maps, according to the vehicle based sequence which is the decision behavior, to get the results[60]. But it is not necessary to meet the output requirements of the man-machine interface, such as the sound and visual effects. The latter one uses an electronic map with ordinary accuracy, and the output route planning results will be used as driving route recommendations, and presented to the driver through the man-machine interface.

3.4.2.2.6 Behavior decision

Behavioral decision is the driving mode adopted in the process of vehicle driving, including driving, following, turning, lane changing and parking, etc.

In the stage of driver assistance, the behavior decision system will inform the driver in the way of reminder, forming the driving suggestion to the driver. In the autonomous driving stage, the behavior decision system will determine the driving behavior of the vehicle in real time according to the vehicle data, identification data of road infrastructure and road object, traffic operation data, user travel information data and so on[59]. After the driving behavior decision, the result will be handed to the motion planning system, which will closely cooperate with the behavior decision system to carry out the longitudinal trajectory planning and lateral velocity planning of the vehicle.

3.4.2.2.7 Control and execution

After the longitudinal trajectory planning and lateral velocity planning of the vehicle are formed, it is followed by the generation of operating instructions for the working parts of the vehicle such as the steering wheel, throttle and brake. The Electronic

Control Unit (ECU) of the car receives the operation instructions from the autonomous driving system (vehicle computing platform) through the bus of the car, and each Electronic Control Unit (ECU) will control the corresponding actuators and working parts.

After operating and controlling the working parts of the vehicle, the movement direction, speed and position of the vehicle will be changed. And environmental perception system will continue to obtain vehicle data and traffic environment data, in order to form the new behavior decisions, trajectory planning and speed planning. Then, The operating instructions are output to the Electronic Control Unit (ECU) to form several closed-loop control systems[61].

Through the above analysis of the technologies, it can be seen that the autonomous driving technology is highly dependent on sensors and chips of cars. New Energy Vehicles (NEV) can carry more sensors and computing chips than traditional energy vehicles because their energy drive form is electricity[62]. At present, the development of autonomous driving technology in New Energy Vehicles (NEV) has made greater progress than the development of traditional energy vehicles.

3.4.2.3 Patents

As the result of technological innovation, patent can represent technological competitiveness to a certain extent. So we did a search for patents from 2014 to 2018, searching for patents related to autonomous driving in China, Japan, the United States, and Europe. And the patents include vehicle sensors, dynamic maps, communications technology, identification technology, forecasting technology, judgment technology, operation technology, artificial intelligence, human-computer interface, Operational Design Domain (ODD) field, emergency corresponding, operation management, remote monitoring, remote operation, driver assistance systems, driving shape control

device, automatic driving, level of autonomous and so on. The following data that we obtained.

According to the applicant's country and region, the number of patents is calculated. There are a total of 53,394 patent applications were filed from 2014 to 2018. As shown in the Figure 24. Among them, 20,008 were filed by Japanese applicants, accounting for 37.5 %, it is the top ranking. The United States rank second with 11,311, accounting for 21.2%. Followed by Germany with 10,886 with 20.4% and China with 4,965 with 9.3%. The sum of other countries patents is 6224 with 11.6%.

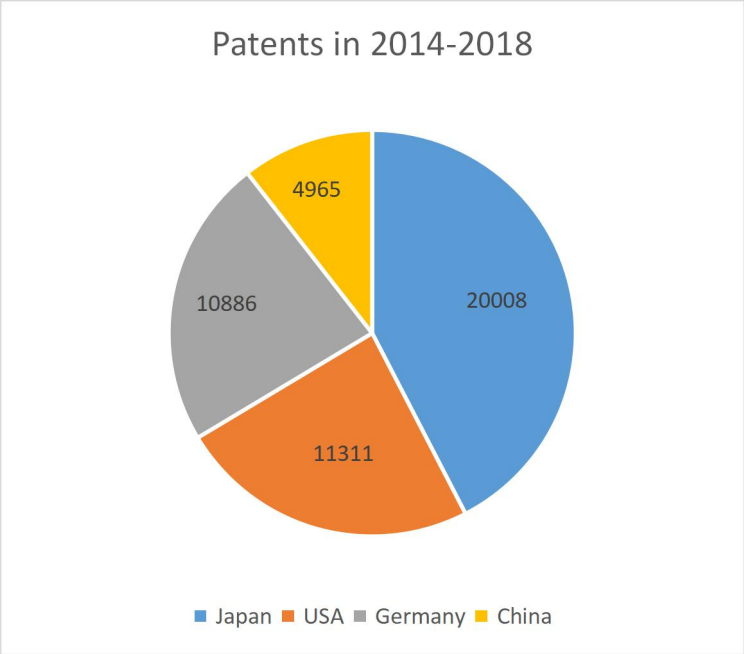

Figure 24. Patents in 2014-2018

- According to technical classification, the following data can be obtained:

1: Vehicle sensors (38,783)

2: Identification technology (31,130)

3: Judgment Technology (28,001)

4: Driving support systems (22,533)

5: Human Machine interface (HMI) (21,666)

6: Autonomous driving controls (19,028)

7: Communications Technology (13,877)

8: Artificial Intelligence (AI) (4,902 items)

9: Remote monitoring, Remote operation (4,087)

10: Operational Design Domain (ODD) (2,349)

A search of patents shows that China is still playing catch-up in the autonomous driving field. In the field of vehicle sensors, China is weak.

- Principal applicant

Ranking by Number of Applications by Applicant (Autonomous Driving related Technologies, Applications from Japan, US, Europe and China)

Table 10. The top 9 companies in patents applicant

Rank	Applicant（countries and regions）	Numbers of patents
1	Toyota (Japan)	4247
2	FORD GLOBAL TECHNOLOGIES (US)	3067
3	Denso (Japan)	2648
4	Honda Motor (Japan)	2460
5	Bosch (Germany)	2207
6	General Motor (US)	1433
7	Nissan Motor (Japan)	1214
8	BMW (Germany)	850
9	Mitsubishi Motors (Japan)	847

As seen in the Table 10. As the largest vehicle enterprise with the largest sales volume in the global automobile market, Toyota has the most outstanding research in the automobile field. As the world's largest manufacturer of automotive electronic components, Bosch has been occupying a large number of resources and orders. Unlucky, Chinese companies do not make the top nine in terms of number of applications. This also shows that Chinese new energy vehicle companies need to

strengthen scientific and technological innovation, to achieve technological breakthroughs, in order to improve their own competitiveness.

In other words, low sales volume of Chinese New Energy Vehicles (NEV) in the world is also related to the lack of patents in the world. Through technical research and a large amount of capital investment, through unremitting efforts, the number of related patents applied by Chinese new energy vehicle brands in China has greatly increased compared with the world patent.

Therefore, this thesis will analyze the patent situation of Chinese new energy vehicle companies in China.

Until June 2020, 8,275 companies in China were involved in applying for autonomous driving patents, with a total number of 40,682, 14,018 of which were authorized. Among these companies, the three companies with the largest number of patent applications were Baidu (2,009), Huawei (1,332) and DJI (705). Of the companies that file patents each year, more than 60% were first time. In particular, between 2017 and 2020, more than 1,400 companies applied for autonomous driving patents each year, among them, more than 1,000 were new entrants. For example, Meituan, Neolithic, Pony.ai and UISEE are all new entrants to the field in the last five years.
The large number of new entrants has directly contributed to the surge in patent applications related to autonomous driving. In just five years, the number of companies applying for patents increased from 966 to 2,479, and the number of new patents increased from 2,852 to 9,750. The volume of patent applications has increased nearly doubled.

In 2021, the top ten of the number of the new energy patent applications in China are, Baidu (2,909), Huawei (1,332), DJI (705), Geely (664), Tencent (522), Pateo (512), Didi (453), Xiaopeng (434), Chery (420) and BYD (397). Among them, internet technology companies account for 5, and traditional vehicles manufacturers account

for 3. From the perspective of patents, internet technology companies have significant advantages in the field of autonomous driving. It can be seen that Chinese New Energy Vehicles (NEV) companies are catching up traditional vehicles companies in the field of autonomous driving. In order to improve their own competitiveness.

3.4.3. Car sharing

Car sharing, as the name suggests, means that multiple people share the same car, which belongs to a common resource rather than one person. It is shown in the Figure 25. At the beginning of the research on car sharing, people hoped that car sharing could improve traffic congestion, relieve travel pressure, save travel time, save the purchase cost of car, in order to provide convenience to people and contribute to environmental protection.

Figure 25. Car sharing

3.4.3.1 The history of the car sharing

In 2011, Autolib, the most famous car sharing platform, was born in Paris. Later, shared cars emerged in the United States, Germany and other countries. The 2015 is defined as the first year of car sharing in China. Since 2015, regional pilot car sharing projects have been expanding quickly, from a few scattered companies in Eastern China to more than 200 emerging enterprises.

3.4.3.2 MaaS (Mobility as a Service)

Transportation consumption began to shift from purchasing to sharing renting (bicycles, private cars, etc.), which greatly improved the efficiency of transportation. However, different transport systems are often independent of each other (for example, bus systems and taxi systems). In order to provide people with a more convenient mode of travel, MasS Mode was born. MaaS mode is a mode of travel service, which presents a platform and an application system for everyone to use. A MaaS platform will integrate all types of transportation in the city, including data sharing, unified scheduling, unified payment and unified management.

MaaS is able to plan one-stop travel solutions, because it integrates a lot of transportation, and master the real time operation data of the whole city traffic, including the real time bus routes, the number of swiping cards of subway gates, the congestion of roads, the flow rate of people in office buildings, the distribution of shared bikes or car and so on.

3.4.3.3 The advantages of the car sharing

According to incomplete statistics, the cars are only used about 5% of time, 95% of time are parking in lots. Even vehicles in use, the car also has 70% of the time is in empty state, there are still lot of seat resources are wasted. Car sharing can greatly increase the utilization rate of cars. From an economic point of view, car sharing can save a lot of car ownership costs due to insurance, maintenance and retention rate. From the convenience point of view, people are able to use it whenever and where ever they want. In the long run, with the popularity of the sharing economy and a sharp increase in the use of vehicles, car sharing can also effectively alleviate thorny problems such as road congestion.

3.4.3.4 The advantages of the Chinese New Energy Vehicles (NEV) in car sharing

In recent years, Chinese car sharing are mostly domestic New Energy Vehicles (NEV), showing a one-sided trend. This is because the operating cost of New Energy Vehicles (NEV) is significantly lower than that of traditional vehicles, and domestic New Energy Vehicles (NEV) have obvious advantages in price performance, matching and after-sales service when compared with imported New Energy Vehicles (NEV).

Then, this thesis analyzes the patent situation of countries in field of the MaSS. Search for Patents related to MaaS technology in China, Japan, United States and Europe. These include ride hailing service, car pooling service, operation management, implementation technology (driving control, passenger identification), APP (map display, trip retrieval, payment), big data collection, big data application, application industry, disaster information, traffic information, scene location, topics, etc.

Number of MaaS technology applications from 2014 to 2018 is 9643 in total. By nationality of applicants, 3283 were filed by Chinese applicants, accounted for 35%. Japan followed with 2173, account for 22.5%, the United States with 2132, account for 22.1%, and Europe with 811, account for 8.4%. As the country with the best sharing economy development, China is in an absolute leading position in the application of MaaS technologies. This is related to Chinese large population and low per capita car ownership.

Table 11. The top 10 in MaaS patents applicants

Rank	Applicants（nationality）	Number of applicants
1	Toyota (Japan)	647
2	DiDi (China)	436
3	Ford (US)	290
4	UBER TECHNOLOGIES（US）	289
5	GM (US)	173

6	HITACHI (Japan)	160
7	Honda (Japan)	143
8	IBM（US）	127
9	Mitsubishi Motor (Japan)	99
10	Hyundai Motor (Korean)	92

From the perspective of enterprises, Toyota, Ford, as shown in the Table 11. GM and other traditional automobile enterprises still have certain advantages in technological accumulation. However, as the sharing software with the largest number of users, DiDi still has a leading position in data collection and technology processing. So, it can be seen that the Chinese New Energy Vehicles (NEV) in car sharing have the certain advantages.

