‘Forced to Green’ or ‘Willingness to Green’?

Behaviors under Uncertainty of Quota
Evidence from China’s Adoption of New Energy Vehicles

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Abstract

This research relates to the social, environmental, political and economic policies in term of the macro-perspective. More importantly, it integrates the macro with the micro-perspectives, digging into individuals' decision under a micro-perspective, providing a comprehensive insight, where it not only has a big picture on the evolution process in the longitudinal historical spectrum, but also a micro-world on its own functional mechanism regarding the individuals' decision making. Accordingly, it is an interdisciplinary research providing a micro insight of behaviours from the evidence of emerging industry of new energy vehicles.

Based on the literature review of the adoption of new energy vehicles, it elaborates two perspectives for the further studies. Firstly, the data fusion provides the insight for the design of sampling and data collection, combining the stated and revealed preference. Secondly, it raises the question of disparity between the willingness to pay and actual payment academically. Meanwhile, it raises the research questions on the behavior under different quota mechanisms. Accordingly, the study is based on samples of two groups, experiment group with a license plate and controlled group without a license plate deployed respectively, to answer and test the hypothesis. Firstly, the function mechanisms of WTP and AP are different, and there is a phenomenon of the "trap of subjective willingness". Importantly, there is a disparity between WTP-AP, the higher uncertainty of utilization and the more learning opportunity with a delayed cost, the higher disparity between the WTP/AP. Secondly, the adoption of NEVs is forced to green under the multi-exclusive quota, simultaneously, there are externalities and spillover caused by the multi-exclusive quota.

The framework is divided into seven chapters, the first chapter is a framework introduction of China's studies, target and data source. The second chapter is the introduction of triangle backgrounds, comprising the international, China's perspectives, then experiment group of Shenzhen. The third chapter focuses on the literature review on the adoption of new energy vehicles, elaborating the further studies on the data enrichment for the sampling and data collection, and disparity between the willingness to pay and actual payment. The fourth chapter is contingent on two furthering studies in the third chapter elaborating the literatures and detailed hypotheses in this research. Specifically, the first part is the literature on the willingness to pay, the commitment cost for the disparity between willingness to pay and actual payment, the second part is the theory of individual transferable quota for the treatment effect. The fifth chapter is the introduction of sampling design and description analysis for the data collection. After that, the sixth chapter is the empirical studies and results according to the literature and sub-hypothesis in fourth chapter. Lastly, it has a conclusion in the seventh chapter.

After the literature review and empirical study, there are five findings. Firstly, for the variation of WTP, it cannot draw the conclusion that the private good's variation is smaller than a public good in the meta-analysis, but it supports that the coefficient variation in the experiment group is higher than the counterpart in the controlled group. Secondly, for the different mechanisms between WTP and AP, the higher green perception of the NEVs, the higher WTP, but this positive relationship for WTP is not applicable to the AP, which indicates there is a phenomenon of the "trap of subjective willingness". However, it supports the hypothesis the higher certainty of the charging location, the higher WTP, this is applicable to both WTP and AP. Besides, it found that the income is a necessary but insufficient condition for the adoption of NEVs.

Thirdly, contingent on the theory framework of commitment cost for the disparity between WTP/AP, it extends the previous research scope, due to the product utilization is strongly connected with the product or service chosen in its study and laboratory experiment, when the focus of uncertainty moves from the monetary value to the utilization, it cannot reach the same conclusion that the higher uncertainty of utilization, the higher disparity between the WTP/AP, which is also demonstrated the importance and necessity of category of product raised in the first hypothesis, public or private good. Additionally, it extends the previous precondition of zero learning cost in the theory of commitment cost, an extension with a learning cost is embedded in behaviors, it finds that the more learning opportunity with a delayed cost, the higher disparity between the WTP/AP.

Fourthly, it finds that the adoption of NEVs is forced to green in the model of multi-exclusive-quotas with a constant TAC and absent of transferable market, the more times participating in the lottery of conventional vehicles, the higher possibility of purchasing NEVs. Additionally, in term of macro-perspective in multi-exclusive quotas, the higher cost and smaller probability of one sub-quota, the higher rate of adoption for another sub-quota. Namely, the adoption of NEVs, is positively associated with a higher bidding price and lower lottery winning rate. Fifthly, in term of externalities, it finds that there is a spillover effect under the multi-exclusive quotas, which counteract the initial target of reducing the volume of conventional vehicles and increasing the volume of NEVs. Besides, there is an externality of discards in the multi-exclusive quotas. The higher cost of the bidding, the higher rate of discards; The lower the lottery rate of winning a license plate, the lower rate of discarding.

Keywords: China's studies, Willingness to Pay (WTP), Actual Payment (AP), Disparity, Commitment Cost, Multi-exclusive Quota, Lottery, Bidding, Electrical Vehicles (NEVs)

Abstrakt

Diese Forschung bezieht sich auf die Sozial-, Umwelt-, politische und Wirtschaftspolitik, unbewusst wird sie auch von der Philosophie und der Geschichte für die Entscheidung der Regierung und der Menschen beeinflusst, vor allem in Bezug auf die Makroperspektive, deckt sie die Philosophie, Geschichte, Soziales, Politik, Umwelt, Wirtschaft und Industriereform ab. Noch wichtiger ist, dass diese Forschung die Makroperspektive in die Mikroperspektiven integriert und die Entscheidungen des Einzelnen unter einer Mikroperspektive untersucht. Sie bietet einen umfassenden Einblick, indem sie nicht nur einen Überblick über den Evolutionsprozess im historischen Längsspektrum bietet, sondern auch einen Mikrowelt über ihren eigenen Funktionsmechanismus in Bezug auf die Entscheidungsfindung des Einzelnen. Dementsprechend handelt es sich um eine interdisziplinäre Untersuchung, die einen Mikroeinblick auf Verhaltensweisen aus den Erkenntnissen der aufstrebenden Industrie neuer Energiefahrzeuge liefert.

Basierend auf der Literaturübersicht über die Einführung neuer Energiefahrzeuge werden zwei Perspektiven für die weiteren Studien entwickelt. Einerseits liefert die Datenfusion den Einblick in das Design der Probenahme und Datenerfassung, wobei die angegebene und die offenbarte Präferenz kombiniert werden. Andererseits wirft es die akademische Frage nach der Ungleichheit zwischen Zahlungsbereitschaft und tatsächlicher Zahlung auf. Gleichzeitig werden Forschungsfragen zum Verhalten unter verschiedenen Quotenmechanismen gestellt. Die Studie basiert auf Stichproben von zwei Gruppen: einer Gruppe *mit einem Nummernschild* und einer Kontrollgruppe ohne eingesetztes Nummernschild, um die Hypothese zu beantworten und zu testen.

Erstens sind die Funktionsmechanismen von WTP und AP unterschiedlich, und es gibt ein Phänomen der „Falle subjektiver Bereitschaft“. Wichtig ist, dass zwischen WTP-AP ein Unterschied besteht: Je höher die Nutzungsunsicherheit und je mehr Lernmöglichkeiten mit verzögerten Kosten vorhanden sind, desto größer ist der Unterschied zwischen WTP / AP. Zweitens ist die Einführung von NEVs gezwungen, im Rahmen des Multi-Exklusiv-Kontingents grün zu werden. Gleichzeitig gibt es externe Effekte und Spillover, die durch das Multi-Exklusiv-Kontingent verursacht werden.

Das Framework ist in sieben Kapitel unterteilt. Im ersten Kapitel geht es um die Framework-Einführung in Chinas Studien, deren Ziele und Datenquellen. Das zweite Kapitel beginnt mit der Einführung von Dreieckshintergründen, die die internationalen Perspektiven Chinas und dann die Versuchsgruppe von Shenzhen umfassen. Das dritte Kapitel konzentriert sich auf die Literaturrecherche zur Einführung neuer Energiefahrzeuge, die weiteren Studien zur Datenanreicherung für die Probenahme und Datenerfassung sowie die Diskrepanz zwischen Zahlungsbereitschaft und tatsächlicher Zahlung. Das vierte Kapitel hängt von zwei weiteren Studien im dritten Kapitel ab, in denen die Literaturen und detaillierten Hypothesen dieser Forschung erarbeitet werden. Insbesondere umfasst der erste Teil die Literatur über die Zahlungsbereitschaft, die Verpflichtungskosten für die Diskrepanz zwischen Zahlungsbereitschaft und tatsächlicher Zahlung, während der zweite Teil die Theorie der individuellen übertragbaren Quote für den Behandlungseffekt behandelt. Das fünfte Kapitel ist die Einführung in das Stichprobendesign und die Beschreibungsanalyse für die Datenerfassung. Danach sind im sechsten Kapitel die empirischen Studien und Ergebnisse gemäß Literatur und Unterhypothese im vierten Kapitel aufgeführt. Abschließend wird im siebten Kapitel eine Schlussfolgerung gezogen.

Nach der Literaturrecherche und empirischen Untersuchung gibt es fünf Ergebnisse. Erstens kann für die Variation der WTP nicht der Schluss gezogen werden, dass die Variation des privaten Gutes in der Metaanalyse kleiner als ein öffentliches Gut ist. Es bekräftigt aber, dass die Koeffizientenvariation in der Versuchsgruppe höher ist als das Gegenstück in der kontrollierten Gruppe.

Zweitens gilt für die unterschiedlichen Mechanismen zwischen WTP und AP die höhere grüne Wahrnehmung der NEVs, die höhere WTP. Diese positive Beziehung für WTP gilt jedoch nicht für den AP, was darauf hinweist, dass es ein Phänomen der „Falle subjektiver Bereitschaft" gibt. Es unterstützt jedoch die Hypothese, dass, je höher die Sicherheit des Ladeorts, desto höher die WTP; dies gilt sowohl für WTP als auch für AP. Außerdem stellt es fest, dass das Einkommen eine notwendige, aber unzureichende Voraussetzung für die Einführung von NEVs ist.

Drittens, abhängig vom theoretischen Rahmen der Verpflichtungskosten für die Ungleichheit zwischen WTP / AP, erweitert es den bisherigen Forschungsumfang, da die Produktnutzung stark mit dem Produkt oder der Dienstleistung verbunden ist, die in seiner Studie und seinem Laborexperiment ausgewählt wurden, wenn der Schwerpunkt auf Unsicherheit bewegt sich vom Geldwert zur Nutzung, es kann nicht die gleiche Schlussfolgerung gezogen werden, dass je höher die Unsicherheit der Nutzung, desto größer die Disparität zwischen dem WTP / AP, was auch die Bedeutung und Notwendigkeit der in der ersten Hypothese angesprochenen Produktkategorie zeigt, öffentliches oder privates Gut. Darüber hinaus wird die bisherige Voraussetzung von keinen Lernkosten im Rahmen der Theorie der Verpflichtungskosten erweitert. Eine Erweiterung mit Lernkosten ist auf Verhaltensweisen gestützt. Je mehr Lernmöglichkeiten mit verzögerten Kosten vorhanden sind, desto größer ist die Ungleichheit zwischen WTP / AP.

Viertens stellt sich heraus, dass die Einführung von NEVs im Modell der Multi-Exklusiv-Quoten mit konstanter TAC und ohne übertragbaren Markt zu einer Ökologisierung gezwungen ist. Je öfter an der Lotterie konventioneller Fahrzeuge teilgenommen wird, desto höher ist die Wahrscheinlichkeit, NEVs zu kaufen. In Bezug auf die Makroperspektive in Multi-Exklusiv-Quoten ist die Akzeptanzrate für ein anderes Unterkontingent umso höher, je höher die Kosten und die geringere Wahrscheinlichkeit eines Unterkontingents sind. Die Einführung von NEVs ist nämlich positiv mit einem höheren Gebotspreis und einer niedrigeren Lotteriegewinnrate verbunden.

Fünftens stellt sich in Bezug auf die externen Effekte heraus, dass die Multi-Exklusiv-Quoten einen Spillover-Effekt haben, der dem ursprünglichen Ziel entgegenwirkt, das Volumen konventioneller Fahrzeuge zu verringern und das Volumen NEVs zu erhöhen. Außerdem gibt es eine Externalität von Rückwürfen in den Multi-Exklusiv-Quoten. Je höher die Kosten für das Bieten sind, desto höher ist die Rate der Rückwürfe. Je niedriger die Lotterierate für den Gewinn eines Nummernschilds ist, desto geringer ist die Rate für das Verwerfen.

Schlüsselwörter: Chinas Studien, Zahlungsbereitschaft (WTP), tatsächliche Zahlung (AP), Disparität, Verpflichtungskosten, multiexklusive Quote, Lotterie, Ausschreibung, neue Energiefahrzeuge (NEVs)

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Abbreviations

AC: Alternative current
AP: Actual Payment
ATE: Average treatment effect
ATET: Average treatment effect on treated
ATEUT: Average treatment effect on untreated
BRI: Belt Road Initiative
CNKI: China's Knowledge Index
CA: Conjoint Analysis
CBDs: Center Business District
CAAM: China Association of Automobile Manufactures
DC: Direct current
DCE: Discrete Choice Experiment
DRC: Development and Reform Commission
EVs: Electrical Vehicles
GDP: Gross Domestic Production
GPS: Global Position System
ITQ: Individual Transferable Quotas
IID: Independent identically distributed
NEVs: New Energy Vehicles
NPE: Nationale Plattform Elektromobilität
NGOs: Non-governmental organizations
PCT: Patent Cooperation Treaty
PPP: Public-private partnership
PTW: Pump-to-wheel
R&D: Research and Development
SCI: Science Citation Index
SSCI: Social Science Citation Index
SPID: Spatial Difference-in-Difference
TAC: Total Allowable Catch
TPB: Theory of Planned Behavior
WTA: Willingness-to-Accept
WTP: Willingness to Pay
MLW: Minimum legal willingness

Chapter 1 Introduction

1.1 Introduction of Macro-perspective

"Made in China 2025" [1] is an initiative launched by the State Council in 2015 to comprehensively upgrade China's industries, which has clear principles, sector focus, to achieve the target of innovation-driven, green development and optimize the industry structure. It is widely integrated into different industry components, but the plan highlights 10 priority sectors, new energy vehicles, autonomous vehicles are included in the list.

Meanwhile, China is the largest greenhouse gas emitter[2] who is constantly criticized by the citizens. The traffic congestion with serious air pollution has become a problem in many mega-cities in the process of urbanization(Meyer, Leimbach, & Jaeger, 2007), which has become the largest source of vehicle exhaust PM2.5[3] and be considered as a major source of pollution (Lang et al., 2013). Furthermore, the vehicles consume half of oil used in China(Ma, Fu, Li, & Liu, 2012), as the fact that there is a large growth of car ownership with an annual growth rate of 23% over the past two and a half decades, reaching the peak of 28.88 Million in 2017[4], which contributes the challenge to the energy security and emission. Particularly, when China pledged to seek the carbon peaking by 2030 and carbon neutrality by 2060, one of the strategies deployed is the electrification of transportation sector.

Therefore, as the importance of emerging industry, challenges of carbon neutrality, the sub-optimal programs, such as license plate control, have been deployed to ease the tension and accelerate the adoption of NEVs, such as Beijing(lottery), Shanghai(bidding), Guangzhou (both lottery and bidding) and Shenzhen (both lottery and bidding). Apparently, New Energy Vehicles is granted much more attention to the problem from the policies makers, and has already promulgated series favorable policies for the consumers and industries.

1.2 Research Objective of Micro-perspective

In term of the micro-perspective, the objective of the research aims to study how and what affect individual's decision in the adoption of NEVs incorporating with the quota, bid and lottery imposed by the government. What is the mechanism of individual's choices under uncertainty? Is the willingness to pay (WTP) a reliable variable to study individuals' behaviors? If no, what is the disparity between the willingness to pay and actual payment? What elements and how do they contribute to the disparity? Meanwhile, what is the treatment effect for the adoption of NEVs under the multi-exclusive quotas, instead of multi-inclusive quotas?

- *Research on the mechanism for willingness to pay (WTP) and actual payment (AP) for the adoption of NEVs, namely, the "trap of subjective willingness", besides, study the disparity between WTP and AP based on the commitment cost theory and extend the theory.*
- *Study the treatment effect of quota on individuals' choice and whether the adoption of*

[1] China's State Council, "Made in China 2025", it not only highlights the sector of industries, but also elaborates the technology roadmap.

[2] From the report of Netherland Environmental Assessment Agency, 2013. Until now, China is still the largest emitter in tem of the total amount, although the emission volume per capital is not so high, but the strategy is to upgrade the economic structure and reduce the energy consumption per unit of GDP.

[3] PM2.5 refers to microns' particles in the atmospheric that the diameter is less than or equal to 2.5, also known as particles into the lungs, which is a primary attribute to assess the air quality in China.

[4] CAAM, China Association of Automobile Manufactures.

NEVs is forced or not. Meanwhile, study externalities caused by the multi-exclusive quotas.

1.3 Data Source for the Micro-perspective Studies

In term of the empirical study, the data consists of two parts, the first one is contingent on the second round of survey, which started from 23rd, May, 2017 to 18th, August,2017, consisting of two groups. One is the experiment group from Shenzhen, another one is the controlled groups from China's others cities where no license plate quota has been implemented to promote the adoption of NEVs. Additionally, the data collection was cooperated with a NEVs dealer and charging service provider, Judian, the firm's APP is the company's customers' service platform, which has been downloaded by the customers or the potential ones, looking for the charging piles, the NEVs sale services, etc. In order to control the sample, initially, the two-questionnaire links for the two groups are separated presented in the APP, the respondents can choose the link according to the description of the two groups, namely, Shenzhen, and other cities but exclude Beijing, Shanghai and Guangzhou, as the first-tier cities, complicated but different vehicles policies have been implemented over a long period. After the submission of survey and in order to stringent control the two groups, the samples from the excluded cities will be erased according to the address that participants write. This part of data could be regarded as the micro-perspective.

The second part of data is provided after the application of disclosure and compiled from Shenzhen government and agents who publish the data of the lottery and bidding in the license plate quota market monthly. This part of data could be regarded as the macro-perspective. Accordingly, these micro and macro perspectives data provide the availability for the empirical study and test the sub-hypothesis.

Chapter 2 Research Background

A new energy vehicle (NEV) is defined as a vehicle that uses alternative fuel and electrification technologies, such as unconventional vehicle fuels as a power source, or vehicles using conventional fuels with new automotive propulsion systems, advanced integrated vehicle dynamics control and driving technologies. Meanwhile, for the background, it focuses on the international, China's perspectives, then the experiment group of Shenzhen, elaborating the details in the development of NEVs industry, what policies have been deployed by different governments, which provides a comprehensive background for the policies deployed by different governments.

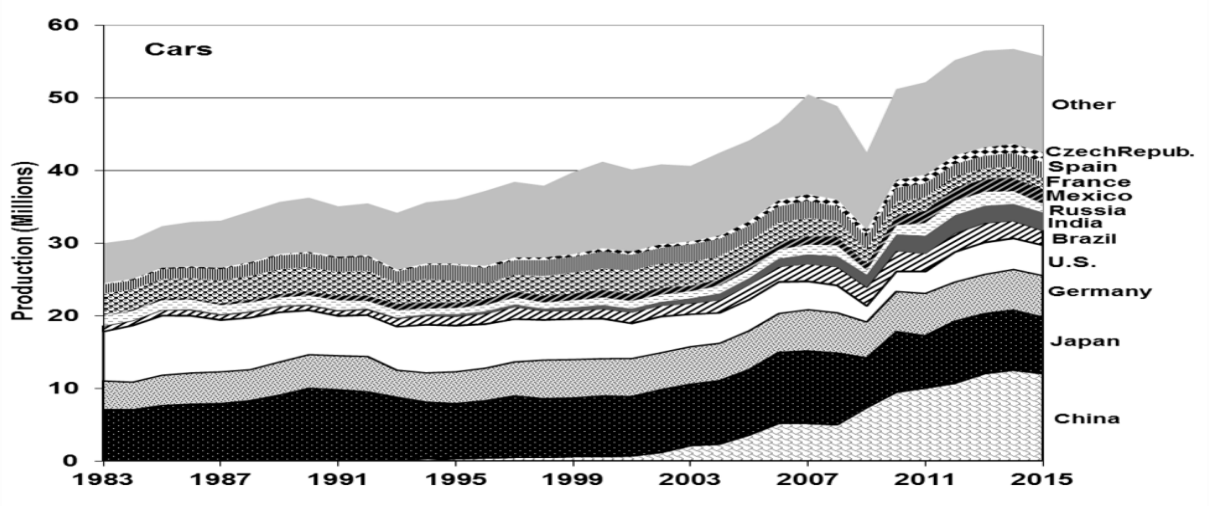
2.1 International Perspective

For the international perspective, it consists of two parts, including the development of conventional auto industry, and NEVs policies deployed by different governments. For the conventional vehicles, it will elaborate countries' development of both production and sale, while for the perspective of NEVs, it focuses on the policy trajectory and comparison among different countries.

2.1.1Conventional Vehicles

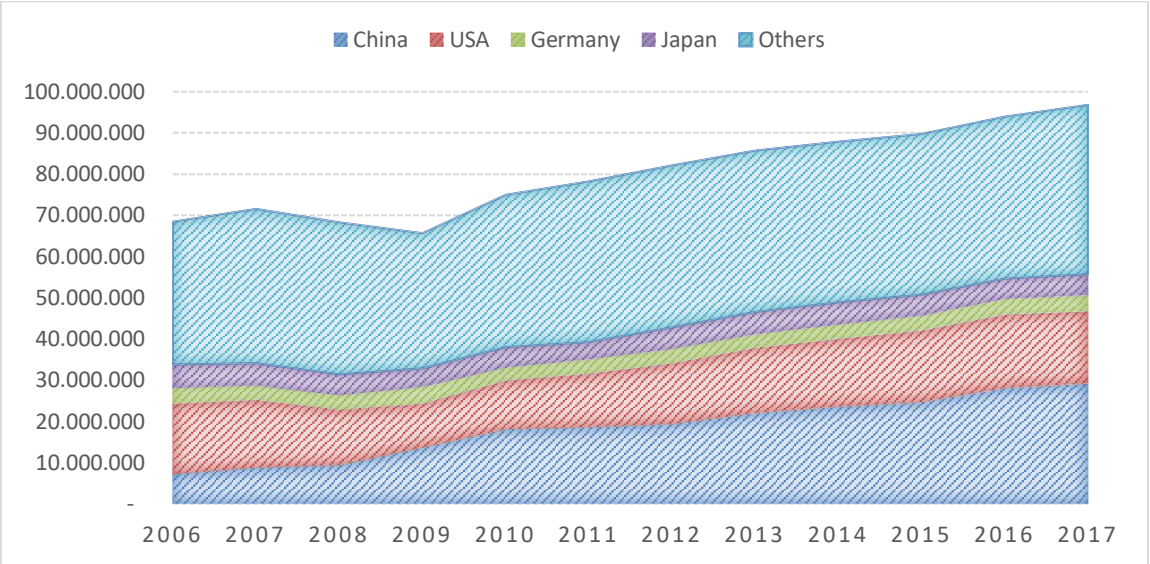
The massive-adoption of automobile exerts highly pressure to the limit of energy security and environment protection. Over 1983-2015, the world car production has almost increased one time. while it is one of the most important industry to stimulate the economic development, particularly, the long supply chains in the auto industry, to assure the employment market, and the multi-national auto firms deploy different strategies to expand the market share and increase the profitability locally and globally.

Figure 1 World Car Production over 1983-2015



Source: Ward's Communications, where the data is the volume of production within a country, instead of sales, due to the existence of globalization and localization in the market simultaneously, so the statistics is different.

Figure 2 World Car Sales over 2006-2017



Data source: CAAM, China Association of Automobile Manufactures. It will publish the detailed data for different countries annually, and the data in the figure is collected from the annual report, then plot the graph. Meanwhile, it is different from the above graph, this one is presented in term of the sale amount, while the above one is based on the production amount.

From the above figure, the absolute amount of increase in term of the world total sale, it has reached to about 28 million from 2006 to 2017, over this period, China has experienced an absolute volume increase by 21.9million. This increase in the world sale was mainly contributed by the growth of China' consumption, accounting for 77% of the total growth in the world over the same period. This tremendous growth, from a certain extent, elaborates the potential side effect of vehicles in China, such as air pollution, traffic jam in the metropolis, etc., which also provides a necessary reason for the policy makers to limit the consumption of conventional vehicles (such as the license plate quota) and promotion of NEVs.

2.1.2 New Energy Vehicles

For new energy vehicles, the expected gains are the environmental performance with the advancement of fuel efficiency of internal engine, but it causes the additional cost relating to the conventional ones. The study in Europe shows that the electrification of vehicles reduces the CO_2 emissions with adequate support to decarbonizes the electricity generation. Meanwhile, the additional cost could be a problem in the beginning, which will go down given that the market barriers can be overcome(Thiel, Perujo, & Mercier, 2010). As the importance of reducing emission and a potential explosive industry, many countries have initiated incentive policies for the industry, such as the support for R&D and market penetration(Yuan, Liu, & Zuo, 2015). However, although there are lots of debate and challenge on the benefits of NEVs, each market attaches much more emphasis on the development of NEVs.

In the introduction of international perspective on the NEVs policies, it primarily focuses on USA, Germany, and Japan, then a comprehensive description among different countries. Overview all the incentives deployed by different countries, subsidy as the monetary incentive is on the top agenda. But there are differences on the subsidy, such as the different extent of amount launched by the governments, meanwhile, the discrimination policy over the plug-in vehicles, besides, the subsidy is not eligible to the premium vehicles, and the cap of purchase price is different. Additional to the subsidy, the exemption of taxes is also deployed by different

countries, the non-monetary policies, such as the free parking for the NEVs. Particularly, China and USA have clear plan of phase-out after the massive adoption of NEVs.

(1) USA

USA has a strategic goal in the '2016-2020 Strategic Plan[5], with the mission to create and sustain its leadership in the transition to a global clean energy economy. More specifically, it includes the development of sustainable transportation technologies, the increasing generation of clean electric power, the integration of different clean energy into a reliable and efficient system. Meanwhile, it has a clear guideline in each sector and phase, starting from an applied research, development and demonstration, then focus on the market barriers. Lastly, it achieves the strategical goal, such as the cost reduction, performance improvement, the validation of technology and reduction of market barriers. Importantly, it has clear indicators to reflect the milestones in different stages. Specifically, in its plan for the acceleration of development and adoption of sustainable transportation technologies, it has clear and quantitative indicator to test the target. For the incentives policies on the adoption of NEVs, it has the specific measures from both national federal and sub-federal level. Nut in a shell, the subsidies are deployed by the federal government, while for the sub-federal government, it not only has additional subsidies, but also bureaucratic incentives deployed, such as the preference policies for the charging fee and facilities, traffic limitation in the cities center.

Table 1 USA incentive guideline for NEVs policies

Category	Details
Federal[6]	According to the size of vehicles and battery capacity, the federal tax credit is for $2,500 to $7,500 per NEV purchased in the USA.
States	Meanwhile, depending on the different states, there are monetary or non-monetary incentives, including vehicles or infrastructure vouchers or rebates, low-cost charging fee, reductions of vehicles registration fee, loans, and additional tax credits.
Phase-out	After the sale amount exceeding 200,000 NEVs (electric vehicles and plug-in hybrid) as accumulated from January 1,2010 by one manufacturer, the government will begin to phase out at the beginning of the second calendar quarter.
After Phase-out	After the reaching of 200,000, there is a drop for the subsidy, reducing from $7,500 to $3,750 for the first 6 months, then $1,875 for the next coming 6 months, until the credit runs out completely. According to the report of US federal tax credit, Tesla and General Motors have reached the cap by July,2018 and Nov.2018 respectively, and the gradual phase-out will begin in Jan.2019. But before the starting of phase-out, in March 2018, the US automakers asked the congress to preserve the subsidy to support the growth continuously.

NOTE: The federal and sub-federal government have different focuses, but both targeting on the hindrance for the adoption of NEVs, meanwhile, it also has the plan of phase-out after the accumulation of a specific amount.

Additional to the subsidy from the federal government, different states in USA have launched diversified monetary and non-monetary incentives for the adoption of NEVs. The state of California is the typical one in the promotion of NEVs, and it has the largest number of consumers who have adopted NEVs among all the states in US.

[5] United States Department of Energy, for each target, it has detailed verified indicator by the end of 2020, it includes the sustainable transportation technologies, domestic clean energy manufacturing, etc.

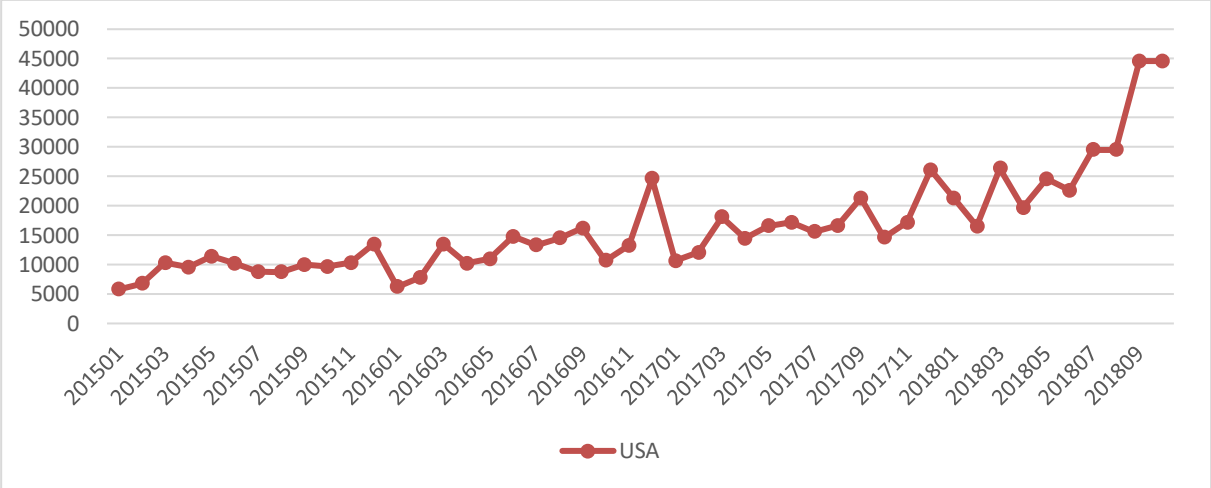
[6] For more detailed information about USA's incentives policies, where it is the homepage for the USA department of energy, there are detailed information on the tax incentive and credit for the NEVs from both federal and sub-federal government. Meanwhile, it has detailed description for the qualified categories, more detailed information, please refer to the USA Energy Department.

Table 2 Additional incentives in the state California for the NEVs policies

California[7]	Filing Status	Gross Annual Income	Fuel cell	Battery electric	Plug-in Hybrid[8]	Zero-emission motorcycle
Low-Income	≤ 300 percent of the federal poverty level (FPL)		$7,000	$4,500	$3,500	$900
Standard Rebate	Individual	300% FPL to $150,000	$5,000	$2,500	$1,500	
	Head of Household	300% FPL to $204,000				
	Joint	300% FPL to $300,000				

NOTE: In the state of California, the additional incentive has different levels contingent on the household income, poverty basement and categories of vehicles, simply, the less income and less emission, the more subsidy. Meanwhile, according to the state report, the state of California has the largest sale volume of NEVs among all the USA states.

Figure 3 USA sale volume of NEVs monthly



Data source: 'the First China NEVs Research Center', will publish the detailed data monthly. It was collected one by one, then compiled together and presented here.

With the subsidy support from both federal and sub-federal government, there is a constant and stable growth in the sale volume of NEVs, it has experienced the increase from 5,774 in Jan.2015 to 29,514 in Aug.2018. But from the below figure, there is a substantial growth in Sep.2018, as the fact that the sale volume has reached the phase-out cap of 200,000, and consumers concern that the subsidy would be removed gradually.

(2) Germany

Initially, Germany was reluctant to deploy the monetary subsidy to the consumption of NEVs, primarily targeted on the research support for electric mobility. But there was no substantial increase for the adoption of NEVs, therefore, under the lobby of auto industry and the consideration of real scenario, the monetary subsidy was adopted with the target to accelerate the promotion of NEVs.

[7] Fiscal year 2017-2018 funding plan for USA clean transportation incentives.

[8] With an electric range of at least 20 miles, this is the precondition to get the subsidy for the plug-in hybrid vehicles.

Table 3 German policies trajectory for the NEVs

Year	Contends
May 2010	Under its National Program for Electric Mobility, there is no subsidies to the sales of plug-in electric vehicles, however, for the research of electric mobility, the fund is adopted to support it. Furthermore, there is an exemption of annual circulation tax for the electric and plug-ins vehicles for a period of five years. After the end of first round of exemption, in 2016, the annual circulation tax exemption was extended from five to ten years.
June 2013	It ends the existing tax disadvantage for corporate plug-in electric. The amount one can offset will sink annually by €50 per kilowatt hour. But the least range criteria for the plug-in hybrid vehicles will increase to 40 km (25 mi) from the beginning of 2018. Accordingly, it can be descripted as the end of disadvantage but the increase of range for the plug-in vehicles.
November 2014	There are only about 24,000 plug-in electric cars on German roads. Therefore, there is proposal to provide more incentives and offer a tax break for zero-emission cars, meanwhile, more subsidies to charging infrastructure, particularly fast chargers.
February 2015	There are non-monetary incentives and measures to privilege battery-powered cars, fuel cell vehicles and some plug-in hybrids, offer free parking and reserved parking spaces, for these vehicles with CO2 emissions of less than 50 g/km or an all-electric range of over 30 km (19 mi). Accordingly, it is the bureaucratic incentives deployed by the government to stimulate the adoption of NEVs.
February 2016	There is a proposal for the auto industry from German government. Private buyers would get the full €5000 subsidy, while corporate buyers would receive €3000 for each electric car, and the program is expected to run until 2020, the deadline for the phase-out set to achieve the goal of 1 million electric cars on German roads, but according to recent report on the sale volume in Germany, it is an unrealistic target until 2020. But recently, the target is removed and has been postponed to 2022.
April 2016	There is a €4000 subsidy for the electrical vehicles' buyers and €3000 subsidy for the plug-in vehicles' buyers, but the subsidy is not eligible to the premium car of exceeding €60,000 for the purchase price.

Note: This table primarily presents the trajectory of German incentive policies for the NEVs, and the information is from the German National Electric Mobility Platform, Nationale Plattform Elektromobilität (NPE). For a simple description for the German incentives policies on the adoption of NEVs, initially, it primarily focused on the research fund support for the electrical vehicles, then lots of non-monetary incentives have been deployed to support the NEVs, but the result proves that it is not enough to accelerate the adoption, lastly, the monetary subsidy has been employed to stimulate the penetration of NEVs in the auto industry.

Figure 4 Germany NEVs sale volume monthly

Data source: 'the First China NEVs Research Center', which will publish the detailed data monthly. It was collected one by one, then compiled together and presented here.

From the policy trajectory deployed in Germany, after the subsidy incentives in April,2016, it

has experienced a substantial increase from the below figure demonstrating the trend of sale volume monthly.

(3) Japan

Japan was the first country launching the incentives package to stimulate the promotion of NEVs, and there is a comprehensive package to cover all the sectors in the auto industry. It not only targets the consumption of NEVs, but also accelerates the scrapping of old conventional vehicles. Furthermore, tremendous subsidies were granted to the operator and constructor of charging facility.

Table 4 Japan's incentive trajectory for the adoption of NEVs

Year	Contends
1998	There is an Introduction Project for the NEVs, which provides subsidies and tax discounts for the purchase of electric, which is up to 50% incremental costs compared with the price of a conventional vehicle. Therefore, the subsidy is contingent on the price disparity between the conventional vehicle and NEVs, to cover the additional cost for the adoption of NEVs.
2009	In order to accelerate the scrapping of a used car, there is a tax deductions and exemptions, such as subsidies for owners scrapping a 13-year or older: US$2,700 for a standard or small car, and US$1,300. For the new one, subsidies vary between US$2,100 to US$9,600. Meanwhile, the subsidy not only cover the passenger car, it is also eligible to trucks and buses meeting the stipulated fuel efficiency and emission criteria, which varies between US$4,300 to US$19,000. Accordingly, the policies from Japan, it not only focuses on the adoption of NEVs, but also the incentive to accelerate the scrapping of old conventional vehicles.
2011	The Japanese government has clear target of accessing fast charger within each 15KM or 30KM of the radius, more importantly, the subsidies are also funded to the charging operators, for example, $47,000 per charger and up to $420,000 for the construction cost.

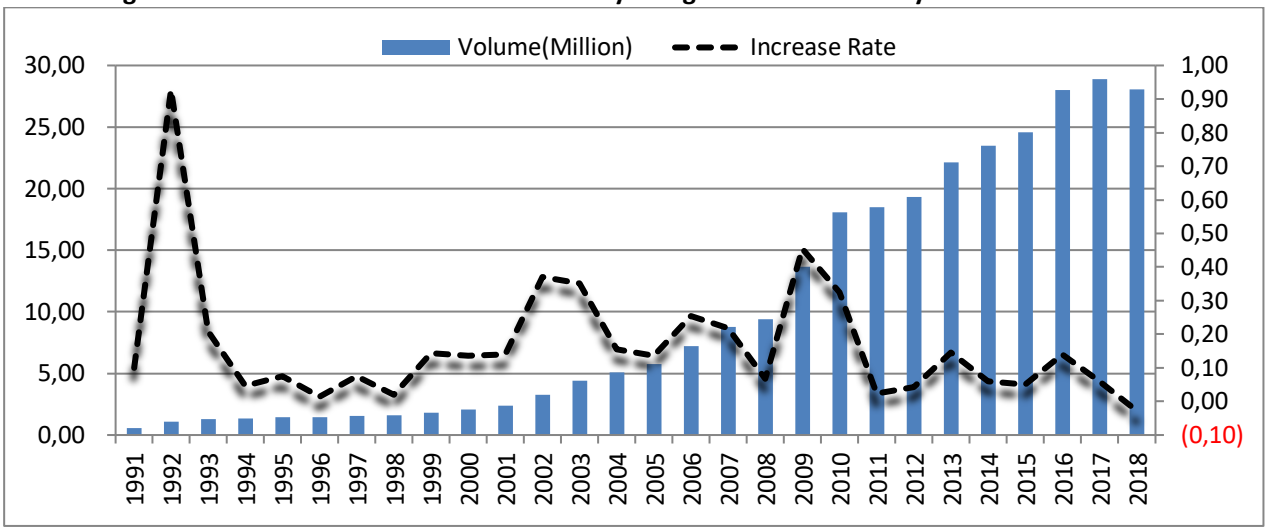
NOTE: This table presents the trajectory of incentives policies for NEVs in Japan, and the source of information is based on the Japan Automobile Manufacturers Association for Green Vehicle Purchasing Promotion Measure. it not only focuses on the adoption of NEVs, but also the incentive to accelerate the scrapping of old conventional vehicles. Additionally, it also has subsidy for the construction of charging facility.

What incentive policies have been deployed by other governments? With the consideration of all policies deployed by different governments, such as India, France, UK, Italy, South Korea, Mexico, Brazil, etc., there is no any special tactics, monetary subsidy is always on the top agenda. Contingent on its own features, countries have diverse incentives, but with similarities. Firstly, the amount of incentive usually depends on the battery size or the reliable range, and the amount will decrease continually; Secondly, beside the financial incentives, it integrates with the exemptions of fees, such as charging, parking, tolls, congestion fee, and the accessibility to the bus lines, etc. Thirdly, imposing the disincentives on the conventional vehicles, particular for the high emitter ones. However, in terms of differences, for the hybrid(plug-in) one, it is excluded in some countries while included in others, moreover, the incentives in some countries cover all the brand of NEVs while others only cover the listed brands.

2.2 China's Background

Regarding China's background in this industry, it primarily focuses on the policy trajectory over different times in term of national and sub-national governments, providing a macro-perspective to better understand the effect of policies. Before the elaboration of NEVs' trajectory, it is necessary to know the overall growth rate and volume in term of total sale vehicles.

Figure 5 Sale volume of China's auto industry and growth rate annually over 1991-2018



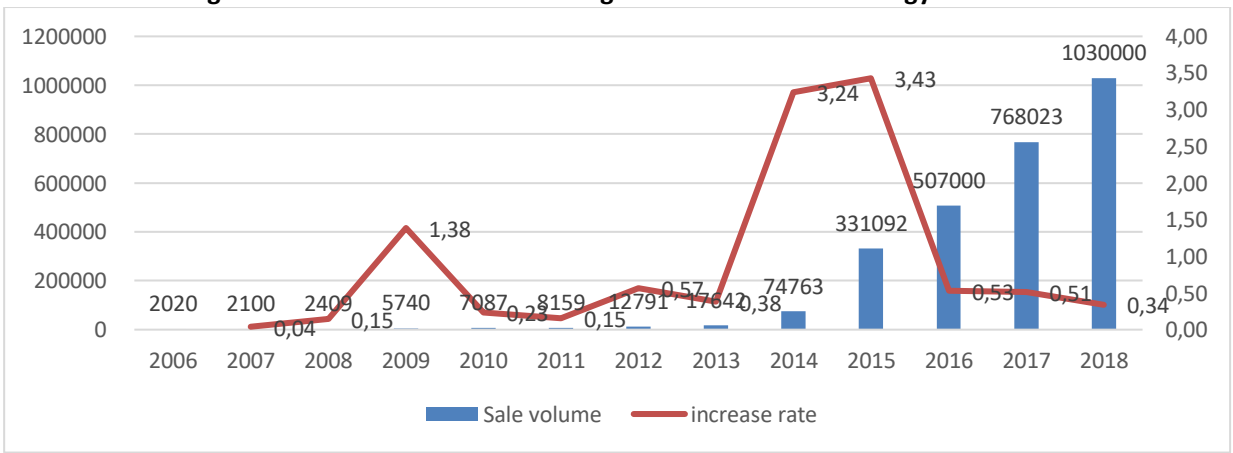
Data source: CAAM, China Association of Automobile Manufactures, the data is compiled from the different years' reports. The left axis is the sale volume and the right axis is the growth rate.

Over the period of 1991-2018, the average sale growth rate of China's vehicles is 17%; Particularly, from 1999 to 2010, the average growth rate is 23%, except for the year of 2008 with 7% due to the economic crisis. Then it transformed to relative slightness growth with the average of 7% over 2011-2016. And the volume has gone to peak amounting to 28.88 million in the year of 2017, then it has experienced a slight decline of 2.8% in 2018.

2.2.1 National level of NEVs Industries Policies

As the comprehensive utility of NEVs industry, including the building of a world-leading industry, energy security, reduction of carbon emission and air pollution, the government has announced a series of policies to promote the transformation of industry structure, from the R&D, supporting facilities, market penetration, etc. From 2010, the government provides financial subsidies and supporting policies, as of the end of 2016, China's new energy vehicles sold more than 1 million, becoming the largest market of new energy vehicles.

Figure 6 Sales volume and increasing rate of China's new energy vehicles

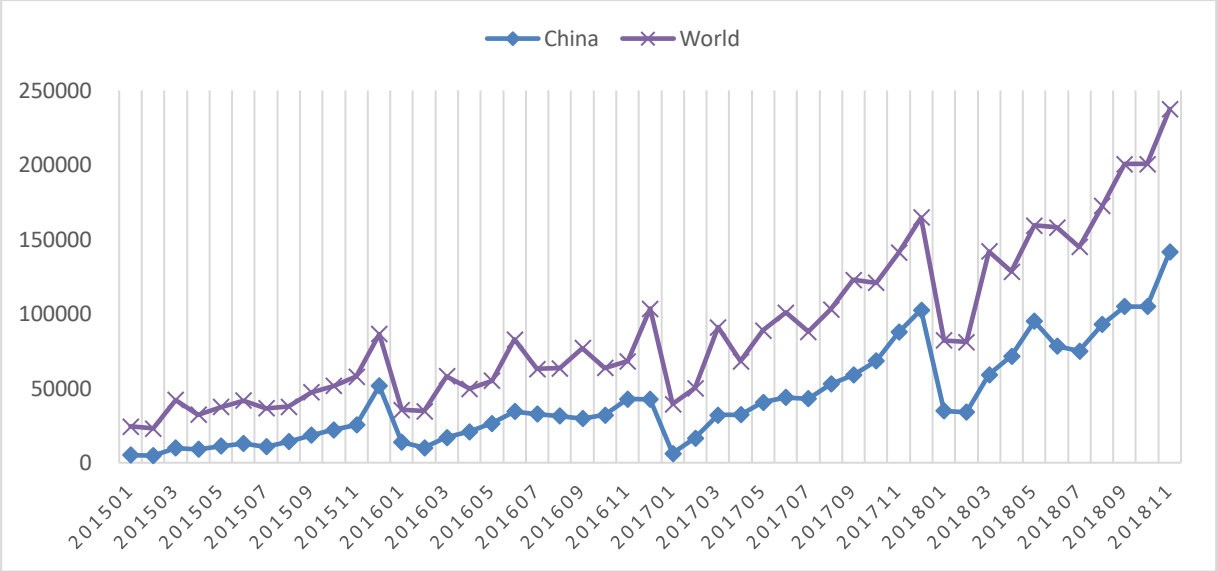


Data source: CAAM, China Association of Automobile Manufactures. It will publish the detailed information monthly or annually, then the data is collected one by one and plot the graph. And the sales volume accounts for about 50% of global sales. The elements contributing to the substantial growth in the adoption of NEVs, are multi-perspectives, such as the government pilot purchasing program, national and sub-national subsidies, cities-level policies to limit the conventional vehicles, NEVs share mandate for the automakers. Which has been elaborated

in the description of national and sub-national policies. Additionally, there is a little difference in term of the NEVs sale volume annually between two primary data sources, the difference falls on whether it includes the sale amount of commercial NEVs, such as the sanitation trucks and commercial buses.

According to data of Automobile Association, in 2011[9], sales of new energy vehicles are 8159 (5579 pure electric, hybrid 2580), slightly increase to 12,791 (11,375 pure electric vehicles, plug-in hybrid electric 1416) in 2012; There is a tremendous increase in 2014, amounting to 74,763 units, an increase of 320% comparing to 2013 (Pure electric 45,048 units with an increase of 324%; plug-in hybrid electric 29,715 with an increase of 878% respectively). Obviously, after the promulgation of subsidy in 2013, the sale takes off and witnesses an incredible growth rate with 324% in 2014 and 343% in 2015 amounting to 74763 and 331092 respectively. There is a constant growth in the sale volume of NEVs until now.

Figure 7 Sale volume of NEVs between China and the world monthly



Data source: 'the First China NEVs Research Center', which publishes the detailed data monthly. It was collected one by one, then compiled together manually. Comparing to China's total sale volume with world total volume, the percentage is always fluctuating about 50%.