Generally speaking. As the largest market for car sharing services, China has strong competitiveness in the field of car sharing. The high number of users and low per capita car ownership have helped Chinese car sharing services take the lead in the world. To a certain extent, car sharing services can also solve the waste of resources, thus further achieving the goal of carbon neutrality.

3.4.3.5 Development bottleneck and prospect

- **Bottleneck**

With the large-scale distribution and investment of car sharing, and when all parties are full of expectations for the future of car sharing, various problems come along, such as parking inconvenience caused by scarce parking Spaces, shutdown handling of major traffic accidents, poor user experience caused by poor management, financial pressure caused by vehicle maintenance and insurance costs, etc. Therefore, on the one hand, car sharing has not really opened up a large area of the market; on the other hand, the huge operating costs and unclear profit methods make it difficult for more and more enterprises to stick to it. In many places, the "car sharing cemetery" like the

Figure 26 shown in the below. People are starting to realize that car sharing is not as good as they thought.

Figure 26. The discarded shared cars

- **Prospect (The combination of car sharing and autonomous driving)**

The development of car sharing is hindered by high operating costs, difficult scheduling, inconvenient ways of picking up and returning cars, etc. While the intervention of autonomous driving can solve most of the above problems, so as to significantly reduce operating costs and improve user experience. "Sharing" is also the best application scenario of automatic driving, which has become the consensus of the industry. "car sharing + autonomous driving" will become the general trend of human travel in the future, that is to say, in the future, car sharing and RoboTaxi (autonomous driving taxi), which is now hotly discussed, will come to the same destination.

3.5. Summary

Through analysis, there is no obvious advantage of Chinese New Energy Vehicles (NEV) in trade. Mainly due to the small export volume of Chinese New Energy Vehicles (NEV), most of them are sold in China. Through SWOT analysis, it can be seen more clearly that Chinese New Energy Vehicles (NEV) have an absolute leading position in infrastructure, market capacity, and related industrial chain development. However, due to low brand awareness, Chinese New Energy Vehicles (NEV) do not have a strong influence in the world. Through factor analysis, the data obtained by SWOT can be quantified. The Chinese New Energy Vehicles (NEV) get high scores in factor analysis, mainly related to market share and basic infrastructure. In terms of technological innovation, Chinese New Energy Vehicles (NEV) are still in a process of catching up. In the field of automatic driving in the international advanced level. In terms of MaaS technology, due to the large number of users, Chinese New Energy Vehicles (NEV) are in a leading position in the world.

4. Market investigation and research on the influencing factors of consumers' choice of New Energy Vehicles (NEV)

4.1. The reason and objects of the research

Due to the emergence of New Energy Vehicles (NEV), the diversity of products has been enriched, so that people have more choices when buying cars. Traditional energy vehicles are no longer the only choice for automobile consumers. According to the data source of Zhiyun Data, in 2021, the retail sales volume of passenger vehicles in China will be 210.55 million, and the cumulative retail sales volume of New Energy Vehicles (NEV) will be 2.921 million, with a market share of about 13.9%. It can be seen that although the sales volume of New Energy Vehicles (NEV) show an overall increasing trend, it is still far smaller than the sales volume of traditional energy vehicles. It shows that the choice concept of automobile consumers has not a watershed change. So our purpose is to find out the key factors, and judge the feasibility of improvement, for the current new energy vehicle industry to put forward reasonable suggestions.

The development of New Energy Vehicles (NEV) advances by leaps and bounds, but the market share is still very low. With the increasing disposable income of Chinese residents, the demand for automobile consumption shows an upward trend. It is obvious that the Chinese market still has great potential for development. Therefore, the purpose of our research is to provide solutions for Chinese new energy vehicle companies, to make them better to exploit market and formulate marketing plans, to improve their market share and gain dominance in the new energy vehicle market.

The Chinese traditional automobile industry started late. Therefore, compared with other countries, there is an insurmountable gap in technology. However, in the research of New Energy Vehicles (NEV), our country has made great achievements, making it very comparable with imported New Energy Vehicles (NEV). In 2021,

Chinese New Energy Vehicles (NEV) continue to lead the world, ranking first in the world for seven consecutive years. It can be seen that in the field of New Energy Vehicles (NEV), China and international auto giants are standing on the same starting line to compete, so the most important thing at the moment is to understand the advantages of Chinese New Energy Vehicles (NEV), and continue to maintain and innovate, to find out the gap with foreign New Energy Vehicles (NEV).

4.2. Research method

From the perspective of consumers, to research consumer behavior, analyze the influencing factors of consumer behavior, and combine the previous analysis with the characteristics of New Energy Vehicles (NEV). Finally, various factors that affecting consumer behavior of New Energy Vehicles (NEV) are summarized, and as the basis, to determine the research framework, plan survey process, form the questionnaire. Finally, the questionnaire data will be recycled and statistically analyzed, to quantitatively evaluate the significance of the various influencing factors on the consumer behavior of New Energy Vehicles (NEV), that can put forward reference suggestions for the current new energy vehicle industry and provide theoretical reference for consumer behavior researching of New Energy Vehicles (NEV).

4.3. Research on influencing factors of consumer behavior

Consumer behavior refers to the decision-making process, influence and actions carried out by consumers when they purchase goods[63]. The mainstream view of the consumers purchase decision-making process is proposed by three professors (Engel, Kollat, Blackwell), named "Engel model (EKB Model)"[64]. According to this theory, the purchase behavior of consumers will go through the following five steps: determining the demand → information collection → plan evaluation → purchase decision → post-purchase evaluation[65]. The process is shown in the figure 27.

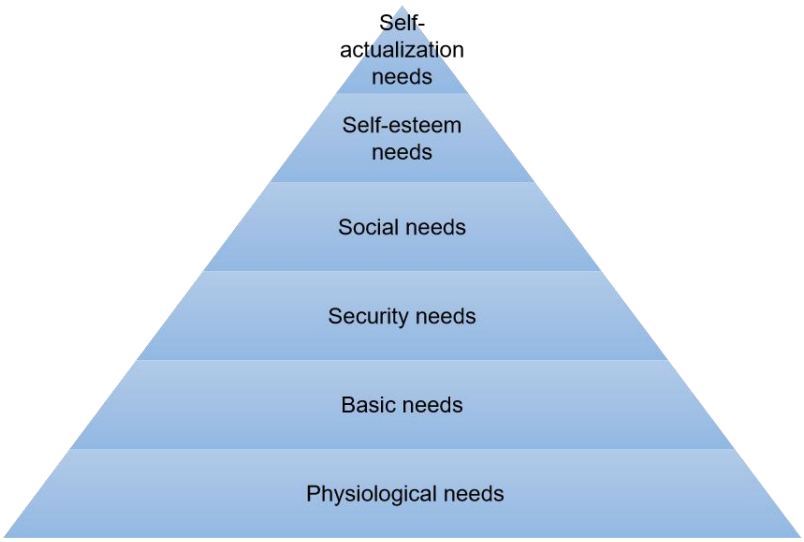

Figure 27. Needs pyramid.

①First, need to determine their own needs. The purchase process starts from evoking buyers' needs for an event or an object. Everyone always has many needs at any time, such as physiological needs, basic needs, security needs, social needs, self-esteem needs and self-actualization needs. As shown in the Figure 26. These requirements become the driving force for buying, and when a consumer confirms a requirement or need, the buying process begins.

②After determining the demand, consumers will collect market information related to their demand. Inward-consumers search through their own reserve information and experience, and outward-consumers search through other information channels (ex: website, advertisement, family or friends).

③After consumers obtain various market information, they will screen, sort out, analyze and evaluate the information. The whole analysis and evaluation process can be highly subjective.

④After consumers evaluate a lot of option plans, they will form a purchase intention, and then produce purchase behavior.

⑤When consumers purchase products and have consumption experience, new experience information will be formed to generate purchase evaluation, which will be summarized into new information and input into the information base, thus affecting the subsequent demand and purchase behavior.

From the perspective of the whole process from demand to decision, there are many factors that affect the purchasing behavior of consumers, and each step may change the purchasing choice of consumers because of these influencing factors.

At present, researchers no longer spend too much time to study the purchasing process of consumers, but to research the influencing factors of consumer behavior at a deeper level[66, 67]. There are abundant research literature on the influencing factors of consumer purchasing decision-making behavior.

In the late 20th century, psychologist Ajzen published the theory of planned behavior and proposed five elements of consumer behavior, including attitude, subjective norms, perceived behavioral control, behavioral intention, and actual action[68]. In 2009, Dennis put forward an e-commerce(electronic commerce) consumer behavior model based on this, believing that people's behavioral intention is affected by attitudes, subjective norms and perceived behavioral control[69]. Ajzen believes that external factors and internal factors will jointly arouse and form motivation, and affect consumers' psychological activities and purchasing decision behaviors. Among them, external factors play a role through the external things and environment of consumers, such as the influence of advertising, the influence of specific buying situations and of other consumer attitudes, etc[70]. Internal factors mainly refer to the influencing factors of consumers themselves, including personalized living experience, demand, life attitude and so on.

Since the 21st century, consumer behavior has continuously introduced psychology, social psychology, economics, anthropology, sociology and other traditional

disciplines, and become a new branch of consumer behavior research, such as advertising, marketing, marketing planning, e-commerce and so on[71]. At present, the research scope of consumer behavior has been still expanding, and the research topics will be diverse[72].

4.4. Factors influencing consumer behavior of New Energy Vehicles (NEV)

Through the reading and analysis of the literature on the influencing factors of consumer behavior, combined with the relevant research on the new energy vehicle industry in the previous chapter, this paper finally summarizes the influencing factors on consumer behavior of New Energy Vehicles (NEV), mainly focusing on the following six aspects: 1. Psychological factor; 2. Demographic characteristic factor; 3. Social factor; 4. Product economy factor; 5, Product quality factor; 6. Government policy support factor.

4.4.1. Psychological factor - people's psychology is the main factor that decides consumer behavior.

4.4.1.1 Motivation

First of all, consumers will find and confirm their needs. When the needs reach enough intensity level, it becomes motivation. This demand is derived from internal or external stimulus factors. From internal factors, consumers will find their own internal needs. When consumers are not satisfied with the existing products or services or can not meet the current demand, that can generate a variety of needs to change the current situation. In terms of external stimulus factors, enterprise operators will make consumers realize the gap between the ideal state and their actual state through various marketing means, which will prompt consumers to find the motivation of demand, so as to stimulate consumers to produce more demand.

4.4.1.2 Perception

Consumer perception is the main factor affecting consumer behavior. Consumer perception refers to the process by which customers collect and analyze information about a product to form a meaningful image of a particular product.

4.4.1.3 Learning

Learning refers to the change of personal behavior caused by experience, it refers to the process in which consumers continuously acquire information, knowledge, experience and ability when they purchase and use products. Through continuous learning, consumers gradually accumulate product information, master brand knowledge and purchase experience, and constantly strengthen their preferences and loyalty to specific brands or products, which will produce certain consumption habits.

4.4.1.4 Attitudes and beliefs

Consumers have certain attitudes and beliefs. Based on this condition, consumers will treat products in a specific way, thus affecting consumers' purchase decisions. This attitude plays an important role in defining the brand image of a product.

4.4.2. Demographic characteristic factor

4.4.2.1. Age

Age is one of the important factors affecting consumer behavior, because consumers of different age bracket have different consumption view. And their acceptance of new products and things is also different. Young people have the strong ability of exploring new things and are willing to try new products and new lifestyles. But older consumers tend to be more conservative. Therefore, consumers of different age groups may have different acceptance of New Energy Vehicles (NEV).

4.4.2.2. Gender

In the case of free-market competition, most female consumers care more about the appearance of goods, and are more prone to emotional consumption or impulse consumption; However, most male consumers pay more attention to the inner core and functionality of goods, and their consumption is relatively rational.

4.4.2.3. Full-time educational background

Generally, for all kinds of new products and ideas, consumers with higher education will be more receptive and more willing to try new things. And they may have a better understanding of the concept of green consumption with the green consumption, which will promote the consumption behavior of New Energy Vehicles (NEV).

4.4.2.4. Income

Income is the most direct factors affecting consumer behavior. Income is the premise of consumer behavior generation, and the consumption level of consumers is affected by the current disposable income. Under normal circumstances, the higher average personal monthly income, the stronger economic capacity they have, so purchasing power is stronger. This will directly affect vehicle purchasing budgets of consumer.

4.4.2.5. Job

The type of vehicle that consumers choose is affected by their job(i.e. job nature, job category, job specification). Some consumers believe that vehicles are a symbol of identity, so when choosing a vehicle, they will consider the brand, price and model positioning more, and a more noble model can better meet their needs. And some consumers pay more attention to the practicality of vehicles, such as running transport customers, so for this kind of customers, small and miniature transport vehicles might

be better suited to their needs. However for consumers in the art industry, they may choose more fashionable and colorful models.

4.4.3. Social factor

Through consulting relevant experts and literature research, the main research of social factors in our paper includes three aspects: public infrastructure, reference group and social development trend.

4.4.3.1. Public infrastructure (Charging Station)

When consumers buy a vehicle as a tool for daily use, the first thing they consider is reliability and convenience. Experts from all countries agree that the primary condition for the large-scale development of New Energy Vehicles (NEV) is still the construction of convenient and fast charging networks. Therefore, we also agree that the improvement of infrastructure construction is conducive to improving the sales of New Energy Vehicles (NEV).

4.4.3.2. Reference group

Here are two reference groups. One is a group of people who interact with consumers, including family members, friends and colleagues. They can have a direct impact on consumer attitudes and behavior. Another is indirect groups favored or worshiped by consumers. These groups may have no actual contact with consumers, but only indirectly influence consumers through advertisements or their own behaviors.

4.4.3.3. Social development trend

With the reduction of oil and the increase of carbon emissions, environmental pollution is becoming more and more serious, so the development of New Energy Vehicles (NEV) is the current trend.

4.4.4. Product economy factor

Product economy includes two aspects: on the one hand, economy in product development, design and production process, which will be included in the cost consideration of enterprises or manufacturers. On the other hand, it is the economy generated by consumers in the process of using the product. In other words, it is the cost that consumers need to invest in order to ensure the normal use of the product. For example, the energy consumption generated in the use of the car (here refers to oil or electricity cost), maintenance costs, repair costs. Therefore, for consumers of New Energy Vehicles (NEV), they will not only consider the price of New Energy Vehicles (NEV) products themselves, that is, the price of car purchase, but also consider the costs of New Energy Vehicles (NEV) in the use of the process, that is, energy consumption, maintenance costs, repair costs, etc.

4.4.5. Product quality factor

In a broad sense, product quality refers to the sum of the performance and function of products that meet the requirements of relevant standards of international organizations, countries and enterprises, and meet the needs or potential needs of consumers. Product quality includes the quality of tangible products, that is, the physical quality of products, and the quality of intangible products, that is, the service quality of products. Generally speaking, product quality includes 5 aspects: ①Material aspects, such as product material safety, raw material composition;

②Operation and use, such as whether the operation is convenient, safe and reliable;
③Time, such as service life;
④Appearance, such as fashionable appearance, beautiful packaging；
⑤Functional aspects, such as some features of the product to meet consumer needs.

Product quality is also closely related to core technology. As the most important part of New Energy Vehicles (NEV), batteries are always the focus of consumer attention. Battery safety, life span, charging time and other performance indicators are the key factors affecting New Energy Vehicles (NEV). These indicators will directly affect the consumer behavior of New Energy Vehicles (NEV).

4.4.6. Government policy support factor

This chapter is a questionnaire survey conducted for Chinese consumers and analyzes Chinese policy support for New Energy Vehicles (NEV). Therefore, the analysis of government policy support factors here is divided into government subsidies and government welfare policies.

It can be seen that for the current development of New Energy Vehicles (NEV), national policy support is the main driving force for the rapid development of the new energy vehicle industry. At present, Chinese policy support for the new energy vehicle industry is mainly financial subsidies, including monetary subsidies and tax preference policy. So far, Chinese new energy vehicle industry has experienced the start-up stage of relying on government support and the expansion stage of relying on government subsidies. At present, Chinese new energy vehicle industry is experiencing the transition stage from long-term policy subsidy support to complete marketization.

In 2019, restrictions on license plates and driving of New Energy Vehicles (NEV) were proposed to be canceled in the document issued[73-75]. In densely populated cities with congested roads, New Energy Vehicles (NEV) will be more convenient and advantageous than traditional energy vehicles.

For the scale part of the questionnaire, according to the above comprehensive analysis, the item pool of our survey is preliminary set up. After relevant expert inquiry, research and discussion of group members, and a preliminary encounter survey, we select and screen our items, and finally determine our research variables as follows in the Table 12.

Table 12. The factors corresponding to each item

Influencing Factor	Variables
Demographic characteristic factors	• Age, gender, full-time educational background, income and job of new energy vehicle consumers or potential consumers
Social factors	• The public infrastructure of the NEV (fraction of coverage and quantity of the charging station) • The influence of family, friends, colleagues, etc. • The influence of advertising, media, celebrity idols, etc. • The social development trend
Product economy factors of NEV	• The selling price of the NEV • The daily cost of the NEV (daily charging cost) • The maintenance and after-sales costs of the NEV
Product quality and technology factors of NEV	• The NEDC of NEV • The charging time of the NEV • The battery life span of the NEV • The battery safety of the NEV • The driving feeling of the NEV (strong acceleration, low noise) • The exterior and interior design of the NEV • The functions and configurations of the NEV
Government policy support factors	• The government subsidies of the NEV • The government subsidies of the NEV
Psychological factors	• Green Concept：The NEV are conducive to energy saving and emission reduction, meet the needs of sustainable development, and belong to the green travel. • The brands of the NEV

4.5. The survey process

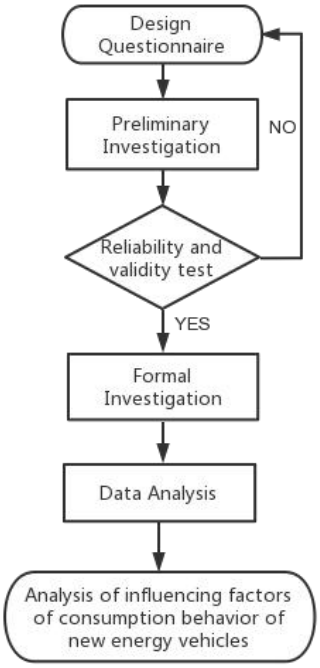

Figure 28. The survey process

4.6. The design of questionnaire

In consideration of the quality of questionnaires and the timeliness of statistical data, online electronic questionnaires are used for survey and data collection. The questionnaire is sent to Jinan, the capital of Shandong province and a second-tier city in the north. Considering the comparison of traditional energy vehicles and New Energy Vehicles (NEV) is fair, so avoid a car irresistible factors, for example, in Beijing, Shanghai and other first-tier cities, traditional energy vehicles have a license is extremely difficult, consumers have to choose New Energy Vehicles (NEV); Meanwhile, Second-tier cities in China have the greatest development potential in the field of New Energy Vehicles (NEV), with huge market shares to be developed. Therefore, it is of great significance to improve the sales of New Energy Vehicles (NEV).

In this questionnaire, people who have a car purchase plan in the past two years are taken as the investigated objects (samples), which makes this questionnaire more representative, comprehensive and effective. In order to protect personal privacy and make the interviewees fill in the questionnaire according to the real situation, the questionnaire survey is conducted anonymously.

This questionnaire consists of five parts.

①Introductory remarks: To thank the respondents and explain the research purpose and confidentiality of this questionnaire.

②The demographic characteristics of the respondents, that is, the demographic characteristics of consumers and potential consumers, including basic information such as age, gender, income, full-time educational background and job. After completing the basic information in the second part of the questionnaire, all respondents are divided into two types through question jump setting. Consumers who choose traditional fuel vehicles need to complete the third part of the questionnaire, and consumers who choose New Energy Vehicles (NEV) need to complete the fourth and fifth parts of the questionnaire.

③A multiple choice question. This multiple choice question is aimed at consumers who choose traditional energy vehicles. This multiple choice includes 7 factors that consumers consider when choosing traditional fuel vehicles, and each person can choose 1-3 options. Through the analysis of these consumer choice factors, the main disadvantages of New Energy Vehicles (NEV) in the current Chinese market are obtained, so as to find the development direction of New Energy Vehicles (NEV).

④Scale scoring questions. The scoring questions of the scale are aimed at consumers who choose New Energy Vehicles (NEV). There are 18 items in this scale, and each question is divided into five levels, 5 points (very important), 4 points (important), 3 points (general), 2 points (not important), 1 point (very not important). The average

score of each item reflects consumers' attention to the influencing factors of the item mentioned. The scale describes the questions in a declarative way and sets fixed options, so that the respondents can clearly understand the questions and choose the appropriate answers. And the fixed answer is easier to carry out statistics and analysis. Through the analysis of these consumer choice factors, the main purchase factors considered by consumers of New Energy Vehicles (NEV) in the current Chinese market are obtained.

⑤A multiple choice question. The respondents who completed the fourth part need to continue to complete the multiple choice question, which contains 7 factors that consumers consider when choosing to buy Chinese New Energy Vehicles (NEV) or imported New Energy Vehicles (NEV). Each person can choose 1-3 options.
Then by comparing the proportion and reasons of consumers choosing Chinese New Energy Vehicles (NEV) or imported New Energy Vehicles (NEV), the choice trend of consumers is obtained, and the advantages and disadvantages of present Chinese New Energy Vehicles (NEV) are analyzed, so that Chinese New Energy Vehicles (NEV) can get better development, and then improve the competitiveness of Chinese new energy vehicle companies.

4.7. Pre-survey

For the scale part of the questionnaire (the fourth part), firstly we completed the preliminary survey before the formal survey to ensure that the questionnaire used in the formal survey is scientific and effective. If there is any problem, the questionnaire can be modified in time. The preliminary survey was distributed randomly on the internet, with a total of 50 questionnaires. After collecting data, the reliability and validity of the questionnaire were analyzed, and the final version of the questionnaire was determined. Then the questionnaire was conducted and the questionnaire was officially started.

4.7.1. Reliability test of questionnaire

Reliability test: It refers to the reliability of the measured results of the scale prepared. The higher the reliability of scale, with the less affected by environmental factors such as time, place. The results tested by this scale are more stable. In this paper, the most commonly used reliability test methods are adopted - Cronbach's α reliability coefficient method.

The formula is:

$$\alpha = \frac{k}{k-1}(1-\frac{\sum S_i^2}{S_x^2})$$

The k is the total number of items in the scale, S_i^2 represents the variance of the score for item i, S_x^2 represents the variance of the total score for all items.

The coefficient α is between 0 and 1. The higher the α coefficient is, the higher the reliability of the scale is and the better the internal consistency is. It is generally believed that if the overall reliability coefficient α is between 0 and 0.6, it indicates that the item design quality of the questionnaire scale is poor and some items need to be deleted. If the overall reliability coefficient α is between 0.6 and 0.7, it indicates that some items in the questionnaire scale need to be modified. If the overall reliability coefficient α is between 0.7 and 0.8, it indicates that the reliability of the questionnaire scale is within the acceptable range. If α coefficient >0.85, it indicates that the scale of questionnaire is of use value.

In this research, Cronbach's α reliability coefficient method is used to test the internal consistency of the questionnaire. The results are shown in Table 13. Cronbach's α coefficient is greater than 0.9, indicating that the questionnaire has high reliability and good internal consistency. So the questionnaire has certain use value.

Table 13. Reliability test results

Cronbach's α coefficient	The number of items
0.991	18

4.7.2. Validity test of questionnaire

Validity refers to the validity of the scale, which refers to the degree to which the measuring tool or means can accurately measure the things to be measured. The validity test is to check the validity of the scale in the questionnaire. Generally speaking, it indicate that the measurement results are more consistent with the content to be investigated, and the more effective the questionnaire is. Validity test generally includes content validity test and construct validity test.

4.7.2.1. Content validity test

Content validity also known as face validity or logical validity. It refers to whether the items set in the questionnaire scale are reasonable, whether these items can represent the content or topic to be measured, and whether there is a logical relationship between these items and the variable factors to be measured.

The design of the questionnaire in this paper is based on previous theoretical research, and refers to a large number of literature and scales. During the design of the questionnaire, experts' opinions were adopted and a lot of modifications were made. It can be seen that this questionnaire has good content validity.