Meanwhile, for the technology roadmap in the vehicles industry, it primarily focuses on the new energy vehicles and intelligent network vehicles, the former one adheres to the transformation of energy structure. While for the intelligent vehicles, it targets on the improvement of traffic safety, energy conservation and emission reduction, congestion reduction and enhance social efficiency. It can also promote the coordinated development of automobiles, electronics, communications, services and social management, which has great strategic significance to promote the industrial transformation and upgrading. But the intelligent vehicles are not being emphasized in this research, which is coordinated with the

[9] China Association of Automobiles Manufacturers: both the volume of new energy vehicle and conventional vehicle are compiled from the annual report; the data also lists on report of electrical mobility, The number refers to the sale volume, for the production volume, which is slightly greater than the sale one, such as the year of 2016, it is 8,000. Meanwhile, the volume includes not only the passenger vehicles, but also the commercial bus. But some reports do not include the volume of commercial vehicles, such as bus, sanitation trucks, which is why for the existing of difference among different report in term of the volume.

artificial intelligence, information technology, etc. Accordingly, it primarily elaborates the policy trajectory on the perspective of NEVs.

Table 5 China's national-level policies for NEVs

Year	Policies for the new energy vehicles[10]
2001	National 863 Plan has stated the R & D pattern for new energy vehicles, namely, "three vertical and three horizontal", which clearly pointed that the "three vertical" refers to the hybrid vehicle, pure electric vehicles, fuel cell vehicle, and "three horizontal" refers to the multi-energy power control system, motor control system and battery management system.
2004	Energy saving program and long-term guideline for the new energy vehicles.
2005	The national standard clearly stipulates the qualitative test regulations, safety requirements, methods of dynamic performance test and pollutant emission measurement, etc., which provides a preliminary guidance for the manufactures in the vehicles industry.
2007	The government published the guidance of accessing rules for the NEVs production, emphasizing the capacity requirements for vehicles firms.
2008	There is a pilot program for the marketization in Beijing Olympic Village;
2009	China initiated a program, named Ten Cities-Thousand Vehicles to stimulate the development of New Energy Vehicles focusing on the t application of government service through a large-scale pilot, with the accelerating and promotion of marketization.
2010	In June 2010, Shenzhen, Shanghai, Hangzhou, Changchun and Hefei were selected to subsidize the purchase of NEVs for individuals on a trial basis.
2012	Until 2012, the development of NEVs was still at an exploratory stage, viewing as a developing period for this sector, while for the next five years, which is regarded as the important period to tackle the technologies issues, which makes a well preparation for massive marketization.
2013	September 17, 2013, four ministries jointly issued a document to clear the specific allowances and credits for hybrid, pure electric cars and buses. Meanwhile, it also expanded the scope of subsidies to the whole country and indicated that provisions ratio of non-local brands should not be less than 30%, with the target of undermining the protectionism from local governments. Furthermore, it primarily focused on the incentive to increase the energy efficiency and density.
2014	Four ministries jointly released the guideline of Green-Energy Vehicle Purchase for Government Agencies and Public Institutions, promoting the market volume of new-energy vehicles. Additionally, on Sept. 1, 2014, China exempted the 10-percent purchase tax for new energy vehicles until the end of 2017.
2015	May 2015, the Ministry of Finance, Ministry of Science and Technology, the Ministry of Industry, Development and Reform Commission jointly issued a third round of subsidy policy for new energy vehicles, which indicated, from 2017, the subsidies will be gradually reduced and will be withdrawn after 2020. As the marketization is gradually promoted, the government has planned to deploy the market-oriented principle, survival of the fittest, meanwhile, with the intention to reduce firms' expectation and reliance on subsidy.
2016	Due to the cheating in the subsidies, on January 20, 2016, the four Ministry Departments jointly issued the notice "on the promotion of new energy vehicles to stimulate the application in the market", it also formed an investigation team targeting on companies. Furthermore, Ministry of Industry has revised and substantially increased the threshold of accessing NEVs manufacturing market, in order to eliminate the backward production capacity. Importantly, the Development and Reform Department has promulgated the guidance for vehicles production suggesting that it will not approve the new manufacture plant for conventional vehicles basically, which is regarded as the direct incentive information and government's determination for the development of NEVs. Additionally, the "NEV Share Mandates[11]", for the traditional passenger vehicles companies in China with the annual output or import volume of more than 50,000 passenger vehicles, it sets the annual proportion of new energy vehicles in

[10] Policies of the development of new energy vehicles from the Committee of National Development and Reform Department. China Association of Automobiles Manufacturers; the policies list compiles from the different report in different stages.

[11] The draft of "NEV share mandates", has caused enormous concerns by the traditional vehicles manufactures.

	the total volume. In the years of 2016 and 2017, the proportion of NEVs does not do the assessment and implemented compulsorily. Over the year of 2018 to 2020, the proportion of new energy vehicles accounted for 8%, 10%, 12%, after 2020, the ratio is required to be formulated separately.
2017	After the intensive discussion, the State Council has decided to postponed the "NEV Share Mandates" to 2019, the requirement is still the same as the previous one, 10% in 2019 and 12% in 2020. After the promulgation of draft, "NEV Share Mandates", it is regarded as the "stick" to the vehicles manufactures, comparing to the subsidy over 2013-2020 as the "carrot". Meanwhile, in order to better promote the development of new energy vehicles, the government has issued the specific new energy vehicles license plate in the five pilot cities, including Shanghai, Nanjing, Wuxi, Jinan, Shenzhen, which can be more effective and convenient to distinguish the identification of new energy vehicles, the implementation of differentiated traffic management policies for new energy vehicles to facilitate travel services, tax concessions. Furthermore, the claim of the subsidy has been transferred from the 'budget' to a 'conditional claim', which is subject to the condition of both energy density (above 140Wh/KG) and accumulated driving range (above 20,000KM) simultaneously.
2018	It has substantially decreased the subsidy, meanwhile, it has deleted the share ceiling of 50% for the foreign investment in the vehicles industry, and deployed the 'Negative List'. Meanwhile, the subsidy for the range less than 150 km has been removed in Feb, and it has increased the amount of subsidy from 44,000RMB to 50,000RMB for the vehicles' range higher than 400km. The target is obvious to support the competitive product in the market. After the publication of 'NEV Share Mandates' for the firms' compulsory NEVs percentage in the production, it has proposed the calculation formula for the credit, contingent on the electrical range, such as 80-150,150-250,250-350,>=350, the corresponding credits are 2,3,4,5 respectively, but the final credit formula is (0.012*electrical range +0.8)*adjustment factor, but the amount of credit is capped at 6, and the credits can be sold and brought in the market to meet the compulsory target in the plan of 'NEV Share Mandates'.
2019	Development plan for the new energy vehicle industry over 2021-2035, accounting for 25% market share in 2025.

NOTE: The trajectory of China's policy could be described as the key words of 'Guideline-Pilot-Subsidy-Share Mandatory-Marketization'. Initially, it promulgated the development pattern of 'three verticals and three horizontals', then there were lots of pilot programs to tackle the preliminary challenges and hinderances. In order to promote the massive adoption of NEVs, the subsidy was deployed. Meanwhile, in order to incentivize the firms' transformation, the mandatory share of NEVs for the firm was formed. Accordingly, it has formed the 'incentives' for both the consumers and suppliers, namely, both the demand and supply perspectives. Lastly, after the nurture and support in the infant stage, the market-oriented drives the marketization.

Accordingly, from the guidelines of NEVs' preferential policies, it suggests that the emphasis is transferring to the establishment of market mechanism, based on the survival of the fittest and elimination of backward capacity, instead of the simple subsidy for every company, otherwise, which will support the lagging technology and eradicate the incentive for the innovation.

Table 6 Incentives for NEVs over 2013-2020

Type	Reliability	Sources	2013	2014	2015	2016	2017	2018	2019	2020
Electric Vehicles	80≤R<100km	National	3.5	3.325	3.15	0	0	0	0	0
		Sub-national	3.5	3.325	3.15	0	0	0	0	0
	100≤R<150km	National	3.5	3.325	3.15	2.5	2	2	1.5	1.5
		Sub-national	3.5	3.325	3.15	2.5	2	2	1.5	1.5
	150≤R<250km	National	5	4.75	4.5	4.5	3.6	3.6	2.7	2.7
		Sub-national	5	4.75	4.5	4.5	3.6	3.6	2.7	2.7
	R≥250km	National	6	5.7	5.4	5.5	5.5	4.4	3.3	3.3
		Sub-national	6	5.7	5.4	5.5	5.5	4.4	3.3	3.3
Hybrid Electric Vehicles	R≥50km	National	3.5	3.325	3.15	3	2.4	2.4	1.8	1.8
		Sub-national	3.5	3.325	3.15	3	2.4	2.4	1.8	1.8

Data source: Minister of Finance, Ministry of Finance, Ministry of Science and Technology, the Ministry of Industry and Development and Reform Commission. It has decreased the amount continuously and plans to withdraw the subsidy until 2020. With the intention to support the nurture of this industry in the infant period, meanwhile, reduce the expectation and reliance on the subsidy and cultivate the core competitiveness in the R&D. but this table is based on the plan in 2013, there are changes over the development process, for example, since Feb.2018, the subsidy for the range less than 150 km has been removed in Feb, and has increased the amount of subsidy from 44,000RMB to 50,000RMB for the vehicles' range higher than 400 km. Accordingly, comprising to the incentives deployed by USA, the condition of phase-out is different, USA is contingent on a cap amount of 200,000, while China has announced the annual decrease on the subsidy to manage the firms and consumers' in advance.

In 2016, the threshold of the subsidy for pure electric vehicles will increase from 80 km to 100 km, meanwhile, further reducing the number of subsidies for the coming years. Furthermore, in addition to fuel cell vehicles, the subsidy for pure electric and plug-in hybrid in the years of 2017--2018 will decrease by 20% on the basis of 2016; similarly, the years of 2019-2020 will decrease by 40% on the basis of 2016. The target of this subsidy from the government, initially, increases the financial capacity for the companies, then converts to the incentives for the consumers, secondly, however, decreases companies' expectation of government's subsidy as the decrease year by year, which is also consistent with the guidelines of preferential policies.

However, with the gradual decline of the subsidy in 2017 and the fact that local subsidies stipulated by the state cannot exceed 50% of the national subsidies. After the year of 2020, China's new energy vehicle financial subsidies will be completely withdrawn, in order to prevent the withdrawal of subsidies to bring the decline of new energy vehicles sales substantially, the Ministry of Industry, Finance, Science and Technology and Development and Reform Commission (hereinafter referred to as the four ministries) began to study the incentive to pick up subsidies policy. At the end of 2016, four ministries and commissions adjusted the financial subsidies, enhanced the technical threshold, reduced the subsidy standards.

Figure 8 Sample of different license plate for new energy vehicles

NOTE: This photo is a sample from the website of Shenzhen Transportation Department elaborating the meaning of different part for the NEVs license plate, which is a clear symbol to differentiate the category from conventional vehicles, more importantly, to assure the implementation of non-monetary incentives for the NEVs.

In order to implement the State Council on new energy vehicles, traffic management differentiation policy, Ministry of Public Security has issued the license plate of new energy vehicles on December 1, 2016 in five pilot cities, including Shanghai, Nanjing, Wuxi, Jinan, Shenzhen, which can be more effective to distinguish the identification of new energy vehicles, facilitating travel services, tax concessions, and assuring the implementation of incentives for NEVs. For the characteristics of the NEVs' license plate, firstly, it highlights the green elements, reflecting the distinctive features with a green-based color to demonstrate the environmental friendliness. Secondly, the logo embodies electric characteristics with a letter "E" (Electric). For further differentiation policy, the license plate has the letter "D" on behalf of pure electric vehicles, the letter "F" on behalf of non-pure electric vehicles (including Plug-in hybrid and fuel cell vehicles, etc.).

2.2.2 Sub-national level of policies in different Cities

With tremendous increase of auto registration and the worsen traffic congestion in the major cities, the control of automobile ownership has been a practical solution, including Shenzhen. The experience draws from the counterparts, including Singapore, Beijing and Shanghai. But policies are different, Singapore, as the first sample in the world, starting from 1990 with the bidding for the license plate, which suggests the controlling of absolute automobile numbers and quality of cars imported due to the crowding effect for economic vehicles, however, it suffers from the unexpected side-effect of speculation(Chin & Smith, 1997). Meanwhile, Shanghai (starting from 2002) bases on the monthly license auction that eases the traffic congestion, but exerts a distortional impact on the auto industry with the favor of luxurious vehicles while hampering the development of economic vehicles, simultaneously, the non-local license has appeared as the sky-rocking bidding price, which is ridiculed as the "most expensive iron piece". Nevertheless, for the bidding policy, the individual's acceptance is moderately low but effective to the ease of congestion(Chen & Zhao, 2013). While in Beijing starting from 2010, it relies on the lottery within a specific amount monthly to lessen the explosion of automobile ownership, but Shenzhen melts these two together into one combination.

Table 7 the cities deploy one quota in the regulation of auto license plate

Cities	Year	Policies
Shanghai	1994	bidding
Beijing	2010	Separated Free lottery
Guangzhou	2012	Free lottery and bidding
Guiyang	2011	Free lottery and bidding
Hangzhou	2014	Free lottery and bidding
Tianjin	2013	Free lottery and bidding
Shenzhen	2015	Free lottery and bidding

It is different from Beijing and Shanghai with the plate lottery system and plate auctions respectively(Chen & Zhao, 2013), while Singapore has the combination of the congestion pricing and vehicle ownership restraint(Chu, 2014). Similar situation is not unique in Beijing, until the third quarter of 2017, there are eight cities (Beijing, Shanghai, Guangzhou, Guiyang, Shijiazhuang, Tianjin, Hangzhou and Shenzhen) implementing restrictions on consumers' vehicles consumption. Meanwhile, six of the eight cities (Beijing, Shanghai, Guangzhou, Shenzhen, Hangzhou and Tianjin) have promulgated special preferential policies and

incentives for the new energy vehicles.

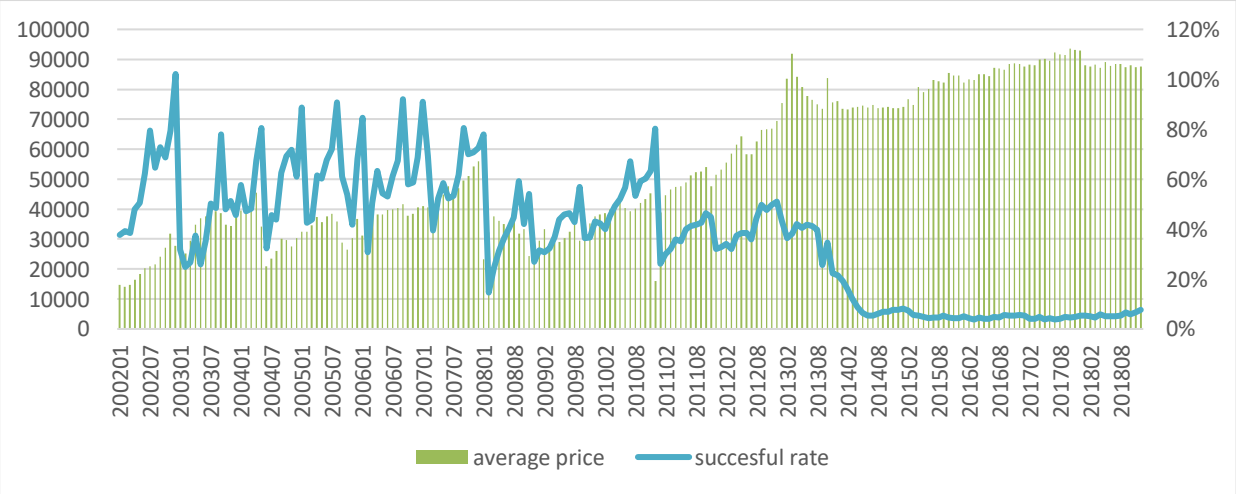
Table 8 Comparison of NEVs and conventional vehicles policies in different cities

Items	Beijing	Shanghai
Precondition	Payment of social security in the previous 5 years consecutively	Payment of social security in the past 24 months consecutively
Subsidies	There are state and municipal government subsidies, range from 30,000 to 66,000rmb depending on the mileage, meanwhile, exemption from vehicle purchase tax (8.5%), and no restriction during the rush hours of the working day, but only pure electric passenger cars are subsidized.	There are state and municipal government subsidies (except for the imported NEVs), but the total amount shall not exceed 50% of the vehicle purchase price. It is eligible to both pure electric and hybrid passenger cars.
NEVs license	free	Free
Conventional license	Lottery (but the rate is 0.05% in Dec.2018)	Bidding

NOTE: This table simply compares the differences on the license plate quota markets between Beijing and Shanghai, the differences fall on the precondition, and the favored and discriminate policy for the hybrid vehicles and the way of soliciting the license plate. Definitely, the experiment group of Shenzhen in my study is also different, so when Shenzhen is taken as the experiment group in the sampling, the samples from Beijing, Shanghai etc., will be deleted in the controlled group, with the target to clearly define the scope of controlled and experiment samples. it has detailed explanation in the chapter of sampling.

Accordingly, the primary difference is the way of soliciting license plate, in Beijing, all the license plate is contingent on the lottery for both conventional vehicles and NEVs, but these two categories are separated, it is free but the winning probability of conventional vehicles has declined to 0.05% in Dec.2018, However, the bidding for the license plate of conventional vehicles is deployed in Shanghai, and the cost has soared to more than 80,000 RMB in 2018 with a relative higher winning probability of 5%. While for the license plate of NEVs, it is free.

Figure 9 Average bidding price and successful rate over the period of 2002-2018 in Shanghai monthly



NOTE: The data is published by the Shanghai Transportation Department monthly, it is collected from its website one by one then draw the graphic manually. And the left axis is the average cost for one license plate, the right axis is the successful rate for maintaining a license plate in the competitive market.

Starting from the April, 2014, the successful rate in the bidding section has declined to less than 10%, with an average of 5.2%, but the bidding average price is constantly growing, amounting to 93,000 RMB in November, 2017. Besides, the successful rate is constantly fluctuating about 5% and the average price is above 80,000 RMB over the years of 2014-2018.

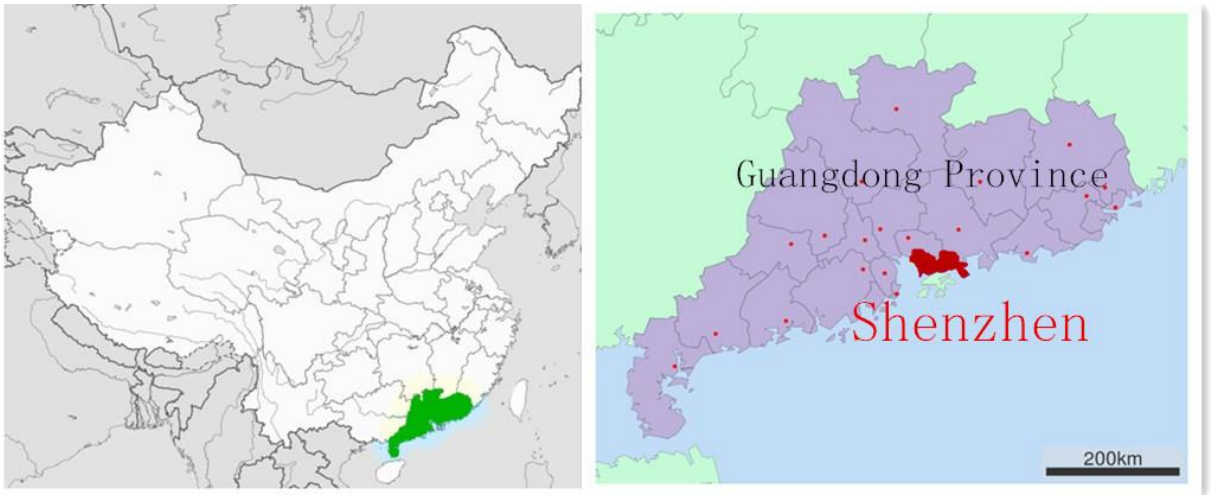
Accordingly, for this part of China's background, it elaborates the national policies for the NEVs industry, including the growth in the conventional vehicles, NEVs policies' trajectory over different periods, besides, the sub-national policies in different cities, particularly, in the metropolis, the license plate has been deployed to impede the explosion growth of conventional vehicles and accelerate the adoption of NEVs. For the coming part, it will focus on the sub-national policy of license plate in Shenzhen as the experiment sample in my study.

2.3 Experiment Group's Background of Shenzhen

2.3.1 Geography and History

Shenzhen is located in the south-central coastal area of Guangdong Province. "Shenzhen" as the name of place first appeared in the early Ming Dynasty (1410), Shenzhen in the Hakka language means the ditch. In the early years of China's reform and opening up, Shenzhen is taken as an experimental field. In March, 1979, the central government issued the policy and piloted the Export Special Zone in Shenzhen, Zhuhai, Shantou and Xiamen. In March 1980, the Standing Committee of the National People's Congress formally approved the establishment of the "Shenzhen Special Economic Zone." In March 1981, Shenzhen was upgraded to the same level of the provincial-level city as the province capital city, Guangzhou. Due to the booming economic development, in November 1988, Shenzhen has become a separate planning city.

Figure 10 Location of Shenzhen in Guangdong Province and China



NOTE: Based on the original photos, then draw the color elaborating the specific location based on the software of Meitu.

In December 1990, the Shenzhen Stock Exchange was established as one of the two major stock exchanges in China, it is an important financing platform for Chinese companies and enterprises. In February 1992, Shenzhen was authorized by the Standing Committee of the National People's Congress to have the legislative power in the local laws, which granted the legislative possibility in the development of experiment. And the tech-intensive industries have been echoed as the pillars in Shenzhen.

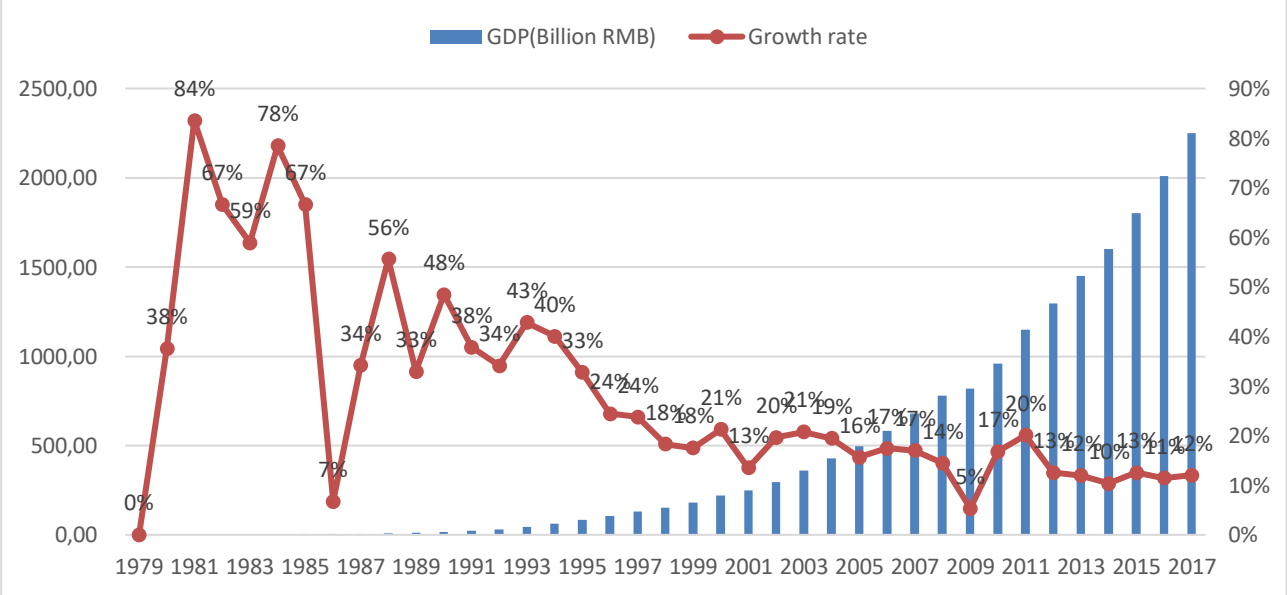
Figure 11 One of Shenzhen's CBD (Futian District) from different angles

NOTE: The left one is cited from the city's homepage, and the right one is taken by the author from the angle of an apartment.

2.3.2 Economic and Demographic

Shenzhen, regarded as China's Silicon Valley, has experienced explosive economic expansion. Shenzhen's GDP is $338 billion in 2017. Its per-capita GDP was ¥183,544($27,038) in 2017[12]. The overall GDP grew by 16.3 percent yearly on average, it has slowed to around 10% per year since 2012. Shenzhen is in the top ranking among mainland Chinese cities in terms of comprehensive economic power, especially, for the virtuous interaction of innovation, market vitality and venture capital, and ranks firstly for the application of PCT (Patent Cooperation Treaty) for consecutive 12 years in China. In 2015, there are 6 companies' headquarters locating in Shenzhen among the top 10 applicants[13]. For more detailed economic and demographic information, the following figures will demonstrate it in terms of the GDP, GDP per capita, population, and the distribution of charging facility.

Figure 12 GDP volume and growth rate annually over 1979-2017

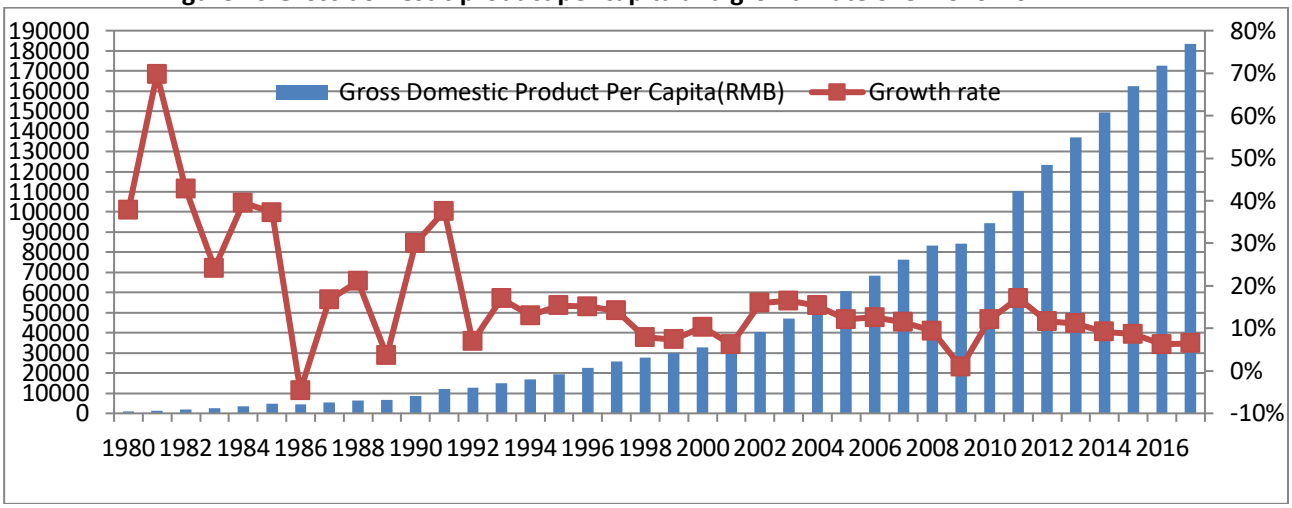


[12] The data in the part comes from the Shenzhen Statistical Yearbook, it is a comprehensive statistical report covering all the perspectives in the city of Shenzhen. Meanwhile, if there is no specific citation of data reference in this part, it is based on the city yearbook.

[13] Shenzhen Statistical Analysis Report on IPR in 2015.

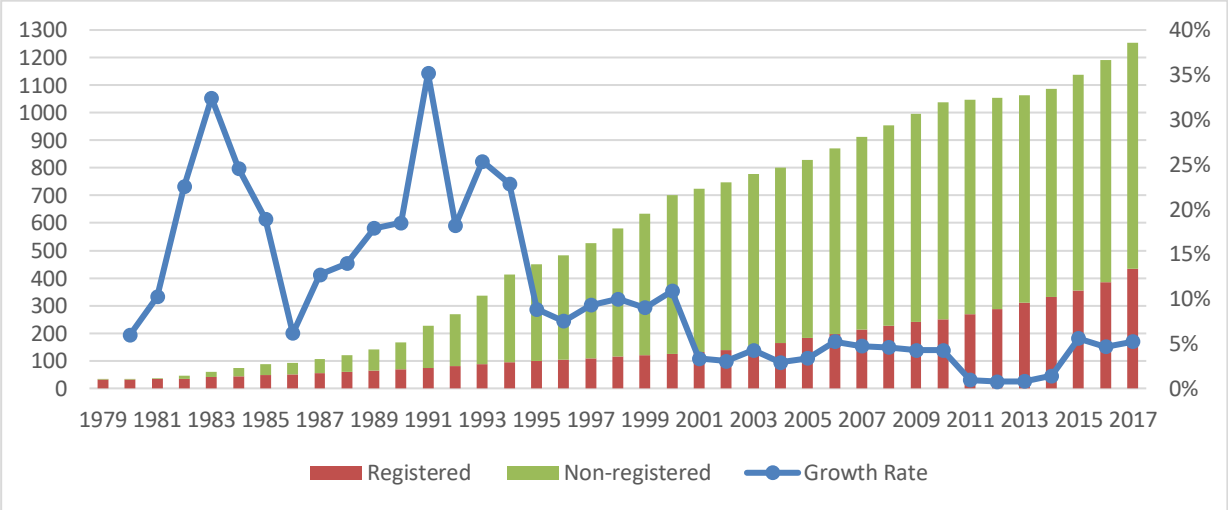
Data source: Shenzhen Statistics Yearbook. The left axis is the GDP and the right axis is the growth rate. According to the new GDP Accounting Methodology in 2016, the cost of R&D should be included in the volume of GDP, the data of GDP over the period of 1995 to 2016 should be revised, but the data presented here is only revised over the period of 2015 to 2017. Meanwhile, it is the current price.

Figure 13 Gross domestic product per capita and growth rate over 1979-2017



Data source: Shenzhen Statistics Yearbook. The left axis is the GDP per capita and the right axis is the growth rate. There is a constant growth in the GDP per capita, but the growth rate has experienced a decrease. The amount is the nominal one, and the currency is the RMB.

Figure 14 Hukou, Non-Hukou Population and total growth rate over 1979-2017



Data source: Shenzhen Statistics Yearbook. The left axis is the amount of population (unit: 10,000 persons) and the right axis is the growth rate. From the above figure, it has elaborated Shenzhen's feature, as a migrant city.

As the economic prosperity and vitality, the population has increased substantially from a fishing town with the amount of 314,100 in 1979[14], to a modern economic center with the amount of 12.5 million in 2017. However, the population boom has slowed down as the change and restructure of industries.

[14] Demographic: According to "People's Republic of China Household Registration Regulations", household population refers to the citizen has registered permanent residence in its regular place of residence management authority, namely Hukou. Resident population refers to people living in a certain area actually with a certain time (more than six months); In Shenzhen's statistical yearbook, the population refers to the resident population who lives in Shenzhen more than 6 months.

Table 9 detailed information in Shenzhen's different districts in 2015

Area	Land Area (sq.km)	Population (Million)	Registered Population (10,000)	Non-registered Population (10,000)	Density (person/sq.km)	GDP per capita (USD)[15]	Ranking
Total	1997	10.78	332	746	5398	26071	
Futian	79	1.36	83	52	17253	38524	2
Luohu	78.75	0.95	55.92	39.46	12110	29097	5
Yantian	75	0.22	6	16	2901	36133	3
Nanshan	187	1.14	71	43	6069	52504	1
Baoan	396.6	2.74	42.13	231.52	6898	15495	10
Longgang	389	1.98	42	155	5083	21433	7
Guangming	155	0.50	6	44	3244	21356	8
Pingshan	165.9	0.33	4.44	28.72	1998	22185	6
Longhua	176	1.43	17	127	8170	18306	9
Dapeng	295	0.13	4	9	453	32967	4

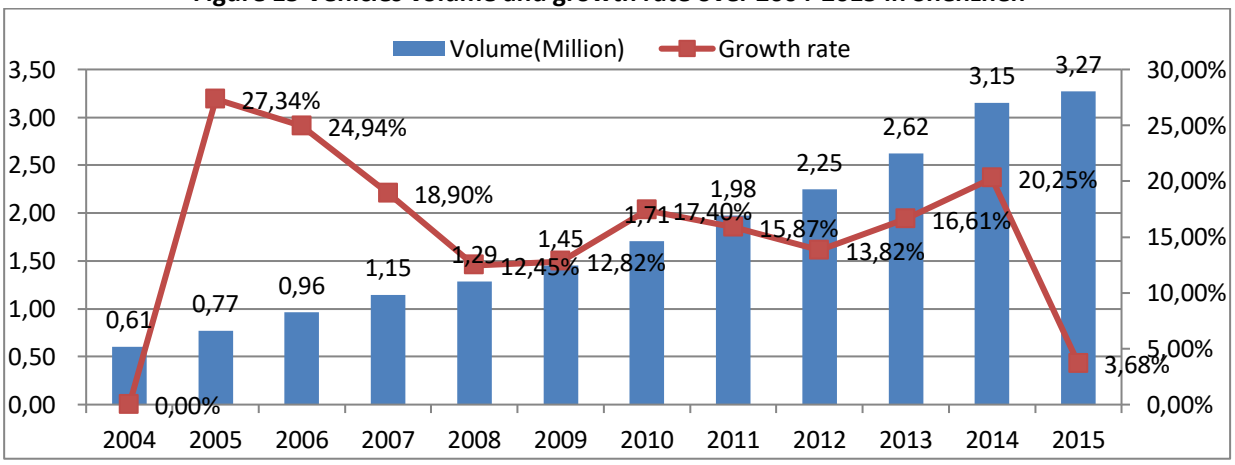
NOTE: the data is from Shenzhen Statistical Yearbook. This table presents the detailed information in Shenzhen's different districts, due to the diversified economic structures, there is a disparity among different districts. Meanwhile, the attribution of GDP per capita is somewhat distorted, as the fact that the denominator in the calculation is the amount of population, but lots of individuals would work in the CBDs, but live in other areas where are cheaper comparing to CBDs. Therefore, the population in the CBDs is underestimated and the GDP per capita is overestimated according to this calculation.

CBDs (Center Business District), such as Futian (municipal government and financial center), Luohu (financial and trading center) and Nanshan (High-tech center), have a higher population density and GDP per capita. Other districts, such as Baoan (manufacture and airport), Yatian (container port, second largest in Mainland, China, third in the world[16]), are regarded as different centers.

2.3.3 License Plate Quota in Experiment group of Shenzhen

In order to ease urban traffic congestion and improve the air quality, meanwhile, cultivate and accelerate the development of NEVs industry, starting from December 29, 2014, Shenzhen has promulgated the regulated vehicles quota system, namely, the quota on the license plates, it not only sets the total volume of vehicles annually, but also sets the sub-volumes and mechanism getting the license plate according to the category of vehicles.

Figure 15 Vehicles volume and growth rate over 2004-2015 in Shenzhen



[15] The GDP per capital is based on the data of 2015.

[16] World Shipping Council.

Data source: The data is from the Shenzhen Statistic Department, after the implementation of license plate quota in 2015, the total growth in the volume is subject to the 80,000 conventional vehicles and increase of NEVs. Where the left axis is the total amount and right axis is the growth rate.

Apparently, over the period, it has witnessed a continuous growth with an average of 16.7%, starting from 0.61 million in 2004 to 3.27 million in 2015[17]. However, there is a shocking decline amounting to 3.68% in 2015 due to the implementation of quota, which suggests the practical effect on the controlling of rabid expansion. Therefore, it is successful in term of the aggregate volume under the quota, but what are the individuals' behaviors among different ways? Is it successful to achieve the green target as the compulsory promotion of adoption of NEVs?

Temperately, the quota period lasts five years over 2015-2020 with the provision of 100,000 annually, of which 80,000 are conventional vehicles, and NEVs for the remaining 20,000. But after one year, the cap of 20,000 for the volume of NEVs is removed and there is no cap limitation for NEVs. Apparently, setting the target vehicles volume, the demand management policy holds multi-functions with reduction of congestion and the support of NEVs industry. And as the original intention of the restriction policy, it is bound to make it much easier for consumers to buy new energy vehicles, expecting to boost its development.

Firstly, it is very important to know who could apply to the vehicle quota in Shenzhen, for more details listed on the document of Shenzhen Reform and Transportation Department, the primary prerequisites for individual's application in the vehicle quota system should meet the conditions simultaneously.

- *Individual doesn't own a car registered in Shenzhen (but recently, there is a slight change, if individuals own a conventional vehicle registered in Shenzhen, it can also apply for an additional new energy vehicle);*
- *The city residence (Hukou) or non-city residence but holds a valid residence permission, have paid the basic comprehensive insurance (namely, "five insurances and one fund")*[18] *for more than two consecutive years in Shenzhen;*
- *Hold a valid certificate of driving license above C level*[19]*;*

Besides, there are other restrictions on individuals who have get the license plate in the quota market. Firstly, the index of a license plate is valid for six months; individual should purchase vehicles according to the category of license plate and register it under its own name within this period of 6 months, it is not allowed to re-sale, namely, there is no transferable market in the quota. Otherwise, which is regarded as a waiver of the license plate, and from the next day since the expiry, the individual cannot apply for license plate within next two years. So the

[17] Volume of cars refer to the no. of cars that the license plate register in the Shenzhen, which doesn't include the no. of vehicles that are used in Shenzhen but the car license plate doesn't register in Shenzhen; There are limitation policies preventing this condition in order to reduce the air pollution and traffic congestion, such as the rush hour, over 7-9am and 5-7pm, the vehicles with other cities' license plate cannot drive on the city center, otherwise, there will be a penalty amount to 300RMB(about 40 Euro according to the exchange rate on Jan.2019). This policy targets on easing the traffic jam and pressure in the city center over the such hours. The data is from the Shenzhen statistics yearbookhttp://www.sztj.gov.cn/xxgk/tjsj/tjnj/;

[18] "Five insurances" refers to the five kinds of insurance, namely, retirement insurance, medical insurance, unemployment insurance, industrial injury insurance and maternity insurance; "one fund" refers to the housing accumulation fund. This is compulsory for the employees and employers to sign a contract and pay these insurances and fund. This condition is compulsory due to the fact that it is regarded as the certificate for license plate applicants who has worked and lived in Shenzhen.

[19] According to the guideline of driving license, the different levels of A, B and C are applicable to trucks, public bus and private cars respectively.

procedures refrains from the possibility of a second-vehicles-license-market that successful license owner sales the valid license plate to others with the target of making money under the fluctuation of price, namely, it curbs the possibility of speculators and transferability, although it is criticized as the unrealized welfare gain and misallocation(Li, 2015).

The configuration cycle is 12 months, and the amount is evenly allocated within 12 months. Generally, it is a fixed volume each month. But if there is a remaining quota in the previous month, it will be subsequently added to next month. Meanwhile, the transportation department will publish the configured number for next month before the date of the application. Individuals can only choose one of three alternatives, lottery with a small probability but free for conventional vehicles, or bid with a higher probability but additional cost for the conventional vehicles or free with 100% for NEVs. The distribution ratio of incremental index is 2: 4: 4 with the total configured amount of 100,000 annually, which is monthly distributed and can be cross-cycle configuration, and configure as the following three ways.

Table 10 the initial distribution of sub-quotas in Shenzhen annually

Types	Quotas annually[20]	Methods
New Energy Vehicles	20,000	Lottery
Conventional cars	40,000	Lottery
Conventional cars	40,000	Bidding

The procedures can be descripted as two steps simply. (1) Submit an application base on the unique ID number to obtain application coding on the website; (2) Choose one alternative among the three ones. The bidding bases on the online manner, according to the bidder's final offer, it will be traded in a descending order. Namely, the higher price, the priority of winning, if there is a same price bid, then the earlier offer the price, the priority to win. winners only should pay their own bids, namely, 'discriminatory', instead of uniform-price. Meanwhile, all bidders have their own account in the authority quota system and offer the bidding price that others could not know, accordingly, which could be regarded as the sealed-discriminatory-bid rule. But the authorities try to avoid the fluctuation of bidding price, so the average bidding prices in the whole market will be published twice, and the bidder can revise its price[21]. Besides, it is different to the mechanism of Singapore that bases on the prevailing traffic condition and road capacity to announce a total volume of growth rate every year, more important, it was transferable (Koh & Lee, 1994). An applicant in Shenzhen license plate quota should follow these detailed procedures for a license[22], for bidding, each bidder should transfer 5,000 RMB

[20] Incremental indicators, individual indicators accounted for 88 percent of the quota, 12% for the organizations in Shenzhen, but for the study, I only focus on the individual parts.

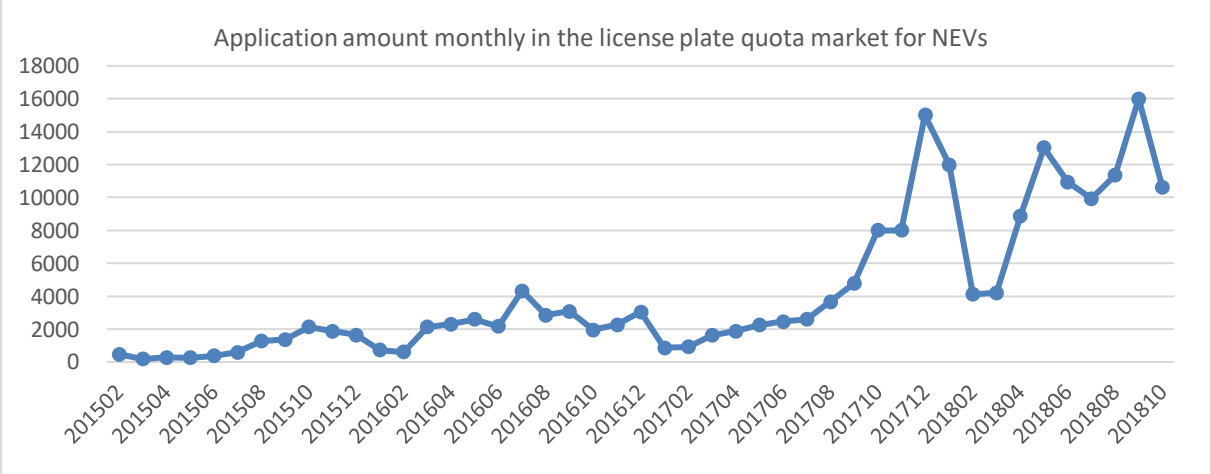
[21] The bidding and lottery are carried out online, and the website for the license plate is as following link http://www.szxqcjj.com/.

[22] The website for the bidding of license plate: http://www.szxqcjj.com/;
The coming steps have a clear procedure for the bidding in the license plate of quota market. The bidding in the license quota could be descripted as a semi-transparent mechanism, individuals can revise its initial bidding price based on the average price of whole market published by the bidding organizer who try to avoid the tremendous price fluctuation.
(1) Submit an application to obtain application coding; (2) Eligibility audit, confirmation application as an efficient encoding; (3) With a valid code, participate in the lottery or auction. Individuals can only get an application coding and choose either lottery or auction. (4) Individuals should apply to the incremental index before the 8th of each month; otherwise, it will be postponed to next month. (5) If applicants want to change the type of application; after the withdrawal of the original one, it should submit a new application before the 20th in the month. (6) For

as the bidding deposit and the reserve price is 10,000 RMB. Meanwhile, the online auction follows the principle "price priority then time priority" in the descending order over the continuous bidding period of 9:00-15:00, and at the point of 11:00 and 13:00, the organizer will release the average price of whole bidders over the respective periods; Moreover, bidders can revise their initial price twice based on the reported average price. Lastly, the valid period of the successful license is six months; individuals should own a new car and register in the transportation department within the valid period. Otherwise, the overdue will be regarded as the waiver of the license; moreover, the individual can not apply for an incremental index within next two years starting from the next day of expiry date.

Accordingly, the license plate quota is a multi-exclusive mechanism, individuals can only choose one of three alternatives, lottery with a small probability but free for conventional vehicles, or bid with a higher probability but additional cost for the conventional vehicles or free with 100% for NEVs. Contingent on the description of the license plate quota, it is a multi-exclusive quota, instead of multi-inclusive, meanwhile, the license plate cannot be sale to others, namely, there is no transferable market in the license plate quota, additionally, the amount of quota for each month is fixed. Meanwhile, the process is total transparent with a full enforcement and compliance. Accordingly, it can be descripted as a multi-exclusive quota with a fixed amount of quota and compliance but without a transferable market.

Figure 16 Application amount in Shenzhen's license plate quota market for NEVs monthly



the lottery, Index Governing Body will organize on the 26th of each month, if it is on non-working day, which will be extended accordingly. Lottery will be lawfully notarized by a notary public. And then the results should be publicized. (7) For the auction, each bidder should pay 5,000 RMB for the bidding deposit; and the auction reserve price is 10,000 RMB, and the offer should not lower than the reserve price. On the 25th of each month, the Index Governing Body will organize the online auction, if it is on the non-working day, then it will be extended accordingly. (8) The online auction follows the principle "price priority then time priority". Firstly, according to the bidder's final offer, it deals in the descending order; when the last valid offer has same amounts, then according to the chronological order. (9) Over the continuous bidding period of 9:00-15:00, at the point of 11:00 and 13:00, the organizer will release the average price of whole bidders over the respective periods; moreover, bidders can revise their initial price twice based on the reported average price. (10) The bidding price should be an integral multiple of 100; meanwhile, it cannot be more than twice of last month's average price, and the valid price takes the last offer. (11) The valid period of the successful license is six months; individuals should own a new car and register in the transportation department within the valid period. Otherwise, the overdue will be regarded as the waiver of the license; moreover, the individual can not apply for an incremental index within next two years starting from the next day of expiry date.

Data source: The data is shared by the Shenzhen Transportation Department after my application for the purpose of dissertation writing. Previously, all the data will be published monthly, including the bidding, lottery, and application for NEVs, but after one year, the cap of 20,000 NEVs in the license plate quota market was removed, so Shenzhen Transportation Department has not published the amount of NEVs monthly. Where the volume of NEVs includes both the electric vehicles and hybrid vehicles.

Figure 17 number distribution of charging station in different districts

NOTE: The map of Shenzhen's districts is cited from the city homepage, and the number is added by myself according to the numbers of Chong Dianzhuang (an APP for the drivers who look for the charging stations) in each district. The distribution of charging stations is consistent with the economic status and consumption, where the high-tech center, Nashan, ranks the first amounting to 189[23], then Futian as the second. Most importantly, given the interaction of distribution charging stations, population density (higher Hukou percentage, less non-hukou percentage) and the precondition for the applicants in the vehicle quota mechanism, the districts, including the Nashan, Futian and Luohu are the ideal options for the sample selection in the study. The number in the photo is calculated until the time of Decenber,2016.

Table 11 Guideline for Shenzhen's preferential policies to new energy vehicles

	Types	Detailed policies[24]
Subsidies Modes	purchasing subsidies	In accordance to the regulations in Shenzhen, the sale and registration vehicles should be within the jurisdiction of Shenzhen area. The new energy vehicle production enterprises sale the vehicles to buyers with the price after the deduction of subsidies, then the municipal authorities transfer the subsidy funds to the enterprise.
	charge subsidies for consumers	Within the jurisdiction of the Shenzhen area, and legally register to obtain a license, the municipal authorities give the subsidies to the car buyers in accordance with the actual use of electricity.
	Subsidies for the investors of charging	Within the jurisdiction of the Shenzhen area and after the completion and acceptance of charging facilities, the municipal government gives subsidies to investors in accordance with procedures.