4.7.2.2. Structural validity test

Structural validity test refers to the correlation between scale items and measurement results in the questionnaire. This chapter uses principal component analysis and Exploratory Factor Analysis (EFA), the common factor is extracted with the characteristic root value >1.0 as the standard.

After item selection and factor analysis, all the original 18 items are retained in the scale part of the questionnaire on influencing factors of consumer behavior of New Energy Vehicles (NEV). The KMO value is 0.980, higher than 0.9, and the Bartlett's spherical test χ^2 value is 15081.417 (P<0.001), the P is smaller than 0.05. In conclusion, the results show that the questionnaire is suitable for factor analysis. One common factor is extracted in this research, the loading value (loading value indicates the integrating degree of the items in the common factor) is above 0.9, higher than 0.6, and the cumulative percentage (cumulative percentage indicates the total explanation of the questionnaire) of explained variance is 88.160%, higher than 60%, these show the questionnaire has a good structure validity. The result is shown in the Table 14 and Table 15.

Table 14. KMO test and Bartlett's spherical test

KMO test		0.980
Bartlett's spherical test	**χ^2**	15081.417
	df	153
	P	<0.001

Table 15. Component matrix factor analysis

Item	Loading value
10.1 The public infrastructure of the NEV (fraction of coverage and quantity of the charging station)	0.910
10.2 The selling price of the NEV	0.915
10.3 The daily cost of the NEV (daily charging cost)	0.906
10.4 The NEDC of NEV	0.928
10.5 The charging time of the NEV	0.930
10.6 The maintenance and after-sales costs of the NEV	0.931
10.7 The battery life span of the NEV	0.936
10.8 The battery safety of the NEV	0.934
10.9 The driving feeling of the NEV (strong acceleration, low noise)	0.960
10.10 The exterior and interior design of the NEV	0.952
10.11 The functions and configurations of the NEV	0.958
10.12 The government subsidies of the NEV	0.946
10.13 The government subsidies of the NEV	0.956
10.14 Green Concept：The NEV are conducive to energy saving and emission reduction, meet the needs of sustainable development, and belong to the green travel.	0.959
10.15 The social development trend	0.951
10.16 The brands of the NEV	0.957
10.17 The influence of family, friends, colleagues, etc.	0.947
10.18 The influence of advertising, media, celebrity idols, etc.	0.924

* It only extracts a common factor and cannot rotate

* The order of this table is based on the order of the questionnaire questions, which are randomly generated to ensure the validity of the survey.

4.8. Data recycling

The questionnaire in this paper was distributed in the form of online electronic version, so the recycling rate of the questionnaire was 100%. The total number of questionnaires distributed is 450. Through the elimination of invalid questionnaires, the final valid questionnaires are 429, with an effective rate of 95.3%. Among them, 51 questionnaires were completed for traditional fuel vehicles, accounting for 11.89%, and 378 questionnaires were completed for influencing factors of New Energy Vehicles (NEV), accounting for 11.89%. For the scoring questions in the scale part, the number of samples is more than 18 times that of the questions, indicating that the questionnaire data supported statistical analysis.

4.9. Data analysis and results discussion

Firstly, this chapter shows the descriptive analysis of demographic characteristics, and then analyzes the data from macro and micro aspects. From the macro point of view, to do a holistic analysis of the questionnaire answers. For the two multiple choice questions, the number and proportion of people choosing each influencing factor are counted. For the scale scoring questions, the average score of each influencing factor is counted. Then from the micro point of view, using statistical method, to analyze the scale scoring questions.

4.9.1. Descriptive analysis of demographic characteristics

Through data analysis of the second part (basic information) of 429 valid questionnaires, the basic demographic characteristics of the respondents can be obtained as shown in the Table 16 below.

Table 16. Basic demographic characteristics of the respondents

General Information	Groups	Number of people	Percentage (%)
Gender	Male	231	53.85%
	Female	198	46.15%
Age	18-29	173	40.33%
	30-39	116	27.04%
	40-49	58	13.52%
	50-60	82	19.11%
Monthly income (Yuan)	<4000	132	30.77%
	4001--8000	150	35.00%
	8001--15000	102	23.78%
	15001--25000	32	7.45%
	>25000	13	3.00%
Full-time Educational background	High school or below	73	17.01%
	College or Undergraduate	254	59.21%
	Master or above	102	23.78%
Job	Civil servant	30	6.99%
	Professional and technical personnel	151	35.20%
	Individual business	33	7.69%
	Student	64	14.92%
	Service staff	29	6.76%
	Worker	39	9.09%
	Freelancer and others	83	19.35%

The 429 respondents were almost evenly divided between men and women. In terms of age, 18-29 and 30-30 groups account for the majority of 289 people, accounting for

67.37%. In terms of income, there are very few respondents with an income of more than 15,000 yuan, and most of them are below 15,000 yuan, accounting for 89.55% of 384 people. In terms of full-time educational, most of the respondents had received college or undergraduate education, with 356 people in total, accounting for 82.99%. In terms of occupation, there are many types, but professional and technical personnel account for the majority, 151 people in total, accounting for 35.20%.

4.9.2. The macro analysis of the questionnaire

4.9.2.1. Analysis of factors influencing consumer behavior of traditional energy vehicles

Among the 429 respondents surveyed, 51 of them completed the part ③ of the questionnaire, and they did not consider buying New Energy Vehicles (NEV) at all, still choose to buy traditional fuel cars. The influencing factors of consumers' choice of traditional energy vehicles are analyzed, and the number and proportion of people choosing each influence factor are calculated. Specific data are shown in Figure 27.

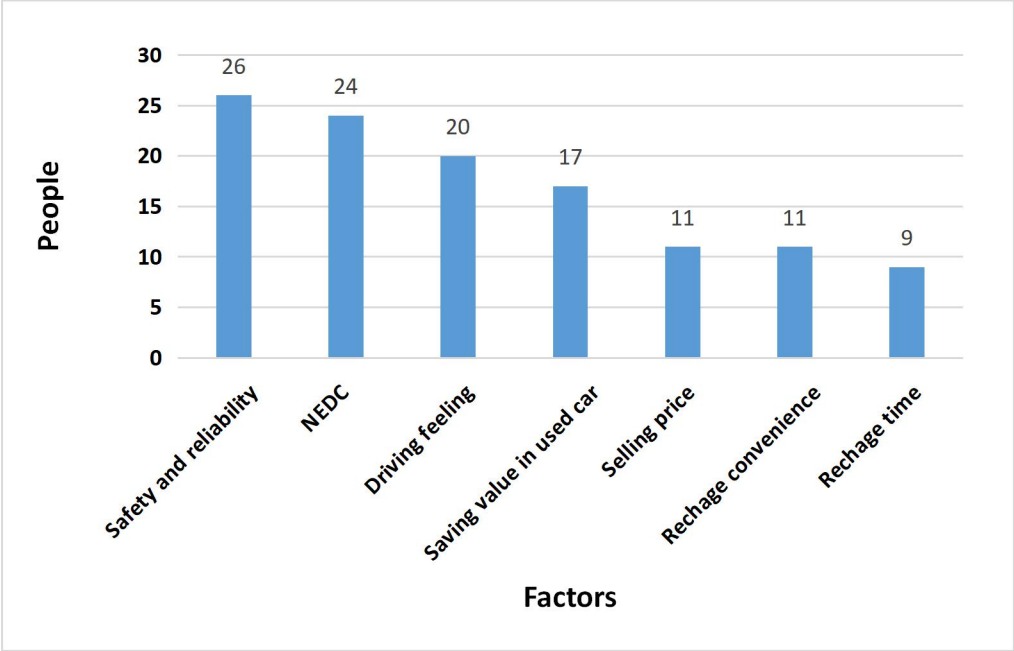

Figure 29. The distribution of people choosing traditional energy vehicles

As shown in Figure 29 , according to data statistics, among those who choose to buy traditional energy vehicles, three factors are mostly selected, they are "Safety and reliability" (a total of 26 people, accounting for 50.98%), "NEDC" (a total of 24 people, accounting for 47.06%) and "Driving feeling" (a total of 20 people, accounting for 39.22%).

It can be seen that in the minds of consumers, the safety and reliability is the most important. Previously, due to the battery safety problems, some people have concerns in their minds, leading to not choosing the New Energy Vehicles (NEV). Therefore, the New Energy Vehicles (NEV) should be vigorously developed in safety and reliability, especially battery safety, to dispel consumer concerns, in order to improve the recognition of the New Energy Vehicles (NEV).

NEDC is the second most important factor. Compared with traditional energy vehicles, NEDC of New Energy Vehicles (NEV) has obvious disadvantages. The NEDC of traditional energy vehicles is generally more than 500km, and has little influence with climate and temperature, while the NEDC of New Energy Vehicles (NEV) is generally short. In cold winter, or the using time of the battery is too long, the NEDC will be greatly reduced. It greatly affects the user experience.

The third is the driving feeling. It can be seen that those who still choose traditional energy vehicles are used to its driving feeling, or can be said that they enjoy the pleasure brought by the sound and feeling of the engine and machinery. Of course, the New Energy Vehicles (NEV) can be considered to cater to this part of consumers and simulate the sound by electronic technology.

Through this part of data analysis, find out the main contradiction between the traditional energy vehicles and the New Energy Vehicles (NEV) in people's mind, as far as possible, to make adjustments and progress, so that the New Energy Vehicles (NEV) are accepted by more people.

Of the 51 people, 26 people have personal vehicles, 25 people use traditional energy vehicles and 1 people uses the New Energy Vehicles (NEV). And this person who has a new energy vehicle now, but chooses to buy a traditional energy car, the reason given is driving feeling. This is very instructive, and it is also worth pondering by the New Energy Vehicles (NEV) industry.

4.9.2.2. Analysis of factors influencing consumer behavior of New Energy Vehicles (NEV)

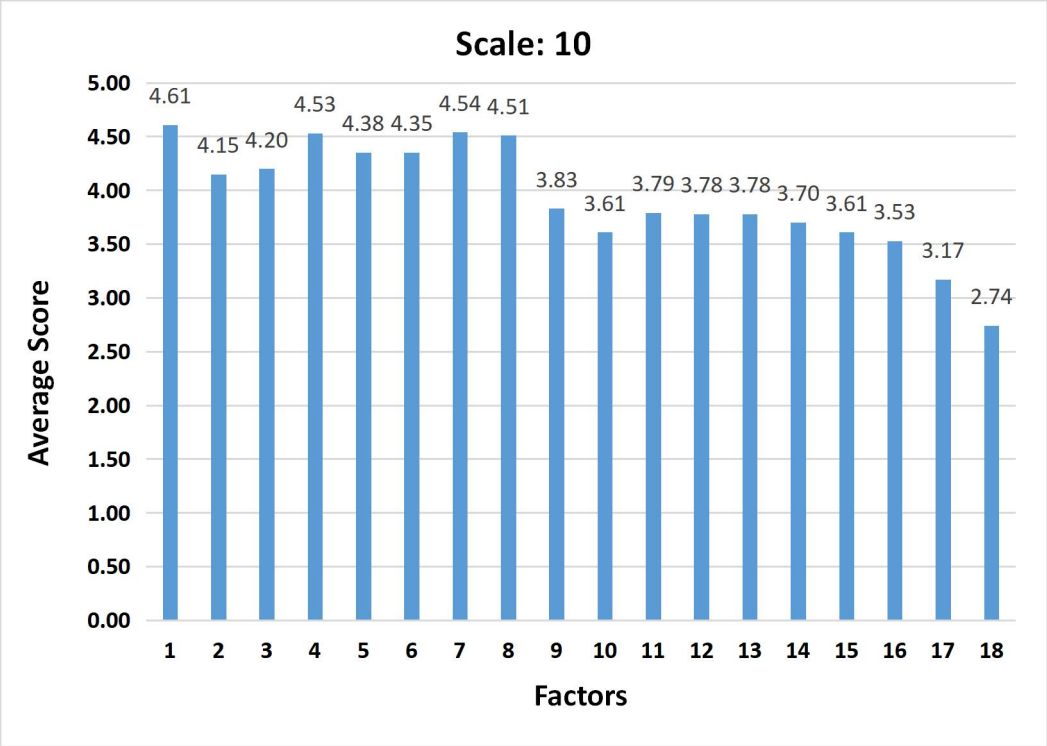

Figure 30. The average score of each item in the scale

Among the 429 respondents, 378 of them, accounted for 88.11%, completed the part ④ and part ⑤ of the questionnaire, that is, they are considering buying the New Energy Vehicles (NEV). This shows that the vast majority of people still accept and are willing to buy the New Energy Vehicles (NEV), and the popularity of the New Energy Vehicles (NEV) has done a good job in the Chinese market.

378 consumers of New Energy Vehicles (NEV) scored the 18 questions in the scale. From the average score of each question, we can see which aspects are valued by consumers or potential consumers of the New Energy Vehicle (NEV), and which are not important. The specific mean score of each influencing factor is shown in the Figure 30 above.

There are 8 items average score higher than 4. The item with highest average score is "10.1, The Public Infrastructure of The NEV (Fraction of Coverage and quantity of The Charging Station)", average scored 4.61. We can fully see the importance of the infrastructure of the New Energy Vehicle (NEV) in consumers mind. Because the number and popularizing rate of charging stations are related to the convenience of daily use, and it directly affect consumer experience, it is really the key factors for purchasing New Energy Vehicles (NEV).

The next four items, all closely related to battery technology, are "10.7 The Battery Life Cycle of The NEV", average scored 4.54, "10.4 The NEDC of NEV", average scored 4.53, "10.8 The Battery Safety of The NEV", average scored 4.51, and "10.5 The Charging time of The NEV", average scored 4.38. It can be seen that the battery is the power source reserve of New Energy Vehicles (NEV), and is one of the key factors in the technology of New Energy Vehicles (NEV), and the maturity of battery technology is closely related to the daily feelings of consumers. Due to this reason, consumers pay more attention to it.

"10.7 The battery life cycle of the NEV" determines the service life of the purchased New Energy Vehicles (NEV), or the time it takes to replace the battery. If the battery life is not enough, it will greatly increase the cost of cars for consumers.
"10.4 The NEDC of NEV" and "10.8 the Battery safety of the NEV" have been analyzed before in this paper. These two points are the main disadvantages of New Energy Vehicles (NEV) compared with traditional energy vehicles at present, and it is not surprising that consumers pay special attention to them.

"10.5 The charging time of the NEV" is another major disadvantage of New Energy Vehicle (NEV) compared with traditional energy vehicles. At present, the popular fast charging technology on the market still needs 0.5-1 hours to charge the battery to 80%, while the ordinary slow charging technology need 6-8 hours. In contrast, it only takes about five minutes to fill up a tank in a traditional energy vehicle. In contrast, it only takes about five minutes to fill up a tank of petrol in a conventional car. The charging time of the New Energy Vehicles (NEV) is too long, which directly affects the convenience and timeliness of consumers. For example, during the May Day or National Day holidays in China, due to the large number of people traveling by car, the New Energy Vehicles (NEV) often need to queue for several hours at charging stations on highways and then spend several hours charging.

There are also three items with an average score more than 4, which are all economic factors of New Energy Vehicles (NEV), respectively "10.6 The maintenance and after-sales costs of The NEV", with average scored 4.35. "10.3 The Daily Cost of The NEV (Daily Charging Cost), with average scored 4.20. and "10.2 The selling price of The NEV", with average scored 4.15. As we all know, price is the number one factor that drives consumers to buy. From buying to using and to keeping a car, the level of cost will affect the choice of consumers.

In conclusion, the 8 items should be considered in the future development of the New Energy Vehicles (NEV), so to improve their competitiveness and impress consumers.

On the contrary, there is only one item with an average score is less than 3, which is "10.18 The welfare Policy of The NEV", with a score of 2.74. Although, in the market economy, the role of marketing is crucial, but it should also be built on the basis of hard power, which is the core technology of New Energy Vehicles (NEV).

Nowadays, information is more and more transparent, and there are various ways to obtain information, which makes it easier for people to obtain objective information.

Objective information is more conducive to improving people's discrimination, which can reduce the phenomenon of blindly following, so that consumers can choose goods more objectively according to their own information.

Through the data analysis of 18 items, it is not difficult to see that in the field of New Energy Vehicles (NEV). First of all, the development of New Energy Vehicles (NEV) should be established on the basis of a good core technology, and set a reasonable price, coupled with strong government support and good after-sales service, the last and a convincing marketing. These are enough to improve the awareness of New Energy Vehicles (NEV) among consumers and improve the competitiveness of new energy vehicle companies.

4.9.2.3. Comparison between Chinese New Energy Vehicles (NEV) and foreign New Energy Vehicles (NEV)

After the respondents who chose New Energy Vehicles (NEV) completed the fourth part of the questionnaire, 378 respondents made their own choices about whether to choose Chinese New Energy Vehicles (NEV) or foreign New Energy Vehicles (NEV) and completed the fifth part of the questionnaire. Among them, 294 people chose domestic New Energy Vehicles (NEV) and 84 people chose imported New Energy Vehicles (NEV). As shown in the Figure 31.

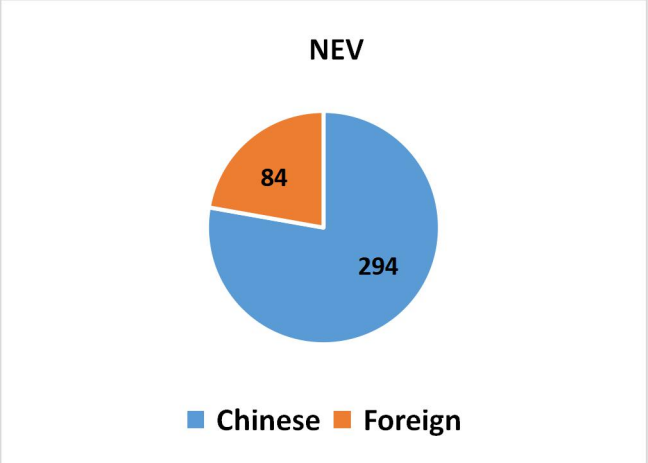

Figure 31. The number of people choosing Chinese/foreign NEV

The influence factors of 294 respondents who chose Chinese New Energy Vehicles (NEV) were statistically analyzed, and the proportion of each influence was calculated. Specific data are shown in Figure 32.

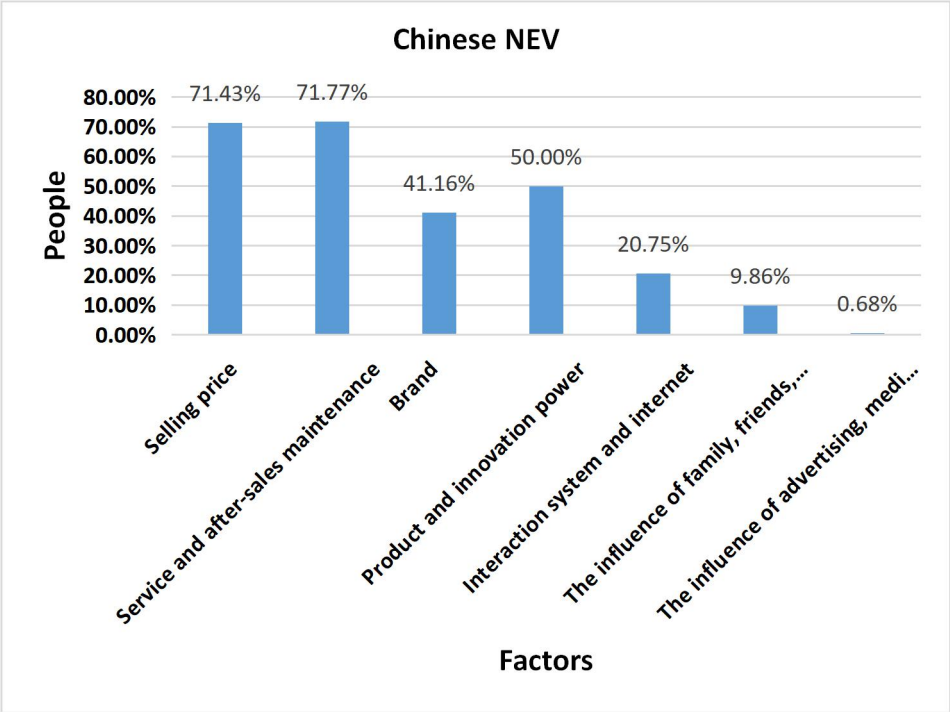

Figure 32. The proportion of the reasons of people choosing Chinese NEV

"Selling price" and "Service and after sales maintenance" are the most attractive for consumers to choose Chinese New Energy Vehicles (NEV), with 71.43% and 71.77% respectively. On the one hand, compared with imported New Energy Vehicles (NEV) at the same level, Chinese New Energy Vehicles (NEV) have higher configuration, more affordable price and good price performance ratio. On the other hand, China has a developed service sector, which benefits from people's sense of service and cheap labor. In the field of New Energy Vehicles (NEV), Chinese new energy vehicle companies provide consumers with good service and after-sales guarantee from the vital interests of consumers. For example, BYD installs household charging piles for new customers and provides a permanent warranty on the quality of the battery cells.

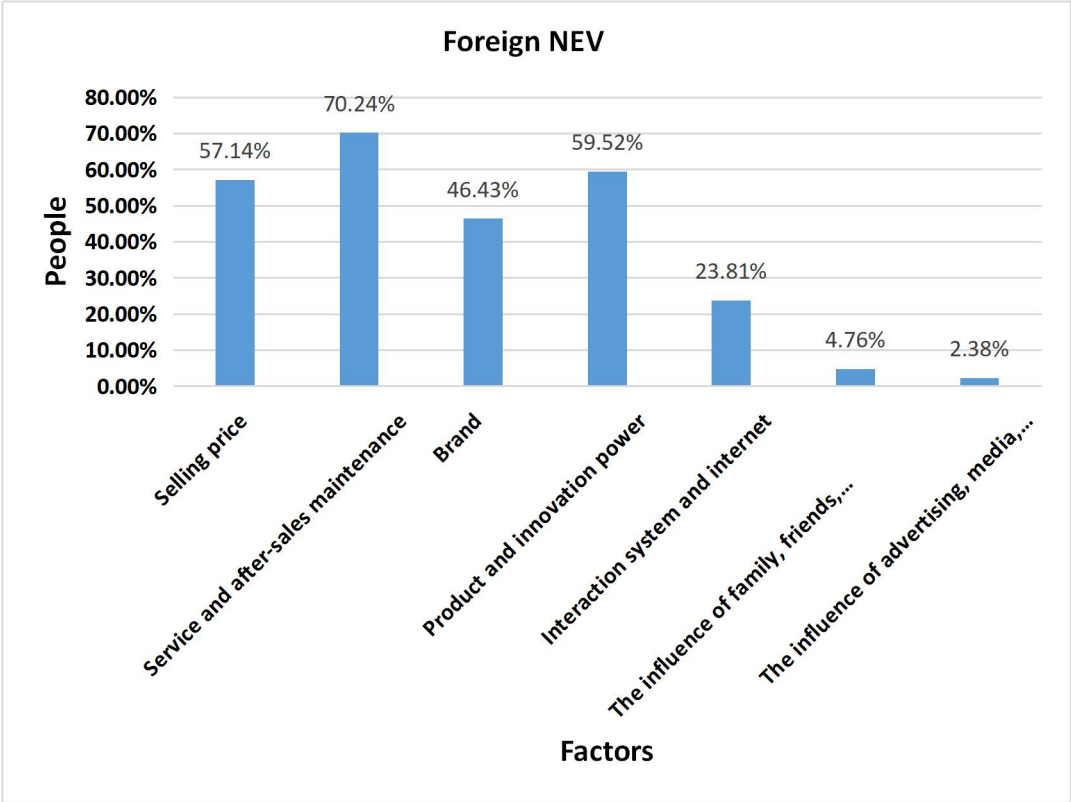

Figure 33. The proportion of the reasons of people choosing foreign NEV

Through the analysis of 84 respondents' reasons for choosing to import New Energy Vehicles (NEV), the following data are obtained, as shown in Figure 33. "Service and after sales maintenance" still accounted for the highest proportion, accounting for 70.24%. is shows that whether consumers choose Chinese New Energy Vehicles (NEV) or imported New Energy Vehicles (NEV), they are very concerned about after-sales service and guarantee. "Brand and Product and innovation Power" is another major selling point of imported New Energy Vehicles (NEV), accounting for 59.52%. After all, imported brands are traditionally seen as more technologically advanced. It can be seen that the influence of imported brands is huge.