[23] The No. of charging station in different district is from the APP until 26,09,2016， namely, charging station, in Chinese (Chong Dian Zhuang), owned by the future of E-mobility, which is the most popular APP for the e-drivers to find the charging stations, and payment for the charging fee. On the APP, it not only provides locations, but also the type of charging station, the fast or slow charging, the parking and other service fee, how many charging stations are available now, and send your application to the organization where could build a charging station, and the feedbacks about the charging station from the drivers.

[24] Shenzhen Municipal Development and Reform Commission issues the policy about "Shenzhen 's financial support to promote the use of new energy vehicles in 2016". Municipal Finance Commission, the Municipal Development and Reform Commission will adjust the subsidy policy based on national and provincial policies, as well as new energy vehicles, technological progress, industrial development, the scale of application, cost changes and other factors.

	Recycling subsidies	NEVs manufacturers should be responsible for the recycling of NEVs and battery, and the municipal government subsidizes the production enterprises according to the cost of recycling.
Requirements for Subsidy object	Requirement for vehicles	The NEVs should be in line with the national requirement of driving range, through the national special inspection, in line with state-level new technical requirements and standards.
	Requirement for sales and manufacture companies	NEVs manufacturers should provide consumers with quality assurance consisting of the power batteries, other energy storage devices, drive motor and motor controller. For the private car, manufacturers should provide the quality guarantee with not less than 8 years or 120,000 km; for commercial vehicles, including coach, special vehicles, trucks, etc., it should provide the quality guarantee with not less than 5 years or 200,000 kilometers. Automobile manufacturers and power battery manufacturers should assume the main responsibility for battery recycling.
	Requirement for the charging facilities	The charging facilities (stations, piles, installations) shall be constructed in accordance with the national, industrial and local technical standards for charging facilities. For business operation, it also should be in line with the "Shenzhen City, the new energy vehicle charging facilities for the record management approach" and the relevant provisions. But there is no subsidy for the new construction of charging facility that is required by the planning and design.
Subsidies standard	Purchasing subsidies	Pure electric private cars: 100 ≤ R <150 km (R is the standard operating range, unit: km,) 25,000 RMB/one, 150 ≤ R <250 km 45,000 RMB / one, R ≥ 250 km 60,000 RMB/one.
		Plug-in hybrid private cars: R ≥ 50 km 31,500 RMB / one.
		Pure electric bus: 500,000 RMB /one for the standard bus (R≥250 km (10 m <L ≤ 12 m, L is the body length), 0.5 times subsidies in accordance with the standard car for the bus with 6m <L ≤ 8 m; 0.8 times subsidies in accordance with the standard bus for the bus with 8M <L ≤ 10 m; 1.2 times subsidies in accordance with the standard bus for the bus with L≥12 m.
		Fuel cell vehicles: Fuel cell private cars 200,000 RMB / one; fuel cell light buses, trucks: 300,000 RMB /one; large and medium-sized bus, heavy trucks: 500,000 RMB / one.
	One-time charging subsidies for consumers	There are 5,000 RMB and 1,000 RMB for the pure electric car and plug-in hybrid car respectively.
		For light and minivans with a load of 3 tons or less, and obtaining the operation permit of the transportation administration department, there is a one-time charging subsidy according to the standard of 600 RMB per kilowatt-hour of battery capacity.
	Pure electric taxi	For the taxi companies, there is one-time subsidy with 110,800 RMB for one pure electric taxi, but the premise is that rent monthly of the pure electric taxi should not be higher than the fuel vehicles. For the substitution from the fuel vehicle taxi to pure electric vehicle taxi, there is another subsidy for the renewal on the basis of the 80% remaining life of the depreciation amount, and the maximum is 32,000 RMB.
	Subsidies for charging facilities constructor	The condition for a single operator that applies for subsidies should be more than 8000KW totally in the construction of charging pile; charging station for buses, taxis, logistics vehicles, sanitation trucks and rental cars, the subsidy is 300 Yuan / kW for DC (direct current) charging equipment and 150 RMB /KW for the AC (alternative current) charging equipment;
	Subsidies for the recycling enterprises	The standard of subsidies for the recycling enterprises should be 20 RMB per kilowatt-hour. The municipal finance department shall provide subsidy to the enterprise by 50% of the amount determined by auditing, and the subsidy fund shall be specially used for the recovery of power battery.

NOTE: This table descripts the preferential policies from the experiment group of Shenzhen, elaborating the subsidies models, requirements for obtaining the subsidies and subsidies amount contingent on the categories. The city's financial support for new energy vehicles is mainly limited to the Shenzhen area, including purchasing subsidies, one-time charge subsidies for consumers, construction subsidies of charging facilities and power

battery Recycling subsidies. But the total amount of subsidy from both of national and sub-national one cannot exceed 60% of vehicle prices.

A comprehensive introduction for the above two chapters, it elaborates the backgrounds in terms of international, national and city's perspectives. In term of international and national perspectives, it primarily presents the incentives policies deployed to accelerate the adoption of NEVs. While for the experiment city of Shenzhen, in addition to the subsidies, more importantly, it figures out the quota of license plate, it can be descripted as a multi-exclusive quota with a fixed amount of quota and compliance but without a transferable market. Accordingly, the next chapter will focus on the literature review on the adoption of new energy vehicles in China, which will lay out the structure of theories, methodologies and works needed to be further done.

Chapter 3 Literatures on the adoption of China's new energy vehicles

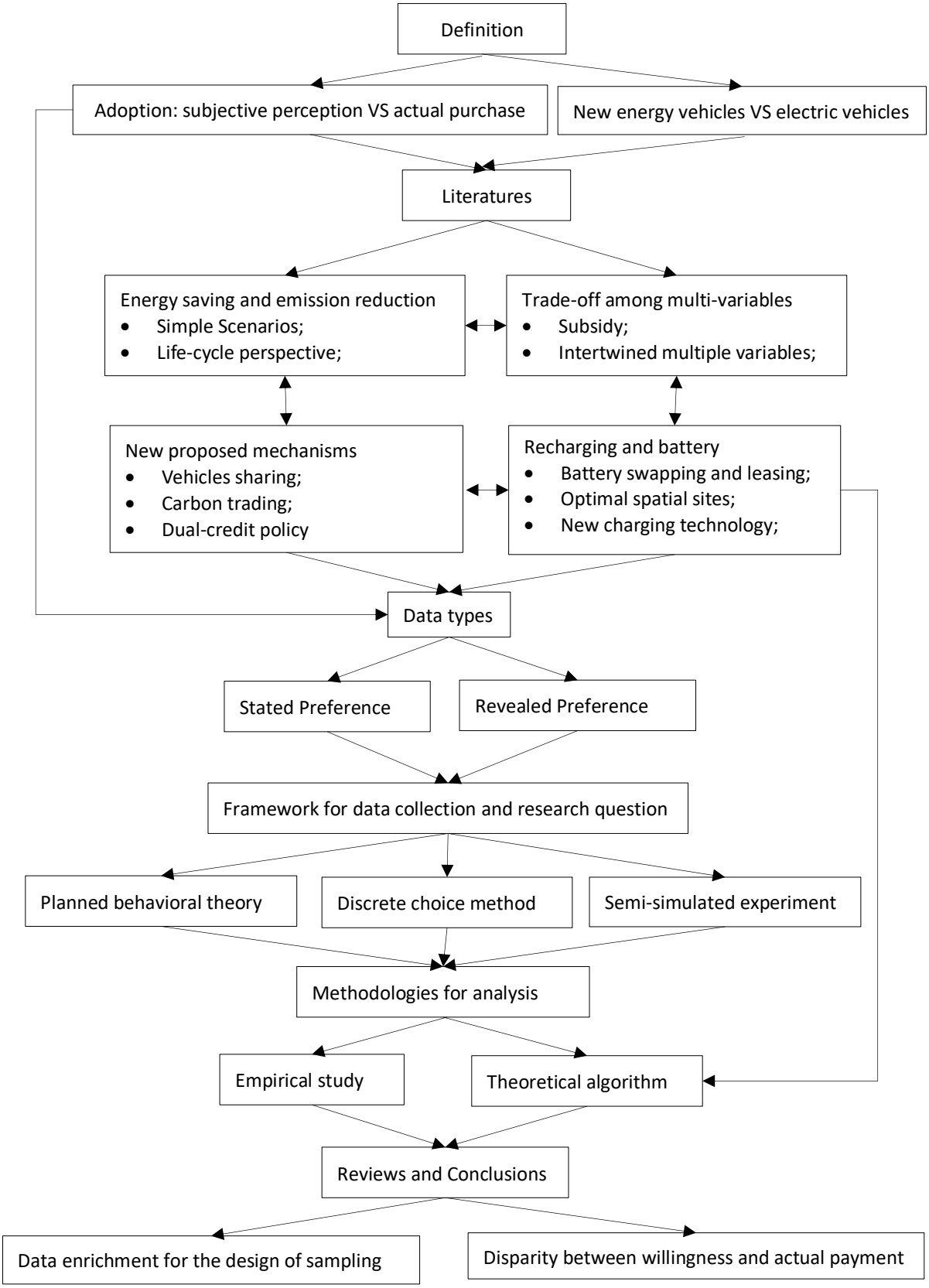
China has an ambitious development target to mitigate the environmental pollution. From the macro-perspective, a tremendous emission reduction for per unit GDP has been announced by China's government, targeting on the reduction by 40%-50% in the end of 2010 and 60-65% in the end of 2030 based on the benchmark in 2005[25]. While the transport related emissions account for more than a quarter of a global total emissions(Thiel, Perujo, & Mercier, 2010). Therefore, a number of policies have been instituted to accelerate the diffusion of electrical vehicles. While the actual process is far lagged behind the target. The factors, such as the infant technologies, deficient subsidy policies, local protectionism, embarrassed charging infrastructure, contribute to the unexpected results(Zhang, Rao, Xie, & Liang, 2014).

Moreover, the strategical importance of an emerging industry, is attached on the government top agenda in many countries. But what is the practical performance? A scientometric analysis is applied to evaluate the trends and status quo on electric vehicle(Hu, Sun, Li, & Pan, 2014). Besides, in order to study the policies effect on the adoption, the market share is the dependent variable, the independent variables, such as the amount of subsidy, the dummy variable of tax exemption, dummy variable of traffic restriction, average gasoline price, number of patent application, suppress demand due to the restriction policies(Ma et al., 2017). Additionally, a comprehensive analysis of the trend in the future has been done in term of the technological roadmap, sustainable promotion mechanisms(Zhao, Wang, & Wang, 2018). Accordingly, what effect could it have on the adoption? What challenges are there? What is the interrelationship among different variables and mechanisms? What is the optimal solution for the long-term sustainable development? What methodologies have been deployed? What are the merits and demerits for different theories and methodologies? This part, for the literature review and methodologies deployed, will elaborate, then draws the conclusions and provides an insight for the further research.

Additionally, in order to have a macro-perspective for the structure and logic in the literature review, it will be elaborated in the following figure.

[25] China's State Council, the target and plan on the energy saving and emission reduction. http://www.gov.cn/zhengce/content/2017-01/05/content_5156789.htm

Figure 18 Flowchart of the literature and methodology reviews



Note: This flowchart is based on the literature review and methodologies deployed to elaborate the logic among different components, which provides a clear guideline on the literature review of electrical vehicles' adoption.

3.1Definition

For this part, it focuses on two definitions on this topic, 'adoption' and 'new energy vehicles/electrical vehicles', particular for the implication of adoption, which decides the choice of sample collection, data type, theory, and corresponding methodology for the data analysis and simulation.

3.1.1 Adoption

According to Cambridge Dictionary, the definition of 'adoption' has two meanings, where the first one refers to 'the act of taking another person's child legally into your family to raise as your own child'; While the second one refers to 'the process of starting to use a new product or service, method, system, law, etc., the act of accepting or beginning to use something'. Obviously, the meaning in this research refers to the later one. However, the later one consists of two layers of confusing meanings, 'the process of starting to use something new or the act of accepting or beginning to use', in practice, does it refer to the adoption of subjective willingness/intention or actual purchase? The different understanding on the adoption for the behavioral study of electric vehicles is important to figure out the following research question, sampling, data collection methodology and conclusion.

Firstly, in term of the adoption, when it refers to the cognitive willingness or intention to accept something, which deploys the planned behavioral theory and discrete choice experiment, to study the effect of multi-variables on the adoption of electric vehicles, such as the attitude toward environmental behaviors(Tonglet, Phillips, & Read, 2004), an overall positive or negative attitude toward the purchasing of new energy vehicles(Aizen & Klobas, 2013), the effect of trip modes daily, transportation expenditure, driving range, gender and age on the willingness of electric vehicle(Wang & Yan, 2015), referring to diffusion(Liu, You, Xue, & Luan, 2017), consumers' intention(Wang, Li, & Zhao, 2017), the effect of recharging facility on the adoption of electric vehicles(Li, Zhang, & Wu, 2018), the perceived usefulness, intention, attitude and perceived risk(Wang et al., 2018). Basically, the data type in these researches is stated preference based on the personal perception and subjective willingness.

Secondly, regarding adoption, another perspective refers to the meaning of actual purchasing, instead of subjective perception or willingness. However, due to the limitation and difficulty of gathering the actual purchasing data in the early period of new vehicle's adoption, there are ways proposed with the target to access and simulate the actual behaviours. The first one could be called the semi-experiment by inviting the consumers to participate in a pilot demonstration over a period. It collects the data about the driving and charging behaviours, personal demographic information, and final decision under different scenarios. For example, there is a detailed and experiment-oriented interviews(Kurani, Turrentine, & Sperling, 1996), a subsequent trial of electric vehicle and a small sub-samples who can test the electric vehicle(Gould & Golob, 1997), quantitatively study the driving habits and performance by collecting the data before and after the trial(Caperello & Kurani, 2012), long-term GPS tracking data and digital elevation map(Liu, Yamamoto, & Morikawa, 2017), a real GPS trajectory data to simulate the consumers' charging behaviors and find the best location planning of charging stations(Bai, Chin, & Zhou, 2019).

3.1.2 New energy vehicles vs Electric vehicles

How does it define the new type of vehicles? Typically, there is no rigorous definition, which primarily has two perspectives contingent on the technological driving comparing to the

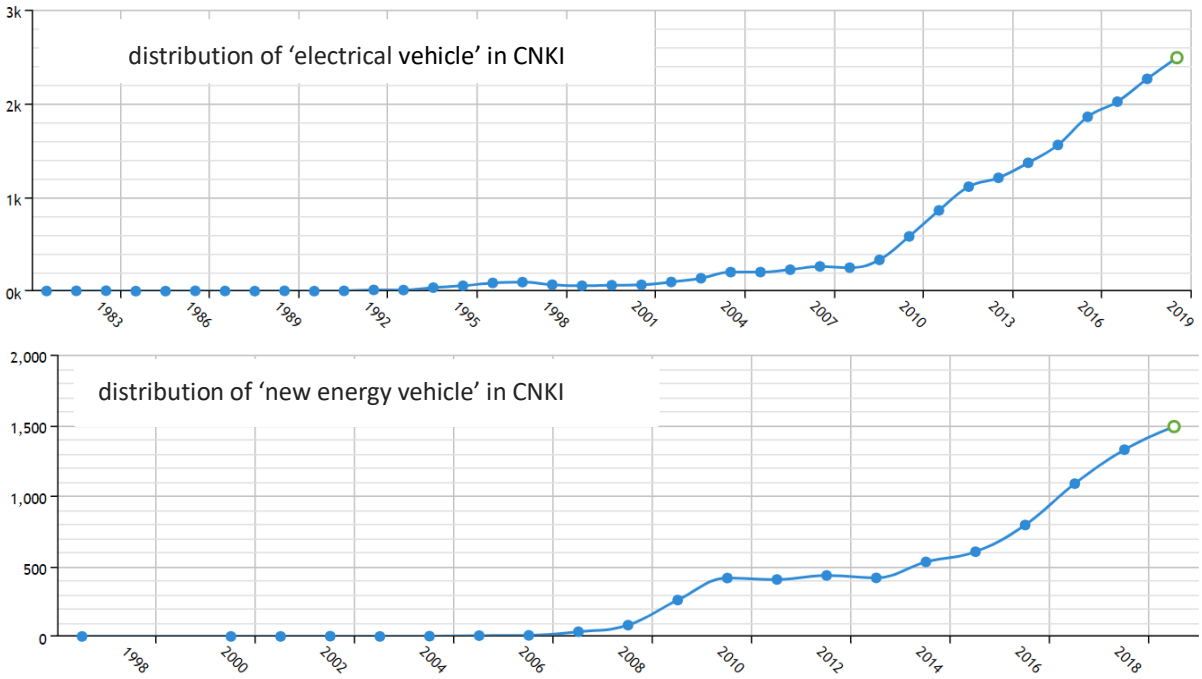
conventional one and the categorical reference.

In term of the technological perspective, it emphasizes the different driving power system comparing to the conventional one who consumes gasoline or diesel, such as electricity, fuel cell, battery. Previously, when there is no dominant and clear technological roadmap, it has a broad scope in term of the alternative energy driving, such as ethanol-dedicated car in Brazil(Bastin, Szklo, & Rosa, 2010), the application of natural gas(Nie, Lin, & Jin, 2016), alternative energy instead of fossil fuel as power source(Zhang & Bai, 2017). Gradually, it clearly refers to the electricity generated, fuel cell generated or the hybrid in the market due to a clearer and dominant technological roadmap in the market.

In term of the categories, generally, different countries have a similar category division, such as hybrid electric vehicles, battery electric vehicles or fuel cell electric vehicles. It refers to the new electrified vehicles in EU(Thiel et al., 2010), hybrid electric vehicles, battery electric vehicles and fuel cell electric vehicles in Greece(Xiouras, Angelis-Dimakis, Arampatzis, & Assimacopoulos, 2012), where in Sweden the government policies refer to the energy-efficient vehicles(Whitehead, Franklin, & Washington, 2014). Therefore, the electric vehicle is driven by a motor, and the power is supplied by the rechargeable battery or other portable energy storage devices, main types are fuel cell electric vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, and battery electric vehicles(Wu & Niu, 2017). Therefore, in term of the categories, it has a consistent scope gradually, but in term of practical incentive policies, which has a discriminative policy to certain sub-categories.

However, due to the diversified categories, is there a consistent terminology in the academic or markets, or even different countries? New energy vehicles, electric vehicles, alternative fuel vehicles are utilized to refer the category, which is an important but ambiguous terminology. In order to clarify the un-unified referring name in China and other countries, the comparison will be based on the database of 'China's knowledge Index' and 'web of Science' to clarify the difference and find a proper terminology.

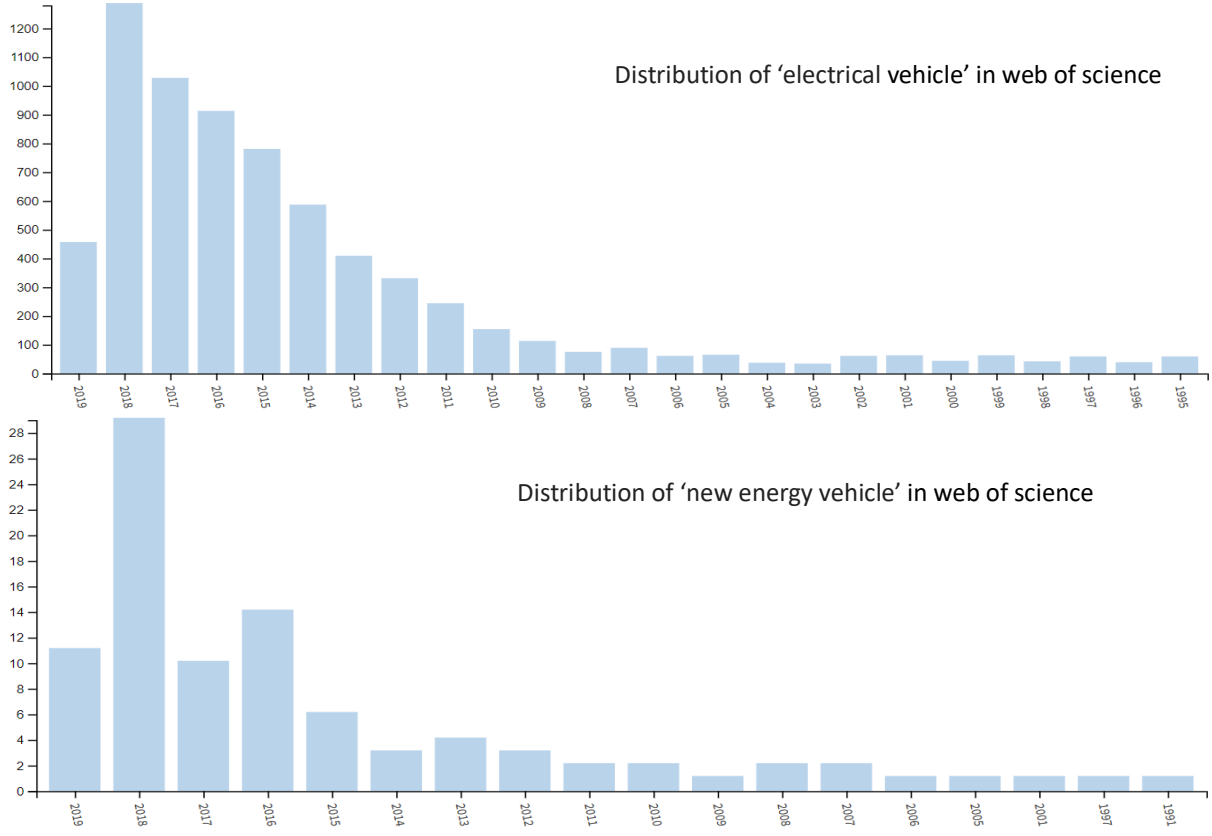
Figure 19 Comparison of published works between 'electrical vehicle' and 'new energy vehicle'



Note: The total volume deployed are 15740 and 6782 for 'electrical vehicle' and 'new energy vehicle' respectively. This first volume refers to the number of papers including the key words of 'electrical vehicle' in the title. And the below volume refers to the specific number of papers including the key words of 'new energy vehicle' in the title. The statistics in the database is collected until 19 May,2019, which have the same setting for the statistics with a better comparison. More specifically, the number in the figures are not only including the social science works, but also the natural science. And the CNKI refers to China's Knowledge Index.

While in the database of web of science, the volume is disproportional between the 'electric vehicle' and 'new energy vehicle', where the primary deployed terminology is electric vehicles. Even the key words of 'new energy vehicles' in the published works, there are more than half of them submitted by China's scholars. Therefore, it can draw that the 'new energy vehicles' is a typical China's terminology referring to the new type of vehicles according to the translation of the used Chinese name.

Figure 20 The volume distribution of published papers as the key words of 'electric vehicle' and 'new energy vehicle' from the web of science



Note: This above one refers to the number of papers including the key words of 'electrical vehicle' in the title, which amounts to 7341 totally. And the below one refers to the specific number of papers including the key words of 'new energy vehicle' in the title, the volume is only 94, and 55 papers of them are from China in term of research area. The presented figure is the statistic until 19 May,2019 in the database of web of science, besides, it has the same setting for the statistics with a better comparison.

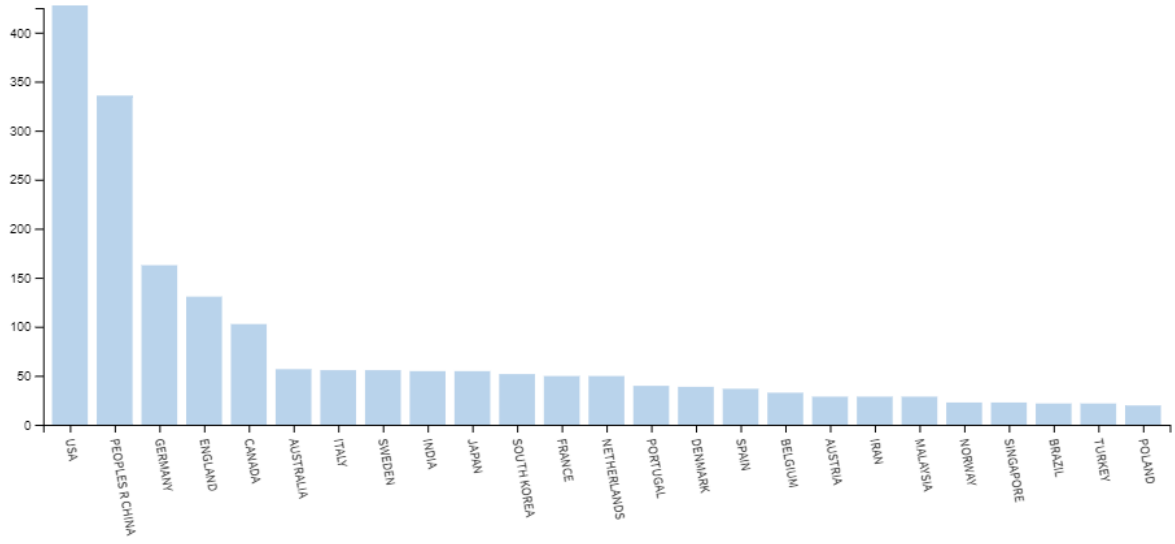
Accordingly, for the terminology, in China, it has a relative balanced utilization between the 'new energy vehicle' and 'electric vehicle'. In term of literal meaning of 'new energy vehicle', it is compared to the conventional ones with a broad definition covering all the new type vehicles when there is no dominant technological roadmap in the industry. When the technological roadmap of electrical power-motor has been regarded as a dominant trend, in China's current actual meaning, it has the same reference to the terminology of 'electrical vehicle'. Therefore, in order to form a consistent terminology in China and others countries, it is better to deploy

the terminology of ‘electric vehicles’ in this article.

3.2 Literature review on the electric vehicles

The literature review on this topic is based on the database of ‘Web of Science’. In term of countries/regions, the distribution of published works is presented as the following figure, where USA, China, Germany and England rank the top in term of the total published volume.

Figure 21 Published papers in term of countries/regions on the topic of electric vehicle



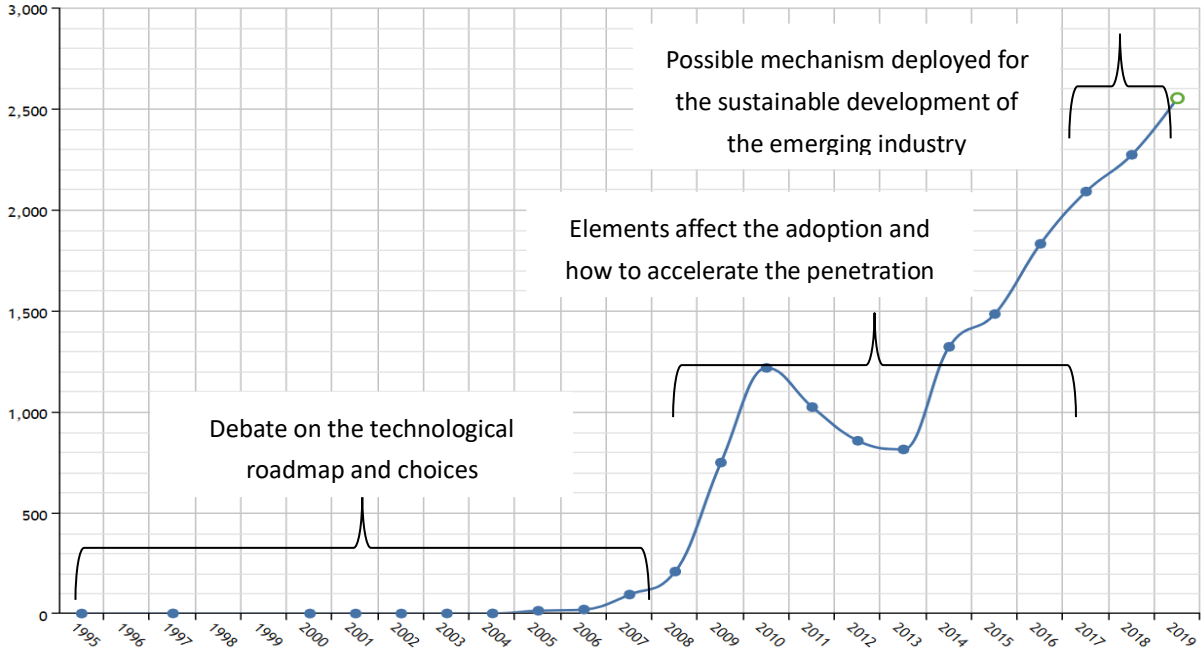
Note: Based on the data in the web of science until May, 2019, where the key search word is ‘electric vehicle’ and it excludes the Science Citation Index (SCI), only includes the Social Science Citation Index (SSCI). Besides, the figure is the visualization after the search on this topic in term of countries/regions in Web of Science.

3.2.1China’s studies on the adoption of electric vehicles

Before it comes to the detailed researches that have been done in China, it is better to have a macro-perspective. In term of both longitudinal and transverse perspectives, it provides a simple guideline for the literature review.

Firstly, from the historical longitudinal perspectives, initially, the researches primarily concentrate on the importance and possible technological roadmap of emerging potential industry, then the debate on what strategies could be deployed to promote the adoption of electric vehicles integrating with the perspective of industry development, technological models, firms’ incentives. After the market pilot period of electric vehicles for consumers, it focuses on the potential reference and measures responding to the adoption barriers, and possible mechanism for the sustainable development of electrical vehicles.

Figure 22 The historical longitudinal perspective on electric vehicles in China's database



NOTE: the data for the distribution on this topic is based on the database of China's knowledge Index until April,6th, 2019, where the link of website is: http://www.cnki.net/, and the key words in the search are "new energy vehicles" and "*新能源汽车*"in Chinese. Besides, the number in 2019 is the forecasted amount automatically based on the previous trend in the database. Meanwhile, the y axis is the number and the x axis are the specific year. In term of the longitudinal perspective, in the earlier period, it primarily focused on the importance the emerging industry and possible technology roadmap, then after the pilot projects and relative increase adoption of electric vehicles, substantial researches concentrate on what elements affect the adoption, then integrating with others mechanisms to study how to promote the sustainable growth of electric vehicles.

While for the earlier period, it primarily focused on the importance of the emerging industry and the debate of the possible technology roadmap and strategy. In the end of last century, there was a report about the huge challenge for the air pollution and side effect caused by the conventional vehicles, and the transformation necessity for the new energy vehicles for China(Jian, 1997). Besides, based on the grey systematic theory to forecast the demand, it discuss the strategy for the development of electric vehicles, meanwhile, it provided the technology roadmap for the substitution of conventional internal combustion engine automobile(Wang, 2002). Clearly, over this period, there was no one technology roadmap regarded as a dominant position, and the definition and alternatives for new energy vehicles were diversified. But after 2006, with previous technology competition, the electricity vehicle has got the support from industries and policies makers(Zhang & Ning, 2006). Therefore, as the dominant position of electrical vehicles gradually, it focuses on how to accelerate the adoption and what attributes hinder the penetration, such as the price of charging for the electric vehicles(Li & Ouyang, 2011), the charging inconvenience, short battery range, purchase cost(Tan et al., 2014), unreliable batteries, deficient subsidy policies, local protectionism, embarrassed market and unmatched charging infrastructure(Zhang, Rao, Xie, & Liang, 2014), range anxiety, resale anxiety(Lim, Mak, & Rong, 2014). Lastly, it focuses on the possible mechanism for the sustainable development, incentivizing the participation of different components in the whole supply and demand chains, such as the license plate-controlled(Xiang Zhang, Bai, & Zhong, 2018), vehicles sharing(He, Mak, Rong, & Shen, 2017), spatial time-dependent reservation at the car-sharing stations(Zhao et al., 2018), car-sharing

system for the autonomous connected electric vehicles(Miao, Jia, Li, & Qiu, 2019). Besides, the carbon trading for both personal participation and enterprise emission cap, such as carbon price in the emerging carbon market, is also proposed(Liu & Xiao, 2018).

Secondly, from the transverse perspective, notwithstanding it has a broad research on this topic, but it primarily focuses on the potential benefits of energy saving and emission reduction, trade-off among different variables, challenge of recharging and battery, and new mechanism for the sustainable promotion of electrical vehicles. The following table presents a clear guideline for the sub-research topics in term of transverse perspective.

Table 12 Sub-research topics on the adoption of electric vehicles for the transverse perspective

	Sub-topic	Research contents
Energy saving and emission reduction	Simple Scenarios	• Primarily, focusing on the driving process; • Positive for the energy saving and emission reduction; • while it also has skepticism on the effectiveness.
	Life-cycle perspective	• The measure of life-cycle perspective, consists of electricity life-cycle and vehicle life-cycle, from the resource exploitation and transportation, electricity production, electricity transmission and distribution, electric vehicles production and operation; • Debate on the emission reduction with a cost increase, environmental justice; • Neglect the recycling mechanism of battery;
Trade-off among multi-variables	Subsidy	• Positive and stimulating effect on the adoption of electric vehicles; • Problems of the subsidy: local protectionism, subsidy fraud, crowding effect in the firms' R&D intensity;
	Intertwined variables	• Trade-off among multiple variables and different contexts; • Problems: endogeneity, samples biased, only stated preference, and the challenge on the validity;
Recharging and Battery	Battery swapping	• swap for the fully-charged ones; • new problems, such as the battery standardization; optimal charging design under multi-targets.
	Battery leasing	• Lease vs sale; not only the leasing of battery, but also the lease of electric vehicles; • public-private partnership (PPP), the mechanism of building the battery leasing and swapping stations
	Optimal Spatial sites	• Design of optimal charging sites; • what are the constrains for the optimization of spatial design? • What are the diversified sub-targets in the optimization?
	New charging technology	• wireless power transfer for the charging of electric vehicles; • reshape the organization and operation format and mechanism;
New proposed mechanisms	Vehicles sharing	• A space-time network in a dynamic system with stochastic demand; • Connected with the car-sharing and autonomous driving;
	Carbon trading	• The effect of a personal carbon trading system; • Challenge the positive spillover of carbon trading for the adoption of electrical vehicles in practical extent;
	Dual-credit policy	• Regarded as the carrot and stick for the producers in the supply management;

Note: This table is based on hundreds of works have been published in the web of science, utilizing the scientometric analysis to figure out the common sub-research topics on the adoption of electrical vehicles.

3.2.1.1 Energy Saving and Emission Reduction

Due to the rapid motorization, it has caused tremendous pressure on the environment and

traffic condition, so an important role in the mitigation of pollution emission is attached to the electric vehicle. Because the emission reduction is the moral advantage attached by the policies makers comparing to the conventional ones. What the real result is it regarding the moral advantage of energy saving and emission reduction?

(1) Simple Scenario of driving

Generally, different researches have a similar conclusion that the electric vehicle can reduce the energy consumption and decrease the emission. Based on a simulation model to predict the possibility of reducing emissions, it indicates the electrification vehicles provide possibility to achieve it regarding scenarios for 2010,2020 and 2030(Thiel et al., 2010). In term of the energy consumption, with an increase of electric vehicle penetration by 10%, there is a reduction by 5% of coal equivalent consumption(Yao, Lang, Song, Yang, & Zuo, 2013). Meanwhile, it discusses different scenario for the road transportation in term of energy consumption reduction and mitigation of harmful emission, such as passenger vehicle, light truck, etc., while there is a same conclusion of a positive effect on the energy saving and emission reduction(He & Chen, 2013).

Moreover, compared with the current gasoline vehicles, the electric vehicle would reduce energy consumption by 37.5% and greenhouse emission by 35% under the prediction of energy structure for the electricity-generation in 2020, importantly, this positive effect is not substantially affected by the changes in travel distances and charging frequencies(Liu & Santos, 2015). Additionally, there is a simulation study on the improvement of air quality due to the penetration of electric vehicle, which will bring the improvement of 0.86%,9.01% and 12.23% for PM2.5 respectively, indicating a promising improvement of air quality with the penetration of electric vehicle(Du, Wu, Hu, & Guo, 2015). The effect of trip characteristic on the energy consumption of hybrid vehicle, including the daily travelled distance (28.44km), daily travelled frequency (2.69), daily travelled time (101.96 minutes), the integrated fuel consumption is reduced by 26.02%(Wu, Chen, & Demenkov, 2016). Using a well-to-wheel method, the electric vehicle has a significant effect on the reduction of emission comparing to gasoline vehicles, while it is varied in different countries(Wu & Zhang, 2017). Accordingly, it has a positive evaluation for the energy saving and emission reduction basically.

But it also indicates it is not enough for the emission reduction. The energy saving and emission reduction is regarded as the granted merits. After the identification of more than 175 policies from national, regional and provincial levels, the topic three targets are improving air quality, reduction of fossil oil energy and revitalizing automotive industry(Zhang & Bai, 2017). But there is also opposite conclusion from certain researches. When it compares to the substantial growth of transportation, the electric vehicle's contribution to improving city's air quality is limited, more importantly, it should focus on the increasing renewable energy resources, integrating with the process of energy transmission, transport and storage(Yu, Li, Huang, & Shan, 2017). Meanwhile, by establishing a life-cycle assessment framework for the battery production, it implies a 30% increase in the vehicle production than the conventional vehicles(Hao, Mu, Jiang, Liu, & Zhao, 2017). Accordingly, the positive benefits of energy saving and emission reduction is not only determined in the driving process, but also contingent on the energy structure and the life-cycle performance.

(2) Life-cycle perspective for the evaluation of emission reduction

For the problem in these previous researches, it only focuses on the emission reduction and

energy saving in the specific driving process. Typically, in order to accurately measure the energy saving and reduction of emission and compare between the internal combustion engine and plug-in or battery vehicles, the analysis for the whole life-cycle of electric vehicle is necessary. In term of the energy consumption and emission, instead of a specific driving period of the energy consumption. The life cycle divides into the electricity life cycle and vehicle life cycle, including the resources exploitation and transportation, electricity production, electricity transmission and distribution, electric vehicles production and operation.

The reduction effectiveness is different across countries due to the diversified energy structures, such as US, France and China, where China has a larger reliance on the coal to generate the electricity. Meanwhile, if it only focuses on the actual energy use and emission for a specific process, which leads to an mismatch comparison regarding the energy saving and emission reduction(Zhai, Christopher Frey, & Rouphail, 2011). Besides, it proves that the electric vehicle can reduce the energy consumption evaluated through an energy conversion analysis and a life cycle assessment, and a higher proportion of coal-fired energy structure is associated with a higher emission factor for the electric vehicle comparing to the sources of hydropower, natural gas-fired power and clear energy power(Lang et al., 2013). It indicates that a marked difference in energy saving and emission reduction for electric vehicle by different regional grids in China, and the benefit will be more obvious in future(Zhou, Ou, & Zhang, 2013). There is a comparative advantage for the energy efficiency and pollution to the environment in the stage of pump-to-wheel(PTW), but it is debatable(Tang, Wu, & Zhang, 2013). More specifically, the comparison between the natural-gas-to-electricity powered electric vehicle and gasoline vehicle for the greenhouse emission, when there is no carbon dioxide capture and storage technology installed, the reduction can be amount to 36%-47%, meanwhile, the reduction can be 71%-73% when the carbon and dioxide capture and storage installed comparing to the conventional gasoline vehicles(Ou, Zhang, Zhang, & Zhang, 2013).

In term of life-cycle perspective, it indicates the positive result, however, there is an ongoing debate on the possible additional cost potentially and the new insure of environmental justice.

The ongoing debate on the reduction of emission indicates whether the emission reduction compensates the cost increment. The cost and purchase price are important for the adoption of electric vehicle, but recently, the researches only focus on the purchase cost, instead of the cost in the whole life cycle of the vehicle. When it comes to the cost in the perspective of life cycle, the study indicates that the cost is higher than the conventional vehicles in China, while the electric vehicle will become competitive when the oil price rises(Lin et al., 2013). Meanwhile, by examining the life cycle cost and greenhouse emission, it indicates that the battery electric vehicles contribute to reduce greenhouse emissions, but it is affected by the potential gasoline price and prioritized in the intensive-used fleet, such as taxis(Hao, Cheng, Liu, & Zhao, 2017). Furthermore, the cost and environmental benefit associated with the electric vehicle is related to the resource portfolio in the regional power generation(Zhang & Han, 2017). So the increase in the battery energy density can reduce emissions by different levels, meanwhile, the same to the previous study, the optimization of energy structure is important for the reduction in term of life-cycle perspective(Yu, Wei, Chen, Peng, & Peng, 2018).

Electric vehicles aim to improve the sustainability and reduce the environmental health impact of transport emission, the shift transportation from conventional vehicle to electric ones in

the urban city has transformed the air pollution emission from the city to rural areas, as the power plants are built here, which could increase the challenge on the environmental justice, and it varies dramatically across cities contingent on the urban income and geography, besides, lower-emission electricity sources can mitigate the issue of environmental justice(Ji et al., 2015). Additionally, in term of life cycle for the comparison of environmental impacts, it demonstrates that it has substantial role preventing potential global warming, abiotic depletion and ozone layer depletion, but it will increase the impact of acidification(Shi, Wang, Yang, & Sun, 2016).

However, the recycling mechanism of the battery is not included in the presented life-cycle perspective. There are additional environmental issues despite the huge benefits for the adoption of electric vehicles, the most concern is attached to the recycling of batteries. After the massive adoption of electric vehicles, the recycling of spent batteries is a substantial challenge, a reward-penalty mechanism integrating the participants' profit, consumer surplus, government supervision cost, emission reduction, indicates that it is suitable for the higher recycling rate modes, requiring a minimum recycling rate as the benchmark for participants(Tang, Zhang, Li, Wang, & Li, 2018). Moreover, for the recycling of deleted battery, it is important to strength the cooperation between the government and manufacturer, meanwhile, in term of total social welfare, it is firstly increased, then decreased with the increase of subsidy(Shao, Deng, Qing, & Wang, 2018). Gradually, the electric vehicles recycling phase is also included in the life-cycle study regarding the economic and environmental benefits, which has been becoming much more important than before, and there is a positive spillover for both economic and environmental benefits(Qiao, Zhao, Liu, & Hao, 2019).

Therefore, in term of the moral granted advantage of energy saving and emission reduction, generally, the answer is positive either a simple scenario or the life-cycle perspective. But it also raises the questions about the environmental justice and the potential increased cost, besides, neglects the recycling mechanism of battery. Importantly, it attaches great importance to the optimization of energy structure and sources.

3.2.1.2 Trade-off among multi-influencing-factors of purchasing intention

Naturally, what are the most important element for individual's adoption of electrical vehicles? This part primarily focuses on the effect of different demographic, perceived variables on the willingness and behavior in the behavioral studies, particularly, for the trade-off among different variables, which is the repeated topic in many works based certain theories and methodologies.

(1) Subsidy

As one of the primary barriers for the adoption of electric vehicles, the subsidy is the expected solution to mitigate the high purchase price. Besides, the cost and the intrinsic essence of the product are the most important (Wang, Wang, & Hao, 2013), similarly, the constrains, such as the price and technology immaturity(Gong, Wang, & Wang, 2013), while the reference group and symbolic factor of the product are not so important as the previous two.

Therefore, what effect could the subsidy have? It reviews the stimulating policies from different countries, and analyzes the relationship between the adoption and incentives policies, indicating a positive interrelationship(Zhang, Xie, Rao, & Liang, 2014). Similarly, focusing on the ownership cost analysis of China's two-phase subsidy, it indicates that it is necessary to provide the incentives to be cost competitive compared with the conventional

ones in the first phase, while in the second phase, it gradually reduces the subsidy intensity due to the decrease of manufacture cost(Hao, Ou, Du, Wang, & Ouyang, 2014). National and regional related incentive with strong government policies, it will play an important role in jump-starting of electric vehicle penetration, and in order to prove it, Norway is descripted as the sample to illustrate the function in the practice(Zhou et al., 2015). Moreover, in term of government promotion policies, it represents typical non-economic incentives regarded as intangible cost and benefits, monetary subsidy is necessary to compensate the additional cost(Diao, Sun, Yuan, Li, & Zheng, 2016). But these works only focuses on the positive benefit and spillover of the subsidy, neglecting the potential detrimental effect for participants in the industry.

Under current scenario, the subsidy is necessary to make the electric vehicle competitive in term of the life-cycle operation cost, but it suggests that the amount of subsidy should adapt to the change of battery cost and gasoline price for the long-term(Hao, Wang, Zhou, Wang, & Ouyang, 2015). While this conclusion is based on the hypothetical condition where consumers' average trip driving distance is 20 km. Lots of researches indicate the importance of subsidy in the initial pilot period, but how much should it be? An optimal subsidy and price discount rates are developed under monopoly and duopoly mechanism(Shao, Yang, & Zhang, 2017), so it is complicated to adapt to different market structures.

Meanwhile, from a survey, it finds that the exemption of purchasing restriction and driving restriction are the most important elements for the adoption of electric vehicles, other monetary incentives, such as the discounted or free charging fee, and vehicle purchase tax exemption, have a positive effect on the acceptance, while reduced parking fees has a weaker one(Wang, Tang, & Pan, 2017). Besides, regarding consumers' view in term of the life-cycle cost, including the initial purchase cost, operation cost, fuel cost, it will increase the acceptance of electric vehicle under a rising oil price, reduction of initial purchase and the imposition of carbon tax(He, Zhang, & Pang, 2017). Undoubtedly, it demonstrates the intertwined relationship between subsidy and other monetary-and-non-monetary incentives.

Moreover, the incentive policies are the primary one affecting the three components of planned behavior theory, perceived economic benefits, environmental benefits and risks(Zhang, Bai, & Shang, 2018). But a drop of financial incentives would not cause a significant decline in the future adoption of electric vehicle given the collected data in Shenzhen(Wang, Yu, Yang, Miao, & Ye, 2017). Furthermore, the joint analysis for the subsidy and infrastructure construction of charging, indicates the endurance range is more efficient in expanding adoption of electric vehicles than the subsidy incentive (Wang, Liu, Shi, Wu, & Wang, 2018). Even further, the financial incentive policy has no significant effect on the intention for the adoption(Wang et al., 2018). Additionally, when there is no subsidy, as the expected abolishment, what will happen? A system dynamic model is predicted that it will result in a sharp decline by 42%, but the license-plate restriction, mandate policy for electric vehicles and driving restriction on conventional vehicles have positive effect on the adoption, while the exemption of parking fee, road tolls and insurance charge have little impact(Wang, Tang, Zhang, & Guo, 2019).

However, what detrimental effects would be brought by the subsidy? The problems have emerged by the policy makers, such as the local protectionism, subsidies fraud(Zhang & Bai, 2017). Subsidies substantially encourage individuals to adopt electric vehicles, but preferring to hybrid ones, instead of battery electric vehicles(Ma, Gao, & Tan, 2017). Furthermore, the

subsidy primary refer to the consumers' perspective previously, but regarding the manufacturers, the increased subsidy promotes the related optimal production quantity and expected utility, while the manufacturers prefer to a low battery recycling rate, giving rise to a potential detrimental effect to the environment(Gu, Liu, & Qing, 2017). Moreover, the government subsidy has a significant crowding effect in the firms' R&D intensity and better deploys the instrument for demand-oriented (Jiang, Zhang, Bu, & Liu, 2018).

Simultaneously, there are lots of debates on which way is better between taxes and subsidies. By building an evolutionary game model between auto manufactures and governments to study the different effect of previous two measures, auto manufacturers to produce electric vehicles are positively correlated with the upper bound of carbon taxations and negatively correlated with the ceiling of subsidies, indicating a combination of dynamic taxation and static subsidies is more effective (Liu, Huang, & Yang, 2017), while it focuses on a static subsidy, but the amount of subsidy is dynamic adapting to different scenarios overtime until the subsidy would be phased out. Meanwhile, the subsidy and environmental tax include in a game-theoretic model to maximize the social welfare under the monopoly and duopoly markets, which indicates that government should charge a higher environmental tax, while offer a lower subsidy under the duopoly market than a monopoly market(Shao, Yang, & Zhang, 2019).

No matter the positive or negative effect of subsidy on the adoption of electric vehicles, the most important is the technology improvement associated with a matured technology and reduced cost. While there are divergent technological strategies among leading electric firms in China due to the diversified and incoherent institutional logics and responses, leading to divergent technological paths(Shen, Feng, & Zhang, 2016). In order to evaluate the efficiency of the policy, the consistent fuzzy preference relations model is deployed, it consists of three dimensions, including industry development, electric vehicles popularization, R&D, and the quantitative weights are integrated with fuzzy preference, indicating that the technology R&D is the most important(Li et al., 2016). Similarly, the driving determinants are the technological innovation, market demand and government support(Wu, Yang, Hu, Wang, & Huang, 2018), which emphasizes the importance of a long-term matured technology. Where a multivariate model intergraded with a correction model to study the short-term and long-term effect on the diffusion(Ma, Fan, & Feng, 2017), obviously, there is a positive relationship between the electric vehicles market share and the monetary subsidy, tax exemption, limitation on the purchase of conventional vehicles and abolishment for the electrical vehicles' traffic restriction. More important, the technology is the bottleneck, where the effect of technological progress is greater than the financial subsidy, which imply the gradual reduction of subsidy need to fund the R&D.

The priority is building the charging station, and the current massive adopted rebate for the charging subsidy is less effective(Nie, Ghamami, Zockaie, & Xiao, 2016). Therefore, there is the research on whether the subsidy should be offered for consumers or manufacturers, while it finds that the consumer subsidy is more effective than manufacturer subsidy regarding the promoting the popularity and technological breakthrough of electric vehicles. Besides, the subsidy intensity and duration are most important for the policy effectiveness(Sun, Liu, Wang, & Yuan, 2019). Meanwhile, how to allocate the subsidy among diversified participants in the supply chain is important to incentivize the motivation, four components, government, manufacturer, a retailer and consumers, it finds that the priority should be allocated to the electric vehicle customer, it is expected to have more allocation to the manufacturer with the increase of total subsidy, but there is a ceiling and the subsidy may not be important in the

later period in the promotion of electric vehicles(Gu, Ieromonachou, & Zhou, 2019).

Accordingly, for the effect of subsidy, it has positive effect generally, but with different scenarios and extents, due to the diversified combination of contexts in the data collection, which implies that it cannot simply read the research conclusions, but should pay more attention to the research context and combination of multi-variables. Simultaneously, the research is also attached to the possible detrimental effect, such as the local protectionism, subsidy fraud and crowding effect.

(2) Intertwined multiple variables

Normally, the majority works focus on the trade-off among different variables, and the corresponding effect or relationship with the adoption of electrical vehicles. While it has its own problems in the specific study in term of data collection, sample biases, endogeneity and the validity of conclusions.

Given the relevant constrains and numerical experiment, subsidies, loss aversion, performance of both electric vehicle and conventional ones are significant factors in the expected utilities(Zhang, 2014), which is similar to others works, while it enriches and suggests that the potential decision bias in the behavioral model. Furthermore, different models are deployed to forecast the demand, the price of electric vehicle, fossil oil, charging station, taxation policies are important for the forecast and analyze the industrial development(Z. Peng, Yu, Wang, & Yang, 2015). The variables influence the individuals' intentions towards the adoption of electric vehicle, based on the data collection in Macau, which demonstrates the environmental concerns and perception of environmental policy are antecedent factors, then includes the economic benefits, such as the long-term fuel saving, high energy efficiency and cheap electricity(Lai, Liu, Sun, Zhang, & Xu, 2015). These studies on the trade-off of intertwined multiple variables, based on certain theories and framework.

One of the samples is the planned behavior theory, which has three components, subject norms, perceived controlled, and social norm. For the study of electric vehicles' adoption, it has diversified combinations according to its own target and possibility. The numerous hurdles and barriers are commonly encountered worldwide, such as the insufficient charging infrastructures, high initial purchase price and battery cost, short range, unreliable batteries, deficient subsidy policies, local protectionism, embarrassed market and unmatched charging infrastructure(Zhang, Rao, Xie, & Liang, 2014), range anxiety, resale anxiety(Lim et al., 2014), safety, reliability and range per charge rank top three barriers(She, Sun, Ma, & Xie, 2017), the relationship among past experience, perceived return and risk, adopting intention(Li, Long, Chen, & Geng, 2017), driving experience, recharging accessibility, resistibility to emotion, the perceived range anxiety(Yuan et al., 2018). What relationship and trade-off do they have among different variables? Which has detailed presentation in the framework of data collection, regarding one of the guidelines and theories deployed by many studies.

Moreover, in term of manufacturer, the government penalties and subsidies, consumer environmental awareness have particular effect on its decision towards new-energy vehicles(Wang, Fan, Zhao, & Wu, 2015). While the majority studies fall on the consumers-oriented, for example, the consumer-oriented policies promote the diffusion of electric vehicle by testing the deployment of green innovation and detailed city-level policies(Zhang, Xu, & Zhang, 2016). Besides, the same to the consumers-oriented regarding the implication of the initial purchase cost, it is reasonable that the time discounting rate affects consumers choice,

particular for the comparison between a high initial acquisition cost but a low ownership cost and a low initial cost but with a high ownership cost, which finds an irrational purchase behavior and stronger bias to choose the higher total cost with a lower initial cost but higher operation cost(Wu, Shang, Tian, & Wang, 2016). Besides, the variables, such as the government support, cost of vehicles, utility of vehicles, cost of use and stability, deploy in a stochastic game, naturally, where the increasing government subsidy and reduced cost will increase the purchasing intention of electric vehicles(Guan, Zhang, Liu, Tan, & Wu, 2016), similar to its conclusion in this work(Hao, Dong, Deng, Li, & Ma, 2016).

Additionally, deploying a multiple linear regression method to study the incentive measures and social-demographic data, it finds that chargers' density, license fee exemption, no driving restriction are the most important factors for the adoption of electric vehicles(Wang, Pan, & Zheng, 2017). Naturally, individuals with higher income and educational background, owned private cars, familiar with electric vehicles and knowing the potential environmental benefits have a higher extent of acceptance(Lin & Tan, 2017). Similarly, the technological level, policies and regulation, consumers' acceptance and expectation, price models, market structure and completion are critical factors influencing the diffusion of electric vehicles(Liu, You, Xue, & Luan, 2017). Furthermore, it also focuses on the effect of Chinese culture value on the intention of electric vehicle, including the human nature relationship, face consciousness, long-term orientation, risk attitude, implying the promotion efforts should be adapted to different cultural elements(Qian & Yin, 2017). Besides, what role of the electric vehicles' knowledge is it? It is positively related with the perceived usefulness, intention and attitude to the purchase, while it is negatively related with the perceived risk(Wang et al., 2018). An online survey in China regarding the role of environmental concern in the acceptance of autonomous electric vehicles, which finds that the green perceived usefulness, perceived ease of use and environmental concern have a positive relationship with the intention, environmental concern poses an indirect effect on the intention(Wu, Liao, Wang, & Chen, 2019).

However, there are potential problems for the study of intertwined multiple variables, such as the endogeneity, biased samples only collected from the first-tier cities, only stated preference, and the challenge on the validity.

The factors, such as the trip modes daily, transportation expenditure, driving range, gender and age have effect on the willingness of electric vehicle(Wang & Yan, 2015), but it only deploys the stated preference, the extent of validity is questioned. Besides, it conducts a multi-scale model to measure the customer perceived value for the electric vehicle, and finds out the contributing factor for the evaluation of electric vehicle value(Miao, Xu, Zhang, & Jiang, 2014), but it is only a trial and laboratory method, there is no further discussion on the data problem and potential disparity between the laboratory and actual behaviors. Similarly, the problem for the data collection, previous samples are always collected in the first-tier cities, such as Beijing, Shanghai, Shenzhen and Guangzhou, what difference is there for the samples from second and third tier cities? In which indicates that there is a higher price sensitivity for the consumers from lower-tier cities, including the purchasing price and monetary subsidies. Meanwhile, they attach more psychological effects, such as the symbols of vehicle ownership and normative-face effect(Huang & Qian, 2018).

Additionally, when there is an external factor imposed on individuals' behavior, such as the license-plate-controlled policy, does it have a dominant position? Samples in Beijing indicate that the license plate lottery and subsidy policies are the most influential factors in the

promoting of electric vehicles, there are other influential factors, such as annual household income, vehicle performance, travel distance, number of family cars owned(negative)(Xiang Zhang, Bai, & Zhong, 2018). But the problem for this study is also only based on the stated preference, which is not accessing to the disparity between the stated and revealed preference, notwithstanding the external element has been considered in the study. Meanwhile, from a macro-perspective, the panel data from different countries is used to study the impact of multi-factors, demonstrating that the renewable electricity generation, education level, charging stations and population density are positive on the demand, the gasoline price affect the battery electric vehicle more than the hybrid ones(Li, Chen, & Wang, 2017). While the panel data is from 14 countries and there would be an endogeneity among the independent variables. Moreover, in the global comparison and assessment of incentive policies on the promotion of electric vehicles, it finds that the chargers' density, fuel price and road incentives are significantly positive elements associated with the countries' market share, where the samples list from 30 nations(Wang, Tang, & Pan, 2019).

Considering all the works within the studies of trade-off among different variables, it has contributed to the established relationship among the variables that participants care mostly, while it is only the relationship, instead of the causality effect on the decision mechanisms. As the limitation of samples selection, data collection, it also provides a better guidance for the further works, avoiding the possible demerits.

3.2.1.3 Recharging and battery

The recharging, charging models, location, charging cost and price are the focus in this field. The charging facility is not only about the infrastructure, but also the operation mechanism, such as shared, leasing or personal owned mechanism. The key element is the price of charging for the electric vehicles, ensuring the profit of operator and reducing consumers expenditure compared to the conventional vehicle(Li & Ouyang, 2011). Besides, the charging inconvenience, short battery range, purchase cost and psychological factors are interrelated(Tan et al., 2014). Furthermore, in the large demonstration of pilot cities, a model with 5 major factors and 13 observation indicators is developed to assess the city readiness for the adoption of electric vehicle, including the government investment and polices, charging infrastructure, consumer awareness and education, environmental benefits, it has different ranking for a set of cities, indicating the improving charging network, reasonable charging and service price, raising consumer awareness as the most important issues (Wang & Liu, 2015). Therefore, the construction of public charging infrastructure is important for the penetration of infant electric vehicle. But what mechanism could be deployed to tackle the hindrance of charging? Certain researches are proposed, such as the battery swapping stations, battery leasing. Meanwhile, what is the optimal spatial sites for the design of swapping station, battery leasing and charging piles? What relationship do they have among different participants? Is the private-public partnership effective as the mechanism of building charging station? What changes would be brought as the evolution of charging technology?

(1) Battery swapping stations

Battery swapping station, refers to an energy refueling station where electric vehicles with depleted batteries can swap for the fully-charged ones, then the swapped depleted batteries can be recharged. Due to the limited driving range for a single charging and hours cost to be recharged, then the swapping station, exchanging for recharged ones in the middle of long trips, is proposed, and the success hinges on a cost-effective infrastructure network by the

service provider. While what is the best the scenario integrated with the battery swapping station? A integration of charging posts, fast charging stations and battery swap stations is the best remedy, meanwhile, at home charging parking places, the charging posts will take a major role in the charging network, furthermore, in term of the distance, a service radius of 2 KM is ideal for the deployment of fast charging station or swapping station, and charging time management is accommodated to the consumers charging habits optimizing the charging load(Liu, 2012).

Meanwhile, battery swapping stations can be integrated in the demand side management, but what method could be deployed to plan the capacity and location? With the rule of 'first-in-first-out' in the demand side management for the charging power, there is an optimal configuration model where the net profit is maximized and operating cost is minimized. Furthermore, the variables, such as rated power, numbers of batteries, contract pricing, for the optimal location plan, a model in the battery swapping station is built with the objective of minimizing network loss(Liu, Niu, Xu, & Li, 2016). In order to find the optimal charging scheme for the battery swapping station with target of maximizing battery stock level and minimizing the charging damage, it compares different algorithm, such as genetic algorithm, deferential evolution algorithm, in term of the reduction of computational times(Wu, Pang, Choy, & Lam, 2017).

But there are new problems when the swapping station is proposed to tackle the barriers of long charging time. The battery standardization is important for the optimization of deploying battery-swapping infrastructure(Mak, Rong, & Shen, 2013). Simultaneously, for the swap station location, the economic and environmental analysis are integrated with sensitivity analysis to find the optimization location routing(Yang & Sun, 2015). The consideration of users' behavior, charging process and controlled capacity for the queues problem in the application of battery swapping(Xie, Zhu, & Xuan, 2018).

A comprehensive performance evaluation of battery swapping station is crucial after the successful deployment of the planning of swapping-charging related infrastructures(Tan, Sun, Wu, & Tsang, 2017). Similarly, the optimal network for the integration of gasoline station and battery swapping station(Xu, Meng, & Liu, 2017), the battery-swapping model under the Pareto solutions using the fuzzy satisfaction evaluation decision technique(Zhang, Zhang, Xu, Zhou, & Zhang, 2017), are deployed to evaluate the performance. But in term of cost-oriented optimal design for the samples of taxi fleet, the cost of electric vehicle for the taxi fleet is lower than the model of swapping model, and the cost of hybrid electric vehicle is lower than the battery electric vehicles in the charging model(Liu, Wang, & Dong, 2018). Therefore, under the target of minimal total cost for the battery swapping station, including the station construction cost, battery inventory and recharging cost, an integer programming model is used to adapt to the two uncertainties of flow demand and electricity prices, which finds the delay of recharging some batteries is beneficial to stations(Sun, Yang, & Yang, 2019). Accordingly, the battery swapping station, brings its own advantages to tackle the possible hindrance of electrical vehicles, the subsequent problems have emerged, such as the standardization, optimal design and the performance evaluation under multiple targets.

(2) Battery leasing

What could be the necessary supporting policy for the development of electric vehicles? Undoubtedly, the battery is a primary component for the foreseen challenge, and the possible solution is the battery leasing(Li & Ouyang, 2011). For the adoption barriers of electric vehicles,

there are two primary anxieties, range and resale anxieties for consumers, so based on the barriers, a business model to tackle them is important, such as the lease of battery, instead of purchase them(Lim et al., 2014). Moreover, it also compares merits and demerits between the lease and sale of electric vehicles under different scenarios and psychological status, deploying a full life-cycle in term of cost and benefit and providing a guidance for manufacturers and servicers(Miao et al., 2016). But the penetration of electric vehicle is subject to the capacity of charging infrastructure, and the charging piles is mostly sensitive to the initial construction cost(Zhu et al., 2017).

It is not only about the research on the battery leasing, some researches also focus on the leasing of electric vehicles, while it demonstrates that the leasing does not increase the adoption of electric vehicles(Liao, Molin, Timmermans, & van Wee, 2018). Because the profit prospect of battery leasing is still uncertain, and how to achieve the 'win-win' between the operators and consumers, where the battery cost, gasoline and electricity price and vehicle weight have impact on the rent and the battery cost plays a dominant role. Meanwhile, it calculates three thresholds required for the 'win-win' battery leasing.

Both the battery leasing and swapping station, the common target is to reduce the extent of barriers for the adoption of electric vehicles, and both of them are mechanism intertwining and sharing the same target among different participants, but what is the best solution for the building of charging station, either swapping or leasing stations? As an emerging industry, it develops a conceptual model of agent-based system for the business ecosystem evolution, to find out how it develops under different policies scenarios(Lu, Rong, You, & Shi, 2014), and the construction acceleration of supporting facilities and infrastructures is necessary to accommodate the changing demand(Yuan, Liu, & Zuo, 2015). Specifically, a model of public-private partnership (PPP) is an effective supply path for the charging infrastructure to ease the burden of local finance and reduce the operation and construction risk(Yang, Long, Li, & Ur, 2016). Besides, there is an interaction between enterprises and governments in the value chain of electric vehicle, fostering a distinct government-enterprise cooperation with the reduction of government financial pressure and enterprise's incentive for the innovation(Li, Zhan, de Jong, & Lukszo, 2016). Charging price is very important for the financial validity of private-public partnership, which assures the participants with a minimum anticipated return, so the operating cost, charging volume and price are important for the sustainability of this PPP(Zhang, Zhao, Xin, Chai, & Wang, 2018).

(3) Optimal spatial distribution of charging sites

The optimal spatial location design is an important issue in the transport planning and adoption of electric vehicle, which is highly dependent on the local settings and the convenience access to locations. But the design of optimal charging sites is a complicated problem integrated with multi-constrains, therefore, different theoretical algorithm methodologies are deployed to find the optimal design of spatial distribution, which is also applicable to the previous topics of battery swapping and leasing stations. This part will elaborate how and what factors affect the optimal design and what sub-targets it has.

Initially, what and how do they affect the optimization spatial distribution of charging sites? This is a complicated question, not only includes the detailed scenarios and contexts, but also the aggregate supply and demand, consumers' charging behaviors.

Multi-constrains and different methodologies are intertwined for the optimal spatial design. A

multi agent-based simulation framework is deployed to study the spatial distribution at local residential level, and discover a hot zone for the plug-in hybrid vehicle with different charging strategies(Cui, Kim, Liu, Kao, & Bhaduri, 2012). Specifically, planning locations of public charging stations, it incorporates the local constraints of supply and demand, meanwhile, it compares different models for the optimization process(He, Kuo, & Wu, 2016). There are flaws and inaccurate measures in the charging site selection by neglecting the mutual relationship among different variables, so a preference ranking method is proposed for the decision making and describe the fuzziness terms in the decision set(Wu, Yang, Zhang, Chen, & Wang, 2016), but this one is still contingent on the subjective perception by ranking the importance among diversified elements. As the limited driving distance and battery renewal, the challenge to find the shortest path is important to meet the demand daily, so it develops a label-correcting algorithm with state space relaxation to find the optimal path(Huang & Li, 2016). Similarly, based on the empirical study of the real trip distance, it finds that the driving distances are 44.6 KM and 51.4KM for the weekdays and weekend respectively, and the estimated acceptance rate for electric vehicle is very sensitive to the predetermined inconvenience threshold level, the abundant public transport alternatives and traffic management reduce the inconvenience of adoption of electric vehicles(He et al., 2016).

Based on the fuzzy algorithm to rank the alternative charging site, it provides a feasible and easy-to-use decision framework(Wu, Xie, Xu, & Li, 2017). A reliability-based network equilibrium framework integrating with the travel time and monetary expense is explored, and it finds that the difference of travelers' risk attitude affect the route choice(Zhang, Yao, & Yang, 2017). It investigates the charging model with the revealed preference data from battery electric vehicle users, there are three alternatives, normal charging at home, normal charging at public, fast charging at public, indicating that battery capacity, initial state of charging, and past fast charging events are the primary predictors, importantly, it provides new insights into the peak-load shifting and deployment density of public charging stations (Xu, Meng, Liu, & Yamamoto, 2017).

Simultaneously, what factors are considered in the optimization of spatial design? Due to the penetration of electric vehicles, the potential problems, such as overloading, increased voltage fluctuation and uncertain power quality, appear in the charging system, a centralized charging strategy is proposed to balance the benefit of the grid and electric vehicle users, spatial and temporal utilization simultaneously(Yu, Zhao, Chen, & Zhang, 2015). The influence factors for the charging station of electric vehicles, area attribute and geographical environment, are the key factors, while the construction cost and operation and maintenance cost are the objective factors(Wu & Niu, 2017). While in its analysis framework, it consists of the charging demand (area attribute, purchase intention), operating economy (construction cost, maintenance cost), traffic convenience (lane situation, traffic flow). With the substantial penetration of electric vehicle, it will increase the electricity load and load uncertainty, so a charging load model supply company purchase portfolio optimization are proposed, which shows the load risk is positive associated with the a higher market penetration of electric vehicle, and the solution to hedge the risk is to adjust the optimal portfolio allocation to diversified electricity markets(Li & Ren, 2017). A weighted directed graph is deployed integrating with the time and distance factors treated as weights in the transportation network, to minimize the driving time and charging expenses(Liu, Yin, Yuan, & Niu, 2018). Distribution of charging load in the residential area(Wang et al., 2018). Charging frequency, type of charging facility are derived in the prediction of charging deployment in spatial sites(Wang, Zhao, Meng, Ong, & Lee, 2019). The

stochastic demands with an optimal location-routing problem in the vehicle transportation (Zhang, Chen, & Zhang, 2019), The network of charging facility has a positive effect on the popularization of electric vehicles, particularly, under the integration with the monetary incentives (Tian, Hua, & Cheng, 2019). By the maximal spatial and coverage location, a two-step approach is proposed under the stochastic process, which finds the workplace population density, travel flows, transport, retail and commercial sites are positively significant with the demand of charging demand(Dong, Ma, Wei, & Haycox, 2019).

Moreover, the importance of charging behaviors is attached to the optimization spatial distribution. After a relative massive adoption of NEVs, what relationship could have between the customers' driving habit and the lifetime of battery? It is important to optimize the integration between the personal driving habit and lifetime of battery(Wu, Wan, & Zhao, 2012). How could charging stations build as the public infrastructure to maximize the overall travel electrification and avoid the waste of public resource? it is important for the adoption of electric vehicle, while it is a challenge due to the lack of realistic vehicle travel and charging data. Through the mobile internet, the charging device, location data and power allocation can reach the cloud, providing a reliable basis for the public-decision and service, so a cloud computing is proposed to tackle the concern of real-time and cost(Yan, 2016). Besides, in order to study the charging trajectory, a larger scale of 11,880 electric vehicle taxi in Beijing as the sample to study the travel patterns, although it is not the real public travel and charging behavior, which is beneficial to analyze the private vehicle charging trajectory and improve the understanding of charging demand. From this large-scale data, it finds that the collective parking hotspot is a good indicator for where has charging demand, and the distribution of charging station based on the travel patterns is a better parameter to optimize and improve the electrification rate and reduce the gasoline consumption, but it will increase the emission under current grid mix. Besides, in term of charging timing, the power demand for public taxi charging has peak load around noon, which is overlapping with Beijing's summer peak power(Cai, Jia, Chiu, Hu, & Xu, 2014). Additionally, regarding the charging behavior, what charging behaviors do consumers have for the hybrid electric vehicles with 24km electric range? There are four charging models, no charging, charging at the cheapest time, charging at the other times, charging immediately after arriving at home, which indicates the charging price affects all users preferring to charging at the cheapest time, meanwhile, users like to charge it immediately when it is the day time or the cheapest charging price(Sun, Yamamoto, Takahashi, & Morikawa, 2018). Accordingly, this work provides a good indication for the charging behaviors, in term of charging places, times and decision model, etc., although it is a taxis fleet of electric vehicle, instead of public consumers.

What sub-targets does it have in the process of optimization? The process of optimization is under multi-constrains, but also having multiple diversified sub-targets, such as the minimized network loss and social cost, cost-effective. Charging management schemes for drivers and government fall on the cost-effective and environment-friend perspectives(Kontou, Yin, & Ge, 2017). Similarly, there is a target of minimizing the public cost within a given budget and multi-types of battery and charging facilities(Liu & Wang, 2017). The optimal design of location of charging station and charging capacity, is necessary to meet the urban charging plan with reasonable cost(Zhu et al., 2017). Subject to a range limitation, the optimal deployment of charging locations is similar to a network design with multi-targets, minimized generalized cost and time(Zheng, He, Li, & Peeta, 2017). Regarding the recharging locations design and selection, the short-term location might be inefficient design for the long-term, and the

systematical strategy should be designed under the condition of subsidy policy and recharging infrastructure location with a lower budget(Li, Zhang, & Wu, 2018). Optimizing the best route choices for the travel and charging of electric vehicles have multiple targets, such as minimized travel times, energy consumption and charging cost(Wang, Bi, Guan, & Zhao, 2018). A novel reliable path finding algorithm for the stochastic road network is proposed, but with the target of maximizing the on-time arrival reliability and battery energy efficiency(Shen, Shao, Wu, Lam, & Zhu, 2019). By considering an optimal driving route of electric vehicles, an optimization model is constructed to fulfil the target of minimizing total transportation cost and charging cost, particularly, for the slow charging station(Deng, Yu, Li, Gong, & Chang, 2019).

Therefore, in term of the spatial optimization of charging sites, it is a systematic framework integrating with multi-constrains under diversified sub-targets, which also provides the meaningful guidance for the construction of battery swapping and leasing stations, and the design of vehicles sharing mechanism.

(4) New charging technology

The technology evolution will determine the organization formats and operation mechanism. Typically, the charging technology is one of them that will reshape the industry structure and consumers' behaviors. Given the rapid development of charging-while-driving technology, an new equilibrium model attempts to optimize the travel network and battery charging plan(Chen, He, & Yin, 2016). As the existence of charging barriers, such as the shortened range, insufficient charging facilities and extended recharging time, hinder the wide adoption of electric vehicles, but a wireless power transfer technology can provide dynamic recharging when vehicles are moving on the road(Liu & Wang, 2017). As the emerging of new charging model, it also discusses the challenges and opportunity of wireless power transfer for the charging of electric vehicles(Zhang, Zhang, Deng, Wei, & Wang, 2018), safety evaluation of the wireless charging lane(Li, Wang, Xing, Fan, & Wang, 2018).

Naturally, the new charging technology brings challenges to the existing beneficiaries. Firstly, it analyses five business models of battery swapping and leasing service, benefits for battery manufacturers, gasoline enterprises, power companies, where the oil companies are the least competitive, while battery one has the highest competitive, and the operator's profit will increase with an increase of vehicle weight, gasoline price and quantity of electric vehicles (Zhang & Rao, 2016). Besides, it also challenges the existing incentive mechanism, where the interrelation among the battery technology trend, dual-credit policy and market density will be changed(Zhao, Chen, Hao, Wang, & Liu, 2018).

3.2.1.4 New proposed sustainable mechanisms

This part focuses on mechanism and implication behind different policies, and the policies specifically refer to the possible solutions for the barriers on the adoption of electric vehicle. Accordingly, the conception of sharing vehicles and personal carbon trading scheme are proposed and study the feasibility in practice.

(1) Vehicles Sharing

Due to the existing barriers for the electric vehicles, a large-scale one-way sharing system for the electric vehicle in metropolitan area is proposed, determining the optimal sharing station location and corresponding fleet sizes to minimize the comprehensive system cost. The users do not own the vehicles property, who only purchase the utilization right over a specific

timetable. Substantially, it reduces the barriers and hindrances on the adoption of electric vehicles, such as the high initial purchase cost, range anxiety, battery charging and maintenance of all the potential problems for all components. Importantly, it is a complicated optimal and dynamic system, including the large number of individual users, stochastic generated trips, charging time required in the station(Li, Ma, Cui, Ghiasi, & Zhou, 2016). The sharing vehicles, particularly in the free-floating car-sharing, bridges the resource efficiency of public transit and flexibility of personal transportation, addressing numbers of planning questions in the optimization of sharing electric vehicles(He, Mak, Rong, & Shen, 2017).

In a one-way electric vehicle car-sharing mechanism, there is a practical problem of EVs imbalance regarding the spatial time-dependent reservation at the car-sharing stations, a space-time network representation is used to satisfy the dynamical rebalance and relocation of reservation, battery charging with limited capacity and distance(Zhao et al., 2018). Furthermore, the maximization of profit for the one-way car-sharing, is determined by the fleet size, trip price, vehicles' relocation strategy(Xu, Meng, & Liu, 2018). Meanwhile, for the sharing of electric vehicles, the perceived behavioral control is the primary element with the positive relationship of electric vehicles' sharing(Zhang, Guo, Yao, et al., 2018).

The car-sharing system for the autonomous connected electric vehicles, improves the safety, mobility and environmental friendliness in the transportation system, but it is constrained by certain inherent shortages, such as the limited range, long charging time and high-cost for the relocation, while a novel hybrid parking mechanism is proposed to meet the users flexibility and system management efficiency, importantly, the integrated system will substantially decrease the emission(Miao, Jia, Li, & Qiu, 2019).

Therefore, under the adoption hindrances, transportation transformation and the technological evolution, the mechanism of car-sharing is proposed and implemented. Meanwhile, with the gradual maturation of autonomous driving, it can be fully connected with the electrical vehicles in the car-sharing station.

(2) Carbon trading

Lots of studies focus on the incentives from the government to promote the adoption of electric vehicles, such as the monetary subsidies for the purchasing, charging, and managerial preferential policies, but neglecting the potential mechanism for the incentives from consumers themselves. A personal carbon trading system attempts to derive the equilibrium price for carbon allowance, integrating with the gasoline price, vehicle price, interest rate and vehicle miles traveled, when the market price of carbon allowance rises beyond a critical value, consumers have incentive to adopt the electric vehicle contingent on the reduction of personal carbon emission(Fan, He, & Wu, 2016). Similar conclusion indicates that the emission trading scheme promotes the adoption of electric vehicle(Li, Jia, & Zhang, 2017). Meanwhile, a choice experiment is conducted to demonstrate that the personal carbon trading can effectively change the decision to adopt the electric vehicles, specifically, which is more effective than the free parking and elimination of road tolls and vehicle tax, but less effective than government subsides(Li et al., 2018).

But the emerging carbon market, low carbon price and participating in the carbon trading market cannot support the rapid growth rate(Liu & Xiao, 2018). There are different conclusions on the spillover effect of carbon trading. From theoretical perspective, it is reasonable, but it is unpractical to calculate the personal emission precisely, but it provides an implication to

calculate the carbon emission for enterprises or consumers in the industry, setting a specific amount of quota for electric vehicle enterprises, and purchase market credit allowance to offset the additional emission.

(3) Dual-credit policy

The dual-credit policy, refers to the average fuel consumption of passenger cars corporate and new energy vehicles credit regulation, which sets a lowest percentage requirement of new energy vehicles in the markets, then offsets the additional emission that higher than the cap amount. With the phasing down of the subsidies, the credit regulation of evaluating the total emission for the auto-manufacturers is launched, to promote the penetration of electric vehicles continuously, which will pose a dramatic impact on the electric vehicles' development. Which is regarded as the mechanism of supply management targeting on the producers, instead of the sole incentive policies deployed previously for consumers. Previously, the subsidy has boosted the growth of electric vehicles and cut vehicles emission, but it would cause the financial burden for the government, in order to incentivize the transformation of firms, the dual-credit policy is introduced, namely, the new-energy vehicle credit program and corporate average fuel consumption regulation.

There is an additional credit for automakers' production of extremely low emission vehicles(Wang, Zhao, Liu, & Hao, 2018), which is compulsory for the corporates and providing incentive from the supply perspective in the market, instead of only demand perspective from consumers. Where the corporate average fuel consumption rules may increase the adoption of more hybrid vehicles, while dual-credit may increase the pure battery electric vehicles(Ou et al., 2018). Simultaneously, the dual-credit policy also stipulates the trading and transferring of the emission credits between different manufacturers in the trading market, in which the auto manufacturers who have deficiency of electric vehicles credits, must purchase the credits from other firms or market to offset the deficit., which can significantly increase the adoption of new energy vehicles comparing to a simple green subsidy(Li et al., 2018). Accordingly, the dual-credit policy is regarded as a combination of carrot and stick, setting an average fuel consumption level to award those firms with better technology and less fuel consumption, but penalize firms who cannot fulfill the energy standard, which exerts the motivation for both advanced and backward firms, instead of a simple green-subsidy.

Meanwhile, when a vehicle manufacturer produces both the electric and conventional vehicles, what is the optimal strategy for the manufacturer under the certain subsidy? There is a threshold condition for conventional producers to enter the electric markets, relating to internal and external attributes, an increase of the production cost of conventional vehicles, consumers' acceptance and monetary incentives will lower the threshold to enter the electric vehicles and an intention to have a transition, achieving the triple win, inherent economic, environmental and social benefits (Zheng et al., 2018). Additionally, the vehicle credit regulation scheme is expected to have a dramatic impact on the manufacturers in the electric vehicle market, but what impact would be for the technological trends of battery? With the development of energy-saving technology, the popularity will be increased, which will reduce the cost of battery and lead to a higher credit, but the regulation will loss the role as a benchmark to incentivize the manufacturers(Zhao, Chen, Hao, Wang, & Liu, 2019), so the benchmark in the dual-credit policy should be updated adapting to the technological progress.

Therefore, in term of the new proposed mechanism for the sustainable development of electric vehicles, it covers the vehicles sharing, carbon trading and dual-credit policy, which

coordinates the effect of technological evolution, personal and cooperate carbon trading system and a compulsory credit incentive system for producers.

3.2.2 Others countries' studies on the adoption of electrical vehicles

A comprehensive analysis is conducted to figure out the studies in other countries, including the environmental hazards and benefits, technology simulation and forecast, trade-off among different variables and the recharging problems. Comparing to China's studies, it has similar sub-topics, while the researches on the potential environmental benefits, possible transition from conventional one to electric vehicles and debate on different technological roadmaps are earlier than China. But after the stage of a relative-massive adoption, China has more works on the optimization of systematic mechanism integrating consumers with producers, government, charging providers.

(1) Environmental hazards and benefits

In response to the energy crisis and oil dependency in the 1970's, there was a surge of interest in the electric vehicle for USA, and a potential benefit of 'zero emission' has been discovered as the legislation of Clean Air Act[26]. In the earlier period, the researches primarily focus on the potential benefit of the emerging industry, environmental effect, the forecasting of technology evolution. For example, The benefit of reducing the emission and energy consumption is dependent on the type of energy used in the power plant, while it is certain that the traffic noise will be reduced by 13% as the 100% electrification(Hamilton, Morecraft, & Carriere, 1981). While the research indicates that there is a substantial greater transformation-efficiency in the generation of electricity for the electric vehicle (Hamilton, 1980), however, which is not consistent with the conclusion that the electric vehicle is not energy conservative, as the coal is the prime energy source in the electricity generation(Agarwal, 1982). But after that, it finds the incentive to evaluate the environmental effect for the specific project is absent, and a completed framework for the environmental cost of electric vehicles is necessary, which attaches much attention to the environmental hazards of spatial variation(Roque, 1995).

After the adoption of hybrid electric vehicle in the market, it is necessary to evaluate the energy performance, demonstrating the lowering energy consumption between 1.2% and 60% compared to the similar conventional vehicle(Coelho & Luzia, 2010). It has attached great importance on a common evaluation mechanism of environmental benefits, and life-cycle perspective is proposed.

Accordingly, in the earlier stage, in term of the energy saving and emission reduction, it has different conclusions, as the fact that it does not have a common evaluation mechanism, gradually, with the introduction of life-cycle perspective, which grants a common basis for the assessment, particularly, with the continuously clear refinement of the component in the life-cycle perspective.

(2) Technology simulation and forecast

The evolution of technology is important for the development of electric vehicles, and the technology immaturity is the primary hindrance for the adoption of the emerging vehicles. Contingent on the Monte Carlo simulation in 1987, it indicates that the battery life is limited to 600 charging-times, and the maximum range for the new battery is 80 miles then decreases

[26] The official link for the USA's clean air act: https://www.epa.gov/clean-air-act-overview

to 48 miles at the end of battery lifetime, besides, based on the requirement of the least used vehicles, it could meet almost all the tours (92-96%) in the daily life(Horowitz & Hummon, 1987). There is also a skeptic on the electric vehicle, as no electric vehicle comparison to conventional internal combustion one that has been produced in a mass production (Kreith, Norton, & Potestio, 1995).

In the earlier period, it focuses on the examination of roadmap for the support of electric vehicle from the federal, state and local policies(Slifko & Rigby, 1995). The technology S-curve is deployed to forecast the technological change for the electrical vehicles industry(McGrath, 1998), which focus on the technology evolution and forecast in the future.

Particularly, the state of California is a pioneer in the field of electric vehicles as a response to the air problem, which is also regarded as the sample to simulate the effect and forecast on a specific city. It deploys the conjoint analysis to forecast the market for electric vehicle in California(Segal, 1995). The emerging electric vehicles would provide a new growth for California as the crisis of deindustrialization, and it emphasizes the importance of government policies(Scott, 1995), and the employment shifting from the conventional to electric vehicles(Wolff, Rigby, Gauthier, & Cenzatti, 1995). Regarding the example of California's electric vehicle program, government has a special role in the shaping of new technologies, and the civil values within the electric vehicle technology(Brown, 2001).

(3) Elements affect the adoption of NEVs and trade-off among different elements

Gradually, researches have focused on the factors affecting the adoption of electric vehicles after a small-scale pilot, such as the trade-off among different variables, but having different variable combinations with different theories, such as household trade-off among value, operating cost and size of cars(Beggs & Cardell, 1980), the range, speed, recharging time, cost or delay of the battery(Chéron & Zins, 1997). Moreover, the most influential factors in discouraging the purchase of electric vehicles, such as the range, maximum speed, cost of the battery and recharging time, have been conducted to assess its relative importance. While it finds that the primary concern is the possible dead battery with the implication of limited range or speed(Chéron & Zins, 1997). Besides, it elaborates what challenges of uncertainty and cooperation among auto-makers-supplier with multilateral mechanisms and motives in Japan, and the motors are the most problematic point for the collaboration as it is regarded as a core technology in the whole industry(Patchell, 1999). Undoubtedly, the non-economic forces and elements would distort the rational competition behavior regarding the emerging technologies and trajectories(McGrath, 1999).

Secondly, what effect do the subsidy and incentives have on the adoption of electric vehicles? The electric vehicle is considered profitable in terms of the external cost comparing to the conventional vehicles even at lower fuel cost(Mousazadeh et al., 2009). But in practical incentive, the subsidy and tax preferential policy are common choice for different countries. How would the subsidy and tax credit offer to the consumers? It indicates that there is a higher social benefits when the tax credits are offered based on the consumer income and location of purchase(Skerlos & Winebrake, 2010). Simultaneously, the exemption of congestion tax is a positive element for the adoption of NEVs(Whitehead et al., 2014), meanwhile, the elements, such as the distance from home to CBD and the commuting facility across it, indicate the negative and positive respectively.

Thirdly, what effect does the range have on the adoption of electric vehicles? A sociological

analysis on pioneer users for the driving of electric vehicles, the driving range is not a really perceived problem for individuals with a fixed mobility(Pierre, Jemelin, & Louvet, 2011), The range of electric vehicles has long been considered as a primary barrier in the adoption of NEVs, but to what extent does the range affect individuals' decision? But it only indicates that the perceived range barriers can overcome with the assistance of psychological intervention, such as training, information and interface design, accordingly, a stable and reliable range maybe more important than an enhancing maximal range regarding the psychological perspective(Franke, Neumann, Bühler, Cocron, & Krems, 2012). Meanwhile, due to absence of real data for the driving and charging, an experiment is utilized based on the 4-6 weeks driving trial and collect the data before and after the trial, it quantitatively measures the driving and recharging behaviors, more importantly, indicating the gap between the lay and expect understanding in terms of the electric technology and personal motivation(Caperello & Kurani, 2012).

(4) Recharging

It is primary on the charging behavior under different scenarios and constrains. In term of time and places, such as home, workplace and public areas, what effect will the diversified charging behavior have on the electricity demand and energy use? The charging is important for the electricity grid under the constrains and potential impact, there are both short-term and long-term benefits for providing the incentive for the off-peak recharging of the existing transmission capacity(Mullan, Harries, Bräunl, & Whitely, 2011). It focuses on the optimization of electricity generation and transmission. The charging imposes a modest pressure on the electricity load, and enabling charging in public areas other than home increases the daily electric energy use(Weiller, 2011). There is a potential economic benefit of using vehicle battery to store grid electricity generated at the off-peak time, but it demonstrates that these potential economic benefits do not provide sufficient incentive to the vehicles owner to use the battery pack for the electricity storage(Peterson, Whitacre, & Apt, 2010). The additional cost reduces the incentive to the hybrid consumers for the off-peak charging(Davis & Bradley, 2012).

The simulation of charging and gasoline consumption for the hybrid vehicles is used to determine the timing and quantity of electricity and gasoline consumption, where the scenarios examine the effect of charging location, charging time, charging rate and battery size, integrating with the impact of household characteristics on the consumption patterns, which indicates that a compact vehicle with a about 68 KM electric range travels on battery electricity between 62%-75%, and is also highly sensitive to age(Kelly, MacDonald, & Keoleian, 2012). After the gradual transition for the electric vehicle, the importance of the global supply chain of battery raw material is attached, and the resources reserves, supply and demand, recycling and the geopolitical environment impact the supply chain(Egbue & Long, 2012).

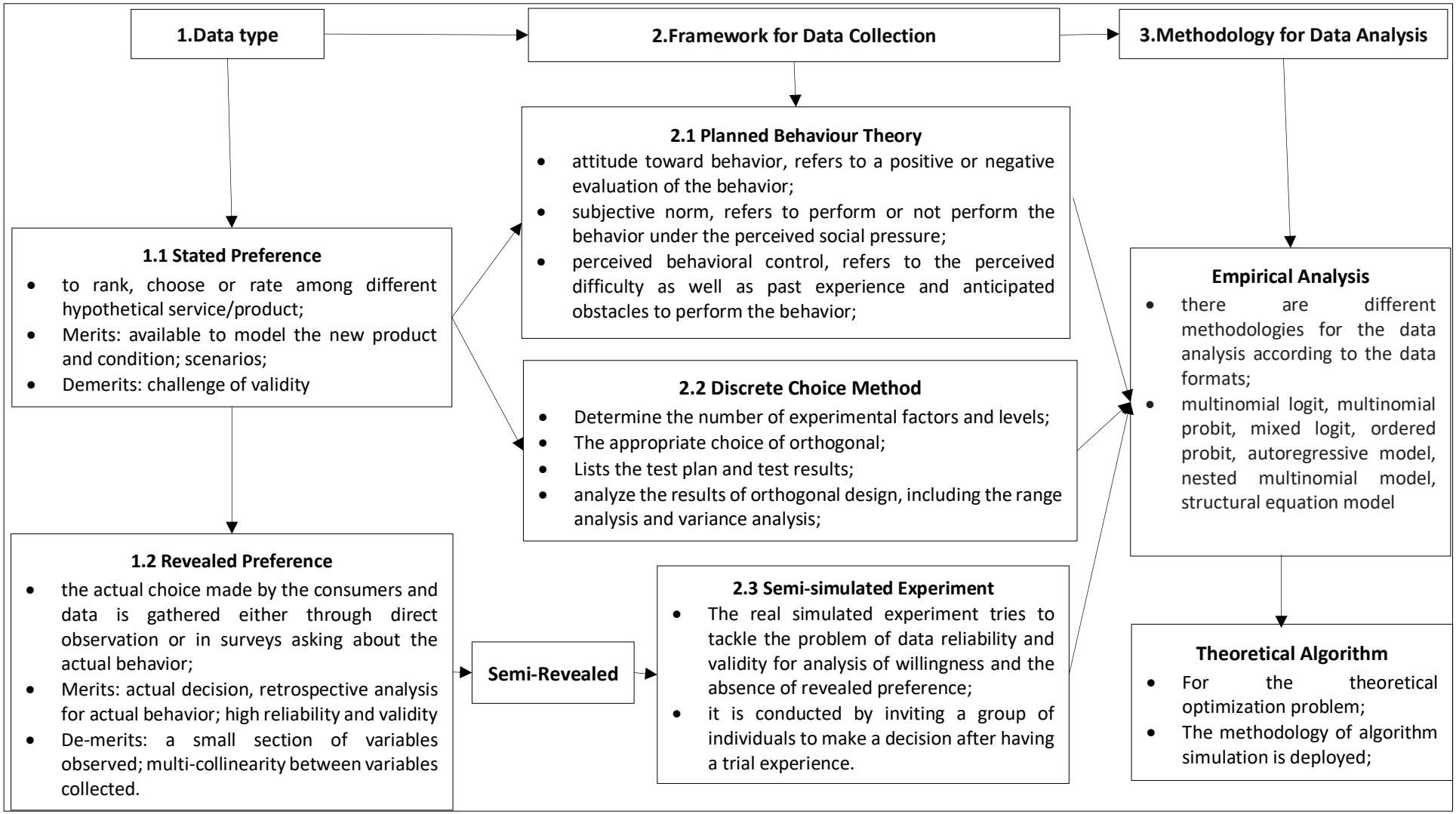
Moreover, the recharging facility is important for the adoption of NEVs. Who can recharge a plug-in electric vehicle at home? A web-based survey is deployed and finds that only one-third of new car-buying household in San Diego have access to the level 2 (220V) charging facility, and 20% of them are both able and willing to install it(Axsen & Kurani, 2012). But what is the optimized mechanism for the infrastructure deployment? A dynamic model to evaluate the competing approaches of battery installation, for example, batteries installed in the electric vehicle, used and new batteries installed in the stationary energy storage systems, among the varied approaches for the batteries installation, none of them could be implemented at a large

scale to offset the additional cost(Hein, Kleindorfer, & Spinler, 2012). This works focuses on which approach is the best for the management and installation of electric vehicles. Where a continuous facility location model is utilized as a graph theory to obtain the optimal location of public charging facility under the consideration of demand uncertainty(Sathaye & Kelley, 2013). The charging facility for switching, it indicates that Individuals have higher willingness to pay for the electric vehicles given the providing of battery-switching service(Ito, Takeuchi, & Managi, 2019), while it is still estimated by the stated preference.

3.3. Methodology

This part will elaborate the methodologies deployed for the adoption of electric vehicles. In term of methodologies, it will figure out the relationship among the stated preference, revealed preference regarding data type, the primary framework and theories for the data collection and research questions, empirical and theoretical methodologies for the data analysis, which are intertwined with each other, providing a clear flowchart about the works have been done on this topic.

Figure 23 The methodology flowchart for the studies of electric vehicles



3.3.1Data Type

There are two types of data for the fieldwork and empirical study, which have different merits and demerits under diversified contexts and scenarios. The researches have been published, are primary stated preference as it is difficult to find the real consumers in the emerging phase of electric vehicles.