Through comparison with the Figure 32 and Figure 33 above, it can be concluded that in terms of selling price, Chinese New Energy Vehicles (NEV) have a great advantage, with the proportion of 71.43% far higher than that of 57.14%. In terms of Brand and Product and innovation power, Chinese New Energy Vehicles (NEV) have

disadvantages, but the disadvantages are not obvious. The proportion of consumers choosing Chinese New Energy Vehicles (NEV) is 41.16%, slightly lower than 46.43% of imported New Energy Vehicles (NEV). As mentioned above, imported new energy vehicle brands have a long history, such as Tesla, which has a strong brand influence. However, most Chinese new energy vehicle brands are new brands. Even the relatively influential brands like BYD still have a certain gap with Tesla. In terms of product power and innovation power, 50.00% of Chinese New Energy Vehicles (NEV) accounted for slightly lower than 59.52% of imported New Energy Vehicles (NEV). Influenced by the development of traditional energy vehicles, it is generally believed that imported New Energy Vehicles (NEV) are better than Chinese New Energy Vehicles (NEV) at the same level. However, the data show that with the development of Chinese new energy vehicle technology, more and more people understand the product power and innovation of Chinese New Energy Vehicles (NEV). More and more people are willing to choose domestic new energy brands, even if they put aside patriotism and support for domestic products.

4.9.3. The micro analysis of the questionnaire

The micro analysis of the questionnaire is the analysis of differences among different groups. Using statistical methods, to analyse18 items data. SPSS software is mainly used for statistical analysis. Statistical methods mainly include descriptive analysis, T test, analysis of variance. T test is used to compare the mean of quantitative data between the two groups. One-way ANOVA (ANOVA analysis) is used to compare the mean of quantitative data between multiple groups. After that, to compare the result by LSD analysis. $P < 0.05$ is considered as statistically significant difference.

Here, the 18 items in the scale are classified into five influencing factors, and the Average score and Standard deviation of each item are calculated. Shown in the following Table 17.

Table 17. Average score and Standard deviation of each item

	Item	M±SD	M±SD（total）
Social factors	10.1 The public infrastructure of the NEV	4.61±0.73	14.12±2.27
	10.15 The social development trend	3.61±0.74	
	10.17 The influence of family, friends, colleagues, etc.	3.17±0.86	
	10.18 The influence of advertising, media, celebrity idols,etc.	2.74±1.03	
Product economy factors of NEV	10.2 The selling price of the NEV.	4.15±0.76	12.7±1.58
	10.3 The daily cost of the NEV (daily charging cost).	4.2±0.84	
	10.6 The maintenance and after-sales costs of the NEV.	4.35±0.69	
Product quality and technology factors of NEV	10.4 The NEDC of NEV.	4.53±0.67	24.68±2.11
	10.5 The charging time of the NEV.	4.38±0.7	
	10.7 The battery life cycle of the NEV.	4.54±0.56	
	10.8 The battery safety of the NEV.	4.51±0.62	
	10.9 The driving feeling of the NEV	3.83±0.61	
	10.10 The exterior and interior design of the NEV.	3.61±0.71	
	10.11 The functions and Configurations of the NEV.	3.79±0.6	
Government policy support factors	10.12 The government subsidies of the NEV.	3.78±0.71	7.56±1.13
	10.13 The welfare policy of the NEV.	3.78±0.61	
Psychological factors	10.14 The NEV are conducive to energy saving and emission reduction, meet the needs of sustainable development, and belong to the green travel.	3.7±0.68	7.22±1.1
	10.16 The brands of the NEV.	3.53±0.68	

Then, we calculate the total average score and total SD of each factor through the above statistics of average score and SD of each item. Then each item of basic information involved in demography is statistically analyzed for each factor to find out the factors with statistical significance ($p<0.05$, the difference is statistically

significant). Then compare and find out the average score difference between each item in the factors, analyze the cause of the difference.

4.9.3.1. Age distribution

The statistics and analysis of average score and standard deviation of different age groups in each factor are shown in the Table 18, it can be seen that p value is less than 0.05 in "Social factors", so there are statistical differences in scores of "Social factors" among different age groups. The total average score of "40--49 year-old" group is the highest, and the difference is statistically significant compared with "18--29 year-old" group (P =0.004) and "30--39 year-old" group (P=0.01).

However, there are no significant differences in "Product economy factors" of NEV, "Product quality factors" of NEV, "Government policy support factors" and "Psychological factors". (p>0.05)

Table 18. Average scores and standard deviations for all age groups

	18--29 M±SD	30--39 M±SD	40--49 M±SD	50--60 M±SD	F	P
Social factors	13.9±2.25	13.96±2.53	14.93±1.87	14.17±2.06	2.994	0.031*
Product economy factors of NEV	12.8±1.48	12.69±1.61	12.38±1.67	12.76±1.69	0.959	0.412
Product quality and technology factors of NEV	24.78±1.9	24.44±2.22	24.89±1.91	24.68±2.47	0.758	0.518
Government policy support factors	7.69±1.09	7.41±1.07	7.62±0.97	7.46±1.35	1.475	0.221
Psychological factors	7.14±1.04	7.2±1.24	7.33±0.98	7.37±1.09	0.883	0.450

Note： * p<0.05, the difference is statistically significant.

For the groups with statistically significant in "Social factors", "18--29 year-old" group, "30--39 year-old" group and "40--49 year-old" group, this thesis makes statistics on the scores of each group. It is shown in following Table 19.

Table 19. The average score of "18--29", "30--39" and "40--49" year-old groups in "Social factors"

	Items	18--29	30--39	40--49
Social factors	10.1 The public infrastructure of the NEV	4.69	4.59	4.67
	10.15 The social development trend.	3.54	3.59	3.78
	10.17 The influence of family, friends, colleagues,etc.	3.14	3.01	3.44
	10.18 The influence of advertising, media, celebrity idols,etc	2.54	2.77	3.04

As can be seen from Table 19 above, the scores of "18--29 year-old" group and "30--39 year-old" group in "Social factors" are basically the same. By comparing The differences between these two groups and "40--49 year-old" group, it can be seen that everyone reached an agreement on "10.1 The Public Infrastructure of The NEV", and the score is about 4.6. The main differences are mainly in "10.17 The influence of family, friends, colleagues,etc." and "10.18 The influence of advertising, media, celebrity idols,etc.". For "10.17", the score of 40--49 years old group is 3.44, much higher than the score of "18--29 year-old" group 3.14 and 30--39 years old group 3.01. For "10.18", the score of "40--49 year-old" group is 3.04, much higher than the score of "18--29 year-old" group 2.54 and 30--39 years old group 2.77.

According to the above data, it can be seen that people aged 40--49 are the mainstay of the society. After experience, they become more calm, mature and comprehensive, so they are more willing to learn from others' opinions. The two groups of people aged "18—29 year-old" and "30--39 year old" belong to the new generation of society. They have independent thoughts and distinct personalities, and prefer to follow their own mind to make choices.

4.9.3.2. Gender distribution

To use T test for statistical in gender distribution, the statistics and analysis of average score and standard deviation of different gender groups in each factor are shown in the Table 20. It can be seen that p value is less than 0.05 in "Social factors". So there are statistical differences in scores of "Social factors" among different gender groups. The score of "males" group is 13.72±2.41, lower than that of "females" 14.57±2.01.

However, there are no significant differences in "Product economy factors" of NEV, "Product quality factors" of NEV, "Government policy support factors" and "Psychological factors".

Table 20. Average scores and standard deviations for all gender groups

	Male M±SD	Female M±SD	*T*	*P*
Social factors	13.72±2.41	14.57±2.01	3.736	<0.001*
Product economy factors of NEV	12.57±1.55	12.85±1.61	1.743	0.082
Product quality and technology factors of NEV	24.61±2.18	24.76±2.02	0.709	0.479
Government policy support factors	7.49±1.17	7.63±1.07	1.158	0.248
Psychological factors	7.14±1.18	7.33±0.99	1.685	0.093

Note： * p<0.05, the difference is statistically significant.

For the groups with statistically significant in "Social factors", "male" group and "female" group, this thesis makes statistics on the scores of each group.

Table 21. The average score of "male" and "female" groups in "Social factors"

	Items	Male	Female
Social factors	10.1 The public infrastructure of the NEV	4.58	4.59
	10.15 The social development trend.	3.52	3.71
	10.17 The influence of family, friends, colleagues.	3.02	3.34
	10.18 The influence of advertising, media, celebrity idols,etc	2.61	2.88

Through Table 21 above, the "male" group and the "female" group are compared in their scores on "Social factors", and it is found that "10.1 The public infrastructure of The NEV" scored basically the same, which everyone agree its importance.

For "10.5 The social development trend", "female" group score of 3.71 is slightly higher than "male" group score of 3.52. This shows that women are more willing to follow the social development trend. In contrast, for "10.7 The influence of family, friends, colleagues" and "10.8 The influence of advertising, media, celebrity idols,etc", "female" group score 3.34 and 2.88 is higher than "male" group score 3.02 and 2.61, respectively, the difference is around 0.3. This shows that female consumers are more willing to accept the influence of external factors, while male consumers are more independent and have their own ideas.

4.9.3.3. Educational background distribution

The statistics and analysis of average score and standard deviation of different "Full-time educational background" groups in each factor are shown in the Table 22, It can be seen that p value is less than 0.05 in "Product quality and technology factors", so there are statistical differences in scores of "Product quality and technology factors" among different "Full-time educational background" groups. The total average score of "Master and above" group is the highest, and the difference is statistically significant compared with "High school and below" (P =0.021).

However, there are no significant differences in "Social factors", "Product economy factors" , "Government policy support factors" and "Psychological factors".

Table 22. Average scores and standard deviations for all full-time educational background groups

	High school and below M±SD	**College and Undergraduate** M±SD	**Master and above** M±SD	F	P
Social factors	14.25±2.4	14.19±2.29	13.85±2.11	0.88	0.412
Product economy factors of NEV	12.73±1.53	12.68±1.64	12.73±1.49	0.051	0.950
Product quality and technology factors of NEV	24.51±2.26	24.54±2.16	25.14±1.82	2.936	0.050*
Government policy support factors	7.8±1.05	7.56±1.11	7.41±1.2	2.160	0.117
Psychological factors	7.25±1.2	7.23±1.12	7.2±1	0.037	0.964

Note： * $p<0.05$, the difference is statistically significant.

For the groups with statistically significant in "Product quality and technology factors", The "high school and below" group and "The master and above" group, this thesis makes statistics on the scores of each group.

Table 23. The average score of the "high school and below" and "the master and above" groups in "Product quality and technology factors"

	Items	The high school and below	The master and above
Product quality and technology factors of NEV	11.4 The NEDC of NEV.	4.37	4.60
	11.5 The charging time of the NEV.	4.27	4.42
	11.7 The battery life cycle of the NEV.	4.49	4.63
	11.8 The battery safety of the NEV.	4.42	4.52
	11.9 The driving feeling of the NEV	3.89	3.90
	11.10 The exterior and interior design of the NEV.	3.63	3.73
	11.11 The functions and Configurations of the NEV.	3.85	3.86

Through Table 23 above, The scores of "The high School and below" group and "The master and above" group in "Product quality and technology factors" are compared.

It shows that the average score of each item in "The master and above" group is higher than "The high school and below". It can be seen that people with relatively high education background pay more attention to product quality and technology. In particular, the average scores of "11.4 The NEDC of NEV", "11.5 The charging time of the NEV", "11.7 The battery life cycle of the NEV" and "11.8 The battery safety of the NEV" are about 0.15 higher in each item. These four items involve the core technology of New Energy Vehicles (NEV), which are also the main problems faced by New Energy Vehicles (NEV) at present, but also the main development direction in the future. In general, people with relatively high education background have a clearer understanding of the current situation of New Energy Vehicles (NEV).