3.3.1.1Stated preference

Stated preference techniques is a research tool that ask respondents to rank, choose or rate among different hypothetical service/product scenarios, which is within the field of utility theory and demand forecasting. Furthermore, it is an established methodology to elicit the consumers' preference as the absence of enough owners to measure the revealed data, but it is a hypothetical setting and does not represent the actual demand, although it is carefully designed and well conducted.

However, the absence of real-life experience with the product in the stated preference is one issue. As lots of researches only refer to the stated preference with a hypothetical setting to elicit individuals' preference , the preference and attitude towards electric vehicles are indeed affected by the real-life experience(Jensen, 2014), but in reality, the participants in samples, are lack of enough knowledge of electric vehicles, let alone the real-life experience. Therefore, there are lots of skepticism about the stated preference method, which is changed with the real experience, particularly integrated with evolution of new emerged technology. In the stated preference, the factors, levels and alternative can be defined by the researcher, estimating the trade-off for factors that are difficult to measure. But individuals would be unfamiliar with the specific scenario of different variables' combination. Moreover, there are numbers of limitations for the practice of stated preference survey. Initially, the stated preference survey may not represent the adequately context, such as the garage ownership, first or second car, refueling condition(Massiani, 2014). Due to the potential problem of validity, such as the stated choice through an Internet survey to study the effect of subsidy and charging facility on the adoption of electric vehicles(Ma, Gao, & Tan, 2017), it test the information conformity by answering the question before and after the received information, such as the price, range, parking space, which indicates that the existence of divergence for the preference(Cherchi, 2017).

Therefore, there is a skepticism over the validity of stated preference due to the drawback of diverged preference and bias. But the stated preference is deployed as the primary data type by the majority studies. Therefore, some tests are deployed to examine the consistency and rationality, such as the 'repeat questioning', which is carries out at different times, but preferences may vary over time. Meanwhile, the assumptions of the stated preference are the economic rationality and utility maximization, while research evidence indicate the differences due to the different representing attributes in the stated preference experiment.

3.3.1.2Revealed Preference

Revealed preference, is observed behavior with available alternatives, and the data is gathered either through direct observation or in surveys asking about the actual behavior, which is the actual choice made by the consumers, avoiding the problem associated with hypothetical responses. For example, charging models with the revealed preference data from battery electric vehicle users, there are three alternatives, normal charging at home, normal charging at public, fast charging at public, it will ask the electric owners about the actual ways deployed

by them for charging(Xu, Meng, Liu, et al., 2017).

But there are limitations in the revealed preference, for example, it is difficult to observe large set of variables sufficiently, giving rise to the calculation of a small section of individuals' utility function. Besides, it has strong correlations between variables in the dataset, namely, multi-collinearity. The revealed preference, reflects the actual behavior, it is an advantage but expensive and difficult accessing to them.

With the consideration of the advantage and disadvantage for stated and revealed preference, for the searches with better accessing the actual behavior, which is better to combine both of them. Accordingly, the data fusion or data enrichment is introduced and it refers to the combination of both stated and reveled preference data, which builds on the strengths and diminishes the drawbacks for the two methods to a larger extent.

Table 13 The comparison between the stated preference and revealed preference

Tips	Stated preference	Revealed preference
Setting	• Hypothetical	• Actual
Merits	• Available to model the new product and condition;	• Actual decision, retrospective analysis for actual behavior; • high reliability and validity
Demerits	• Challenge of validity	• A small section of variables observed; • a multi-collinearity between variables collected.
Solution	• Data Fusion or data enrichment, refers to the combination of both stated and reveled preference data, which builds on the strengths and diminishes the drawbacks for the two methods.	

Note: the data fusion provides a possibility to study the mechanism contributing to the disparity between stated and revealed preferences, willingness to pay and actual payment.

3.3.2 Theory and Framework for Data Collection and Research Questions

The framework refers to the theory or mechanism backbone for the design of survey and data collection and research questions, which provides a detailed guidance for how to design the survey and what data will be collected, and the implication of the research questions. Based on the literature reviews, two primary frameworks are utilized, theory of planned behavior and discrete choice experiment, but the collection of data type is stated preference. While the semi-simulated experiment is proposed with the target to increase the data validity and try to access to the actual preference. It has a similar framework in the survey design, but with a difference of respondents who have a real and practical experience on the studied object, instead of a conscious perception.

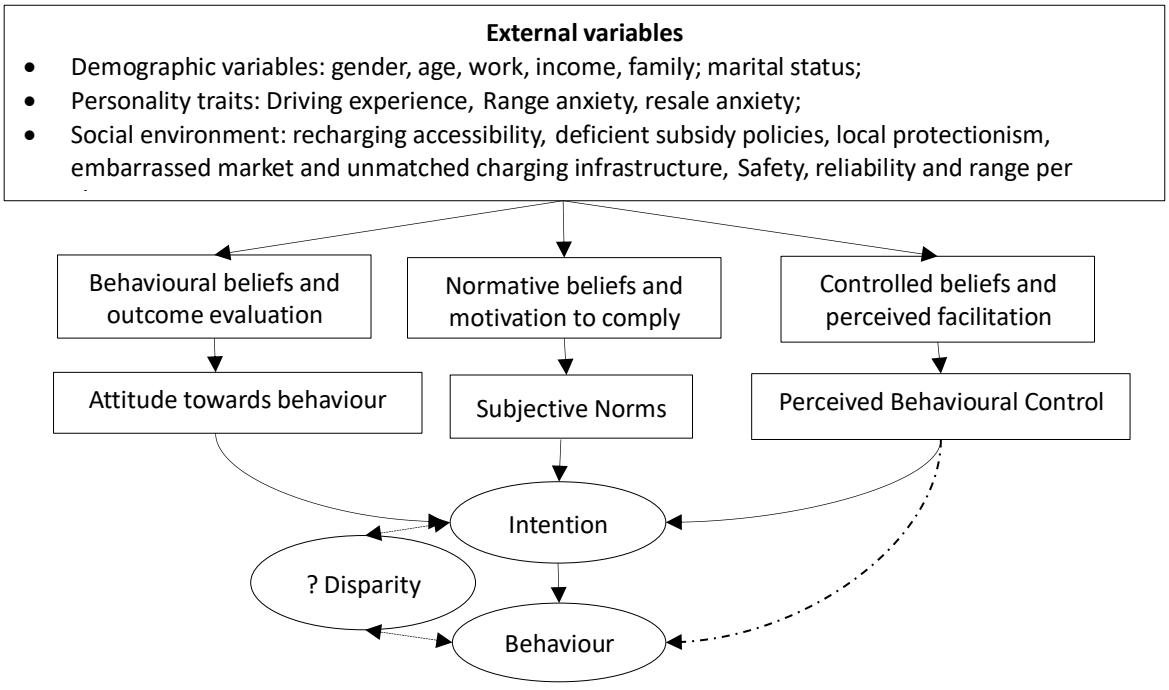
Meanwhile, these methodologies are often utilized for forecasting issues for a long-term events, but the weakness is the difficulty to forecast due to the long-term uncertainty(Shiue & Lin, 2010). Notwithstanding by combining a disaggregate choice model with a diffusion model, it forecasts the demand of electric vehicles, and a time-dependent factor is crucial in the diffusion forecast model(Jensen, 2014). But a data collection of both revealed and stated preference from a field test, by asking the participation of electric vehicles' drivers, collecting the driving behavior and driving style, which is important to find the dynamic correlation between the driving style and energy consumption, furthermore, a prediction model of energy consumption is proposed based on the data fusion of both revealed and stated preference(Hu, Wu, & Liu, 2018). Accordingly, lots of researches know the limitation of these methodologies, so some advanced survey techniques are proposed to integrate with a multi-stage in-depth

interviews, scenarios analysis and discrete choice experiment, with the effort to dig the potential real choices. But these efforts are still within the circle of two frameworks regarding the subjective preference.

3.3.2.1 Theory of Planned Behavior

The conceptual framework of planned behavior, briefly, consists of three determinants, including behavioral beliefs for the likely consequences of behavior, normative beliefs for the normative expectation of other people or social norm, control beliefs for factors that hinder or further the performance of behavior(Ajzen & Madden, 1986). Respectively, the aggregates three level of determinants, firstly, the attitude toward behavior, refers to a positive or negative evaluation of the behavior, secondly, subjective norm, refers to perform or not perform the behavior under the perceived social pressure, thirdly, the perceived behavioral control, refers to the perceived difficulty as well as past experience and anticipated obstacles to perform the behavior, in which all three predictors make independent contributions to the behavior study(Daigle, Hrubes, & Ajzen, 2002). The theory of planned behavior, originates from the theory of reasoned action(Ajzen & Fishbein, 1969;Ajzen & Fishbein, 1977), which indicates that the fully functioning individual processes the available information to mediate the effect of environmental factors on behavior, so the cognitive self-regulation plays an important role in the prediction of behavior. But the key factor is the individual's intention to perform a given behavior in a specific context, in which the motivational or impended factors are assured to be captured by individual's intention that affects a behavior. But for the prediction accuracy of behavior intention, it is much higher with multiple-alternatives than only one choice(Ajzen & Fishbein, 1969). An empirical study in many different behavioral domains confirms the correlation among attitude, subjective norms and control beliefs; furthermore, the intention is a good predictor of the behavior.

Figure 24 The planned behavioral theory on the adoption of electric vehicles



Note: the framework is the integration of previous works, such as reasoned action(Ajzen & Fishbein, 1969; Ajzen & Fishbein, 1977), unethical behavior(Chang, 2013). Lots of researches are based on the theory and framework

in the studies, but it is only simply regarded it an application, there is no further study on what extent the intention predicts the actual behavior, so the challenge in the theory framework is the additional disparity between intention and behavior. Besides, there is a gap between the awareness and behavior, acceptability of government policies is significant in the statistical respect, meanwhile, the subjective norm is more important than other psychological factors(Du et al., 2018). Accordingly, for this theory, after massive researches deploy it as the theory basement, it should pay more attention to the validity and disparity between intention and behavior, instead of regarding it as a granted method.

(1) First determinant of attitude toward behavior

The individual's attitude toward behavior to a particular object is reflected by a continuing positive or negative evaluation, which divides into particular behavioral outcomes from individuals and the evaluation of results (outcome evaluations). So the basic formation of attitude to the behavior of purchasing NEVs, has a particular outcome with a certain subjective value, combining the strength of beliefs and outcome evaluation, which generates an overall positive or negative attitude toward the purchasing of electric vehicles(Aizen & Klobas, 2013). Therefore, the accurate information about behavioral beliefs is important for the attitude toward the purchasing of electric vehicles.

Social and psychology theory assume that intentions cause the change of behaviors, however, most of the studies only test the correlation of intention-behavior rather than causal inference. For example, the effect of past experience on the intention, it can generate an automated cognitive processes instead of elaborating decision processes when the behavior becomes habitual(Verplanken & Van Knippenberg, 1998). For psychosocial benefits, including mastery, self-esteem, feelings of autonomy, protection and prestige, but self-esteem is associated with the type of vehicles(Ellaway, Macintyre, Hiscock, & Kearns, 2003). Over time, the importance of consumer characteristics such as travel attitude, personality and different lifestyle incorporate into the individual intention(Choo & Mokhtarian, 2004), which indicates higher environmental awareness led to higher willingness to the purchase of EVs(Kishi & Satoh, 2005). So the service should be designed to accommodate the requirement by the customers(Beirão & Sarsfield Cabral, 2007), which is also influenced by the type of journey, individual characteristics, lifestyle and the perceived performance of different transport modes, namely, the social-economic factors and environmental perception(Ziegler, 2012). Meanwhile, the self-identity has a substantial impact on the intention to environmental protection behavior(Mancha & Yoder, 2015). Therefore, the first determinant of attitude toward behavior forms a general positive or negative evaluation for a specific object.

(2) Second determinant of subjective norms

The second determinant of behavioral intention is subjective norms, which is the individual's cognition of social pressures taking a particular action. Another element is the motivation to comply with the norm under the social pressure, namely, the motivation to comply. Moreover, the descriptive norms are also incorporated into the revision of the theory of planned behavior(Ajzen, & Fishbein, 2005). Self-expectations and internalized norms to adopt a given behavior, indicate that an individual who has high moral norm scores shows a stronger intention-behavior relationship compared to those with lower moral norm scores(Godin, Conner, & Sheeran, 2005). The perceived benefits of electrical vehicles rely on the social-special relationship and the individual lifestyle. But the vehicle is not only a kind of transport, but also the felling of freedom, sensation, power, status, and superiority(Steg, 2005).

Meanwhile, the altruism is also included in the subjective norm. The payment for the public environmental pollution is regarded as the implementation of “polluters pay”, compensating to the negative externality for the public, but also regarded as the altruism, such as the donation voluntary. But there is a gender difference on the altruism when altruism is expensive, women are kinder, while men are more altruistic when it is cheap, indicating the cross of demand curves for altruism between male and female(Andreoni & Vesterlund, 2001). Besides, there is no support that the moral responsibility matter for the voluntary neutrality(Bulte, Gerking, List, & de Zeeuw, 2005).

Furthermore, the individual contributions to the environmental protection as the public good depend on the wealth and heterogeneous preferences, for the comparative static analysis, which indicates an initial level of public good, individual wealth and technology are important for the donation(Kotchen, 2009). For environmental awareness and social norms, there is a non-positive willingness to pay, only a minority is willing to sacrifice particularly high amounts, which is correlated with the features of subjects, including the education level, perception of climate change, the exogenous environmental controls, such as the meteorological conditions, furthermore, the price effect is robust and negative, but quantitatively weak, and the variables linking to moral responsibility dominate the price effect(Diederich & Goeschl, 2011). Similarly, the beliefs of the future temperature change, the mass-media exposure and the agreement on the emission reduction, especially for the biggest emitter, are positive associated with the preference to adopt environmental (Akter & Bennett,2011).

Moreover, it also intends to understand the interpersonal influence, the peer effect on the behavior change, which can be more effective than the focus on the individual level. More importantly, the perceived norms affect the peer effect rather than the actual norms, which leads the gap between the perceived and actual regarded as the misperception that forms the foundation of social norms approach(Gardner & Abraham, 2010). Furthermore, individual’s moral obligation refers to a sense of responsibility to act and the internal state construct, which is regarded as one explanatory variable in the subjective social norm and can better predict the behavioral intention for pro-environment(Chen, 2015). In certain contexts, for the behavior change, it needs to consider not only perceived social pressures but also the personal feelings of moral obligation to perform the behavior. Besides, the network theory explores human behavior in terms of the relationship among members of societies, including macro network approach and micro network approach (Park, Lim, & Park, 2015), which is used to examine patterns of communications between actors.

Accordingly, the subjective norms, are not only the rules or regulations in the society, but also the internal perception of the norms, reflection of the peer effect and self- altruism.

(3) Third determinants of perceived behavioral control

The third determinants, perceived behavioral control refers to the perception of the difficulty of performing the behavior or the extent of control to a particular behavior, but it varies across behaviors and situations. Meanwhile, it is comprised of two components, self-efficacy, and controllability. The perceived probability of succeeding at a given behavior, as the counterpart, defines as the expectancy of success, which leads to the trade-off between perceived control and perceived motivation over a specific behavior. More specifically, the measurement of perceived behavior control can ask the questions on the basis of beliefs indirectly about the ability to deal with the facilitating or inhibiting factors, or directly the capability to perform a behavior, of which the belief-base measures have a cognitive insight of behavioral control,

while the majority of the studies are based on the capability, direct approach(Daigle, 2002). Therefore, in the questionnaire, the respondents are asked the questions about the perceived likelihood, frequency or the extent to which the control factor has the power to facilitate or impede the performance respondents.

The majority of the studies are based on the techniques of experiment design and the individual regarded as the unit of analysis, which indicates the fuel cost savings and incentives, such as the tax-free purchases and free parking, which could encourage households to adopt a cleaner vehicle(Potoglou & Kanaroglou, 2007). Similarly, monetary attributes includes purchase price, annual fuel, and maintenance cost, and the demographic variables tend to be robust, more specifically, the per-capita income is significantly correlated with the purchasing EVs, while negative with the mean age, but it is not distinguishable from zero for gender and educational attainment(Gallagher & Muehlegger, 2011). It finds that not only the financial benefits relating to the transport policies are important to the consumers' motivation, but also the social norms and willingness to comply with the social norms(Ozaki & Sevastyanova,2011). Moreover, early adopters are motivated heterogeneous by the financial benefits, new technology, environmental awareness and vehicles performance attributes(Tran, Banister, Bishop, & McCulloch, 2013).

The electrical vehicles industrialization not only dependent on the development of related advanced technologies but also a mature industry chain, including the downstream supporting infrastructures (such as the charging station) and the upstream industries (such as the power cell industry). And the charging station is one of the key elements for the popularization(Yuan, Liu, & Zuo, 2015). Apart from the performance attributes of EVs, other economic instruments, such as the commuting time and costs are also important for the adoption. It also find that with the combined package of subsidies and attributes, gasoline vehicles continue to be more attractive to the consumers in USA and China based on the choices-based conjoint surveys over 2012-2013, state tax incentives are positively correlated with increased hybrid vehicle adoption(Helveston et al., 2015). Meanwhile, Chinese respondents have significantly higher relative willingness-to-paying for the electric vehicles. A sales tax waiver is associated with more than ten-fold greater increase in EVs.

Table 14 Different factors affecting individuals' subjective preferences of EVs

Perspectives	Literatures' determinants	Relationship	Sources
Intention and attitudes	Environmentalism	+ or?	(Kishi & Satoh, 2005); (Diederich & Goeschl,2011)
	Environmental consideration and awareness	+	(Ozaki & Sevastyanova, 2011)
	Concern the global warming	+ or?	(Andreoni & Vesterlund, 2001)
	Low emission rates	+ or?	(Xian Zhang, Wang, Hao, Fan, & Wei, 2013)
	Past experience	?	(Verplanken & Van Knippenberg, 1998)
	type of journey	?	(Choo & Mokhtarian, 2004)
Normative and Subjective norms	Community's values and social norms	+ or?	(Ozaki & Sevastyanova, 2011); (Godin, 2005)
	Self-actualization, motivation	+ or—or?	(Godin, 2005)
	Culture	?	(Fowler & Breen, 2014);(Choo & Mokhtarian, 2004)

Controls factors	Financial consideration	+ or?	(Mourato, Saynor, & Hart, 2004); (Ozaki & Sevastyanova, 2011); (Fowler & Breen, 2014)
	Fuel economy, running cost, gasoline price	+	(Potoglou & Kanaroglou, 2007a);(Gallagher & Muehlegger, 2011)
	Purchase price	+ or—or?	(Lave & Train, 1979); (Kishi & Satoh, 2005); (Gallagher & Muehlegger, 2011);(Tran et al., 2013)
	Driving performance (automatic gearbox)	+	(Adamson, 2005);(Tran, Brand, & Banister, 2014)
	Safety, reliability, comfort, speed, and practicality	+	(Adamson, 2005)
	Comfort, quietness, ease of driving, and automatic transmission	+	(Tran et al., 2013)

Note: This table presents the basic conclusions contingent on the three components of planned behavior theory. While there are different conclusions for a same variable due to the different contexts, or because of the stated preference varies according to the scenarios.

An empirical study base on the data collection, which indicates that the monthly income and the number of family owns affect the purchasing behavior(Hao et al., 2016). Besides, regarding the attitude toward electric vehicle, subjective norm, and perceived behavioral control, it confirms that it has good explanatory power in predicting consumers intention to adopt electric vehicle(Wang, Fan, Zhao, Yang, & Fu, 2016).

Moreover, based on the improved planned behavioral theory, the interrelationship among the perceived behavioral control, subjective norms and perceived usefulness has similar conclusion, but how does it quantify the variables? It establishes a discrete choice model contingent on the variables in the planned behavioral theory(Wang & Dong, 2016), naturally, the results indicate that subjective norms have a significantly positive effect on the purchase intention. With an extension of theory of planned behavior and structural equation model, to study the factors affecting the purchasing attention of NEVs, where the financial benefits, environmental concerns and policy privileges have a positive impact on the intention(Wang, Zhao, Yin, & Zhang, 2017).Divide policy measures into three categories, financial incentive, information provision, and convenience policies(Wang, Li, & Zhao, 2017). The three components of planned behavior theory, perceived economic benefits, environmental benefits and perceived risks are correlated with each other, which can explain the attitudes toward purchasing intention under the incentive policies(Zhang, Bai, & Shang, 2018). Influencing factors for the public cognition, such as network externality, price acceptability, environmental concerns, government subsidies(Lin & Wu, 2018). Personal norm has a positive influence on the adoption(He & Zhan, 2018).

Based on the planned behavioral theory, a total of 502 valid samples are collected, it finds that the perceived behavior control, product perception, monetary incentive, and attitude have significant effect on the intention to purchase, while subjective norms and non-monetary policy are not significant(Huang & Ge, 2019). In a stated choice experiment, the availability of the home-charging facility has the strongest influence on consumers' choice, then it is the speed of fast charging station and the free-license-plate for consumers(Qian, Grisolia, & Soopramanien, 2019).

Additionally, conflict values mean no option meeting all of the objectives among different choices perfectly, which is recognized as a major source of decision difficulty. So how do people

make a decision among multi-attribute alternatives when no alternative dominates? So the key research problems are to measure the different weights and values assigned to the attributes, however, which is highly contingent on the context factors and the host of the task. For the decision-making, individual intends to maximize its expected utility, while the preference reversal phenomenon also exists under the uncertainty as for the preference to a higher probability of winning.

Therefore, the theory elaborates the different components and definition in the application of behaviors study, forms a framework for the explanation of behavioral intentions, contingent on the attitudes, subjective norms and perception of behavioral control, specifically, integrating with the charging inconvenience, short battery range, purchase cost and psychological factors, etc. have different combinations in the empirical studies. It provides a clear guideline for the sampling choice, questionnaire design and research framework on this topic. Simultaneously, what format does it present for different combination of choices? The discrete choice experiment is deployed as primary solution.

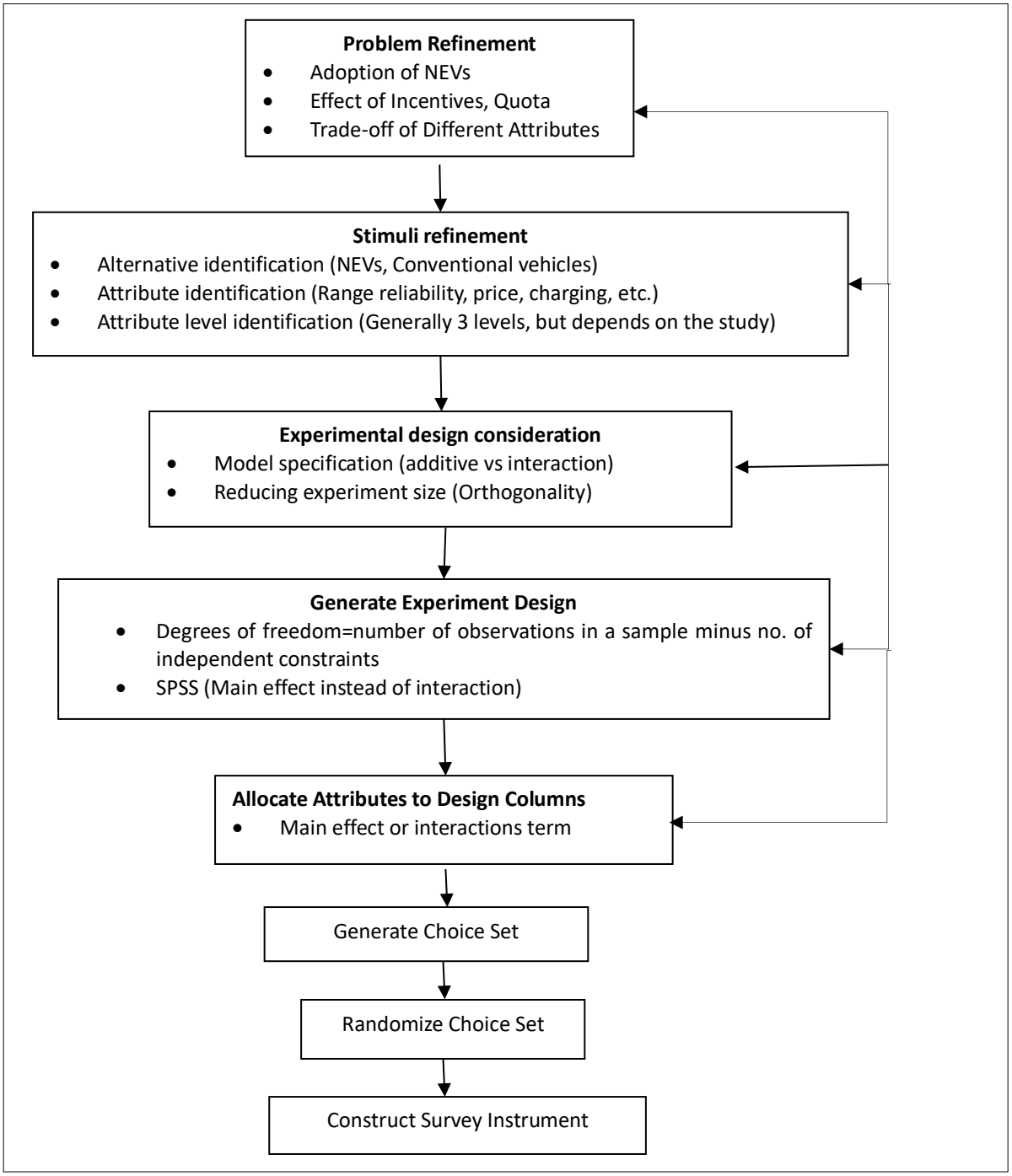
3.3.2.2Discrete Choice Experiment

Discrete choice model indicates each individual faces a finite options and prefers to one alternative that maximizes its utility. The random utility maximization is the theoretical basis for the discrete choice model, the assumption is that individual is rational enough to evaluate among different alternatives. Meanwhile, it is a stated preference approach, and a quantitative research method used to measure attributes of the alternatives, assessing the stated preferences and trade-offs toward the choice decision between new energy and conventional vehicles. The model utilizes a random utility framework and some functional form relating choice probability to product and/or consumer attributes, to measure individual preferences with comparison of several product profiles, which are defined as set of attributes, such as the brand, type, price, operation cost, etc.

Accordingly, discrete choice experiment is an attribute-based approach to collect the stated preference data, by presenting a sequence of choice sets composed by several competing alternatives. Respondents are asked to choose their preferred scenario among multi-alternatives. The choice-based approach is more realistically as a true buying scenario, in which it only chooses one product rather than rank several(Huber, Wittink, & Johnson, 1992).

The process of discrete choice experiment will as follow steps(Hensher, Rose, & Greene, 2005), 1) determine the number of experimental factors and levels; 2) set the appropriate choice of orthogonal; 3) list the test plan and test results; 4) analyze the results of orthogonal design. Therefore, the method of discrete choice experiment is used to select a reduced sub-set sample of choices, a “fractional factorial” design rather than the “full factorial” choices for the respondents. Based on refinement of research questions, there are alternative identification, attribute identification and attribute level identification, then the Orthogonal design is used to generated the different combinations satisfying the orthogonality, namely, there is no correlation between attributes, that is also important for the empirical study.

Figure 25 The design process for discrete choice experiment



Note: This figure is based on the framework of experiment design process(Hensher, Rose, & Greene, 2005) and discrete choice experiments(Ryan, Gerard, & Amaya-Amaya, 2008), which has detailed explanation for the application in different fields. Then it integrates with the specific scenarios and attributes on the topic of electric vehicles.

Accordingly, the construction process is important for the discrete choice experiment. Firstly, it is the generation of choice option. In order to promote the adoption of NEVs under the condition of quota policy, there are different options for individuals, including the random selection with high probability for NEVs, random selection with low probability for traditional vehicles and bidding with relative higher probability but also higher cost for traditional vehicles. Meanwhile, some researches only list two choices in the experiment, namely, a dummy

variable representing electric vehicle or conventional vehicle.

Secondly, it is the identification of attributes, how well the researcher identifies factors that influence choice determines its capability to capture the systematic component in the decision making. The researcher has to narrow the number of attributes down after having identified a long list of variables. But there is no concreted rule to determine the attributes and levels presented to respondents(Ryan et al., 2008). The variables consist of two parts; one is the intrinsic performance of vehicles, including the price, fuel cost, reliability, charging, etc., another is the factor imposed by the government, including the additional license cost and probability as the limited supply.

Thirdly, it is the assignment of attributes levels and labels. Price, fuel cost for the two different kinds of vehicles, reliability, convenience of charging. Particular care should be attached to the qualitative scales, such as ordinal or categorical numbers, where respondents would have different interpretation. Meanwhile, it will also affect the analysis of marginal utility when it comes to the ordinal or categorical numbers. There is no need to set a same level for different attributes. For the number of levels, theoretically, it would have better understanding with more levels, but the size of experimental alternatives will increase at an exponential rate with every additional level of variable.

Fourthly, it is the construction of choice set. A full factorial design is available to investigate all attributes, while in practical situations, it is not tractable due to the large number of all possible combinations. A subset of all possible combinations is selected, but it should be greater than the degree of freedom. Meanwhile, the orthogonality requires that levels of each attribute vary independently of each other. In practice, it refers to the zero or low correlation among the attributes, namely, the independent variables in the empirical studies. According to the attributes and levels in the discrete choices, the different combinations will be generated and a sub-set of combination will be listed in the survey.

Table 15 Discrete choices experiment in the application of electrical vehicles' adoption

Study	Econometric model	Choice set, attributes and levels	List of attributes	Conclusions
(Beggs & Cardell, 1981)	Ranked/ ordered logit	16, 9, NA	Price, fuel cost, range, top speed, number of seats, warranty, acceleration, air conditioning	The limited range and long refueling periods are the hindrance for the adoption of electric cars. The lower operating costs of electric could not be regarded as a sufficient counterbalance to demerits.
(Calfee, 1985)	Probabilistic choice model	30, 5, NA	Price, operating cost, range, top speed, number of seats	There are trade-offs among attributes; among individuals, it is diversified.
(Bunch, Bradley, Golob, Kitamura, & Occhiuzzo, 1993)	MNL and Nested logit	5, 7, 4	Price, fuel cost, range, acceleration, fuel availability, emission reduction, dedicated versus multi-fuel capability	the most important attributes are range and fuel cost.
(Brownstone, Bunch, & Train, 2000)	MNL and Mixed logit; Joint SP/RP	2, 13, 4	Price, range, home refueling time, home refueling cost, station	data are plagued by multi-collinearity, and there is an implausible prediction.

	Mixed logit		refueling time, station refueling cost, station availability, acceleration, top speed, tailpipe emission, vehicle size, body type, luggage space	
(Ewing & Sarigöllü, 2000)	Ranked logit	15, 4, NA	Price, fuel cost, range, top speed	There is a low willingness to trade off the CVs' performance levels of range, acceleration, and refueling time. And the NEVs market creation is not sufficient by the regulation alone.
(Dagsvik, 2002)	Ranked logit	15, 4, NA	Price, fuel cost, range, top speed	The limited driving range is the biggest hindrance. There is a considerable uncertainty on the battery technology.
(Hidrue et al., 2011)	MNL; random utility model	NA, 6, primarily, 4 levels	Price relative to your preferred GV; Driving range; Time it takes to charge battery; Acceleration relative to your preferred GV; Pollution relative to your preferred GV; Fuel cost	A person's propensity to buy a NEV increase with youth, education, green life style; it is more likely to buy NEVs for the individuals who have a tendency to have a small and medium size vehicle; the Main barriers are the range anxiety, long charging time and high purchase price.
(Nie, Ghamami, Zockaie, & Xiao, 2016)	Optimal algorithem	NA, 4, normally, 3 levels	Charging time interval, travel models, charging models	The priority is building the charging station, and the current massive adopted rebate for the charging subsidy is less effective.
(Ito et al., 2019)	Mutli-nominal regression	It is a mixed structure; each variable has different categories with different levels	Fuel availability, cruising range, vehicle body type, manufacturers, annual fuel cost, purchase price	Battery-switching might greatly promote the adoption of electric vehicle by alleviating the barrier of limited range.

NOTE: This above table presents the primary researches on the adoption of electrical vehicles contingent on the methodology of discrete choice model, partly, it is based on the previous work(Hidrue et al., 2011), to elaborate the primary components in the samples of discrete choice model, such as the attributes listed in the alternatives, different choice sets, attributes, levels. However, the discrete choice model is another hypothetical version of willingness to pay, instead of actual payment, accordingly, there is still a disparity between the simulation in this methodology and actual payment (NA in the table refer to not available). The objective of the discrete choice experiment is to identify the most important attributes in the decision making and how attributes interact. Joint hybrid choice model and orthogonal design account for different combination of variables with different levels.

Therefore, with the consideration of all the advantage and disadvantage in the adoption of electrical vehicles, normally, a rule-based screening methodology is deployed to obtain a choice set closing to the real consumers' choices with regard to the socioeconomic and mobility patterns(Lopes, Moura, & Martinez, 2014). Meanwhile, in the experimental simulation, it is better to be unlabeled, because the label name will be regarded as an attribute and result in a failure regarding the model assumption of IID, namely, Independence and

Unrelated Distribution(Hensher et al., 2005). Moreover, in term of the practical experience, the decision makers would be based on the previous perception of the label name rather than the combination of different variables and levels.

3.3.2.3 Semi-simulated Experiments

The semi-simulated simulated experiment tries to tackle the problem of data reliability and validity for the analysis of willingness and the absence of revealed preference, then it is conducted by inviting a group of individuals to make a decision after having a trial experience over a period. According to previous framework for the planned behavior and discrete choice experimental design, individuals choose preference among hypothetical combination of vehicles attributes. But the respondents have not actual experienced for the studied object of electric vehicles in the survey, so the trial and demonstration of electric vehicle are used to assess individuals' behaviors that are relative accessing the actual ones to a certain extent.

In a nutshell, it collects the data after a trial experience from respondents. A detailed and experiment-oriented interviews is devised to households with multi-cars, there are four stages in the process, including a video of electric vehicle use and recharging, a three-days daily trip, a map of activity locations and a vehicle choice experiment that is formulated in the discrete choice experiment integrated with other attributes(Kurani et al., 1996). Similarly, in order to test how the real experience affect the perception of electrical vehicle, there is a subsequent trial of electric vehicle for households who have participated in the survey(Gould & Golob, 1997), but there is only a small sub-samples who can test the electric vehicle.

Gradually, it pays more attention to the difference before and after the trial, which provides a perspective to study the effect of trial experience. For example, it collects the data at the start and end of the 4-6 weeks trial driving to quantitatively study the driving habits and performance(Caperello & Kurani, 2012). Similarly, it collects the data by leasing 40 electric vehicles to 40 drivers to study the effect of range on the satisfaction of electric vehicles(T. Franke et al., 2012), and a thematic analysis based on the participants' narratives after the test and trial(Caperello & Kurani, 2012), a decision tree model is deployed based on the travel survey and charging behavior models(Davis & Bradley, 2012). Dependent on a demonstration project to collect two set data, namely, before-and-after the demonstration, then it uses hybrid choice model to estimate the before-and-after real-life experience with electric vehicles, and to identify the best utility specification. The hybrid choice model shows a changing preference with a real-life NEVs experience, particularly, the preference for the driving range. But it only dependent on the stated choice to elicit potential consumer's preferences, including the environmental concern, general opinion towards electrical vehicles, etc.

Furthermore, the travel tracking data by the GPS is essential to find individuals' behavior in the adoption of electric vehicles. A set of GPS-based travel data from 459 private passenger vehicles is collected to study the travel routine, charging behavior(He et al., 2016). By combining long-term GPS tracking data and digital elevation map, it studies the electricity consumption with the travel distance, and the effect of downgrade braking on the energy regeneration(Liu, Yamamoto, & Morikawa, 2017). Based on the real GPS trajectory data, A hybrid evolutionary algorithm with neighborhood search is proposed to simulate the consumers' charging behavior and find the best location planning of charging stations(Bai, Chin, & Zhou, 2019). With the help of tracking data, it accesses to the real behavior on the adoption of electric vehicles.

3.3.3 Methodology for the data analysis

For the methodologies, contingent on the topics and data types, it has different methodologies for the analysis, where the primary part is the deployment of empirical study, while another one is the theoretical model to simulate the real scenarios and mechanism behind the operation, particular for the complicated optimal problems under multi-constrains.

3.3.3.1 Empirical methodology

Based on the data type, there are different methodologies for the data analysis. After the data collected, the most commonly model is the multinomial logit, while it has been widely criticized for the reliance on the restrictive assumptions. Meanwhile, similar methodologies have been deployed contingent on the type of data, such as multinomial-probit, mixed logit.

Therefore, the discrete choice experiment provides a framework on the adoption of electric vehicles, identifying the important attributes and interaction among them dependent on the multinomial logit model for the multi-vehicle households(Beggs & Cardell, 1980). A three-stage stated preference is implemented to predict the individuals in the adoption of electric vehicle from conventional ones, the attributes in the measurement, including the limited refueling station and range, purchasing price, fuel operation cost emission levels and performance. Namely, which is contingent on the framework of discrete choice experiment to collect the data, then the multinomial logit is used to analyze the trade-off among different attributes(Golob, Kitamura, Bradley, & Bunch, 1991). In a two-waves survey in California households, there is a decline in the environmental perception, which is associated with the exposure to the specialized media and the interpersonal interactions. Subsequently, a sample of household were chosen to participate in a trial driving for two weeks, which find that the environmental perception has been improved, but this perception is no longer a cited element for the purchase of electric vehicle, attaching more importance on the incentives referring to methodology of multinomial-probit(Gould & Golob, 1997).

A scenario simulation is deployed to study the sensitive analysis (Li & Ouyang, 2011), experimental design to study relationship between the human driving characteristics and electric vehicle(Wu, Wan, & Zhao, 2012), a similar empirical study with large amount of sampling (Wang, Wang, & Hao, 2013), a multinomial logit is deployed. Besides, the same methodology is used to study the effect of congestion tax under diversified groups, such as living and working both in the community, living but work outside the community, living outside but working within it, living and working both outside the community(Whitehead et al., 2014).

Among several combination of variables in the city evaluation of electric vehicle adoption in China, the Clustering analysis model is employed(Wang & Liu, 2015). The collected data are analyzed by the confirmatory policy analysis and structural equation modeling(Lai et al., 2015). The latent class logit fits the data collected for the three categories of decision makers for the charging choices(Wen, MacKenzie, & Keith, 2016). There is a longitudinal data from 2013 to 2015 for 88 China's pilot cities, treated as cross-sectional data due to the time interval with only three years, and a pooled regression is deployed to estimate the effect of policies in the pilot cities(Zhang et al., 2016). Besides, the consistent fuzzy preference(Li et al., 2016), multi-variables for the time series(Ma et al., 2017), a policy dependency mapping enabling to study the interaction and dependency over different times and regions(Zhang & Bai, 2017), which constitute complex policy system and various level government with multiple purposes, then

decodes the dependency paths and reveals the incentive policies for the adoption of EVs.

Table 16 Empirical methodologies for the data analysis

Data type	Framework	Researches	Sources
Stated-preference	Pooled data for different times	Random-effect, fixed effect and random-parameter generalized linear regression	(Bai, Liu, Guo, & Xu, 2015)
Cross-sectional data	NA	a pooled regression is deployed to estimate the effect of policies in the pilot cities	(Zhang et al., 2016)
Stated preference	Planned theory	A rescannable price, accurate positioning of target groups and convenient site layout and usage are required for the successfully launch of a new transportation model.	(Wang & Yan, 2015)
Stated preference	Discrete choice experiment	Conducting a discrete choice experiment by a mixed logit model, including subsidy, and social-psychological determinants.	(Wang, Tang, & Pan, 2017)
Stated preference	Planned behavior theory	Contingent value method and Ordered Probit Model	(Lin & Tan, 2017)
Revealed data from web by data mining	Real behavior	Univariate time-series, and autoregressive model for the sales forecast	(Zhang, Zhong, Geng, & Jiang, 2017)
Stated preference	Planned behavior	Effect of subsidies and charging facilities on the	(Ma, Gao, & Tan, 2017)
Stated preference	NA	The battery cost, charging condition and energy price are the primary element based on the nested multinomial model.	(Qian, XunMin, & XiLiang, 2018)
Stated preference	Planned behavior	Multinomial Logit and Random Parameter Logit models	(Nie, Wang, Guo, & Shen, 2018)
Stated preference	Discrete choice	Speed, range, charging time and price all matter substantially in the acceptance of the electric motorcycles.	(Guerra, 2019)

Note: The diversified methodologies are contingent on the data type and categories. Generally, the data type is stated preference formed as the panel data, so the specific methodology is the regression, including logit, multinomial. Additionally, from the date type of stated preference, it indicates the challenge on the validity of these researches once again.

3.3.3.2 Theoretical Algorithm

For the optimization problem under multi-constrains, it prefers to deploy the methodology of algorithm simulation to find the optimized results, such as charging sites, battery swapping and leasing stations.

A simulation algorithm is used to study the charging station network and the optimization of the network among the fast charging station, charging swap and charging posts based on the real data collected by the charging station and(Cui et al., 2012). Similarly, an optimization algorithm is deployed to simulated the planning of battery-swapping infrastructure(Mak et al., 2013), and a Monte Carlo simulation is used to study the balance between different participants in the charging facility(Lei Yu et al., 2015). Moreover, there are different researches based on diversified algorithm adapting to the complicated context, such as the stochastic evolutionary game to simulate the effect of different variables(Guan et al., 2016), a simulated game theory(Li et al., 2018),a systematic dynamic to forecast the substitution between the conventional and new energy vehicles(Sun & Wang, 2018), the difference-to-difference to study the effect of one policy by selecting the samples over times(Tan, Tang, & Lin, 2018), multi-regression analysis(Du et al., 2018). It provides a theoretical model for the

dynamic optimization, but now the problem is that the constrains are primary internal variables about the mechanism itself.

Table 17 Methodology of algorithm for the optimization design

Topic	Researches	Sources
Battery management	the rule of 'first-in-first-out' in the demand side management, an optimal configuration model where the net profit is maximized and operating cost is minimized, meanwhile, the variables, such as rated power, numbers of batteries, contract pricing. Besides, for the optimal location plan, a model in the battery swapping station is built with the objective of minimizing network loss.	(Liu, Niu, Xu, & Li, 2016)
Swapping battery station	A genetic algorithm-based model for the location of charging stations and numbers of chargers.	(Zhu, Gao, Zheng, & Du, 2016)
Sharing electric vehicle station	A continuum approximation model for the design of a one-way sharing system for electric vehicles, determining the location and fleet size.	(Li, Ma, Cui, Ghiasi, & Zhou, 2016)
Charging stations	Incorporation of local government requirements and spatial distribution of potential sites, supply and demand.	(He et al., 2016)
Charging-while-driving	Integration of urban road networks and travelling networks under complementarity constrains.	(Chen, He, & Yin, 2016)
find the shortest path	As the limited driving distance and battery renewal, it develops a label-correcting algorithm with state space relaxation to find the optimal path.	(Huang & Li, 2016)
Travel and charging time	Genetic algorithm to obtain the routes and charging plan under a dynamic traffic environment.	(Shao, Guan, Ran, He, & Bi, 2017)
Minimization of public social cost	Trilevel programming to find the optimal value within certain constrains for the wireless power charging.	(Liu & Wang, 2017)
Public sharing electric vehicles	A programming with a geographical service, customers' adoption behavior and fleet management.	(He, Mak, Rong, & Shen, 2017)
Imbalance of one-way electric vehicles car-sharing	a space-time network representation is used to satisfy the dynamical rebalance and relocation of reservation, battery charging with limited capacity and distance.	(Zhao et al., 2018)
Charging price in the private-public partnership	Charging price is very important to assure participants with a minimum anticipated return based on the systematic dynamic model.	(Zhang, Zhao, Xin, Chai, & Wang, 2018)
Relocation of one-way car-sharing	A mixed-integer convex programming model.	(Xu et al., 2018)
queues problem for battery swapping	Monte-Carlo stochastic simulation for users' behaviour, charging process and controlled capacity.	(Xie et al., 2018)
Evaluation of battery swapping station	A novel mixed queueing network with numerical simulation.	(Tan, Sun, Wu, & Tsang, 2017)
Location of charging station	A hybrid evolutionary algorithm with neighbourhood search	(Bai, Chin, & Zhou, 2019)
Vehicles routing problem	A heuristic approach based on the adaptive large neighbourhood search.	(Zhao & Lu, 2019)
battery swapping station	an integer programming model is used to adapt to uncertainties of flow demand and electricity prices.	(Sun, Yang, & Yang, 2019)
battery swapping station	A generalized benders decomposition, with the general an optimization and local optimization for one swapping charging station.	(Tan, Qu, Sun, Li, & Tsang, 2019)

Note: Regarding the optimization design, it primarily relates to the spatial distribution of charging sites under certain constrains, meanwhile, it is the same problem to the site optimization for the battery swapping and leasing. Accordingly, the same condition for the theoretical algorithm deployed is a dynamic and interacted system to find an optimal solution under multi-constrains.

3.4 Reviews and guideline for further research

In term of the literature review, it starts from the definition of 'adoption' and 'new energy vehicles/electrical vehicles', then focuses on two perspectives, the longitudinal and transverse ones, providing a clear guidance on the sub-research topics, including the energy saving and emission reduction, trade-off among multiple factors, recharging and battery, new proposed sustainable mechanisms. Furthermore, in term of the methodology, it starts from the data type, including the stated and revealed preference, which is contingent on the two layers' definition of 'adoption'. Besides, it clarifies the theories and frameworks for the sampling, questionnaires, data collection and research questions, including the planned behavioral theory, discrete choice experiment and semi-simulated experiment. Lastly, it elaborates the methodologies for the analysis, including the empirical and theoretical algorithm ones.

With all the consideration of the above studies, the further reviews will be elaborated from two perspectives. Firstly, in term of sampling, questionnaire and data collection, it should have the combination of both stated and reveled preference data, namely, data fusion or data enrichment, which builds on the strengths and diminishes the drawbacks for the two separated methods, as the drawbacks of hypothetical setting in the scenarios and context of data collection. Therefore, the challenge on the validity has been raised, notwithstanding there is an effort of semi-simulated works trying to accessing to the actual behaviors. Secondly, in term of academic research questions, it raises the challenge of disparity between the subjective willingness and actual behavior. Previously, the primary theory and framework for the researches, such as planned behavioral theory and discrete choice experiment, are regarded as the granted theories, but neglecting the mechanism contributing to the disparity between stated preference and revealed preference. Besides, there is no further improvement for the deployed theory.

These two perspectives are intertwined with each other; the data types provide the possibility for the further research questions in these works, while the theories and frameworks provide the guideline for the design of sampling, questionnaire and data collection. But previous works are repeated within an internal circle of conscious-stated-relationship on the adoption of electric vehicles. The breakthrough regarding the academic contribution falls on the disparity between subjective willingness and actual behavior under certain constrains.