4.9.3.4. Income distribution

According to the statistics and analysis, all the P value are bigger than 0.05, so there is no statistical differences between each other. It is shown in the Table 24.

Table 24. Average scores and standard deviations for all income groups

	<4000	4001~8000	8001~15000	15001~25000	>25000	F	P
	M±SD	M±SD	M±SD	M±SD	M±SD		
Social factors	9.01±4.13	9.27±3.95	9.59±3.32	9.66±3.47	8.08±4.05	0.723	0.577
Product economy factors of NEV	11.02±4.85	11.15±4.5	11.73±3.55	10.97±4	9.62±4.59	0.874	0.480
Product quality and technology factors of NEV	21.03±9.13	21.53±8.45	22.66±6.55	22.94±7.66	21.46±9.73	0.755	0.555
Government policy support factors	6.68±2.99	6.55±2.72	6.95±2.16	6.41±2.38	6.08±2.96	0.599	0.664
Psychological factors	6.15±2.82	6.29±2.58	6.7±2.14	6.56±2.38	6.38±2.99	0.737	0.567

Note： * $p<0.05$, the difference is statistically significant.

4.9.3.5. The job distribution

(1 = Civil servant, 2 = Professional and technical personnel, 3 = Individual business, 4 = Student, 5 = Service staff, 6 = Worker, 7 = Freelancer and others)

The statistics and analysis of average score and standard deviation of different "job" groups in each factor are shown in the Table 25. It can be seen that p value is less than

0.05 in "Government policy support factors", so there are statistical differences in scores of "Government policy support factors" among different "job" groups. Group of "Professional and technical personnel" scored lower than group of "Individual business" (P =0.048) and lower than group of "Freelancer and others" (P =0.001).

However, there are no significant differences in "Product economy factors" of NEV, "Product quality factors" of NEV, "Social factors" and "Psychological factors". (p>0.05)

Table 25. Average scores and standard deviations for all job groups

	1	2	3	4	5	6	7	F	P
	M±SD	M±SD	M±SD	M±SD	M±SD	M±SD	M±SD		
Social factors	14.15 ±2.43	13.82 ±2.43	14.38 ±2.41	14.13 ±2.03	14.33 ±1.93	14.63 ±2.16	14.23 ±2.17	0.808	0.564
Product economy factors of NEV	12.73 ±1.4	12.67 ±1.59	12.45 ±1.64	12.93 ±1.43	12.04 ±1.63	12.89 ±1.81	12.8± 1.58	1.145	0.335
Product quality and technology factors of NEV	25.23 ±2.23	24.54 ±2.03	24.9± 1.8	25.11 ±1.91	23.75 ±2.23	24.51 ±2.61	24.73 ±2.1	1.663	0.129
Government policy support factors	7.62± 1.13	7.34± 1.23	7.79± 0.98	7.65± 0.97	7.33± 1.27	7.51± 0.98	7.86± 1.04	2.259	0.037*
Psychological factors	7.12± 1.48	7.16± 1.11	7.34± 1.11	7.22± 0.99	7.08± 0.97	7.46± 1.01	7.28± 1.12	0.546	0.773

Note： * p<0.05, the difference is statistically significant.

For groups with statistically significant in "Government policy support factors", The "Professional and technical personnel" group, "Individual business" group and the "Freelancer and others" group, this thesis makes statistics on the scores of each group.

Table 26. The average score of "Professional and technical personnel" group, "Individual business" group and the "Freelancer and others" group in "Government policy support factors"

	Items	2	3	7
Government policy support factors	10.12 The government subsidies of the NEV	3.65	3.9	3.96
	10.13 The welfare policy of the NEV.	3.69	3.9	3.91

Through Table 26 above, to analyze the score in "Government policy support factors" of "Professional and technical personnel" group, "Individual Business" group and "Freelancer and Others" group. The scores of the "Individual business" group and "Freelancer and Others" group are basically the same, and each score is about 0.3 higher than that of the "Professional and Technical personnel" group. It indicates that consumers in the "Individual business" group and "Freelancer and Others" group care more about "Government policy support factors", which reflects that in the daily life of these two groups of people, and can enjoy more the convenience brought by government policy.

Generally speaking, combined with age distribution, gender distribution, educational background distribution, income distribution and job distribution among various factors, not many groups are found to be statistically significant. This can also fully demonstrate that due to the development of the Internet and the high degree of information openness, everyone is able to get the same information. However, different age, gender, educational background, income and job may lead to slightly different understanding of information. Moreover, people's thinking has become more comprehensive and independent, and there are fewer and fewer labels inherent to each group of consumers.

For example, in age distribution, the scores of the female group and the male group are basically the same, which also indicates that with the development of society, women become more independent and have their own ideas when choosing to buy

New Energy Vehicles (NEV). And in income distribution, there is no statistically significant difference, indicating that although people have different incomes, the factors that they care about are all the same. However, when choosing New Energy Vehicles (NEV), there will be differences in the sales price level.

4.10. Summery

There are many factors affecting the development of new energy vehicle companies. This chapter is from the perspective of consumers, to research consumer behavior, analyze the influencing factors of consumer behavior, and combine the previous analysis with the characteristics of New Energy Vehicles (NEV). And as the basis, to determine the framework consists of five parts of the questionnaire, include introductory remarks, the basic information of the consumers, the influencing factors of consumer behavior in choosing traditional energy vehicles (a multiple choice question), the influencing factors of consumer behavior in choosing New Energy Vehicles (NEV) (scale scoring questions), the contrastive analysis on the influencing factors of consumers' choice of Chinese New Energy Vehicles (NEV) or imported New Energy Vehicles (NEV) (a multiple choice question). Then, the survey process is formulated to form the questionnaire. After the reliability and validity of the preliminary survey is qualified, the questionnaire is officially issued. Finally, the data of the questionnaire is recovered and the data is statistically analyzed from the macro and micro parts.

In macro analysis, there are three components. Firstly, it is the multiple choice completed by consumers who choose to buy traditional energy vehicles. By analyzing the number and proportion of each choice in the multiple choice, it can be concluded that the main advantages of traditional energy vehicles are "Safety and reliability", "NEDC" and "Driving feeling". Secondly, it is the scale completed by consumers who choose to buy New Energy Vehicles (NEV). By scoring 18 items in the scale, the

average score of 8 items are more than 4, and the average score of 1 item is less than 3. The higher the score is, the more attention consumers pay to the influencing factors mentioned in the question. The highest average score is No. 11.1 The "Public Infrastructure of The NEV (Fraction of Coverage and quantity of The Charging Station)" , average scored 4.61. We can fully see the importance of the infrastructure of the New Energy Vehicle (NEV) in consumers mind. Finally, it is a multiple choice of comparison between Chinese New Energy Vehicles (NEV) and imported New Energy Vehicles (NEV). By analyzing the proportion of each option in the multiple choice, it can be concluded that the main advantages of Chinese New Energy Vehicles (NEV) is "Selling price". The main disadvantages are "Brand" and "Product and Innovation Power".

The micro analysis is only for the scale scoring questions, through T test and ANOVA analysis, by using SPSS software, to confirm the statistically significant groups in each factor, and to do comparative analysis. However, there are not many groups with statistical significance, which also indicates that with the development of society, people in all groups are basically at the same level in terms of cognition of New Energy Vehicles (NEV).

This part through the form of questionnaire, and analyze the collected data. Find out the advantages and disadvantages of current New Energy Vehicles (NEV), especially Chinese New Energy Vehicles (NEV), to indicate the main problems existing in Chinese New Energy Vehicles (NEV), and put forward suggestions for Chinese New Energy Vehicles (NEV), it also helps to improve the competitiveness of Chinese new energy vehicle companies.

5. Conclusion and prospect

All countries in the world with achieved success in economic development have to go through the process at the expense of excessive consumption of resources and the environment. Therefore, environmental pollution caused by economic development appears all over the world. At present, governments around the world have realized the seriousness of these problems, and at the same time, because of the non-renewable nature of petroleum fuels, development of new energy has become a strong target. In the automobile industry, the New Energy Vehicles (NEV) have become an important measure for governments to improve the energy structure.

For New Energy Vehicles (NEV), the United States and Germany started first, and the technology and market popularity were earlier than China. However, China is more aggressive in its strategy. Not same as other countries, which are conservative, most of Chinese New Energy Vehicles (NEV) brands are emerging enterprises. This also leads to Chinese new energy vehicle companies being more innovative in marketing innovation than traditional energy vehicle manufacturers. While, the subsidy policies of New Energy Vehicles (NEV) in various countries increase year by year, Chinese New Energy Vehicles (NEV) subsidies began to decline. It can be seen that, in the field of New Energy Vehicles (NEV), China has formed its own competitive market. New Energy Vehicles (NEV) in China already have the opportunity to compare with traditional energy vehicles. Chinese New Energy Vehicles (NEV) also have certain competitiveness in the international market.

The specific research methods and process of this thesis are as follows.

Firstly, through the analysis of International Market Share (IMS) and the Trade Competitiveness Index (TC) of China, the United States, Europe and Japan in the trade of New Energy Vehicles (NEV), we can see that Chinese New Energy Vehicles (NEV) in the international market, there is a large space for improvement.

Then, through SWOT analysis, the advantages and disadvantages of the development of Chinese New Energy Vehicles (NEV) are analyzed in detail. Currently, Chinese New Energy Vehicles (NEV) is in a leading position in the world in terms of infrastructure, market capacity and related industrial chain development, but its popularity in the international market is low. At the same time, It also faces strong competition from international giants. Therefore, for Chinese New Energy Vehicles (NEV), we should use our advantages to develop Pure Electric Vehicles (PEV) and break through core technologies to further promote the development of Chinese New Energy Vehicles (NEV), in order to increase the competitiveness of the Chinese new energy vehicle companies.

And through factor analysis, it can be seen that Chinese New Energy Vehicles (NEV) have a high score. Mainly related to the achievements of Chinese New Energy Vehicles (NEV) in infrastructure construction. China has been stepping up infrastructure construction for New Energy Vehicles (NEV), with the government coordinating with companies to promote the construction of a large number of fast-charging stations.

After that, statistics and analysis of patents in the field of autonomous driving and car sharing. In field of the autonomous driving, China still needs to make efforts to catch up other developed countries. In contrast, in the field of car sharing, especially MaaS, Chinese new energy vehicle companies are in a leading position. Therefore more business models of New Energy Vehicles (NEV) can be realized based on MaaS in China. It is good to reduce the production cost of Chinese New Energy Vehicles (NEV), to improve the competitiveness of Chinese New Energy Vehicles (NEV) enterprises, in order to improve the purchasing ability of consumers, promote the popularity of New Energy Vehicles (NEV).

Finally, learn form of questionnaire, and analyze the collected data. Find out the advantages and disadvantages of current New Energy Vehicles (NEV), especially Chinese New Energy Vehicles (NEV), to indicate the main problems existing in Chinese New Energy Vehicles (NEV), and put forward suggestions for Chinese New Energy Vehicles (NEV), it also helps to improve the competitiveness of Chinese new energy vehicle enterprises.

5.1. The competitiveness of the Chinese new energy vehicle companies.

Through the previous overall research and analysis of Chinese new energy vehicle companies, and the comparison with other countries' New Energy Vehicles (NEV), as well as the investigation of Chinese new energy vehicle market, we can specifically analyze the competitiveness of Chinese new energy vehicle companies.

Since Chinese traditional energy vehicles started much later than developed countries, it is difficult to catch up with Germany, Japan or other countries in engine, gearbox and chassis. But in new energy vehicle field, China has achieved "corner overtaking" in the field of battery, motor and electronic control. From this point of view, China is in a leading position in three major fields of the New Energy Vehicles (NEV).