Accordingly, the two perspectives, data enrichment and fusion for the design of sampling and data collection, raising and challenging the disparity between the stated and revealed preference regarding the academical research questions, which provide a clear guidance for my further and following research. For the coming chapters, the 4th chapter will elaborate the literature on the disparity between willingness to pay and actual payment, and the fifth chapter is the sampling design for the explanation of data enrichment and fusion.

Chapter 4 Literature Review and Hypothesis

Based on the conclusions in last chapter, there are two perspectives, data enrichment and fusion for the design of sampling and data collection, raising and challenging the disparity between the stated and revealed preference regarding the research questions.

For the topic, “forced to green” or “willingness to green”, the behaviors under the uncertainty, there are two key words and focuses for the refinement, namely, “willingness to pay” for the “willingness to green” and quota as the practical remedy for the “forced to green” in the theoretical part. In this chapter, the first part will focus on the mechanism of “willingness to pay”, after the literature review, then it emphasizes on the disparity between willingness to pay and actual payment, and the mechanism of commitment cost causes the disparity. Besides, the second part will concentrate on the treatment effect of quota to answer whether the adoption of NEVs is forced or not, then it also covers the externalities caused by the impose of quota. Accordingly, in the theoretical part, the theories on the willingness to pay (WTP) and quota will be presented, following the literatures, reviews and hypothesis.

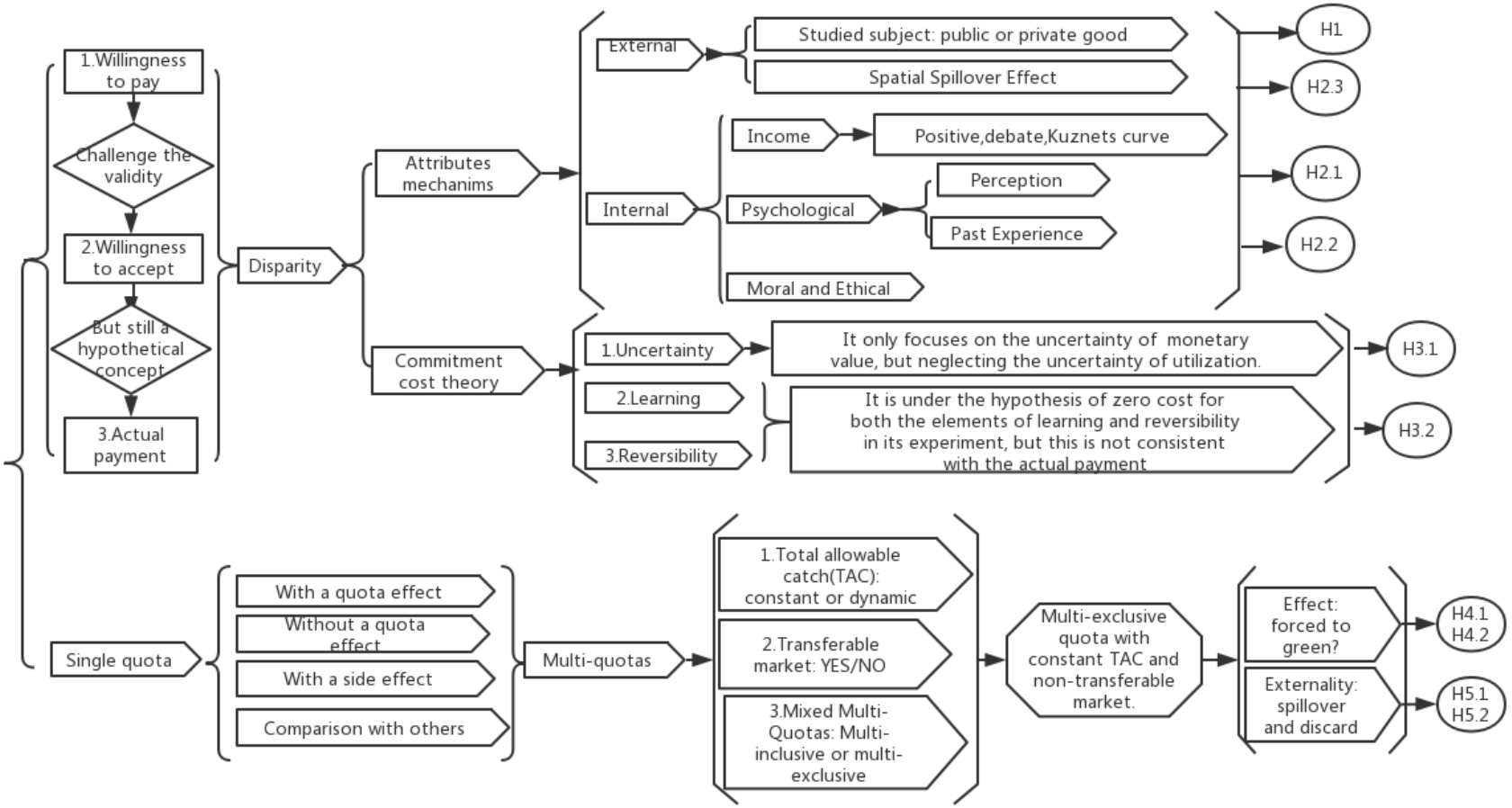
For the data fusion in the design of sampling and data collection, the fieldwork of the survey consists of two groups, one is the experiment group in Shenzhen with the impose of quota, another one is the controlled group in other cities without the imposed of quota. Within each group, it is also divided into two segments, the segment of “willingness to pay” for the individuals who do not own vehicles in both the controlled and experiment samples, and another segment of individuals who have owned vehicles in both two samples.

Main Hypothesis:

- *1.The function mechanisms of WTP and AP are different, and there is a phenomenon of the “trap of subjective willingness”. Besides, there is a disparity between WTP-AP, the higher uncertainty of utilization and the more learning opportunity with a delayed cost, the higher disparity between the WTP and AP.*
- *2.The adoption of NEVs is forced to green under the multi-exclusive quota, simultaneously, there are externalities and spillover caused by the multi-exclusive quota.*

Where the first theoretical framework, “Willingness to Pay” will elaborate the first main hypothesis, starting from the definition and literature, the disparity between the WTP/AP and the components of commitment cost for the disparity, then raises the hypothesis for the first part separately. Moreover, the theoretical framework of quota will demonstrate the literature and details for the second main hypothesis. It starts from the definition and a single quota, then to multi-quotas coexistence, where there are three most important elements, total allowance catches, transferable market, multi-inclusive or multi-exclusive quotas, which extends the previous research to study the effect of quota and externality. Accordingly, the framework and flowchart for the literature and hypothesis elaborate in the following chart, which is better to understand the logic.

Figure 26 The framework and flowchart for the literature and hypothesis



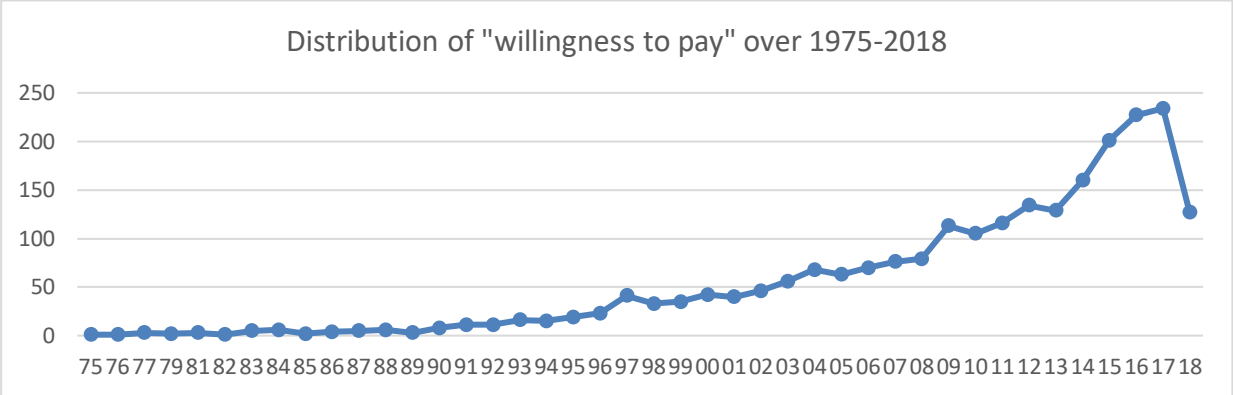
Note: this framework consists of two parts, the disparity between WTP/AP and the effect of quota, then is divided into 5 hypotheses based on the literature review, then to test the hypothesis contingent on the empirical studies. Most importantly, it is based on the work in the 3rd chapter to figure out the problem for the current works, the validity challenge of subjective willingness to pay, and the disparity between the willingness to pay and actual payment.

4.1. Willingness to Pay and Actual Payment

4.1.1 Definition and Literature

In the database, Web of Science, “willingness to pay” as the key word in the title, there are 2640 papers entitled to this condition until the end of June,2018, additionally, for the categories, after it excludes the notes, meeting abstract, finally, the remaining number of articles is 2240, where the distribution is presented as the following figure.

Figure 27 the distribution of papers on the topic of “willingness to pay” over 1975-2018



Note: The volume is the total amount until July,2018 in the database-web of science.

“Willingness to pay” was firstly emerged in 1975(Fischer, 1975), on the study of behavioral criterion for the environmental decision-making, indicating a maximum amount that individuals with the willingness to pay for a good. The willingness to pay technique was pioneered and deployed by the environmental economics to study the perception and adoption of non-traded goods, with the characteristics of public and hard-defined property rights. Generally, it is regarded as a behavioral criterion for the environmental decision making(Fischer, 1975), marginal WTP for environmental quality(Mäler, 1977), wetlands preservation (Whitehead, 1990), pest control(Miller & Lindsay, 1993),organic production and reduction of pesticide usage in the agriculture(Hammitt, 1993), mortality and public health(Johannsson, Kristrõm, Borgquist, & Jõnsson, 1993), public goods(Kahneman, Ritov, Jacowitz, & Grant, 1993), the maximum amount for a common good (Gafni, 1998), the treatment of healthcare(Bala, Mauskopf, & Wood, 1999), conservation of elephants(Bandara & Tisdell, 2005), reduction of risk for the small loss(Courbage & Rey, 2008), WTP for the green electricity(Menges & Traub, 2009), forest conservation(Haltia, Kuuluvainen, Ovaskainen, Pouta, & Rekola, 2009), for the preference of green electricity (Zhang & Wu, 2012), age of nuclear reactors(Mahieu, Pythagore Pierre Donfouet, & Kriström, 2015), the irrigation water system(Biswas & Venkatachalam, 2015), energy efficiency label(Zhou & Bukenya, 2016), food safety label(Wongprawmas & Canavari, 2017), the climate change mitigation(Winden, Jamelske, & Tvinnereim, 2018), green electricity(Xie & Zhao, 2018).

Therefore, reviewing the published academic works of more than 2000 papers over the past 40 years, the conception of willingness to pay (WTP) is widely deployed to study and assess the projects on public health, safety, environmental conservation, etc. and elicits the monetary valuation for goods and services. But it is primarily and simply applied as a method or hypothetical conception in different fields, such as public health, environment, conservation, donation, etc. Gradually, some works focus on the potential problem, particular for the

validity(Amador, González, & Ortúzar, 2005; Soeteman, van Exel, & Bobinac, 2017), and what solution to mitigate these problems contingent on the previous works. Therefore, the question and challenge are raised on the validity of WTP, and the conception of willingness to accept (WTA) is generated to study the disparity between the WTP/WTA, however, WTA is another version of hypothetical conception on the compensation that individuals can accept to sale out the property that individuals have owned the property hypothetically. Naturally, the definition of actual payment (AP) is raised to study the disparity between willingness to pay and actual payment. But there are still no more works on the disparity of WTP and AP.

At the initial stage, the WTP only regarded as hypothetical conception is deployed to study to what extent individuals want to pay for a specific service, particularly, for the public good. Meanwhile, the function mechanism on the WTP primarily focuses on two perspectives, namely, the respondents' attributes as the internal elements, such as income, psychological effect, ethical and moral effect; And attributes of the studied product are deployed as the external elements, such as the categories of the studied goods, definitely, it also includes the integration of two perspectives.

For the first main hypothesis, the function mechanisms of WTP and actual payment are different, and there is a disparity between WTP-AP, importantly, there is a phenomenon of the 'trap of subjective willingness'. The literature is organized and presented as following parts, the literature review on the effect of income, psychological perspective, moral and ethical aspect, namely, the literature is elaborated in terms of two components, internal and external perspectives. After the study of attributes, then it focuses on what elements in the mechanism behind the disparity, accordingly, for the latter part of the first hypothesis, there is a disparity between WTP-Actual Payment (AP) that is contingent on the theory of commitment cost.

4.1.1.1 Internal Perspective

For the effect of internal perspective on the WTP, it will be elaborated in the coming three parts, income, psychological perspective, moral and ethical, which primarily focuses on the effect of individuals' characteristics on WTP. Correspondingly, the external perspective will primarily focus on the features of the studied product or service, such as the debate on the category of good, public or private good, and spatial spillover effect.

4.1.1.1.1 Income

Basically, and conventionally, there is a positive relationship between the income and WTP, as the increase of income, the effect is positive associated as expected. Most works on the study of income effect, the hypothesis is the linear form with the ordinary market goods. Conventionally, it is a financial capacity, the WTP for a personal service or product will increase as the increase of income. Meanwhile, the previous studies, about the effect of income, such as (Sach, Whynes, O'Neill, O'Donoghue, & Archbold, 2004)and (Ethgen et al., 2003), indicating that the higher income and education, the higher willingness to pay for the health care. Similarly, as the continued requirement for the food safety and quality, the traceability and labels have been implemented, and the income, percentage of food structure and price of the food are the primary determinants for the WTP of the certified food (Angulo & Gil, 2007). The income relates positively to WTP for the forest property right and security(Linde-Rahr, 2008), and a premium for hybrids(Erdem, Şentürk, & Şimşek, 2010). Age, educational level, household, after-tax income are correlated with the WTP as the expected(Bostedt, Ericsson, & Kindberg, 2008), and income and age significantly affect WTP in the meta-analysis(Lagerkvist

& Hess, 2010). Besides, the higher propensity to purchase an electric vehicle relates to a higher income, education and a green lifestyle(Hidrue, Parsons, Kempton, & Gardner, 2011b), but it has a new conception of minimum legal willingness(MLW), indicating that it is not the final definite maximum that respondents plan to pay with a 'definitely yes' or 'definitely no', but to what extent the respondent thought the amount is reasonable and willingness to pay, such as 40% or 80%. Higher income and education related with a higher estimation of WTP for the adoption of green electricity, and the attribute of a Veblen effect exists in certain market segments(Zhang & Wu, 2012). Reasonably, the increase of the final electricity price will exhaust the additional capacity of WTP for the electricity from renewable energy sources(Zorić & Hrovatin, 2012). Subsidy is regarded as another form of income, the highly subsidized public transportation, there are the crowding-in and crowding-out effect, and it should highlight the existence of subsidies to generate the crowding-in effect for the WTP of public transportation(Drevs, Tscheulin, Lindenmeier, & Renner, 2014).

Based on the cost-benefit analysis on the healthcare intervention for WTP (Bala et al., 1999), it indicates the fixed income consumer demand curve represent the consumer's maximum willingness to pay for a good, and patient benefits, option benefits and altruistic value are the potential benefits resulted from the healthcare intervention, which are integrated with the income effects. Additionally, income, education and a perception of health status are significant in the WTP for health disorder(Eastaugh, 2000). The lower economic status, the less possible of having the WTP for the insecticide-treated nets(Onwujekwe, Hanson, & Fox-Rushby, 2004). Meanwhile, for the water service, the variables, such as the gender, income, household head's occupation and tenure status, have significant relationship with WTP(Mugabi & Kayaga, 2010). Moreover, products have different elasticity, such as the energy efficient appliance, it has a bigger price elasticity than the normal one(Galarraga, González-Eguino, & Markandya, 2011).

However, there are lots of debate on the conventional conclusions of income effect on the WTP. Initially, for the criticism of WTP, there is a condition that is subject to ability to pay, which represents different weights in proportion to wealth or capacity, a dollar for the rich may not indicate the same utility to the poor, accordingly, the proposal to study it in an equitable society(Gafni & Feder, 1987), it characterized as an emphasis of equity, direct democracy and collective ownership, free distribution, the allocation according to needs. Therefore, under the equitable scenario, comparing to the free public clinic service on the contraceptive measures(Gafni & Feder, 1987), the amount of WTP is higher than the cost, improving the total welfare. Additionally, the amount of WTP is regarded as a substitute of price finding mechanism, but when respondents aware it, there will be a cheating, with an overestimation or underestimation under specific attentional purposes.

Secondly, what has been ignored is the final health effect contingent on the income and corresponding investment between the wealthy and poor, therefore, the WTP to the healthy does not necessarily positively relate with the income and wealth. For the chronic disease, the household income is statistical associate with the WTP(O'Brien & Viramontes, 1994), but other preference variables and health status are not. Simultaneously, the WTP for the longevity, is strongly connected with the quality and quantity of life, and the higher net income increases the predicted WTP, while more education decreases it(Johnson, Desvousges, Ruby, Stieb, & De Civita, 1998). While for the mandatory labeling program of food consumption after the food scandal in USA, wealthier consumers are less likely to pay for the mandatory labeling of country-of-origin(Loureiro & Umberger, 2003). Similarly, the ability to pay is not significantly

related with the WTP in the orthognathic treatment, but the patients have higher WTP than the general public(Smith & Cunningham, 2004). The same to the cataract surgery in Kathmandu(Shrestha et al., 2004), poverty is the primary barrier for the WTP of surgery, and the absence of knowledge also exerts the detrimental effect on the WTP.

Besides, the conventional conception hypothesizes that individuals are risk-averse, and the complement relation between health and consumption in generating utility, meaning the marginal utility of health consumption will not decrease with the increase of health(Liu & Neilson, 2005), specifically, individual health investment will increase as the increase of income, but the private health input will decrease when the private and public health inputs are substitutes. Accordingly, it is a trade-off between the input and out, and the feature of product in what kind of market. Accordingly, effect of income on the WTP is dependent on the substitute or complement relation between the private and public health inputs(Liu & Neilson, 2005), and the private health investment is endogenous due to the strong relationship with its own health condition.

Thirdly, as the budget for the consumers 'behaviors, income elasticity and the environmental pollution, there is a possible existence of an "environmental Kuznets curve"(Hökby & Söderqvist, 2003), as an inverted U shaped relationship between per capita income and industrial pollution, which means that the pollution will increase in the early stage, but with the increased per capita income, it will experience a turning point as the reduction of pollution. However, it is not a full explanation for the relationship. Additionally, the change of technology, behaviors, preferences, etc., are also listed.

Where the environment Kuznets curve demonstrates the relationship between the national income and the pollutants(Jacobsen & Hanley, 2009), indicating that as the economic growth, the pollutant will grow to a certain peaking point, then the pollutant will experience a decline with the continuous increase of income. And the important incentive for the change is the income growth leading to the environmental quality. Additionally, the GDP per capita is a good predictor of WTP as an indicator of income, however, the self-reported income would be inaccurate due to the deliberate misstatement. Furthermore, cconcerning about the income elasticity of WTP for the pollution control, the income elasticity is not constant, but is less than one, which provides a theoretical explanation of the environmental Kuznets curve (Barbier, Czajkowski, & Hanley, 2017). Accordingly, the relationship between the income and the WTP for the environmental protection, it does not always rise with the increase of income, and the empirical evidence indicates that the middle-income class has the strongest WTP for the environmental protection, but more importantly, it is contingent on the degree of environmental pollution that respondents have experienced before(Shuai Shao, Tian, & Fan, 2018). Accordingly, there is an inverted-U shaped relationship between the pollution and income(Lin Lawell, Paudel, & Pandit, 2018), but it has high requirement on the data representing the changes over a long period of times.

Accordingly, as a primary variable of income in the consumers' behavior study, conventionally, it has a positive relationship, gradually, there are lots of challenge on the assessment, then the relation of an inverted U-shaped in the theory of Kuznets curve is raised.

4.1.1.1.2 Psychological perspectives

The WTP is not only affected by the financial capacity, but also the psychological perspectives, additionally, the psychological perspective is also integrated with the past experience,

preference, information dissemination, personal incentives and the perception of public good into the study of WTP, then the literatures on these fields will be discussed for the following contents.

(1) Effect of Perception

Concerning the effect of perception on WTP, it starts from the theory of planned behavior(Ajzen & Fishbein, 1969). Empirical studies in different behavioral domains confirm the correlation among attitude, subjective norms and control beliefs(Ajzen & Fishbein, 1977)(Ajzen & Madden, 1986)Daigle, Hrubes, & Ajzen, 2002), meanwhile, it pointed out that the attitude of the individual to a particular object is reflected a continuing positive or negative evaluation(Fishbein & Ajzen,1975). Besides, poorer perceived health is associated with a higher WTP for the obesity treatment(Narbro & Sjöström, 2000) and the green tariff (Batley et al., 2000); The perception of high quality and security food plays important role in the WTP of organic food(Krystallis & Chryssohoidis, 2005). For the consumers, the higher concerns about the global warming, the more likely to pay a premium for hybrids(Erdem et al., 2010).

Besides, the preference is also subject to the monetary influence and the context, instead of stable and consistent variable(Dale-Olsen, 2006). Risk preference, irreversibility and uncertainty significantly affect the WTP measure(Isik, 2006). Meanwhile, the attitude of community leader has positive effect on the WTP on the bet-nets(Onwujekwe, Hanson, & Fox-Rushby, 2005). Additionally, for a specific service, the self-condition perception is also important in the WTP, such as for the payment of avoiding illness, the better psychological perception of health level, the less amount of WTP(Bandara & Tisdell, 2005). Accordingly, the previous experience affects the perception of the WTP. Similarly, consumers perception and attitude on the modified genetic food are determinant on the WTP(Kimenju & De Groote, 2007), while negative perception for the modified genetic food has a clear detrimental effect on the adoption(Kimenju & De Groote, 2007). The concern for the waste as highly important are more likely to the eco-friendly product, and the effect is diversified across demographic groups(Royne, Levy, & Martinez, 2011).The perceived policy consequence (Li, Jensen, Clark, & Lambert, 2016), subjective perception about household financial, education and environmental values(BUCKLEY, HOWLEY, O'DONOGHUE, & KILGARRIFF, 2016), the perceived effectiveness of a program(Ozdemir, Johnson, & Whittington, 2016), are all important determinants in the study of WTP. But the stability of preference is temporal(Schaafsma, Brouwer, Liekens, & De Nocker, 2014).

Accordingly, with the consideration of perception effect on WTP, to what extent is the new energy vehicles perceived green by the individuals? And how does the perception of NEVs affect the WTP? In the previous literatures, the perception of green new energy in the questionnaires of data collection is stated as the concern about the climate change, air pollution(Batley et al., 2000). But it also find that consumers are not willing to pay more for the recycled plastic of kitchen garbage bags (Anstine, 2000), the possible reason is that the consumers perceive the positive effect will be taken by others, or even cannot detect the positive effect. Similarly, for the reduction of emission, it is perceived as the public duty, instead of an individual task(Menges & Traub, 2009). Meanwhile, the benefits transfer also hinders the WTP for the forest fire protection(Loomis, Le, & Gonzales-Caban, 2005). Accordingly, it is reasonable to study the perception of NEVs as the starting point for the willingness to pay. Meanwhile, the perceived risk from contaminated tap water is regarded as

the primary determinant for the additional cost that willing to pay for the averting from tap water to bottled water(Abrahams, Hubbell, & Jordan, 2000). Similarly, to what extent does the individual perceive the potential risk for the continual popularity of conventional vehicles? Accordingly, for the consumers who perceive the NEVs with an environmental positive spillover, it is a dilemma to account for the additional bearing cost by themselves but sharing the benefits with others.

(2) Past Experience

The past experience will affect individuals' psychological awareness. The study of WTP in the field of public health, it indicates that the amount of WTP to the insurance is positively related with the number of symptoms experience(Thompson, Read, & Liang, 1984), the bad experiences in the past exert the perception and willingness that a patient should take remedy to get rid of it. Meanwhile, the higher of importance of potential threat to the public good, the higher willingness to pay(Kahneman et al., 1993). Besides, poorer perceived health is associated with a higher WTP for the obesity treatment(Narbro & Sjöström, 2000). The WTP for the health care, the better of the past, the less WTP for the health care system(van den Berg, Bleichrodt, & Eeckhoudt, 2005), and vise verse. Patients who actually experienced the healthy problem were willing to pay larger amount (Kerger et al., 2007), increase the WTP for vaccine (Bishai, Brice, Girod, Saleh, & Ehreth, 2007), the better psychological perception of health level, the less amount of WTP(Bandara & Tisdell, 2005), the bad air quality experience with a higher WTP for the good quality(Yu & Abler, 2010), experienced the water shortage increase the WTP of irrigation system(Speelman, Farolfi, Frija, D'Haese, & D'Haese, 2010), which are consistent with the adverse selection phenomenon in the insurance industry where there is a worse condition but with a higher preference to join the insurance coverage. While some researches indicate that individuals unlikely compromise to their past eating habit generally(Hobbs, Sanderson, & Haghiri, 2006). The WTP to cure the chronic disease, it finds that the impairment in the daily living was most strongly associated with WTP(Thompson, 1986), the systematic consideration of personal condition is also important on the study of WTP. Similarly, the personal experience of such kind of risk combining with the higher risk, will lead to higher WTP(Leiter & Pruckner, 2009). Obviously, after the Japanese earthquake and the nuclear disaster, consumers have a negative WTP for the electricity generated by the nuclear(Morita & Managi, 2015). Besides, for the water conservation, older individuals and who has ancestors here are less WTP for it(Groothuis, Cockerill, & Mohr, 2015). Positively, there is a premium price for organic products given that consumers have purchased organic products previously(Sriwaranun, Gan, Lee, & Cohen, 2015).

Individuals' preference for the health risk reduction, it indicates a preference for permanent remediation(Alberini, Tonin, & Turvani, 2007), but the possible daily cost reduction of driving, it is distributed evenly every day when the drivers use it. The age of respondents and past experiences with the offshore wind farms significant affect the WTP(Ladenburg & Dubgaard, 2007). The amount of WTP for the property insurance is marginally higher than actuarially fair value (Hansen, Jacobsen, & Lau, 2016). The past experience of injury severity is positively related with the WTP for road safety improvement(Haddak, Havet, & Lefèvre, 2016). And the WTP for the environmental protection contingent on the degree of environmental pollution that respondents have experienced before(Shuai Shao et al., 2018). Besides, concerning the WTP for the disaster insurance, it is strongly significant related with the past experience of both the insurance and disaster, and the conception of the importance of insurance, the lower income and wealth counties and individuals exhibit lower capacity to afford it, but who are

not necessarily reluctant to accept the natural disaster(Wang et al., 2012). Additionally, when samples under multi-hazard threat show a less WTP due to the expectation of government to tackle the great risk and cover the loss. Accordingly, for the normal condition, the past experiences have great effect on the WTP, particular for some specific contexts, whom bears the cost is embedded in the conception and expectation. Accordingly, for this part of past experience, it is primary about individual's own experience, either good or bad past experience concerning about a specific good or service.

Meanwhile, the interpretation and dissemination for the past information on the WTP will affect the consumers' WTP. In the case of Golden Rice, the mean bids of WTP is highest under the positive information, then followed by the neutral information, namely, no any information(Roosen, Bieberstein, Marette, Blanchemanche, & Vandermoere, 2011), thirdly, the negative information, and the lowest with both positive and negative information, but it also indicates that the positive information is not compelling enough to drastically increase the bids of WTP(Depositario, Nayga, Jr., Wu, & Laude, 2009).In the experiment auction to elicit consumers' WTP, there is no evidence of a premium payment for the green, however, when the bad environmental information is provided to participants, it has a significantly decrease on the conventional polluting one on the WTP(Michaud & Llerena, 2010). Additionally, the form of information dissemination is also important on the psychological perspective, on the comparison between the product video and virtual product experience, it finds that there is a direct positive effect on WTP under the scenario of virtual product experience, where the experience interaction involved in the product shows a higher WTP(Li & Meshkova, 2013). There is an alarmist reaction when the participants have to deal with a conflicting information with both positive and negative ones(De Steur, Buysse, Feng, & Gellynck, 2013). Eco-label exerts a positive incentive to the sale, besides, there is a more favorable perceptual experience for the consumers(Sörqvist et al., 2013), and the same effect happens to the eco-label on seafood(Fonner & Sylvia, 2015). The labeling on the product of consuming beef, it is associated with a consumers' perception of potential risk and food-safety level(Lim, Hu, Maynard, & Goddard, 2014), however, the eco-label does not increase the WTP significantly(Tebbe & von Blanckenburg, 2018).

The positive information is positively related with the estimation of WTP as expected, and the times that delivered is also positive with the estimation(Oparinde et al., 2016). Besides, when more reliable and concrete information provided, the urban citizens will be encouraged to purchase green housing. Consumers' preference and valuation for a specific product is influenced by the asymmetric information problem(Ahn, Bae, & Nayga Jr, 2016). The information disclosure of GM food raises the consumers' WTP(Chen, Liu, & Liu, 2017). Similarly, the information manipulation, leads to the result of two distinct social influence, such as the conformist and payoff-biased transmission(Arce Salazar & Oerlemans, 2016), and a positive information receiver demonstrates a higher premium, with the consideration of information dissemination in the empirical model, it can increase the explanatory power.

4.1.1.1.3 Moral and Ethical Perspectives

The trust, and the credibility on the institution are attributes in the effect of WTP, as the moral and ethical elements, but there is a debate about the effect mechanism, indicating that the moral and ethical elements are endogenous to the law and the common sense in the society.

The lower institutional trust leads to a lower level of WTP for the irrigation system(Speelman et al., 2010), which indicates a potential moral hazard perceived by the consumers. Similarly,

the reduction of emission is regarded as a public obligation, instead of private one, therefore, the belief that others citizens will not contribute to the reduction emission will significantly hamper the WTP(Adaman et al., 2011). Besides, the un-trust of institution will also exert the same detrimental effect. Similarly, the public projects can be hindered due to the distrust toward the government (Oh & Hong, 2012), and experiencing a significant reduction of WTP. The trust level of the certification system is a primary factor affect the disparity between WTP and actual payment(Yu, Gao, & Zeng, 2014). The confidence and trust on government agencies, political leanings were significant explanatory factors(Petrolia, Interis, & Hwang, 2014). Similarly, the trust can lead to a lower self-protecting behavior with a higher WTP, and the positive revealed information is positively related to the trust(Roosen et al., 2015).Lack of trust of government program and fear of corruption, lead to the difference(Shah, Hoag, & Loomis, 2017), and trust in the government has a significant positive role on the WTP for the public goods(Anderson, 2017). The credibility is vital in order to mitigate the risk of consumer deception by self-claimed labels due to the introduction of food safety label in the organic food market(Wongprawmas & Canavari, 2017).

Another one is the public duty. Both altruistic and egoistic may affect the stated WTP and the framing may affect the relative contribution(Guagnano, Dietz, & Stern, 1994), but it is difficult to control the experiment due to the subject misconceptions and preferences. For the reduction of emission, it is perceived as the public duty, instead of an individual task(Menges & Traub, 2009), accordingly, individuals do not have the willingness to pay privately, but the benefits would be shared with public. Conversely, for the WTP to avoid the violent crime, the estimation of WTP is underestimated due to the expectation of duty of government(Bishop & Murphy, 2011). Meanwhile, stated WTP was poorly connected to attitudes of payment scheme and other abstract beliefs and values(Sauer & Fischer, 2010). But for the label of energy star as an indicator of energy saving, it provides both the private benefit, such as the energy cost saving, and the public benefits, such as the good environment, are correlated to the estimation of WTP(Ward, Clark, Jensen, Yen, & Russell, 2011). Accordingly, for the effect of public environmental benefits, it has different conclusions concerning diversified samples. Which is consistent with the conclusion that there is a higher WTP in the collective payment mechanism than the one in a voluntary payment mechanism(Wiser, 2007). More important, the responses of contingent valuation are strongly correlated with the expectation of others, indicating that whom and how individuals bear the final cost and benefit affect the perception and behaviors.

The decision process and attitude formation are affected by the ethical and moral (Ojea & Loureiro, 2007), in order to avoid the feeling of guilt, it indicates the overestimation by the stated belief, but there is no evidence supporting that the observable players' social-economic attributes are related to the WTP(Bellemare, Sebald, & Strobel, 2011). Meanwhile, implicit and explicit motives drive the individual's behaviors, and time pressure and cognitive load to disentangle the motives, and it indicates that increasing cognitive load would reduce the consumption of organic food, but tine pressure doesn't have such effect(Yu, Yan, & Gao, 2014). And the moral and ethical requirements exert burden on the cognitive load. Furthermore, personal attitude, experience of environmental center are correlated with the WTP in the external tariff of green electricity(Batley, Fleming, & Urwin, 2000). While for the pollution abatement, the perception and belief toward the potential entities, government or individuals, bearing the responsibility is important for the WTP, and the household income is significant related to the belief(Jorgensen & Syme, 2000). Similarly, education and public awareness are the most important factors for the solid waste management(Koushki, Al-Humoud, & Al-Duaij,

2004). Meanwhile, the mount of respondents' WTP for a specie conservation is not straightforward related with the potential economic value, due to the possible incorporation of legitimate attitude(Bandara & Tisdell, 2005).

Additionally, the personal inner incentive will be also intertwined with the moral and ethical perspective, such as the external physical inventive. The personal design to control the weight is most likely to pay the greatest amount for the weight-reduction therapy, indicating the importance of personal inner design on the WTP(Fu, Lin, & Huang, 2011). Besides, individuals with a self-transcendence value orientation have a higher WTP than those with a self-enhancement value orientation(Hansla, 2011). Additionally, the psychological perspective also refers to the implication of certain physical material, such as the official document granted for individuals who have the reduction of emission, will add value for individuals to offset the emission, and that is regarded as a symbol of recognition that individuals are made fully aware of them(MacKerron, Egerton, Gaskell, Parpia, & Mourato, 2009). And there is empirical evidence indicating that the WTP with the certificate is higher than the one without the official one for the reduction of emission(De Magistris, Del Giudice, & Verneau, 2015), demonstrating the importance internal incentive and external physical incentive for the moral perspective.

Accordingly, the moral and ethical perspectives, it primarily covers the mutual trust and credibility, the recognition of public duty, but these attributes in the formation of moral and ethical perspective are also intertwined with personal inner incentives.

4.1.1.2 External Perspective

Concerning about the external perspective about attributes of studied products or service on the WTP, it is diversified, including the potential benefits and costs as the introduction of the studies product, and the attribute itself, but the difference is primary contingent on the category of the studied product, generally, it is divided into public and private goods.

(1) Public good or private good

Initially, there are some products or services would be perceived as public goods by individuals, with the psychological perception that the public should bear the cost, instead of simply private individual. The WTP to change the transport noises, is not associated with the income(Nellthorp, Bristow, & Day, 2007), but is the transport noise a public or private good? There is no answer in its study. Apparently, the specific studied object has its own attributes, which will affect individuals' perception on its obligations and responsibilities. More importantly, whom should bear the obligation in the practice to mitigate the detrimental effect? Accordingly, a social acceptable fee should be introduced to avoid the free-ride in the service of solid waste collection(Banga, Lokina, & Mkenda, 2011). While for the lung cancer, patients would be like to pay less than the actual cost of the new medication(Lang, 2010), with the implication that individuals thought the government should bear or share the cost when it is a serious disease, perceiving that the prevention of chronical disease should be taken as public service by the government. For the public good and the benefits shared by the public, individuals tend to overestimate others' WTP for the specific good(Frederick, 2011), which is also a behavioral phenomenon of false consensus effect and endowment effect. However, beyond the climate change mitigation, the introduction of community benefits from the carbon farming can increase the WTP, therefore, the positive values of a co-benefit shared by the community is positive for the estimation, comparing to the previous study about the public cost, it indicates a converse effect on individuals' perception and behaviors.

Besides, the external perspective focuses on the product's treatment effect, including the potential cost and benefits. For the analysis of assisted reproductive techniques(ARTs), the technique of WTP enables to evaluate the ARTs, but its reliability and validity should be continually discussed as the fact that basically the service is provided to the childless families, and it ignores the majority users for this service(Ryan, 1996). Which is the same to the study of antenatal care(Ryan, Ratcliffe, & Tucker, 1997), to address methodological issues. More studies, such as urge incontinence(Johannesson, Conor, Kobelt-Nguyen, & Mattiasson, 1997), WTP is significantly related to the reduction of micturition, namely, the treatment effect; cancer supportive care(Dranitsaris, 1997). For the benefits, the energy-saving residential buildings, including the individual energy saving and environmental benefits, are significantly valued by the consumers(Banfi, Farsi, Filippini, & Jakob, 2008). Besides, brands, categories and locations, as the attribute of the product itself, it indicates a similar brand value among different products. Besides, from the controlled experiment for both high and low quality cell phone, the advertisement could influence the awareness of perceived quality and the WTP(Tsui, 2012). The cross-price has a prominent effect on the WTP and neighbourhood price effect is also significant (Shi, Gao, & Chen, 2014).Environmental soundness is the determining factor for the purchase of wine with sustainable characteristics (Schäufele & Hamm, 2017).

Additionally, concerning products' attributes, the attributes on the product itself, the colored of photographs presented in the survey increase the amount of WTP(Labao, Francisco, Harder, & Santos, 2008), the visual presentation enhances the evaluability, minimizes the errors in the judgement and perception, which is similar to the effect of label information on consumers' WTP for food(Gao & Schroeder, 2009). For the study of protection of national conservation, all thing are identical except for the color of photographs presented in the survey, and increase the amount of WTP(Labao et al., 2008). The duration of the outrage in the power statistically significant to the WTP of avoiding the power outrage(Carlsson & Martinsson, 2008). And the timing is also every important for the amount of WTP in the reduction of mortality risk, the delaying of time from 10 to 30 years reduces WTP by more than 60% in both the samples of aged 40-60 years(Alberini, Cropper, Krupnick, & Simon, 2006) for the payment of life quality. Moreover, for the promotion of clean energy, the attribute in the study consists of the energy security, which is important to the economic performance and social welfare, otherwise, the disruption of energy supply would exert a disaster on the economic. Empirically, in order to internalize the external cost due to the energy security, air pollution caused by the production of electricity, consumers are willing to pay a higher price for it(Longo, Markandya, & Petrucci, 2008). and the perceived hurricane protection is the primary factor for the further restoration support(Petrolia & Kim, 2009), so the psychological attributes are important in the decision of WTP.

(2) Spatial Spillover Effect

For the empirical study, the spatial Difference-in-Difference(SPID), is deployed to study the spatial spillover effect(Hökby & Söderqvist, 2003), which is regarded as an external attributes in the mechanism of WTP. Large gains in accuracy can be realized by moving to a more flexible framework of spatial fixed effects for housing market adjustment(Kuminoff, Parmeter, & Pope, 2010). And spatial links between observations, such as the impact of public mass transit systems on the value of real-estate(Dubé, Legros, Thériault, & Des Rosiers, 2014), which indicates an inverse "U" shape between the house price and the distance from the train station. Similarly, the concern about the adverse effect between the large-scale wind farms and property price, the study indicates a 9-14% decrease of property price due to the construction

of wind turbine(Sunak & Madlener, 2016), however, there is no statistically significant negative effect on the house prices(Lang, Opaluch, & Sfinarolakis, 2014). Apparently, the approaches of quasi-experimental and spatial difference-in-difference are deployed.

Meanwhile, due to the correlations over cross-time and section, the high order spatial lags and time lags are proposed to estimate in the quasi maximum likelihood method and the regression model for cross-sectional data(Li, 2017).The spatial spillover effect exists, for the biodiversity conservation and enhancement, the distance from the larger planted forests influences the estimation of WTP(Yao et al., 2014). Element relating to the product, the WTP strongly positively depends on the duration of power outages, particular higher for the unplanned outrage, but the effect of observed social-economic variables is smaller compared to the pure effects of power outages, this is possible as the fact of studied product of household electricity that is a public necessary good for all citizens, so the diversified social-economic variables are not significant to it. Therefore, there is a spatial effect on individuals' perception and behaviors.

Reasonably, what effect would the distance from the charging station have on the individuals' adoption of NEVs? How does the individual perceive the control factor of charging feasibility? Given that the targeted behavior has happened, conversely, what effect does it have on the perception and adoption of NEVs?

Accordingly, for this part of literature framework, it consists of two parts, internal and external perspectives, where the internal one primarily refers to attributes of individuals as consumers, including income, the psychological, the moral and ethical perspective. While the external one refers to the factors about the products attributes, including the debate on whether a public or private good, and the effect of spatial spillover. But the previous part of literature is only on the WTP, with the challenge raised on the validity of WTP, what is the disparity between WTP-AP? What is the mechanism behind the disparity? Therefore, the next part will focus on the validity of WTP with the introduction of commitment cost to study the disparity between the WTP and actual payment.

4.1.2 Disparity between WTP/WTA/AP

4.1.2.1 Introduction of WTP/WTA/AP

Gradually, there is a debate on the validity of WTP after lots of works deploy the WTP as a granted methodology in their study, accordingly, what is the disparity between the WTP-Actual payment? And what function mechanism does it exist behind the disparity? However, for the existing study of disparity, it primarily focuses on the hypothetical perspective between willingness-to-pay (WTP) for a good and willingness-to-accept (WTA) for a compensation, namely, the discrepancy between WTP-WTA, but both of the two terms are still hypothetical variables, and less works fall on the disparity between WTP-AP.

In the previous works, WTP and WTA, they are both measures of welfare change. The maximum amount stated willing to pay for a good or service (WTP), the minimum amount stated for the compensation that the specific good or service is removed (WTA), namely, compensation demanded or willingness to sell, but it is still hypothetical. Previous experiments indicates the value of WTA is 3-5 times of WTP(Horowitz & McConnell, 2000), and the WTA is 2 times of WTP for a movie ticket (Adamowicz, Bhardwaj, & Macnab, 1993), which only raised a hypothetical scenario for challenging the validity of WTP, and comparing the difference between WTP-WTA. Gains and loss are often treated asymmetrically, and a compensation for

a loss is larger than the amount for an equivalent gain, due to the psychological preference that values more weight on the loss than the gain. But the responses to survey questions could be regarded as another source of bias for the disparity of WTP-WTA(Guria, Leung, Jones-Lee, & Loomes, 2005).

Accordingly, the disparity between WTP/WTA could refer to the phenomenon that respondents attach higher value to the objects they own(WTA) than objects they do not own(Fehr, Hakimov, & Kübler, 2015), concerning the data collecting from the experiment, the misconception also could generate the bias, therefore, the extensive training and rounds of practice can reduce the misconceptions and disparity between the two indicators. But more importantly, there is no evidence to support that the subject misconception is the primary source of the WTP-WTA gap.

While for the actual payment, it is similar to a conversely transaction process of WTA, where the WTA is the minimum amount of cash with the willingness to accept to compensate the remove of a property that owned by itself, but the actual payment is the maximum amount to pay for the exchange of the property of the product. Accordingly, both actual payment and WTA have two properties involved in the process, while the exchange logic is converse. Furthermore, researches focus on the disparity between WTP-WTA, are these conclusions also applied to the gap between WTP-AP? What is the mechanism behind the disparity between WTP-AP?

4.1.2.2 Mechanism on the Disparity WTP/WTA

There are diversified definitions and explanations for the gap of WTP-WTA, substitution effect and endowment effect are the two primary perspectives.

Initially, on the endowment effect, under the sufficiently smooth preferences and absence of wealth effect, indicating that the disparity between the minimum amount that willing to sell and the maximum amount that willing to buy, which is denoted as the endowment effect or prospect theory(Plott & Zeiler, 2005). The loss aversion explains the disparity, namely, the overvalue of the losses and undervalue the gain(Coursey, Hovis, & Schulze, 1987), the disparity should be closed to zero when the value of the good accounting for a very small part of the income, but numerous laboratory experiments and empirical studies do not support it, basically, the studies indicate that WTA is usually larger than the WTP. One assumption for this result is the aversion to loss, namely, the mentality accounting, referring to individuals that value losses much more than the commensurate gains, in the individuals' mindset, WTA is a value of compensation for the loss while WTP is a payment for gaining a good, thus, the WTA is greater than the WTP. Furthermore, the information cost is the one of the elements affecting the endowment, when information cost increases, the disparity between WTP and WTA widens(Kolstad & Guzman, 1999), however, the hypothesis is given that individuals do know the true value of a good, but with the willingness to expend the money or effort to learn the valuation.

Meanwhile, on the substitution effect, Previously, the study attempted to test the element affecting the disparity, such as (Hanemann, 1991),indicating that not only the income effect, but also the substitutability between the goods being valued and the alternative goods in the utility function, namely, the lower substitutability, the higher level of disparity. The lower of the substitution elasticity, the larger the ratio of WTA/WTP(Horowitz & McConnell, 2000), which is intuitive, the disparity between WTA and WTP will be small when there are lots of

substitutes in the market. But based on the previous studies, the difficulty falls on the goods studied are not available in markets, only rely on the hypothetic perspective. In term of economic theory, the disparity should be smaller than the empirical one. The study focuses on the effect of a substitute, which is reduces the disparity between the WTP and WTA(Adamowicz et al., 1993), in its experiment, the availability of the movie in videocassette is regarded as a good substitution for seeing a movie in the theater. When study the WTP in a specific research object, the potential close substitute is an important factor affecting the evaluation. Contingent on the substitutes, it is more discriminating in the evaluation of WTP(Donaldson, Shackley, & Abdalla, 1997). Therefore, the basic and common recognition in a bidding context, the availability of complements and substitutes affect the consumers' WTP for a good, therefore, in a bidding context, implying that the presence of complements would increase the bid price for a good, however, the substitutes would decrease it.

The disparity of WTP/WTA is largely due to the reference dependence effect relating to costs, and due to the interactive effect, the reference dependence are not consistent with the previous conclusion (Viscusi & Huber, 2012), the disparity is also correlated with the loss aversion(Merkle, Schreiber, & Weber, 2017), namely, the uncertainty about the value of the studied objects.

Furthermore, the integration of both substitution and endowment effect plays an important role in the estimation of WTP and WTA. For both of endowment effect and substitution effect(Thampapillai, 2000), the derivation of demand curves is illustrated by integrating the framework of substitution effect, a budget constrain and utility maximization. The disparity of WTP/WTA in terms of the freight transport, the explanatory variables, such as the transit time, delays in the delivery time and service frequency, are essential to define the service(Feo-Valero, Arencibia, & Román, 2016), initially, these are the variables indicting the endowment effect, additionally, the level of endowment effect indicates the capacity in the market, then concerning the substitute effect.