The competitiveness of Chinese new energy vehicle companies in the world is gradually increasing. Based on Chinese strong infrastructure construction capacity, the sales volume of the Chinese New Energy Vehicles (NEV) occupy the first place in several years. Therefore, in a highly competitive market, Chinese new energy vehicle companies also have certain competitiveness in the world. From January to May in 2022, the Chinese vehicles exports reached 1.08 million, among which 174,000 were New Energy Vehicles (NEV). As a core growth point, the export of Chinese New Energy Vehicles (NEV) has changed the passive situation of vehicles exporting only to Asia or Africa. In 2021, among the major exporters of Chinese New Energy

Vehicles (NEV), developed countries such as Belgium, the UK, Germany, France and Australia rank at the top. Among them, in 2021, Chinese New Energy Vehicles (NEV) exports to Europe with the fastest growth of 204%, while exports to North America with growth of more than 100%. While total global sales volume of the new vehicles only grow by about 3% in 2021, and the sales volume of New Energy Vehicles (NEV) grow by about 108%. If New Energy Vehicles (NEV) eventually replace traditional energy vehicles, with Chinese new energy vehicle companies in the production of the dominant position, it will be able to achieve a breakthrough in the field of New Energy Vehicles (NEV) in the future, and to achieve "corner overtaking".

From this point of view, Chinese new energy vehicle companies have certain competitiveness in the world, and their competitiveness is continuing to improve.

5.2. Existing problems in Chinese new energy vehicle companies.

With the rapid development of New Energy Vehicles (NEV), some problems have gradually emerged. All kinds of problems faced by other countries' new energy vehicle companies are also plaguing Chinese new energy vehicle companies. Here are several major problems faced by new energy vehicle companies.

5.2.1. The problem of infrastructure construction

Compared with traditional energy vehicles, the New Energy Vehicles (NEV) still have charging problems in the process of long-distance travel due to the limitation of energy supplement. In China, there are a large number of charging piles including quick charging piles. However, there are certain differences in charging protocols among different companies, leading to the incompatibility of quick charging. In this way, it can provide convenience for consumers of New Energy Vehicles (NEV) to the greatest extent and improve their using feeling. Therefore, the overall competitiveness of Chinese new energy vehicle companies can be improved.

5.2.2. The problem of emerging key technology

At present, Chinese New Energy Vehicles (NEV) are in a leading position in hardware technologies such as batteries and electric motors. However, with the development of the new energy vehicle industry, Chinese New Energy Vehicles (NEV) are lagging behind in some emerging key technologies, especially in autonomous driving technology, which is the main problem to be solved by New Energy Vehicles (NEV) in the future. Foreign new energy vehicle companies are good at grasping the direction of technological development, and good at the research and development of emerging core technologies. Tesla, for example, has been leading the development of the new energy vehicle industry as a leader, especially in the autonomous driving technology, Tesla is far ahead. However, Chinese new energy vehicle companies need to change the identity of followers in emerging core technologies and strive to achieve "corner overtaking".

5.2.3. The problem of popularity

Compared with the New Energy Vehicles (NEV) companies in other countries, Chinese New Energy Vehicles (NEV) companies still need to continue to improve their popularity. Most of Chinese new energy vehicle companies are emerging companies, so consumers in other countries have low understanding and recognition of them. At present, only BYD has good sales volume in foreign markets, but they are mainly in the new energy passenger vehicles. Therefore, among the new forces in car manufacturing in New Energy Vehicles (NEV), NiO, Ideal, Xiaopeng, ALchi, Weimar and so on are actively layout foreign markets. Especially, Nio has previously said that it plans to enter at least five European countries by 2022, and has set foreign sales volume as a development goal to account for 50 percent of total sales volume.

5.3. Prospects for the future development of Chinese new energy vehicle companies.

In view of the problems of Chinese new energy vehicle companies. From the strategic level of improving the competitiveness of Chinese New new energy vehicle companies, the following reference strategies and suggestions are given.

5.3.1. Accelerate infrastructure construction

On the basis of Chinese existing good infrastructure construction, we will further increase investment in infrastructure. To establish the public charging piles and transportation facilities actively. In addition, relying on a large number of charging pile resources, to formulate the relevant charging protocols, so that, Chinese new energy vehicle companies can have the same charging protocol and a common fast charging system. In this way, consumers of New Energy Vehicles (NEV) can be provided with convenience to the greatest extent and sales of New Energy Vehicles (NEV) in China can be promoted.

5.3.2. Improve Research and Development (R&D) efforts

Although Chinese New Energy Vehicles (NEV) stay the international advanced level in terms of product field, they will be abandoned if they do not make progress and improve in the market. The technologies are the core of the product, therefore, for the key technologies, the Chinese government should integrate resources, meanwhile, cooperate with enterprises and scientific research institutions, in order to promote the R&D of key technologies. Especially in the field of autonomous driving, Chinese new energy vehicle companies still have a lot of space for improvement.

5.3.3. Strengthen market popularity

As mentioned earlier, compared with the new energy vehicle companies in other countries, the popularity of the Chinese New Energy Vehicles (NEV) are generally lower. So the development of Chinese new energy vehicle companies should study from international experience, to be market-oriented, then to choose strategic priorities, and to adopt the strategy of paying equal attention to short-term development and long-term development. Chinese New Energy Vehicles (NEV) companies should be based on their own conditions and the local resources, culture, customs and other conditions in the sales area, to develop the corresponding and suitable New Energy Vehicles (NEV) products. According to the market form of continuous adjustment, to improve the enterprise strategic structure and business strategy, so as to improve the popularity of Chinese new energy vehicle companies in the world.

5.3.4. Improve the autonomy of consumers in purchasing New Energy Vehicles (NEV)

In addition, from the consumer side, only where there are consumers can there be a market, and only when there is a market can companies survive. Therefore, companies should enhance consumers' purchasing autonomy to promote the consumption of New Energy Vehicles (NEV).

First of all, the key to promote the consumption of New Energy Vehicles (NEV) is to reduce production and use costs of them. The Chinese companies and related government agencies should accelerate the independent R&D of new energy vehicle technology, to eliminate technical barriers and reduce dependence on foreign technology, in order to furthest reduce the production cost fundamentally. And also the Chinese government should give fiscal and tax support to the R&D and

production of New Energy Vehicles (NEV), and introduce policies for ordinary consumers, such as reducing vehicle purchase fees and providing subsidies, in order to reduce the use cost of New Energy Vehicles (NEV). At the same time, we should further adjust the fuel tax policy and increase the sustainable expenditure of traditional energy vehicles.

Secondly, another key factor to improve consumers' purchasing autonomy is to improve the product power of New Energy Vehicles (NEV). The improvement of product power of New Energy Vehicles (NEV) is complementary to the progress of its core technology. Chinese companies and the government should increase their support for R&D of core technologies, such as battery technology, to achieve technological breakthroughs in battery range and charging speed. Fundamentally improve the convenience of Chinese New Energy Vehicles (NEV) using , to solve the concerns of consumers, in order to make the purchase happen.

At the same time, in order to promote consumers to accept new energy vehicle products more quickly, the Chinese government and industry should also increase publicity of product purchase policy and environmental protection, improve the environmental awareness of the whole society, cultivate the culture of advocating the purchase and use of New Energy Vehicles (NEV), in order to expand the user base of New Energy Vehicles (NEV).

5.4. Summary

In general, the emergence of New Energy Vehicles (NEV) is both an opportunity and a challenge for Chinese automobile companies. Although the competitiveness of Chinese new energy vehicle companies shows a good trend on the whole, compared with other countries, there is still a lot of room for progress in many aspects. In the following development, Chinese new energy vehicle companies should speed up the pace of development in terms of advanced aspects and strive to open the distance with

other countries, and in terms of underdeveloped aspects, appropriate development strategies should be formulated to reduce the gap with other countries, and in new areas, try to be an innovator, not a follower.

It is hoped that through the efforts of Chinese new energy vehicle companies and the strong support of the government, the situation that Chinese companies have been lagging behind in the automobile industry can be changed and "corner overtaking" can be realized as soon as possible.

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Appendix

【Automobile Market Survey】

Aim: The emergence of New Energy Vehicles (NEV) has enriched the diversity of products, especially the rise of Chinese New Energy Vehicles (NEV), so that people have more choices when buying vehicles. The sales of New Energy Vehicles (NEV) show an overall increasing trend, but still far less than the sales volume of traditional energy vehicles. The purpose of this survey is to initially understand the factors affecting people's purchase of new energy vehicles, in order to better promote and sell New Energy Vehicles (NEV) to provide a theoretical basis.

This questionnaire will be conducted anonymously. Please answer it carefully according to your real situation and first intention. Thank you very much!

The basic personal information.

****Note：There are 6 required questions, all of them are single choice.**

1. Gender [Single choice] *

○ male

○ female

2. Age（18--60 year-old） [Single choice] *

○ 18--29

○ 30--39

○ 40--49

○ 50--60

3. Full-time educational background [Single choice] *

○ High school and below

○ College and Undergraduate

○ Master and above.

4. Monthly income (Yuan) [Single choice] *

○ < 4000

○ 4001--8000

○ 8001-15000

○ 15001-25000

○ > 25000

5. Job [Single choice] *

○ Civil servant

○ Professional and technical personnel

○ Individual business

○ Student

○ Service staff

○ Worker

○ Freelancer and others

6. Will you choose to buy a New Energy Vehicles (NEV)? [Single choice] *

○ A. Yes, I'm willing to buy one. (Please skip to question 9.)

○ B. Not yet, but maybe to buy one in the future. (Please skip to question 9.)

○ C. No, absolutely not. (Please skip to question 7.)

The factor of choosing a traditional energy vehicle.

7. Do you have a personal car at present? [Single choice] *

○ Yes. _____ * (Traditional energy vehicles or New energy vehicles.)

○ No

8. The factor of choosing a traditional energy vehicle. [Multiple choice (Max 3 options)] *

□ Selling price

□ Saving value in used car

□ New European Driving Cycle (NEDC)

□ Recharge time

□ Recharge convenience

□ Driving feeling

□ Safety and reliability.

****Note：Please complete the survey after finishing the question 8.**

The factor of choosing a New Energy Vehicle (NEV).

When you choose to buy New Energy Vehicles (NEV), please take the importance of each item as the measurement standard and put the point for each item. The points setting is: 5 points (very important), 4 points (important), 3 points (general), 2 points (not important), 1 point (very not important).

9. Do you have a personal car at present? [Single choice] *

○ Yes. _____ * (Traditional energy vehicles or New energy vehicles.)

○ No

10. The factor of choosing a New Energy Vehicle (NEV). [Scale questions] *

****Note：There are 18 items，No more than six answers should be rated 5 points (very important).**

	5	4	3	2	1
1. The public infrastructure of the NEV(fraction of coverage and quantity of the charging station)	○	○	○	○	○
2. The selling price of the NEV	○	○	○	○	○
3. The daily cost of the NEV (daily charging cost)	○	○	○	○	○
4. The NEDC of NEV	○	○	○	○	○
5. The charging time of the NEV	○	○	○	○	○
6. The maintenance and after-sales costs of the NEV	○	○	○	○	○
7. The battery life span of the NEV	○	○	○	○	○
8. The battery safety of the NEV	○	○	○	○	○
9. The driving feeling of the NEV (strong acceleration, low noise)	○	○	○	○	○
10. The exterior and interior design of the NEV	○	○	○	○	○
11. The functions and configurations of the NEV	○	○	○	○	○
12. The government subsidies of the NEV	○	○	○	○	○
13. The government subsidies of the NEV	○	○	○	○	○

14. Green Concept: The NEV are conducive to energy saving and emission reduction, meet the needs of sustainable development, and belong to the green travel.	○	○	○	○	○
15. The social development trend	○	○	○	○	○
16. The brands of the NEV	○	○	○	○	○
17. The influence of family, friends, colleagues, etc.	○	○	○	○	○
18. The influence of advertising, media, celebrity idols, etc.	○	○	○	○	○

11. Will you choose domestic New Energy Vehicles (NEV) or imported New Energy Vehicles (NEV)? [Single choice] *

○ A. Domestic New Energy Vehicles (NEV)

○ B. Imported New Energy Vehicles (NEV)

The factor of choosing a domestic New Energy Vehicle (NEV) or importing New Energy Vehicle (NEV).

12. The factor of choosing a domestic New Energy Vehicle (NEV) or importing New Energy Vehicle (NEV). [Multiple choice (Max 3 options)] *

□ Selling price

□ Service and after sales maintenance

□ Brand

□ Product and innovation Power

□ Interaction system and internet

□ The influence of family, friends, colleagues, etc.

□ The influence of advertising, media, celebrity idols, etc.

****Note：Please complete the survey after finishing the question 12.**

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