Additionally, for the empirical work on the WTP of drug addiction treatment, the individuals' attributes, such as income, age and others personal attributes have significant effect on both WTP and WTA as anticipated, but the wage rate is correlated significant with neither WTP nor WTA(Borisova & Goodman, 2003), and the possible explanation is the trip cost constituting the largest component in individuals' total treatment cost. Additionally, a rational fee for preventive measures is willingness to pay but without correlation with the income(Wiesemann, Mueller-Buehl, Scheidt, Boehme, & Scheuermann, 2004), while it also indicates the disparity is a function of income elasticity of demand(Amiran & Hagen, 2003).

Furthermore, the integration of substitution effect and income effect affect the welfare measure for the public goods, and it is possible the substitution effect has a greater influence on the disparity than income effect(Hanemann, 1991). Additionally, the larger discrepancy in the empirical studies may not due to the design of data collection, it could be the perception that private-market goods are not regarded as a perfect substitution for the public goods.

When it is a real market, the income effect will definitely be considered (Horowitz & McConnell, 2000). With the increase of income, the consumption will increase for some products, while some products will experience the decline, which is contingent on the goods' characteristics. Besides, some works try to find the substitution of the actual payment in the study, such as the revealed preference, which provides a meaningful link to the real market(Hensher, 2010), but it still falls on the extent of hypothetical perspective.

Combination with the emotion and morality, individuals' maximum WTP for owning a good, is substantially smaller than the minimum willingness to accept not having it, but when there is no misconception, and the discrepancy can be largely explained by the moral and emotion perception(Biel, Johansson-Stenman, & Nilsson, 2011). Accordingly, for this part, it primarily focuses on the substitution effect, income effect, endowment effect, and the mutual relationship among each other.

4.1.2.3 Commitment Cost for the Disparity of WTP/AP

Until now, there is no any theory to elaborate the disparity between the WTP/AP, some works are on the divergence between the stated and actual WTP, but the actual WTP is still a hypothetical conception(Onwujekwe et al., 2005), only with the consideration of methodology how to close to the real WTP and actual payment in the data collection, rather than the actual payment itself. The process of making a decision for the WTP and AP, the former is commonly assumed the condition of decision making is static and certainty, while the latter in the practice is usually in a dynamic setting under the scenario of uncertainty and continuously information dissemination and learning.

Naturally, what is disparity between WTP-AP? What mechanism does exist behind the disparity? The basic theoretical framework will contingent on the work of 'commitment cost' (Zhao & Kling, 2001), previously, which was proposed by (Zhao & Kling, 2001; Kling, List, & Zhao, 2013) for the explanation of the disparity between WTP/WTA, where the uncertainty, limited learning opportunities and irreversibility generate the commitment cost, referring to the difference between the WTP and the expected value of a good. And the commitment cost is deployed to study the transition from a willingness to a purchase decision, where individuals will delay the purchase decision to collect more information as commitment cost increases(Corrigan, Kling, & Zhao, 2008). Meanwhile, it provides an explanation for the guidance in the design of experiment and surveys, therefore, the challenge on the data's validity will arise due to the restriction of timing and the opportunity to gather the relevant information. Therefore, it will be regarded as a basic framework to explore the disparity between the WTP/AP in my study. Besides, the study not only focus on the monetary amount of estimation, but more importantly, before the monetary amount of product, which category individuals will choose is a priority question and the change for the choice made in the WTP/AP.

(1) Uncertainty of Value

The uncertainty refers to the monetary valuation of a good, risk perception increases the discrepancy between WTA-WTP estimation, while the benefits perception decreases it, and the role of risk perception in explaining the discrepancy is contingent on the predicted loss aversion(Kling, List, & Zhao, 2013). A dynamic theory is introduced in the context that the value at different time differs, with the conception of market uncertainty, in the dynamic theory, it is also a process of learning, with the interpretation of different information.

Conventionally, how does the uncertainty affect the WTP? Previously, in terms of the observed divergence between WTP/WTA, it will decrease due to the less uncertainty on the good's value, less information gathered, more impatient, easier revising the previous transaction and the flexibility on timing of purchasing(Zhao & Kling, 2001). Normally, what is an indicator for the assessment of risk? As sample, the marginal WTP(MWTP) was termed to study the reduction of risk(Andersson, 2008). And the WTP for the long-term care insurance, the adoption is driven by the perception of the health and the risk conditional on the survival, instead of the

suitability of the insurance for them(Costa-Font & Font, 2009). Therefore, this is a sample demonstrating that the importance of perception of own health condition, to a large extent, which is an indicator of risk and uncertainty. Probability weighting strongly affects WTP estimates and results in an unstable monetary valuation(Bleichrodt & Eeckhoudt, 2006).

Additionally, the empirical study, such as the phenomenon of disaster aversion, indicating that individuals concentrate on the conditional loss from a specific disaster, instead of a probability(Hu, 2006), individuals pay more attention on the loss in term of uncertainty. The WTP will increase with the increase of magnitude of risk prevention(Leiter & Pruckner, 2009), the subjects' WTP will increase when less information is available about the value of a good. The consideration of risk is the central issue for the adoption of energy efficiency facilities in the building, and the risk-aversion as a determinant element for the consumers' behavior for the unfamiliar products(Farsi, 2010),meanwhile, the substitution effect is not constant, otherwise, it will give rise to misleading estimation of WTP. The WTP for the cancer prevention, the income and the probability of developing cancer are positively related with amount of WTP, indicating that the higher probability relates with a higher WTP(Milligan, Bohara, & Pagán, 2010). Besides, there is a higher WTP for the prescription cost for the disease prevention with a higher perceived risk(Basu, 2013). But there are exceptions, such as the assessment of risk of death, individuals will overinvest in the reduction of risk and discount the cost by the probability of death, but the consideration of discounting the cost for the reduction of risk and the benefit of the wealth that remains after the death, are socially inefficient(Porat & Tabbach, 2011). The trust level of the certification system is a primary factor affect the disparity between WTP and actual payment(Yu, Gao, et al., 2014).

Empirically, the experiments on endowment effects, induced-value tokens are conducted in it, which can be cashed at a predetermined price at the end of the experiment, therefore, there is no uncertainty in the value of tokens, and the products in the experiment, such as the university coffee mugs, pens, that are all available in the university bookstores, combing the accessible products and could-be-cashed tokens in the experiment, it finds that there is no WTP/WTA divergence due to no uncertainty about the token's value, the commitment cost is zero. Besides, when the token is not cashed at a predetermined amount, such as contingent on a lottery of cash transfer, then the divergence will increase(Kahneman, Knetsch, & Thaler, 1990). This experiment is primary on the uncertainty of the value, no mater of the tokens and the category of products, but if the uncertainty is on the attributes of the product itself, such as the uncertainty of charging system for the NEVs, the uncertain of driving range, definitely, which will affect the endowment effect for consumers, but how does it affect the disparity between the WTP/AP?

(2) Learning Opportunities

In a real purchase, consumers may not able to acquire all the information, who will either take the risk or delay the consumption until they get enough information.

Initially, when less information about a good could be gathered, the subject WTP will increase. While for an actual payment, it is a dynamic process with the interpretation of continuous information. Besides, with many available substitutes and income effect, the study on the disparity of WTA/WTP is roughly equivalent, indicating the theory of commitment cost and a behavioral anomaly lead insight into the disparity and the causes, and there is no value disparity for participants with sufficient market experience(Kling et al., 2013), indicating the learning in the market can reduce the disparity and misconception. However, it finds little

difference between inexperienced and experienced buyers(Parcell, Franken, Cox, Patterson, & Randle, 2010). Similarly, the deliberation does not increase the amount of WTP in the mitigation of carbon dioxide, (Dietz, Stern, & Dan, 2009), the deliberation is formed in a group discussion, intending to understand the hypothetical good better, there is no correlation found between the stated WTP and precautionary behavior(Svensson, 2009).

And the data collected from the field survey about the times participating in the lottery or bidding in the vehicles plate market, which covers the perspectives concerning the commitment cost, uncertainty, learning in the process, but no reversibility. Every month, participants can choose one of the way to get kind of the vehicles plate in Shenzhen, each choice has different probability referring to the uncertainty; besides, participant can get the experience and lessons in the process of bidding or lottery, namely, a learning opportunity, additionally, after the specific date, participants cannot revise the choices have made within one month, but over different periods of months, they could have different choice in each month, namely, reversibility over different months. But the difference falls on the categories of choices, such as bidding for the conventional, lottery for the conventional, and lottery for the NEVs. However, for the commitment cost, the final answer falls on the amount of estimation, and with the increase of repeated times, the disparity has an attenuating trendy(Zhao & Kling, 2001), but with the hypothesis of zero learning cost.

(3) Degree of Irreversibility

And there is an increase of WTP given the condition that the reversibility is related to some extent by allowing individuals to return the undesirable goods. The reversal/delay perceptions provide a symmetric experience, which is consistent with the empirical study of attenuating disparity with the increase of market repetition(Kling et al., 2013). The disparity exists here, despite of the absence of endowment effect due to the intention of purchasing for re-sale; furthermore, in the conclusion, the WTP and WTA will increase as the increase of the difficulty on the reversibility and delay. And there is a dynamic evaluation process. And the higher possibility of irreversibility, the higher amount of WTP, both applicable for different scenarios in the experiment and control group, and payment vehicles, either a fixed amount or a lottery auction, namely, when the requirement of irreversibility is relaxed by allowing to return the undesirable goods, it will increase.

Additionally, when the consumer is unsure the value of the good, and there is no probability to revise the initial purchase decision or the change would be imposed high cost, individuals prefer to delay it until the enough information provided. However, there are problems in the experiment, the return of the purchased product is not rigorous reversibility in terms of the absence of cognitive effort to the decision made previously.

Accordingly, the three elements, uncertainty of monetary value, the learning opportunity, reversibility, consist of the theory of commitment cost to study the disparity. But previously, due to the only two terms of WTP and WTA, so it focuses on the disparity between WTP-WTA, but both WTP and WTA are still hypothetical version, and the AP is introduced, so the theory of commitment cost is deployed to study the disparity between WTP-AP.

4.1.3 Measuring and Methodologies

4.1.3.1 Introduction

A number of approaches have been deployed in the measuring of WTP, but the primary

methodology is the contingent valuation, as a hypothetical market method, to measure the object that lack of price in the market, such as the nonmarket value of a good, the environmental protection, drugg therapy, it is also kind of stated preferences techniques.

For the format, it includes the closed-ended, asking respondents whether they would pay for a specific commodity with a binary answer, namely, yes or no. it is also named dichotomous choice that is similar to a sealed bid auction, a binary answer(yes/no) based on the description, then contingent on the previous answer, there are lots of following questions. Where the open-ended means respondents indicate the maximum amount to receipt a commodity directly, it will ask the respondents to state the maximum amount they will to pay for the good, while in the closed-ended questions, a limited set of choices will be regarded as the alternative to choose one of them as the most favorited preference. Among them, the format of closed-ended generates significantly higher valuation than open-ended format in a relatively controlled context (Frew, Whynes, & Wolstenholme, 2003). But the binary closed-ended WTP is more close to the real market situation(Slothuus, Larsen, & Junker, 2018), meanwhile, it is more conservative in comparison with the opened-ended format.

The weakness for the opened-ended format, it would yield an ill-considered value and a low response rate. Conversely, given an indicating range, the values would be more comprehensible to the studied subject, but the indicating range would be regarded as the valid interval. And closed-ended is generally accepted to generate less uncertainty than the open-ended questions, but it supplies a limited quantity of alternatives, giving rise to the difficulty in the estimation of WTP's distribution and the endogeneity in the following questions in the survey. Meanwhile, the price in the first bidding offer set by the organizer maybe wrong and misguiding for the respondents, and it can reduce the possibility of very high or very low bids in the open-ended questions, therefore, it could distort the real value of the good as the object in the study, particularly for the public goods. Although some researchers have added a follow-up question about the extent that individuals assure the choice they made in the previous one(Norwood, Luter, & Massey, 2005). The private goods with active marketable transaction, the market will generate value by itself, and different respondents with diversified characteristics could result in different capacity and willingness for the WTP. But which one is the better in the empirical study? There is no enough sample to conclude that, due to the papers on the topic of WTP have been published only rely on one method to elicit values, instead of the comparison between two formats.

Meanwhile, comparison from the field work, due to the perceived inventive, anchoring and yea-saying, familiarity of payment procedures, the dichotomous choice consistently resulted in significantly larger estimate than open-ended for the public good(Frykblom & Shogren, 2000). Additionally, the hypothetical method is difficult to provide respondents with the necessary incentives to answer truthfully. Besides, for the approach to measure the hypothetical bias generated due to the method itself, a voting decision of a closely similar real-world is introduced, requiring a conduct of a stated preference survey before an actual referendum and comparing the stated preference and actual choice(Bengochea-Morancho, Fuertes-Eugenio, & del Saz-Salazar, 2005). In term of method, it is similar to the difference-in-difference, collecting the data over different timetables.

More importantly, the different scenarios between the laboratory and the real market, and the kind of product used in the laboratory affects the decision, due to the fact that consumers basically do not purchase a product in an experiment or in a laboratory, therefore, the

participants in the experiment, who can wait for a suitable moment to purchase it in a real market. In sum, there are two distinctive features compared between the experiment and survey with the real market, firstly, it is about the limited time and learning, actually, individuals may take time to gather information before the final decision, but they have to make a decision over a short period of survey or laboratory. Accordingly, these method of data collection potentially increase the commitment cost and the disparity between the WTP/WTA(Zhao & Kling, 2001).

Therefore, what is the common methodology in the study of WTP, which is presented in the following table, it is diversified, such as contingent valuation, conjoint analysis, cost-benefit analysis, discrete choice experiment. Meanwhile, for the specific ways to collect the data, there are dichotomous choice contingent valuation, open-ended and the combination of both the previous two. Each way has its own merits and demerits, there are different combination to avoid the demerit in terms of experiment design and data collection.

Table 18 Measures and methodologies for the study of willingness to pay

Methodologies	Ways	Literature	Conclusions
Contingent valuation	Select a random "product scenario", record the willingness and unwillingness for the purchasing	(Cameron & James, 1987)	Marginal mean WTP is 23.4$
Contingent valuation	For the adoption of vaccination, comparison group in Sweden.	(Thorburn, Carpenter, & Plant, 1987)	WTP is positively correlated with the mortality rate, but the correlation emerged a decreased.
Test-retest reliability	Cost-benefit analysis	(O'Brien & Viramontes, 1994)	A reliable measure for the health state preference
Contingent valuation	Waste management, and the respondents are familiar with the information, to a larger extent, avoiding the common problems of contingent valuation	(Lake, Bateman, & Parfitt, 1996)	Socio-economic factors are important in the decision of participating of waste management scheme.
Choice contingent valuation	Closed-ended willingness to pay on the assisted reproductive techniques	(Ryan, 1997)	Further work on the reliability and validity of the methodology
Dichotomous choice contingent valuation	Experiment between the hypothetical dichotomous choice and hypothetical open-ended question	(Frykblom, 1997)	Best approximates a real WTP
Contingent valuation	Benefit-cost analysis for municipal solid waste	(Tiller, Jakus, & Park, 1997)	Operational cost is less than the amount of WTP.
Paired comparison, a binary choice between a specific amount of cash and a good	A wildlife art print as the hypothetic good, it provides a closer magnitude between WTA-WTP.	(Loomis, et al,1998)	Firstly, it can provide considerable numbers of good for the respondent, instead of one good in the contingent valuation basically, additionally, it provides repeated and randomized bid amounts.
Dichotomous choice contingent valuation	Incorporating respondent uncertainty for the protection of threatened fish	(Ekstrand & Loomis, 1998)	The incorporation of respondent uncertainty contributes to the increase of goodness of fit and decrease of standard error.
Conjoint analysis	Healthcare technologies within the cost-benefit analysis	(Ratcliffe, 2000)	The validity of indirect method has been demonstrated, but there is no sensitivity of WTP.
Cost-benefit analysis	Health care intervention	(Bala et al., 1999)	Fixed income consumer demand curve represents the consumer's maximum WTP for a good.
Cost-benefit analysis	The WTP of the cancer and the unpleasant adverse effect of treatment.	(Dranitsaris, Elia-Pacitti, & Cottrell, 2004)	One of the remedies is preferred to another one, it could be regarded as the substitute for each other.
Discrete-choice	The health outcome for the hip and knee osteoarthritis.	(Ethgen et al., 2003)	Higher income and education for the higher willingness to pay.
Contingent valuation	Mothers' WTP to protect themselves and children from suffering an illness	(Liu, Hammitt, Wang, & Liu, 2000)	The WTP for the child is twice as it for the mother to prevent the comparable illnesses. The weaker of the subject, the

			higher WTP.
Contingent valuation	Willingness to pay for improved air quality in Sweden	(Carlsson & Johansson-Stenman, 2000)	WTP was increasing with the higher income, wealth and education, and larger for men.
Contingent valuation with opened-ended questions	The WTP for the obesity problem	(Narbro & Sjöström, 2000)	Poorer perceived health and higher weigh are associated higher WTP.
CV, cost-benefit analysis and elasticity analysis	WTP for the environmental services in Sweden	(Hökby & Söderqvist, 2003)	Effect of income on the WTP is positive and significant.
Contingent valuation with 2 rounds of interviewing for the mosquito nets.	First round with a bidding format of an open-ended question for the hypothetical WTP, while second round asking them the actual willingness to buy it with the cost of Rs75(the modal in the first round)	(Bhatia & Fox-Rushby, 2003)	There is no disparity between the two groups, namely, hypothetical and actual WTP. Although it studies the discrepancy, it is still subject to the behavior before the actual payment.
Face-to-face semi-structured interviews	Pediatric cochlear implantation	(Sach, 2004)	Substantial cost with the WTP for the implantation, and positively related with the income as expected.
Mathematical derivation and empirical comparison	A comparison of empirical models on contingent valuation	(Bengochea-Morancho et al., 2005)	he estimator of WTP is very sensitive to the empirical context.
Contingent valuation email survey	Livestock manure of animal waste	(Norwood et al., 2005)	Manure willingness to pay for the livestock, and it is left-skewed distribution.
CV, stated and revealed behaviour	A water quality improvement	(Whitehead, 2005)	The possible problem of endogenous variable in the contingent valuation.
Choice experiment	WTP for reducing the visual dismantles of the offshore wind power	(Ladenburg & Dubgaard, 2007)	The age of respondents and experiences with the offshore wind farms significant affect the WTP.
Discrete choice experiment	WTP for the diagnose of diabetes	(Shih et al., 2007)	The degree of diabetes is independent to the amount of WTP.
Contingent valuation and conjoint analysis	Farmers' WTP for the rice seed related information	(Horna, Smale, & Oppen, 2007)	Attach the importance to variables, such as cross-price, quality, income
Contingent valuation	WTP for the drug abuse treatment	(Tang, Liu, Chang, & Chang, 2007)	Monetary valuation of drug abuse treatment. And the sequence and payment vehicles affect the amount of WTP.
Discrete choice experiment	A stochastic treatment of attribute processing for the WTP of stated choice.	(Hensher, Rose, & Bertoia, 2007)	Noticeable variation in the mean and standard deviation of WTP.
conjoint analysis and open-ended contingent valuation	WTP for eco-labelled wood furniture	(Veisten, 2007)	CV is a simpler method for obtaining quick preference, although it provides less information than CA.
Conjoint choice analysis	WTP for water service improvements	(Snowball, Willis, & Jeurissen, 2008)	Water service is kind of public good, and it is statistically significant with interruptions to

			supply and price.
Contingent valuation	Consumer WTP for genetically modified food	(Kimenju & De Groote, 2007)	Multi-bounded choices lead to an unbiased approach
Discrete choice experiment	Willingness to accept versus willingness to pay in a discrete choice experiment on hearing aid provision.	(Grutters et al., 2008)	WTA exceeds WTP, and cost coefficient was significantly higher in the WTP format. But it doesn't find an endowment effect.
Discrete choice experiment	effect of preference heterogeneity on WTP for improving service quality in an airline choice context	(Espino, Martín, & Román, 2008)	Individuals' benefits measures are sensitive to the preference heterogeneity assumption.
CV with double-bounded dichotomous choice	the flu symptoms, who may better answer the willingness-to-pay question	(Schwarzinger, Carrat, & Luchini, 2009)	Double-bounded dichotomous choice increases the statistical efficiency than single-bounded.
Discrete choice experiment	WTP for renewable energy, households for micro-generation technologies	(Scarpa & Willis, 2010)	Household value the importance of renewable energy, but the amount is not so significant.
Contingent valuation	WTP for the disease prevention	(Basu, 2013)	a higher WTP for the prescription cost for the disease prevention with a higher perceived risk.
double-bounded dichotomous choice with an open-ended	Consumers' willingness to pay for organic products	(Sriwaranun et al., 2015)	Positively with the previous purchasing behavior
Discrete choice experiment	Determinants of willingness-to-pay for renewable energy: does the age of nuclear power plant reactors matter?	(Mahieu et al., 2015)	Age of nuclear reactor does matter to people living close to it.

NOTE: After reading of the papers, this is a comprehensive table presenting the measures and methodologies for the willingness to pay in terms of diversified topics, obviously, the contingent valuation is the primary one, then the conjoint analysis and discrete choice experiment, but the problem for these literatures and researches, they primarily focus on the subject willingness, which cannot prove the extent of validity.

4.1.3.2 Problem of Contingent Valuation

Contingent valuation, the method is a survey-based approach, for the concern, there is no enough incentives for the respondents to give the truthful answers, meanwhile, as the cautious evaluation from the respondents and the possible rejection of property right in the experiment, therefore, it exerts suspicion on the reliability of WTP, additionally, there is an embedding effect as the potential anomaly for the study of WTP. And in the practical experience, there is a proportion of respondents who are not willing to pay or answer this question due to the fact of insufficient information, or the belief that the government should bear the responsibility rather than the individuals, etc. therefore, there is a general agreement on the validity of contingent valuation, that is the "closed-ended" dichotomous choice questions are better to elicit the individuals' willingness to pay(An, 2000).

WTP based on the test-retest method is a reliable and comparable measure for the state preference(O'Brien & Viramontes, 1994), but it also indicates that the larger variation in the WTP responses would compromise the validity. Besides, the method leads to a distribution of fat tail in the feature of the collected data, then overestimates the WTP(Haltia et al., 2009). However, what is the best method to elicit individuals 'willingness to pay, the existing literatures on different fields, contingent valuation is regarded as the defaulted method, only discuss the difference of collecting the data between opened-ended or closed-ended. However, there is a work on the methods comparison to find which way is better, indicating that Vickrey auction(the highest bid win, but with the payment of second highest bid) is more effective to elicit individuals' WTP(Noussair, Robin, & Ruffieux, 2004). Additionally, the experimental techniques to elicit consumers' WTP have a better control and understand the price revision due to the access of new information in the process(Rozan, 2004).

4.1.3.2.1 Formats effect

The format is an important component for the design of data collection, where the format will affect the data validity and the empirical results.

Initially, the way to collect the data is important in the data quality and distribution. The drawback of the closed-ended format would be difficult to offer an appropriate bid, requiring a larger size of samples, meanwhile, respondents would state positive answer to the closed-ended question showing the support for the project, particular for the public good, that is beneficial to the society, and this preference is called yea-saying and anchoring(Frykblom & Shogren, 2000). Therefore, the positive rate is bigger than the negative one and the bid amount is higher than the expectation. However, for the private good, the different formats do not have impact on the WTP(Amador et al., 2005). No matter the bigger or smaller amount of WTP generates from contingent valuation, it cannot be only regarded as a hypothetical method, the format does affect the validity of WTP and is sensitive to it.

Besides, different contexts in the choice model for a bid of WTP, affect the benefits measures both at the private and social level(Amador et al., 2005), the elicitation of WTP is sensitive to the formats for a public good(Champ & Bishop, 2006), A subtle change, such as sequence of questions and wording, could affect the respondents' response. Besides, the data is also sensitive to the sequence of listing the available answers. In the contingent valuation with a list of bided amount, there are types of sequences to list all amount of bids, including the values listed from high-to-low, low-to-high and a randomized, where the high-to-low version results in a dramatically higher value than other two versions and the valid value may be generated in the randomized set(Smith, 2006). Additionally, the value differed contingent on the format, and there is huge disparity due to the

formats context in the dichotomous choice question(Zhongmin, Loomis, Zhiqiang, & Hamamura, 2006) in the single and double bounded vote contingent on the valuation formats. Therefore, due to the limitation of contingent valuation for the data collection, endogenous variables are also applied in the empirical research. Furthermore, a more detailed scale and realistic range in the choice may help respondents to elicit the value closing to the true one(Soeteman et al., 2017).

The Ordering effect of alternative choices on the WTP, links to respondents' uncertainty and react differently, generally, it yields a lower estimation in the ascending order than the ones in descending order or random order(Voltaire, Donfouet, Pirrone, & Larzillière, 2017).

Additionally, except for the format in the questions, the attributes on the product itself, such as the color, the colored of photographs presented in the survey increase the amount of WTP(Labao et al., 2008), the visual presentation enhances the evaluability, minimizes the errors in the judgement and perception. The duration of the outrage in the power statistically significant to the WTP of avoiding the power outrage(Carlsson & Martinsson, 2008). Gradually, the research continuously work on the peer effect in the process of data collection, the peer effect on the WTP, due to the 'contaminated' effect between the individual and household, it will give rise to the overstate of the WTP(Lindhjem & Navrud, 2009). The payment format effect also exists, the cash is 7% higher of WTP than others methods in the experiment(Hossack & An, 2015). For the comparison between the internet and face-to-face format of data collection, there is no statistically distinguishable across the two survey samples in terms of the estimation of WTP(Nielsen, 2011).

The details in the format presented to respondents in the process of data collection is important, and it is necessary to consider the question formats, context. In the study of WTP for the certificated wood products, individuals who have the higher possibility of premium payment is associated with the expectation of lessening environmental problem, such as deforestation(Aguilar & Vlosky, 2007), similarly, labeling effect for modified genetic food(Hu, 2006). Accordingly, the contingent valuation for the elicitation of WTP is strongly dependent on the assumptions of consumer preference and the empirical inference process(Bengochea-Morancho et al., 2005), and the estimator of WTP is very sensitive to the empirical context.

In a meta-regression analysis on the WTP for the renewable energy, it finds that the design and modelling feature are more sensitive to others factors affecting the WTP(Ma et al., 2015),meanwhile, it is reasonable to use the mean WTP rather than the marginal WTP as the dependent variable in both the contingent valuation and discrete choice model(Spaulding, 1976), as the possible condition that there is no change of marginal WTP.

4.1.3.2.2 Endogenous Variables

Due to the demerits of the methodology, selection bias and endogenous variables could be the problem in the empirical study. The contingent valuation, basically, neglects respondents' inherent relation with the product or service, and coefficients are not consistent when endogenous variables included in the set of independent variables, where an instrument variable could be deployed to tackle the problem. Meanwhile, the price, is recognized as a primary problem of endogeneity for a given product, and the exogenous property tax as an instrument variable, and indicating that the household characteristics are biased when a absence consideration of endogeneity price(Ferreira, 2010). Additionally, preferences vary across individuals, and the measurement error and endogeneity bias in the response to the attitudinal question, and this is reason for the introduction of a latent attitudinal variables.(Hess & Beharry-Borg, 2012).

For the preference estimation of WTP for the public good, the method of omitted variables is

deployed to improve the credibility and problem of endogenous variables (Kuminoff & Pope, 2014). Besides, the research shows the bias due to the filters questions in the survey, and the valuation is a function of the instrument variable (Gyrd-Hansen, Jensen, & Kjaer, 2014), demonstrating the existing of data bias and the remedy to tackle it. And the empirical sample indicates that the dependent variable of direct experience is endogenously determined on the WTP(Voltaire, 2015).

Simultaneously, the problem is also in my dataset, as the group of individuals who have already owned the vehicles, the variables about the perception of NEVs, distance of charging station, etc., are indigenous to the dependent variable of the category of vehicles. And in the latter empirical study, the remedy, such as instrument variable, will be deployed to tackle the problem, but it is difficult to find an instrument variable that satisfies the preconditions.

As the endogenous repressors in the empirical regression model, it is only the magnitude of association, instead of the magnitude of causation that is important and required in the policy study. And this is the reason why the instrumental variable is introduced for the problem of endogenous variables referring to an association between the independent variables and the errors in the regression model. Besides, when it is multi-repressors, the necessary condition for the consistency requiring that all repressors are asymptotically uncorrelated with the error term. Practically, it is a challenge to find legitimate instrument variables, but the basic principle is to looking for a variable that is correlated with the independent variable but does not affect the dependent variable directly. But lots of works give rise to the poor instrument.

4.1.3.2.3 Selection bias

It found that individuals prefer to the tele-medicine due to the easier access to the physician and time saving(Qureshi et al., 2006), but the selection bias existed as the samples are required to come to the hospital, where the requirement can be regarded as a filter process giving rise the bias, namely, the samples who are going to the hospital probably with higher potential demand, instead of a random sample. And metrics cannot be applied when WTP data are not collected prospectively(Jutkowitz, Gitlin, & Pizzi, 2010). And in the process of data collection, the desirability bias is also here due to the different direct and indirect questioning for the solicitation of consumers' WTP(Olynk, Tonsor, & Wolf, 2010).

In the selection bias, the starting point bias is normal and prevalent in the dichotomous way of eliciting the estimation of WTP. In the methodology of contingent valuation, the starting point bias in how the bids are structured should be recognised in the closed-ended questions(Eastaugh, 2000), evaluate and identify the physical and psychological benefits(Cameron & James, 1987; Gafni, 1998). Meanwhile, the preference heterogeneity on WTP in an airline choice context is important and cannot be neglected, otherwise, the measure will be highly overestimated(Espino et al., 2008). In the dichotomous choice, the settlement of starting point would contribute to a bias, but the dummies question in the bidding set is low in detecting the starting bias(Veronesi, Alberini, & Cooper, 2011).

Furthermore, for the value of the WTP, conventionally, it only could be the positive amount, instead of zero, even the negative amount, and find that the absence of negative values in the experiment overstates the aggregate benefits of a landscape change in a national park(Hanley, Colombo, Kriström, & Watson, 2009).There are works on the revision of the data misrepresentation and modification in the process of survey after respondents perceive the misreport for the preferences, it found that the modified approach leads to a substantially downward for the amount of WTP, and the revised estimate of WTP is more consistent with the revealed preference. As the inflated WTPs in the practice, lots of works have attempted to mitigate such inflation by the design of survey,

elicitation and the modification of previous preference. Moreover, the remedies, such as the uncertainty regarding the decision has made.

Additionally, a 'yea saying' has been seen in many setting and a common bias in the survey(Hoffmann et al., 2012), and the secret ballot is deployed to minimize the 'yea-saying' for the eliciting of WTP(Francisco, 2015). Due to the existence of 'yea saying' phenomenon, the anchoring effect is deployed to test the consistency between the first and second response(Costa-Font, 2017).

Contingent on problem of the selection bias, such as starting bias point, 'yea saying ', there are several ways to reduce the bias and increase the validity of the contingent valuation in the practice. Meanwhile, as the existence of bias, the hypothetical bias generated by the contingent valuation gives rise to the overstating of the actual value, accordingly, what could be the follow-up method to reduce the bias?

Initially, there is a comparison of different methodologies among the contingent valuation, conjoint analysis and discrete experiment. But actually, in terms of methodologies, literatures do not provide enough practical guidance, including the survey implementation, payment vehicles, question formats, while the validity of WTP is sensitive to these variables. Such as conjoint analysis, it elicits the values based on either rating or ranking of product with different attributes levels indirectly, CV is a simpler method for obtaining quick preference, although it provides less information than conjoint analysis(CA) (Veisten, 2007), while the choice-based conjoint analysis does not provide an accurate estimation of WTP, generally, with a overestimation(Sichtmann, Wilken, & Diamantopoulos, 2011). Meanwhile, as the existing of long-fat tail in the distribution of WTP, and the sequential choice design is deployed to tackle it(Danthurebandara, Yu, & Vandebroek, 2011). Besides, the discrete choice experiment, certain attributes will be considered in it with different levels, and forming diversified combinations and hypothetical scenarios, which is consistent with the random utility theory. And it is a way to compute the WTP indicator(Hess, Rose, & Hensher, 2008). And the discrete choice method is deployed by many disciplines to assess the trade-offs among different attributes.it is also deployed to study the WTP for the nutritious food, and the effect of information dissemination on consumers conception (Meenakshi et al., 2012). Additionally, cost-benefit analysis is regarded as one of the methods to evaluate the competing project, with the quantified requirement of all cost and benefits data. But the flawless, such as the hypothesis bias, embedding, sequencing problem, all affect the validity of WTP.

Furthermore, about optimization of the contingent valuation itself, lots of works have been done on the optimization of the contingent valuation, which consists of two ways, firstly, it is an introduction of other methods as a complementary to the contingent valuation, as the discussion above of alternative methodologies; The second still focus on the contingent valuation itself, but intends to proposes a remedy to avoid the potential demerits in different contexts.

In order to increase the statistical efficiency, the double-bounded dichotomous choice method is introduced(Schwarzinger et al., 2009), instead of a single-bounded, but the potential bias is still here due to a starting point bias. Besides, in order to ensure the representative of respondent, the double-bound dichotomous choice is deployed with an extension of traditional structure shift model to reduce the potential bias(Czajkowski, 2009), and a dummy variable question is added, particularly, for the public good, when respondents are not familiar with the nonexistent market, it is also called Bayesian updating behavior model.

Meanwhile, a follow-up certainty statement is added to reduce the bias in the data collection and elicitation, namely, a comparison between probably/definitely with a 10-point scale(Blomquist, Blumenschein, & Johannesson, 2009), but the critics are still here as the follow up certainty

statements lead to the hypothetical yeses matching well with the real purchase of health and environmental goods. Besides, the response options could be 'definitely yes', 'probably yes', 'not sure', 'probably no', 'definitely no', with different level of certainty for the final bids that respondents offer, instead of a simple yes/no, higher certainty exhibited marginally higher WTP by the respondents(Bobinac, Van Exel, Rutten, & Brouwer, 2010). And respondents' uncertainty about their own answers integrated into the WTP, it can stimulate the actual payment(Moore, Bishop, Provencher, & Champ, 2010), and generates a lower expected WTP than the standard contingent valuation, and it has proven the follow-up certainty question that is useful to calibrate the approach(Lee & Hwang, 2016). Besides, integrating with the practice condition, there are the zero and missing valuation in the collection of WTP in the open-ended format(Yu & Abler, 2010), the value of zero is necessary and meaningful, particularly in the field of environmental valuation(Reichl & Frühwirth-Schnatter, 2012).

4.1.4 Reviews

Review 1: Public or Private Goods

Public goods, like the environmental quality, due to the absence of clear property right and market price to evaluate the magnitude of value, WTP is deployed to study the perception and extent of payment. The environmental protection and voluntary contribution, are the primary topics in the previous literatures, instead of private goods. Accordingly, what does it affect the WTP in terms of public or private goods? However, the non-market public goods have been discussed in the previous literatures, such as the environmental problem, preserving the habitat for endangered species, which are exogenously to the individuals and still remains as a challenging task for the valuing of goods. Accordingly, the research objects prefer to the public goods, without clear message or indication for the valuation in the market. Which contributes to neglect the characteristics of the studied product itself. Previously, the study on the hindrance elements falls on the individuals' perspectives primarily, such as the financial capability, income, perception of NEVs, neglecting the attributes of the studied object itself. In order to knowing the optimal capacity, it is essential to investigate the marginal cost, conceptual framework and interaction among constrains, but more importantly, the constrains imposed by the studied object also should be included in the framework. Accordingly, constrains are not only on the perspectives of individuals, but also the characteristics of the object itself, such as hindrances imposed by the product, reliable range, accessibility of charging station, etc.

Furthermore, the objects, NEVs or conventional vehicles in my study, are private with clear pricing generating mechanism, instead of the hypothetical perception on public goods. More importantly, WTP is only deployed as a conception to study individuals' behaviours in previous researches. Accordingly, what is the discrepancy of WTP between a public good and a marketable trade good? Meanwhile, public good as studied in the previous literatures, the value of a good relative to the income only accounts for a small part. While the good in this study, is a private good with marketable price and accounting for a relatively large part of annual income.

Besides, the theories and empirical works on the WTP/WTA/AP fall on the estimation value previously, instead of the categories among multi-alternatives, it has sound supports, particular for the public good without a marketable traded reference. There is a debate on the WTP for the estimation amount or categories representing individuals' choice. In the literatures, it is ambiguous to figure out whether it is a public or traded good. But when the studied subject is a market traded product with a clear market price reference, the significance of WTP will fade away to some extent. Additionally, to a larger extent, one individual is a passive price receptor, and exogenous to the market price. Therefore, the market price will be perceived as a benchmark in consumers' mind. But

in my research, the studied object is a market tradeable staff with a clear and visible price and price generating mechanism, and policies imposed from the government are primarily contingent on the categories. Therefore, with the consideration of the theories and the specific condition in my research, for the coming empirical study in my research, it will focus on the category rather than the amount of value due to the fact that consumers prioritize to category of vehicles, then the subsequent value contingent on the category in the behavior decision model.

Review 2：Discrepancy between WTP-AP

Previously, the hypothetical conception of WTP is regarded as a mechanism of demand-revealing (Bohm, 1979), but there is no relationship between WTP and the rational consideration(Muller & Reutzel, 1984), additionally, it has a problematic nature in the assumption of constant WTP(Gabriel, 1987), definitely, this hypothesis is not consistent with the practice. Therefore, after the assessment of willingness, what is the behavior of actual payment? And the study indicates that only a very small proportion of those stating positive WTP did actually transfer the money(Sauer & Fischer, 2010), which indicates the disparity between the WTP/AP empirically.

After the literature review for the past 40 years, the primary works on the topic of "willingness to pay" basically rely on this concept, then integrate with different fields and topics, such as environment, public health, etc. to evaluate programs and study what extent the individuals have the willingness to pay, rather than the mechanism behind the concept, the disparity between the willingness to pay and actual payment, although a new conception of WTA is generated, they are still on the hypothetical perspectives. Therefore, the disparity between WTP/WTA, the two indicators elicit the values for each individual simultaneously.

Lots of finds indicate the gap between WTP/WTA, but it seems to have conflict with the theory of indifferent curve that the endowment effect and budget constraint are independent to the curve. Meanwhile, the observed gap does not demonstrate individuals' preferences, conversely, it is a misconception of the experiment task. Therefore, with the intention to reduce the misconception, different procedures are deployed. And the term 'endowment effect theory' is introduced due to the loss aversion. And the experiment on the disparity may be affected by the variables, such as ownership, physical possession of the object(Andrea Isoni, Graham Loomes, & Robert Sugden, 2011). However, there is no observed WTP/WTA gap when procedures deployed to avoid the subject misconception about the elicitation device(Charles R. Plott & Kathryn Zeiler, 2011). The condition is necessary for the convergences of WTP/WTA when the nonmarketable good is indivisible and qualitatively differentiated(Miyake, 2010).

While for the disparity between WTP/AP, it is difficult to collect the data at the same time due to the two decisions made at different periods. Accordingly, for this part, it will not only focus on a hypothetical WTP, but also an actual behavior, to study the disparity and figure out the diversified mechanism on the perception and actual behaviors. However, there is a demerit on the data of actual payment, which comes from different individuals, instead of one individual with both WTP/AP.

Review 3：Critics on the Commitment Cost for the Disparity

In the theoretical framework of commitment cost, there are three attributes, uncertainty, learning opportunity and reversibility. Accordingly, the commitment cost is put forward as an explanation for the gap under the guidance of laboratory experiments, but there are drawbacks and limitation in experiments design and hypothesis for data collection and simulation of the real condition. Firstly, for the incentive, participants are received an amount of cash, generally, which is the minimum payment of one hour in specific countries in the experiment, then offer the bid on a low-value product, given that, participants might have put little cognitive effort into the strategies to form the

bids, namely, the absence of endowment effect in the decision process. Secondly, the low cost to reverse the transaction decision that has made in the previous step by reselling it to other friends or returning it to the store where it comes from, and lots of experiments were designed under the hypothesis of zero learning cost and reversibility cost. Thirdly, in term of a fixed fee for the return fee, it is not a better remedy to study irreversibility effect on the WTP. While for the proposed hypothesis in my research, it primarily focuses on the uncertainty and learning opportunity.

Initially, the uncertainty only refers to the monetary value, neglects the uncertainty of product utilization. The absence of utilization effect is prevalent, in the experimental study, as the product used in the experiment's incentive is always regarded as a symbolic entity, or a token as the cash equivalent, accordingly, participants do not have any cognitive effort in the consideration of the products' utilization and decision making. Definitely, this is inconsistent with the behaviors in the real practice, where the utilization benefits are one of the primary incentives for consumers' actual payment, instead of the only monetary value.

Secondly, the commitment cost is under the hypothesis of zero cost on the learning opportunity, reversibility and delaying, which can be regarded as a simplifying scenario of actual payment in the laboratory experiment. But it is inconsistent with the actual condition, such as costs in the learning process, time value costs, the cognitive burden after failure of purchasing. Accordingly, the zero cost in the hypothesis and laboratory is inconsistent with the reality.

Review4: Critics for the methodologies

The method of contingent valuation has the hypothesis that respondents have a well-defined preferences and information for the studied object, which is criticized(Chanel, Cleary, & Luchini, 2006), particularly, on the constant preference and the information received and perceived continuously and dynamically. Additionally, the surveys primarily estimate the nonmarket benefits of public goods, there are numerous debates, including content validity, criterion validity, payment ways and question designs, for the public good, the ambiguity of the good itself is worse, such as the health and biodiversity. One challenge is the lack of necessary data for key variables, such as service of medical utilization, it is difficult to measure due to the complicated scenarios, such as whether health insurance or others scenarios imposed by the regulation, meanwhile, it is a challenge to define a variable to assess one medicine performance. Accordingly, for the further study of contingent valuation, it should combine the WTP and behaviour data, which provides additional validity for the method of contingent valuation. It also raises another point about the connection between the behaviour and the amount of WTP that individuals bid, particularly, when the studied object is a marketable service or product, the final choice is not only a number of WTP, but also a precondition that contingent on the previous choice.

Another criticism falls on the data quality as the methodology will result in a larger disparity, especial for the public goods that are not traded in the market. Meanwhile, due to the existing of free-rider effect, respondents may overstate the WTP for the public goods with the target of eliciting higher payment from others, then receiving higher benefits. Furthermore, there are considerable number of respondents with the statement that are not willing to pay, or even absence of knowledge on the specific topic. Therefore, with the consideration of previous problems and the limitation of contingent valuation, the respondent uncertainty, such as a scale of 1 to 10 representing the extent of uncertainty from yes to no, has been incorporated into the study of WTP, such as the protection of threatened fish(Ekstrand & Loomis, 1998), the incorporation of respondent uncertainty contributes to the increase of goodness of fit and decrease of standard error.

Accordingly, the reviews primarily focus on the four perspectives, the discussion on the public and

private good, discrepant effect mechanism between the WTP and AP, commitment cost for the disparity due to the problem that the uncertainty only refers to the monetary value, but no utilization, and the zero-learning cost. Definitely, it also covers the critics on the demerits of methodologies. Contingent on these works, which provide a guideline for the part of hypothesis and the empirical study.

4.1.5 Hypothesis

Contingent on the previous literatures and reviews, the hypothesis is conducted from these three perspectives, including a debate on the public or private good, different effect mechanisms on WTP/AP, and the disparity between WTP/AP.

Hypothesis 1: There is a difference between the public and private goods in the estimation variation of WTP, and the private good's variation is smaller than a public good. Additionally, in the two samples, controlled group without quota is regarded as a higher substitutability, while Shenzhen as an experiment group with the impose of quota, is regarded as a less substitutability sample, therefore, it is also applied to hypothesis that variation in experiment group is higher than the controlled group.

The hypothetical concept is pioneered deployed in the field of medical sector(O'Brien & Viramontes, 1994; Ryan, 1996; Dranitsaris, 1997; Bala et al., 1999; Eastaugh, 2000; Sach, 2004), but most of researches indicates that there is no alternative in the studied subjects' perception, such as the patients, patients' parents etc. Accordingly, it could be regarded as the public good that individuals do not have others alternatives in the market. However, due to the tradeable market product, it has a clear reference for the value of a specific subject, therefore, the variance of bidding offer or the maximum prices that individuals with willingness to pay is much smaller than the counterpart in the non-tradeable product. The WTP will experience a decline when more similar items listed for the WTP in the online auction, namely, the market thickness matter. Besides, lower search cost and more experience lead to a lower WTP(Chan, Kadiyali, & Park, 2007), which is consistent with the hypothesis that private good with more substitutes and easier market access has a smaller variation in the amount of WTP. While the private and public incentives to adopt clean technology differ(Basnet, Ide, Tahara, Tanaka, & Ohdan, 2010). Therefore, as the existing of substitute in the choice, the discrepancy is smaller than the market that is absent of substitute. Meanwhile, with a higher substitutability, it will result in a smaller disparity for the comparison between a private good and public good.

Accordingly, for the marketable product, there is a smaller dispersion with regarding to the bid amount for the WTP than non-tradeable product or service. And the parameter, coefficient covariance, will be deployed to compare the difference, namely, the standard variance divided by the value of mean. Due to the absence of original data in public good, the result will be based on the samples' mean and standard variation value, instead of parametric test, besides, the comparison will be contingent on my data and data reported in previous works. In a nutshell, there are two groups of comparisons, namely, public and private goods, controlled and experiment groups.

Hypothesis 2: The function mechanism between WTP and AP is different.

For this hypothesis, it not only focuses on the effect mechanism of WTP based on the previous literature review, but also compares to the behaviors of actual payment for the NEVs, accordingly, it concentrates on the effect mechanism and differences, is the conclusion on the WTP also applicable to the AP?

Hypothesis 2.1: The higher green perception of the new energy vehicles, the higher WTP, but this

positive relationship for WTP is not applicable to the actual payment.

It hypothesizes that the higher green perception of NEVs, the higher WTP. There are lots of debates on the possible reduction of emission, the more satisfied, the higher WTP(Noe, McDonald, & Hammitt, 1986), which is particular for a continued satisfying experience. So the basic formation of attitude to the behavior of purchasing NEVs, has a particular outcome with a certain subjective value, combining the strength of beliefs and outcome evaluation, which generates an overall positive or negative attitude toward the purchasing of new energy vehicles(Aizen & Klobas, 2013). Therefore, direct experience and media exposure affect the formation of attitude, and attitudes can predict the WTP for the public safety(Donahue & Miller, 2006). But it also indicates that public opinion cannot affect the respondents while the scientific information is positively to the WTP for the privatized public good(Chanel et al., 2006). Similarly, media reports on the positive cases do not experience an increase of WTP, however, dramatically decrease WTP with a negative report for the genetic modified foods(Hu, Zhong, & Ding, 2006). Interestingly, the heterogeneous perception of quality level is also regarded as one determinant for the WTP(Whitehead, 2006). Accordingly, for the perspective of willingness, the higher green perception of NEVs, the higher WTP.

But what is the mechanism of forming the specific perception? For the interpretation of the perception formation, in the group of individuals who have owned vehicles, is the higher operation cost associated with a higher perception of cost-effective and reduction emission? Is there a higher perception on the attribute of reduction emission and cost-effective with an easier access to NEVs, such as the charging station in the working or living places? Accordingly, it will also test the perception formation mechanism.

Hypothesis 2.2: There are several sub-hypotheses about the effect of past experience on the WTP and AP. Firstly, in the controlled samples without the quota, the living years and registered resident do not have effect on individuals WTP for NEVs; while samples in the experiment imposing the quota, the longer of living years and registered resident, the higher WTP for the NEVs. Secondly, the higher driving cost, the higher WTP for NEVs, besides, the higher performance requirement on the NEVs is associated with a lower WTP, and a higher willingness to pay the external fee, such as the license of premium, is related to a higher WTP. But this relationship for WTP is not applicable to the actual payment.

Previously, the literature about the effect of past experience on WTP, it primarily focuses on the insurance industry, the better previous health condition, the less WTP for the health insurance investment. While in this research, the past experience will include two perspectives. Firstly, the time and registered residence, which indicate a possible spillover effect as the fact that the quota has been implemented is within a domain of a city, the longer individuals who live in the city, the less possibility of moving out of the city, namely, the less of spillover effect. Therefore, in the controlled samples without the quota, the living years and registered resident do not have effect on individuals WTP for NEVs; while samples in the experiment imposing the quota, the longer of living years and registered resident, the higher WTP for the NEVs. Secondly, the past driving experience, and this group is specific for individuals who have owned vehicles. The higher driving cost, including the fuel and parking fee, the higher WTP for NEVs. Meanwhile, the higher performance requirement on the NEVs is associated with a lower WTP, and a higher willingness to pay the external fee, such as the license of premium, is related to a higher WTP. Accordingly, in the experiment samples, the longer years of living in the city, the higher WTP for the NEVs, and the registered residence is in the city, the higher WTP for NEVs. The less requirement for the range of NEVs, the higher WTP for the NEVs.

Hypothesis 2.3: The lower uncertainty of the charging location and the lower distance away from

where individuals work or live, the higher WTP, but this relationship for WTP is not applicable to the AP.

How does the distance affect the perception of NEVs, then the adoption of it? It could be regarded as a spatial spillover, and it is a sub-field that deals with the treatment of spatial interaction (spatial autocorrelation) with individuals' perception and behaviors. With the incorporation of spatial interaction, contingent on the mixed regressive spatial autoregressive model, namely, the coincidence of value similarity with locational similarity, the collinear of spatial effect with the repressors can be found(Liu, 2015). The charging station indicates the accessibility of NEVs and possible level of challenges after the consumption, similarly, it has proven that the access to the quality care training will increase the investment of child care for the low-income families(Shlay, Tran, Weinraub, & Harmon, 2005). Meanwhile, it can also be regarded as a strong necessary complement for the NEVs, the accessibility to the demanding complement would increase the WTP, similarly, the accessibility to safe and clean piped water increase the households value and WTP for it(Yusuf & Koundouri, 2005). Additionally, the distance to the water distribution point and to the town center, importantly influence the WTP for the protection of watershed(Moreno-Sanchez, Maldonado, Wunder, & Borda-Almanza, 2012). Similarly, the organic premium, it decreases significantly with the increase of distance between the consumers' home and the vineyard(Ay, Chakir, & Marette, 2017) and the preference is spatially clustered(Czajkowski, Budziński, Campbell, Giergiczny, & Hanley, 2017). Accordingly, the lower uncertainty of the charging location and the lower distance away from where customer work or live, the higher WTP.

Hypothesis 3: There is a disparity between WTP-AP.

Lots of studies focus on the WTP, the WTP could be perceived as problem of probability that to what extent respondents will consume it, while the actual payment is the final decision that tackle all hindrances on the way of consumption. What differences do exist between the WTP-AP? The biggest challenge is the source of samples to support the study of actual payment on the specific subject, due to the fact that previous studies primarily based on a hypothesis subject, or a public good that cannot be purchased in the real market, it is difficult to collect the data about individuals' behaviors of actual payment in the market.

For this hypothesis, it is based on the theory of commitment cost, and for the sub-hypothesis, which will contingent on the elements consisting of theory, uncertainty, learning opportunity, but no reversibility due to the difficulty to collect it in the field. The disparity between the WTP and AP in my research, refers to the change between the initial choice and the final choice, and the initial choice refers to the choice they have made with the largest number of times participating in the quota of bidding or lottery. It is zero when the two choices are the same, while it is 1 when the two choices are different, therefore, a dummy variable is introduced as a dependent variable representing the disparity.

Hypothesis 3.1: The higher uncertainty of utilization, the higher disparity between the WTP/AP.

But when it comes to the uncertainty of utilization, what could be the effect mechanism on the disparity between WTP/AP? Utilization means that to some extent the purchased product meets the demand in the utilization process. Practically, what attributes will be deployed to assess the uncertainty of utilization of NEVs? the primary attribute affects the uncertainty of NEVs' utilization is the charging station; Accordingly, the uncertainty refers to whether knowing the location of charging station, and the distance to the charging station, indicating the endowment value of owning a NEVs in the utilization process. Therefore, in my research, whether knowing the charging station and the distance away from where individuals live or work indicate the accessing possibility, and

represent the uncertainty of utilization.

For the respondents, it is difficult to assess the compound risk, such as morbidity and mortality in the health condition(Andersson, Hammitt, & Sundström, 2015), therefore, it is difficult to assess the risk and make a decision. Similarly, the uncertainty of achieving emission reduction hinders the adoption of alternatives(Williams & Rolfe, 2017). However, there is a question, the uncertainty reduces the estimation of WTP, but it also could reduce the actual payment, therefore, does the disparity between the WTP/AP increase or decrease? The uncertainty of the energy start-certified label actually reduces the estimation of WTP(Li, Clark, Jensen, & Yen, 2016). Meanwhile, the choice consistency is positively correlated with the choice certainty(Brouwer, Logar, & Sheremet, 2017), implying that the higher certainty, the higher consistency over different times. And which could also be interpreted that the higher certainty, the lower disparity between WTP/AP. Accordingly, similar to the uncertainty of value on the disparity between WTP/AP, the higher uncertainty of utilization, the higher disparity between WTP/AP.

Hypothesis 3.2: The more learning opportunity with a delayed cost, the higher disparity between the WTP/AP.

With the increase of the repeated times, the disparity will be reduced(Isoni, 2011), including the reduction of misconception. And the choice consistency is positively related with the choice complicity over different times, but as the learning in the process, the choice complexity fades away (Brouwer et al., 2017), therefore, the continuous learning and interpretation of information, have reduced the disparity between the choices, similarly, it is one of the important reason for the disparity between hypothetical WTP and actual payment. Accordingly, the more times of learning opportunities with a learning cost, the less disparity.

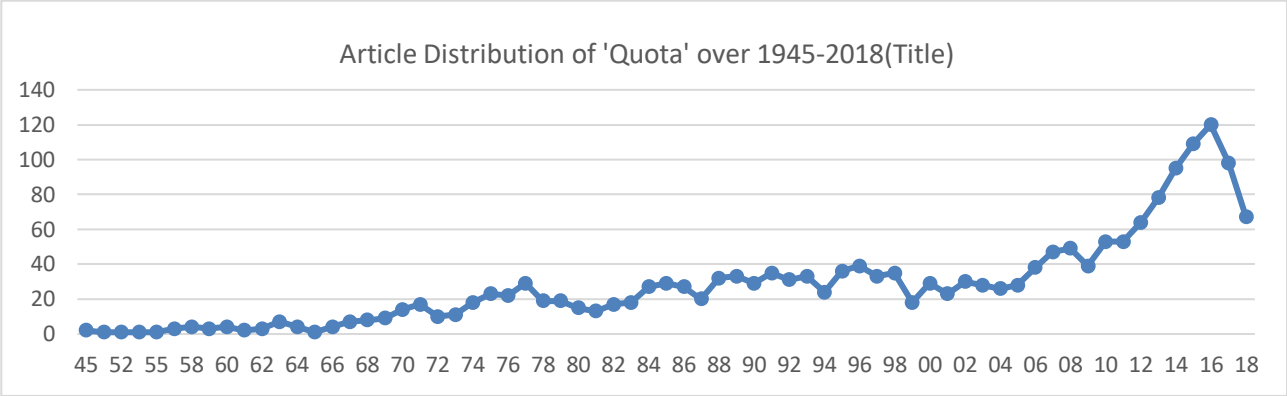
4.2 Quota

This part of literature will consist of two components, initially, it primarily focuses on a broad definition with a single quota only, then it will elaborate a specific theory of individual transferable quota (ITQ) focusing on the multi-quotas coexisting simultaneously, contingent on the review of the two parts and research targets in my work, the hypothesis will be raised subsequently.

4.2.1 Definition and Literature of Quota

The quota, has different forms and classifications, such as the output control and supply control. But no matter what forms, it primarily refers to resources that cannot be used to produce products when the output comes to the ceiling as restricted. The first study about the paradoxical effect of quota starting from 1945, focusing on the discriminatory policy of limiting the numbers of applicants in the universities contingent on certain “racial”(Arsenian, 1945), then the study about the effect of quota on the topic of desegregation in schools and housings(Cohen, 1960), it was regarded as a benign quota for the society integration. The restriction on the demand, including quota, spending tax and point rationing, will stimulate the consumption of others goods generally, it results in demand increase for a substitute good, and with a larger income elasticity and smaller price elasticity under the quota than a free market(Shinkai, 1966). The value of quota is affected by the amount of quota that permitted, a small amount in the quota means a higher value for a quota, vise verse, a larger allocation means a lesser premium(Manes, 1963). Accordingly, the quota is deployed as a mechanism to change participants’ behaviors and fulfill its target.

Figure 28 Article Distribution of 'quota' in the title over 1945-2018



There are 1865 articles with the key word of 'quota' in the data base of Web of Science until 31st September, 2018. And there are clear topics classification over different times, according to the topic distribution over time, the implementation of quota primarily covers some specific topics, such as the quota on trades for the protectionism, gender in legislative institution, education resources, then the fishery management. Recently, it primarily focuses on the carbon and emission trade as the concern for the climate change, therefore, the quota as a policy device demonstrates popular topics over different times, and quota is deployed as a tool to study the effect on these different topics. For example, imposed the steel import quota(Molz, 1970), oil import quota(Areskoug, 1971), quota on education standards(Auerbach, 1972), quota on the oil import(Heitmann, 1973), quota imposed in schools(Greenberg, 1975), employment quota as an incentives for minority-majority (Welch, 1976), quota setting and sales forecasting in the market (Wotruba & Thurlow, 1976), quota in a legislative(Balinski & Young, 1977), quota for the congressional apportionment(Mayberry, 1978), probability sampling with quota(Stephenson, 1979), quota hiring in the police department(Balzer, 1977), sales quota as the device of salesforce management(Darmon, 1979), quota for the employment of disabled people (Bolderson, 1980), the sampling method with probability and quota (King, 1985), quota constrained import category(Aw & Roberts, 1986), quota simulation under the multi-objective(Sakawa & Yano, 1986), the quota on the exchange rate(Rajaraman, 1990), safety factors in the setting harvest quota(Hansen, Staggs, & Hoff, 1991), consumer incentive to meet sales quota (Lovell & Morey, 1991), quota in the electoral system(Gallagher, 1992), a production quota(Fulginiti & Perrin, 1993), effect of market quota on the subsidy(Borges & Thurman, 1994), tax and output quota(Dickie & Trandel, 1996), stock information of quota management(Walters & Pearse, 1996), quota for the women representation in the legislative system(Dhanda, 2000), comparison of quota and tariff(Peng & Mai, 2000), output quota and subsidies(Vukina & Wossink, 2000), carbon emission quota(Germain & van Steenberghe, 2003), quota in special economic zone(Schweinberger, 2003), the relation between price cut and quota reduction(Frandsen, 2003), gender quota in the party(Meier, 2004), Gender quota in the legislative law(Baldez, 2004), effect of quota trading on productivity (Fox, Grafton, Kompas, & Che, 2006), gains from quota trade(Andersen & Bogetoft, 2007), how parties evaluate the compulsory quotas(Murray, 2007), individuals transferable quota for the ecological and economical target(Kulmala, Peltomäki, Lindroos, Söderkultalahti, & Kuikka, 2007), reserved seats, party quotas or the legislative quota for women(Krook, 2007), quota damages harvesters(Matulich, 2008), the gender quota and women's substantive representation(Franceschet & Piscopo, 2008) , the emission quota has a positive effect on firms' adoption of energy saving technology(Oude Lansink & van der Vlist, 2008), gender quota and political model(Krook, Lovenduski, & Squires, 2009), from the maximization catch and profit to generating resource rent in the individual quota(Asche, Bjorndal, & Gordon, 2009), quota for women and minorities in politics representation(Krook & O'Brien, 2010), quota allocation in mixed

categories(Marchal, Little, & Thebaud, 2011), the relation between the gender quota and comparative politics(Krook & Messing-Mathie, 2013), quota on the gender representation(Matsa & Miller, 2013), quota on cumulative carbon emission(Raupach et al., 2014), effect of gender quota on the quality of politicians(Baltrunaite, Bello, Casarico, & Profeta, 2014), electoral quota and political representation(Krook & Zetterberg, 2014), quota for gender equality(Krook & Norris, 2014), quota on a price ceiling(Chernoff, 2015), carbon emission quota(Wu, Fan, & Xia, 2016), allocation quota for the PhD enrollment with the principles of equity and efficiency(Zhu, Zhang, & Wang, 2018). Accordingly, quota rationing schemes are mainly deployed to restrict or re-allocate commodities, such as allocation of pollution permits, radio frequencies, import license, etc.

After the review of all the papers on different topics of quotas, it could be divided into four perspectives primarily, namely, there is a quota effect achieved on its own target, no effect, a side effect, and a comparison between the quota and other similar mechanisms.

(1) With a Quota Effect

There is a quota effect on its initial target, primarily, the study of quota focusses on the import and export, the board of political arrangement between the allocation of gender. The quota and subsidy on the sugar offered by US government resulted in a sharp reduction from the competitors(Wolf, 1959), meanwhile, the quota protected the welfare of sugar consumers and domestic producers(Polopolus & Fuller, 1963), but it only fixed the proportions of consumption, instead of the amount of supply, which is different to my case that fixes the amount of supply, but no limitation on the consumptions. USA imposed the steel import quota over 1955-1968, which increased the domestic steel consumption(Molz, 1970), An additional compulsory sharing in the quota is necessary to avoid the free riders(Heady, 1971). Import quota would avoid the Metzler Paradox, but leads to a inelasticity of demand that a small quantity limitation should be achieved by a larger amount of price adjustment(Falvey, 1975).

How about the quota effect on the trade? There is a causal relationship between the distributed license fraction, and the domestic relative import price(De Haan & Visser, 1979), and a positive relationship between the share of export license and terms of trade. Besides, the quota in the production will lead to a reduction in planned production, and depends on the profit margin and the production uncertainty caused by the quota(Fraser, 1986), the quota restriction on the composition of migrating labor, which gives rise to the income differential between the skilled and lower skilled workers(Canto & Udwadia, 1986), and within a quota constrained import category, it increases the imported quality(Aw & Roberts, 1986). Furthermore, the mandatory tobacco control of quota affect both the value and risk with the property ownership, and the producers have to subject to the wide fluctuation of land value(Vantreese, Reed, & Skees, 1989), and the level of marginal cost relative to the quota price is one of the determinants in the production (Babcock, 1990), simultaneously, the quota on the textiles, steel and autos causes the loss of welfare(de Melo & Tarr, 1990). Quota is regarded as a predominant mean in the international trade protection and internal market resources allocation(James, Anderson & Neary, 1992), from these papers, it has proven the existing practical effect of quota deployed as a trade protectionism. The administration of import license for the cheese gives rise to an oligopsony market power for the importing firms(McCorriston, 1996), a higher comparative advantage for the importing firms. Meanwhile, for a given import quota, it can increase the domestic production, but at the cost of reduced quota rents, and there is a reduction of domestic welfare comparing to a marketable quota(Spencer, 1996). The quota on the milk production in EU increases the production output and decrease the price(Lips & Rieder, 2005).

How about the quota effect on the representation and employment of firm's board? There are two kinds of employment quota for women, firstly, it is the preventive quota indicating that selection of

certain group members should be confirmed in a relative proportion of labor market to ensure the absence of discrimination. Secondly, it is the enhance quotas that not only maintain the non-discrimination in the future but also to make up for the past, such as a higher percentage than the quota due to the discrimination has happened in the past. Seats guaranteed by the effective quota, which are the most important elements in the formation of gender quota (Schmidt & Saunders, 2004). For the effect of quota on the firm's board, as the effect of increase gender diversity on the board, the affirmative action of quota is useful to break down the stereotype against women in the gender discrimination(De Paola, Scoppa, & Lombardo, 2010), on the financial data of publicly listed firms and the control sample of unlisted firms over 3 years, the percentage of female representation on the board have doubled, but the short-term profitability declined after the adopted quota, due to the increased labor cost and higher employment(Matsa & Miller, 2013). The quota on the gender representation a firm's board, shortly, it increases the labour cost and employment level, but reduce the profit(Matsa & Miller, 2013), affirmative action of employment quota to tackle the discrimination of women in the labor market, but with a discrimination effect on the wage, employment and welfare(Akyol, Neugart, & Pichler, 2015). The quota as the affirmative policies, the extent effect depends on whether the policy is regarded favorably by the affected groups(Balafoutas, Davis, & Sutter, 2016), this is why the gender quota is less often approved with a strong individual reaction from advantaged and disadvantaged groups, besides, the quota is imposed regarding the gender itself, the participants are the direct subjects, which is different to my work, the quota falls on the categories of vehicles and license, participants have the right to choose the one favorited. the quota-based labor regulation imposed for hiring Saudi Arabia at private firms, it indicates that there is an increased native employment with a substantial cost, meanwhile, along with a higher barrier of exiting and decreasing of total employment(Peck, 2017), and firms without Saudi employees bear most of the cost.

How about the quota effect on the representation of politic legislative?The voting is deployed to resolve the conflict over quotas, and the enforcement is essential to maintain the quota efficiency (Cave & Salant, 1996). Meanwhile, the quota exerts an influence in the diffusion contingent on both external party system-level influence and internal party characteristics(Caul, 2001), such as women as a higher decision-maker within a party, accordingly, the characteristics of individuals are important in adoption of gender quota. Effective quotas and seats guaranteed by the effective quota, which are the most important elements in the formation of gender quota (Schmidt & Saunders, 2004). Meanwhile, for the quota of gender on the legislative representation, the empirical study on the implication of quota, for example, there is a diffusion of candidate gender quota internationally and transnationally with the emerging notion of equality and representation(Krook, 2006). The female representation in the legislative system, it has the most favorable results regarding the outcome of female seats, and the quota offers the most explanatory power on current women representative(Tripp & Kang, 2008), quota campaigns can generate mandates, but cannot guarantee the substantive representation(Franceschet & Piscopo, 2008), the gender quota in the legislative has helped tackle the hindrance for women's representation, such as the underdevelopment of economic, electoral system and the cultural influence(Tripp & Kang, 2008). The effect of gender quota is small typically characterized by traditional gender roles (De Paola, Scoppa, & De Benedetto, 2014), There is an increase in the percentage of women representation in the legislation(Tan, 2015), and an informality advantage for women in the gender representation in the electoral system(Piscopo, 2016). Accordingly, these works support the conclusion that quota has achieved its initial target on the application of trade, gender representation in the political legislative, etc.

(2) Without a Quota Effect

Some works indicate that there is no effect imposed by the quota. There are basic prerequisites for

the implementation of emission quota, such as a translating calculation mechanism into an amount of pollutant emission, the determination of maximum amount pollutant emission, and a specific limit on one kind of emission(Mandelker & Sherry, 1976). A quota is not a preferred policy of free trade for a market leader(Tower, 1975).The problem how to divide the quota in a legislative(Balinski & Young, 1977), improving the representation of blacks, women and youth in the state delegation was largely a failure(Goodin, 1977), although it is regarded as a justice solution to long-excluded party workers. Besides, it concludes that the fisheries quota prior to 1978 have not fulfilled the target of limiting fishing mortality, although the management quota have a substantial impact on prices, earnings and landings(Kirkley, Pennington, & Brown, 1982), but there is a significant fall in the fishery stock, and the quota may not necessary to avoid the collapse of fishery stock(Kennedy & Watkins, 1985), the quota license is inefficient to achieve the optimality(Anderson, 1987), and the experiment indicates that the quota agreement does not have a better payoff than the equal division(Selten & Kuon, 1993).

Theoretically, the gender quota in the national legislative would have a positive effect on the representation, but the condition is subject to a minimum percentage of women on the lists in the political parties and electable positions(Jones, 2004). Empirically, due to the problem of noncompliance and lack of willingness to nominate women candidates in South Korea, the quota legislation has brought only limited effect on enhancing women's political representation(Yoon & Shin, 2015), it cannot find a detectable effect of quota on the overall development of representation over the 30 years, due to the power of political parties and electoral incentives created by the quota(Jensenius, 2015). Besides, due to the imposed gender quota, the skeptics of qualification for women have been raised, but it indicates that quota women have more local government experience, when the quota is deleted, quota women are less likely to be re-elected, which suggests the subject discrimination of un-qualification limits women candidates(Weeks & Baldez, 2015), the natural experiments is used to simulate the electoral quotas with the intention to improve the winning chance of ethnic groups in the election, but it fails to boost the chance of winning office (Bhavnani, 2017), which is contrary to the substantial positive effect of women’s quota,

Accordingly, without achieving its own target, the problem primarily falls on prerequisites that do not meet the condition, such as the enforcement, the sub-division of quota amount, etc.

(3) With a Side Effect

The imposed quota will also generate a side effect simultaneously. Previously, the quota imposed in schools with the intention to benefit members who are disadvantaged in US(Greenberg, 1975), the quota could be a fixed number or certain percentage, meanwhile, a differential selection criteria is intended to have a same quota effect. And this is part of debate and opposition that it will lower the education standards(Auerbach, 1972). Concerning the employment quota as an incentives for minority-majority convergence, but this incentive will be unfair to the skilled workers (Welch, 1976). The quota change in the international monetary fund among different members may result in a condition that is exactly the opposite of its initial intention, this paradoxical result suggests that the future redistribution quota should focus on both voting shares and negotiating parties(Dreyer & Schotter, 1980).

Quota power is the most important determinant for the payoff disbursement(Funk, Rapoport, & Kahan, 1980), the quota for the employment of disabled people does not fulfill its target, and is ineffective (Bolderson, 1980), in its description of quota, it provides a voluntary register of disabled people, and there is an extrusion effect on the disabled works due to the substitution of cheap labor. Meanwhile, the imposed quota has a greater effect on the organizational outcome, and leads to a reverse discrimination over the majority group(Kroeck, Barrett, & Alexander, 1983), there is a social

loss as the control instrument of quota(Watson & Ridker, 1984), furthermore, the quota restriction on the composition of migrating labor, which gives rise to the income differential between the skilled and lower skilled workers(Canto & Udwadia, 1986), generating a new inequality between the skilled and lower skilled workers. Additionally, there is a extraterritorial interest and conflict when the local authority implements the quota within its own territorial area(McElyea, 1987), it also leads to effects of exclusionary and anticompetitive.

There is a welfare losses due to the imposition of a production quota(Fulginiti & Perrin, 1993), the quota has a distortion effect on the production, although it is still a second good offer(Guyomard, Mahé, Emsar, & Inra-Esr, 1994), there is a small deadweight cost due to the quota for the restriction of market, but paralleling with a bigger distributional effect on the participants' mindset(Rucker, Thurman, & Sumner, 1995). Meanwhile, there is a efficiency loss due to the distortion effect of quota trade(Boots, Lansink, & Peerlings, 1997), it gives rise to the cheating and misrepresentation in the output quota and subsidies, but it is still an efficient means for the income redistribution and market intervention(Giannakas & Fulton, 2000). The rent-seeking as the agent target, an aggressive behavior of rent-seeking by one agent will encourage others to rent-seek more(Bergland, Clark, & Pedersen, 2002), the gender quota leads to the dishonesty behavior as the spillover effect(Maggian & Montinari, 2007), quota trade leads to the inefficiency(Hennessy, Shrestha, Shalloo, & Wallace, 2009). Quota results in a spillover effect on the nontraded sector and transferring paradox(Chao, Hazari, & Yu, 2010). Based on the dynamic computable general equilibrium model taking 30 provinces as the samples, it indicates the quota allocation of efficiency-priority costs the least but widen the income gap among regions (Li, Shi, Shang, & Yuan, 2015), however, the results of equity-priority and target-based quota allocation are opposite to the efficiency-priority allocation.

Therefore, as for the side effect caused by the imposed quota, it generates inequality, welfare loss and efficiency loss, exclusionary and anticompetitive, distortion for the market and individuals.

(4) Comparison between Tariff, Voluntary Constrains and Quota

There is a debate about the merit on a tariff and a quota as the government objective of generating revenue, and they are equivalent in a competitive market with certainty(Dasgupta & Stiglitz, 1977). In terms of the comparison, it primarily consists of two parts, non-equivalence and equivalence. And the criterion for the equivalence and non-equivalence falls on the mechanism effect. Actually, the comparison is similar to the debate on the actual effect on the target, which is result-oriented.

It is nonequivalence between the tariffs and quotas under the monopoly market(Sweeney, Toweir, & Willett, 1977). For example, quota and voluntary export restraint(Takacs, 1978), quota and tariff in the international trade negotiation(Webb, 1984), but as a political choice in the protectionism context, the tariff is much popular than quotas deployed by the government. It combines the public choice and rent-seeking with the comparison of quotas and tariffs, indicating that quotas can be politically superior to tariffs(Kaempfer & Willett, 1989), and the implementation of tariff demands more restrictive polices than quota and voluntary export restraints. While the voluntary export restraints will transfer the rent abroad, but it will be kept domestically under the mechanism of tariffs and quotas. Concerning the political economy explanation, the comparative efficiency is contingent on the extent of protectionism and nature of market, and the quota will be more politically efficient than tariffs under a high level of protection quota(Kaempfer, McClure, & Willett, 1989). The nonequivalence of quota and tariff(Melvin, 1986), comparing three instruments, quota, tariff and transfer, and in a negotiation and bargaining, the strong bargainer prefer to play with the quota, while the weak bargainer prefer to a tariff(Copeland, Tower, & Webb, 1989), and quota promote competition while tariff does not(Rotemberg & Saloner, 1989). But quota is not equivalent to a tariff for the home firm as a quantity-setting leader, on the contrary, it is equivalent when the

home firm is a follower(Fung, 1989). it is non-equivalence in the food processing for the tariff and quota incorporate the imperfect competition(McCorriston, Sheldon, & Hirschberg, 1993). And the quota will generate a lower welfare and higher price comparing to tariff when the tariff is initially positive(Buffie, 1993).

The equivalence of import quota and the voluntary export restraint(Murray, Schmidt, & Walter, 1983). the relationship and effect of quota and tariff in a spatial duopoly market(Benson & Hartigan, 1984), both the quota and tariffs are effective in the improve of payment balance, but the quota's adjustment speed is slower cost more than tariff (Kimbrough, 1985). The quota and tariff are equivalent contingent on the value of conjectural variation, and the domestic price under quota is higher or lower depend on the extent of completion.(Hwang & Mai, 1988), and the voluntary is discriminatory in the VER, is regarded as a quota-equivalent in terms of price and quantity, the welfare under the quota is higher than the VER(Dinopoulos & Kreinin, 1989). There is a same selection bias in both quota survey and probability sample survey(Cumming, 1990),increasing the response rate is a necessary emphasis to minimize the bias. And an exogenous shock effect in the presence of quota is intermediate between tariff and voluntary export restraints(Neary, 1988). In terms of price and welfare, the quota is equivalent to the tariff, but there is a higher welfare level for quotas than tariff when the domestic cost is lower than foreign firm(Chiou, Hwang, & Lin, 2005).

Accordingly, for a single quota in the application of trade, gender representation in political system, carbon emission, etc., it is result-oriented, and primarily concentrates on the quota effect, such as an achieved quota effect, without fulfilling its quota target, or a side effect caused by the quota. But less work focusses on the mechanism and reason behind the result.

4.2.2 Definition and Literature of Individual Transferable Quotas (ITQ)

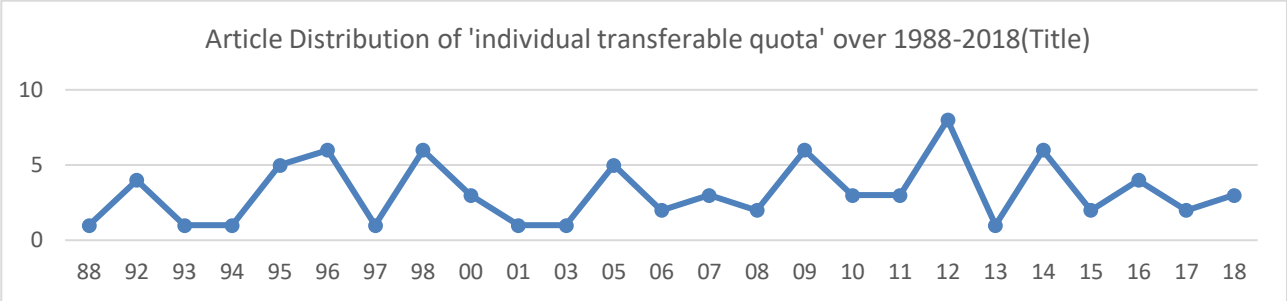
In the above part of literature, it primarily discusses the mechanism effect under the scenario of only one quota, but what will happen under the condition of multi-quota coexisting simultaneously? Previously, the multi-quotas mechanism was primarily deployed in management of the fishing industry. In preventing economic overfishing and achieving sustainable fishery, the management regimes on the allocation of property rights, including the individual transferable quota, attempt to remedy the externality of cost that is not accounted for by the individuals themselves, but adequate monitoring and enforcement are essential to the success of quota, and lots of externalities, such as problem of discards, will be generated. Therefore, a more specific and detailed quota mechanism, individual transferable quota as a mechanism of multi-quotas coexisting, will be elaborated as the following parts.

(1) Definition and Introduction

ITQ is a version of 'catch shares', and a regulatory tool to control fishing deployed by the government. Meanwhile, it is primarily deployed in the fisheries management contingent on the allocation and enforcement of semi-property right in the form of use and access rights. Which gives the owners exclusive and transferable right to a given portion of total allowable catch(TAC), which prevent the drive to 'race for the fish' given that this mechanism is effective in the practice, which was firstly introduced in New Zealand fishery management(Willey, Crothers, & Faulkner, 1988). The mechanism of individual transferable quotas is particularly applicable to the scenario that is fixed in supply, such as nonrenewable resource, forest industry, to capture the rent and prevent the dissipation(Grafton, 1992). But for participants, it is sound for the hypothesis of economic rationale in the theory of ITQ(Boyd & Dewees, 1992), which is given the hypothesis that each one makes its own decision to maximize its utility. Meanwhile, there is a divergence and disparity between the social public and private cost in an open fishery, and general failure to prevent the rent dissipation by regulators. More

importantly, the individual transferable quota exerts a triple bottom line of meeting ecological social and economic goal simultaneously(Péreau, Doyen, Little, & Thébaud, 2012).

Figure 29 Article Distribution of 'individual transferable quota' in the title over 1988-2018



There are 80 articles with the key word of 'individual transferable quota' in the data base of Web of Science until 31st September, 2018. This theory about the quota is primarily deployed by the fishing industry with the emphasis of multi-quotas for multi-species. Previously, the target primarily focuses on the examining of the optimum harvest, number of fishers, technology employed and the total rent. Now it primarily focuses on the compliance for the rules, economic efficiency and ecological sustainability, employment, biomass and rent capture for the economic maximization(Grafton, 1996), namely, the social-economic-ecological objectives. Accordingly, the ITQs tries to ensure a long-term interest by providing a feasible mechanism. The fishers will buy the ITQs from the public regulator or the owner, when the net return is less than the market price for some specific fishers, they will sell the quota. The public regulator or owner will determine the initial quota and verify the compliance of regulations. But in Shenzhen license multi-quotas market, the regulator also needs to verify and check the participants' preconditions meeting the rules. Provided the absence of individual fishing output and only a control of the total harvest, the race for fishing and inefficiencies will still continue. After a simple introduction about the ITQ of multi-quotas, what are the primary components in the ITQ of multi-quotas? What features does it have? How does it affect the quota effect?

There are three primary components in the theory, such as the total allowable catch (TAC), transferable quota, multi-quotas coexisting but with a mutual inclusive relationship. The following part will elaborate the details respectively.

(2) Total Allowable Catch (TAC)

The problem for the open-source common property fisheries gives rise to the misallocation of resources and a subsequent reduction of stock, therefore, the first question is how to determine the initial amount of allocation quota, from the experience of different fisheries, it is based on the historical or/and an existing amount. But it hypothesizes that there is a steady-state fishery where the total harvest equals to the growth in the biomass. Accordingly, the externality and divergence will still exist when there are controls on the total harvest and effort of the inefficient control. Therefore, a term of total allowable catch (TAC) is introduced to improve economic efficiency and reduce the externality, then it will be allocated among fishers as the harvesting right. But it will increase the variability as the increase of TAC(Sanders & Beinssen, 1997), and the increase in the aggregate quota will lower the production because it will lower the marginal price (Sumner & Wolf, 1996). Meanwhile, there are two targets in the quota system, reducing the catch to fulfil the biomass rebuild and sustainability, and an economic sustainability for the participants in the quota(Ford, 2001). However, as the problem of individual transferable quota, the (Ulrich, Pascoe, Sparre, Wilde, & Marchal, 2002).

Furthermore, the relationship between the catch shares and no-take reserves are complementary and can promote a lower total allowable catch when the harvest is relatively high (Little et al., 2010). Therefore, the ITQ as a management scheme should be carefully designed to meet the three generally accepted objectives, ecological, economic and social sustainability(Sumaila, 2010). Due to the uncertainty of total biomass and total allowable catch, there is a debate on the incentives for the long-term sustainability, and a contingent public/private transfer payment is necessary to improve the sustainability(Garrity, 2011), and extreme pressures are imposed on this renewable resource, the restricting accessing and allocation share of a specific amount are deployed(Péreau et al., 2012). There is a weak relationship between fishing effort and TAC, particularly, in the multispecies fisheries, therefore, it is unlikely to reduce the impacts of fishing effort on other ecosystem components when it is only contingent on one category of fishery quota, meanwhile, it will give rise to the localised depletion due to the incentive of reduction marginal cost resulting in the spatial concentration of high yield grounds or near-shore fishing area (Emery, Green, Gardner, & Tisdell, 2012).

Naturally, the ITQ participator maximizes the profit contingent on the quota trading price of previous period, so the initial allocation is very important in the decision of vessel sizes, and a higher initial allocation is positive associated with the investment in a large-sized vessel, meanwhile, the quota price is much higher when the allocation is more unstable and unequal (Tanaka, Higashida, & Managi, 2014). The excess capacity is a primary concern in the management of fisheries, improvement in efficiency have been observed in most of the empirical study, while there is only a modest changes in excess capacity, accordingly, it focuses on the dynamic relationship between the excess capacity and efficiency, it finds that the ITQ system only has a limited ability to alleviate the fisheries problem of excess capacity in the long-run (Rust, Yamazaki, Jennings, Emery, & Gardner, 2017). A new individual transferable effort quota is presented and primarily validated the relation among the fishing capacity, fishing activity, revenues, and variable costs through a semi-quantitative survey(Mulazzani, Camanzi, Bonezzi, & Malorgio, 2018). Accordingly, the TAC as the initial amount of allocation quota, it will affect the efficiency, externality, fishers' investment in the fishing, but it is hard to reduce the overfishing under the multi-quotas, particular for the multi-inclusive quotas.

(3) Transferable Quota

In the mechanism of quota, the transferable or non-transferable attribute concerns the efficiency and spillover externality in the practice. The market incentives are deployed to solve the short-run externalities, but for the long-run externalities, it is via the decision of management quota, and a bankable ITQs is proposed on the optimal exploitation of fisheries stock(Townsend, 1992). There is an economic efficiency from the quota trade, but it give rise to a concentration of quota, and the efficiency will be hampered by noncompetitive forces and necessary to limit the quota transfer and concentration (Lanfersieck & Squires, 1992). Public discontent with the concentration of fishing rights, and the ultimate efficiency may be jeopardized(Pálsson & Helgason, 1995). Increased the operation efficiency and asset management, but it does not expose the underlying moral dilemmas and concern for the social equity and balanced regional development (Symes & Crean, 1995).

Previously, the limitation on the use of fishing inputs have been proved the inefficiency at the stock depletion and preventing of rent dissipation(Dupont, 2000). The increase in the traded quota in the ITQs will result in the efficiency gains and associated cost reduction(Kompas & Che, 2005), due to the transfer from high to low marginal cost producers. It seems at odds for the achieving of economic efficiency and social equity simultaneously in the ITQ(Brandt, 2005). Meanwhile, the outcome is different for the short- and long-term perspective in the management of quota, while if the quota is allocated by the auction, it can capture the total potential rent, but only in the short-term. For the

short-term, the larger fisher benefits more from the introduction of ITQs, but all fishers are beneficial to the increase of price, and there will be a more efficient market for the long-term(Dupont, Fox, Gordon, & Grafton, 2005). Importantly, it can further improve the efficiency due to the permission of transfer of quota, so that more efficient operator will acquire a higher share of the quota. Necessarily, the design of the quota should be addressed the two minimization of transaction cost, the cost of transferring quota right among holders and users, cost of self-governance in the transferable process(Townsend, McColl, & Young, 2006).

But there is a question about the efficient for whom? It should be efficient for all actors in the fisheries, and the public, instead of only the holders of the ITQs(Pinkerton & Edwards, 2009). Meanwhile, in the lease market, the price is the market's perception of the net present value of the fishery net economic returns, furthermore, there is no wealth effect in the initial allocation and the information is perfect for all the actors, which is regarded as the precondition hypothesis in the theory of ITQ. However, it has proven the existing of an asymmetric information in the market. Accordingly, the equal and free information access on the regulatory change and previous data are important to maintain the equity and trade of ITQ.

However, lots of debate are raised, firstly, about the problem of concentration, a few big fishing company develop a monopoly power, it may increase the total welfare of all fishers is the allocation is contingent on the catch history(Heaps, 2003). Meanwhile, With the intention of market efficiency, the fishery's behaviour is consistent with the expected objective, such as the concentration of fishing right and activity, rationalization of the fishing fleet and the change achieving the maximization profit, however, the fishery is more reactive to the export market (Hamon, Thébaud, Frusher, & Richard Little, 2009), accordingly, the unexpected external elements can greatly affect the performance of the quota system. Besides, such as the increasing social inequity, primarily based on the lobbying machinery, instead of the economically efficient (Sumaila, 2010), therefore, it cannot ensure the sustainable management of fishery ecosystems. But It is a natural consequence of concentration in a tradable market, (Garrity, 2011). For the comparison between the individuals transferable quota and auctioned seasonal quotas based on the experimental simulation, it finds that the latter one has a lower risk for the bankruptcy of fishers(Moxnes, 2012). The other firm-specific elements, such as the geographical location, the cost of quotas, whether it is a family firm are more important in the investment strategies, more importantly, the investment strategies may not be driven by the consideration of efficiency, and the tradeable quota may not necessarily increase the allocation efficiency(Nøstbakken, 2012).

In the meta-analysis, variables were deployed to study the management target, such as the ratio of current biomass to target biomass, total catch to total quota, time-series total catch, years since the quota implemented, etc. additionally, it indicates the biomass under the transferability of quota is slightly higher than the biomass with a non-transferable quota, but variables descripting the regional difference have the largest impact on the biomass (Melnychuk et al., 2016).

Transferability of quotas fosters the economic efficiency, but there is a concern on the multispecies fisheries, due to the challenge of multiple stock fisheries, incidental catches of non-target species, uncertainty of each-species catch, discarding of non-target species or less-value species, setting of total allowable catch in multi-species(Dale Squires et al., 1998). Therefore, the high-grading, discards, overages, etc. are the problems in the ITQs. When there is a transferable market, it will be more complicated.

(4) Mixed Multi-Quotas Coexisting

Under a multi-product quota, the flexibility of firms on the product decision is tightly constrained by

the cost structure and technology, accordingly, the firms cannot find its own product bundle to optimize its disposal and net profit under the uncertainty of resource stock for different species (Dale Squires & Kirkley, 1991), and under the multi-species, the potential benefits are diminished due to the additional quota constraints in the joint production(Squires, 1995), it is more complicated than a single quota. Meanwhile, there is a market failure of a multi-product and an ill-structured property right, which may not generate the designed objectives for the multi-product(Dale Squires & Kirkley, 1996). Similarly, the desired rents and achieve biological objectives cannot be generated under a multi-products of ITQs (Dale Squires & Kirkley, 1996), for individuals, the quota imposed by the regular is exogenous variable. Furthermore, under a single quota, the quasi-rent can be measured by the producer surplus either output market or quota market, while under the multiple quotas, it is necessary to have at least one positive production for the firms' continuous operation(Vestergaard, 1999), with a technology input, it is an interaction between the technology and economy, and a distortion exist for others. Accordingly, the primary technical factors in the multi-species is the number of species, stability and abundance level and the selectivity mechanism(Dale Squires et al., 1998). It is concerned about the application in different species and harvest process, entailing the difficulty to assess fisheries with identical technology and behaviours. Fishers can only optimize the yield when there is a high degree of controlling the species mixture in the catches (Branch & Hilborn, 2008), therefore, there is a fishing opportunity that dependent on the expected multispecies composition. Within the multi-species-quotas. More importantly, it is inclusive, quotas' holders can make a combination among different species quota to maximize its interests, however, which will cause lots of problems. For the problems of the multiple-inclusive species, the compliance and discarding are the primary ones, and with a mutual interaction relationship.

1)Compliance

The compliance of the regulation is a fundamental requirement for a successful ITQ programme (Grafton, 1996). When the enforcement is not sufficient to ensure the perfect compliance, over time, the biomass level, TAC will be reduced, but the equilibrium quota price will increase (Chavez & Salgado, 2005). A social adjustment policies and a buy-out scheme are important to attain the ecological sustainable development(Waitt & Hartig, 2000). An ordered-response model is deployed to study the element affecting the quota compliance, and indicating that the conventional economic incentives dominate the level of compliance(Hatcher & Gordon, 2005), although a perfect compliance is a hypothesis for the individual transferable quota achieving a maximum social benefit, and the con-compliance will reduce the equilibrium quota price(Chavez & Salgado, 2005).

Furthermore, what is the effect of market power on compliance? When the participant has the market power in both the quota and the output markets, the participant may comply with the quota even with the absence of enforcement, otherwise, it will always cheat(Aaron Hatcher, 2012). Meanwhile, there is a problem about the quota compliance, it indicates that the informal sanction, such as social disapproval and guilt, there is an indirect effect on the regulation, and a dynamic relationship among the quota prices, compliance level and the norm of compliance(Nøstbakken, 2013). A binding total allowable catch is indispensable in the successful management of ITQ, otherwise, a non-binding TAC will contribute to the open access conditions, and biomass will suffer from the race to harvest(Emery, Hartmann, Green, Gardner, & Tisdell, 2014), which also indicates the importance of TAC and the relationship between different components in the framework of ITQ .

Accordingly, there are further spill-over externality effect under the mechanism of ITQs, such as the bycatches due to the uniformly distribution. The solution to these side-effects, such as the enhancement of transferability of quotas, provision of positive incentives and rewards for the reduction of discards and overages, and the penalty is regarded as an incentive to motivate fishers

comply with constrains of quota.

2)Discard

This problem is more prevailed in the multiple species, but there are complicated biological and technical interactions among species. Due to the imposed quota in the multi-species, the fisher has an incentive to discard less-value fishes to maximize its profit, therefore, a discard gives rise to the loss of fish market value, effort for the fish harvest and the fish reproductive potential(Turner, 1997), over-harvesting and then discarding is the way of minimized cost to generate the specific amount of quota, and the discarding is profit maximizing and cost minimizing for the firm. Besides, if the revenue maximizing legal landings are technologically efficient, then the discarding is not profit maximizing, therefore, in order to reduce the discarding, the way is to ensure the legal landing is technologically efficient, and a value-based individual quota should be considered, rather than a quantity-based quota.

The full observer coverage and mortality accounting would reduce the discard fraction, however, such reduction will be limited due to the severe catch restriction(Branch, Rutherford, & Hilborn, 2006). And the limited hold capacity and the mechanism of transferable quota provide incentives to discard fish, (Kristofersson & Rickertsen, 2009), and indicates the vessels are involved in the high-grading, but without evidence supports the high-grading caused by the price-induced quota, however, there is a predicted discarding quantity amounting to 4.7%, and the banning of discarding increases its profit(Ono, Holland, & Hilborn, 2013).

More importantly, the problem of quota allocation causes the discarding between the different sizes fleets and firms (Gray, Korda, Stead, & Jones, 2011), meanwhile, compare to the scenario before the implementation of ITQ, there is a little decrease of discards since the implementation of fishing quota(Cullis-Suzuki, McAllister, Baker, Carruthers, & Tate, 2012). Naturally, what elements do contribute to discards? The decrease in the discarding is, simply, because the increasing amount of quota(Macdonald, Cleasby, Angus, & Marshall, 2014), the selecting fishing will have a lower discards and higher profit, therefore, a discard ban and catch quotas lead to a strong incentives for the selecting fishing and non-compliance, namely, high-grading, accordingly, the enforcement and monitor are necessary to ensure the profitability by selective fishing, rather than the discarding(Condie, Catchpole, & Grant, 2014). Additionally, what effect would be imposed by the discards ban? Which find that the quota price is sensitive to the penalty rate, and an interdependence between the penalty rate for both over-quota landing and discards in determining quota market(Hatcher, 2014). The over-grading could be the reason for the discarding, and there is a substantial high-grading at the beginning of the year, the participant can respond to changes in the reallocation of quotas(Batsleer, Hamon, van Overzee, Rijnsdorp, & Poos, 2015), but it admits that the challenge and difficulty in obtaining reliable amount of discarding estimation. The landings for a specific category is correlated with the market value and profit, and there is a discrepancy between the quota and scientific recommendation in the catch-quota balancing, so the discarding is a result under the mechanism, in order to reduce the discarding, the species transformation system is introduced(Woods, Bouchard, Holland, Punt, & Marteinsdóttir, 2015).

However, contingent on the multi-quotas, there is quota substitution between an under-harvest species quota and over-harvest species quota, but it is difficult to set the exchange rate, when the rate is inappropriate, which will result in the over-harvesting of less abundant but more valuable species. But in the multiple species, the TAC for each species is an exogenous determined variable, namely, the vertical supply curve without the effect of price. And there is a consideration to reduce the cost of exchange in the multiple species. Accordingly, the mechanism of ITQs is more difficult in a multiple species fisheries, although with a substantial investments in the enforcement, scientific

assessment and monitoring (Garrity, 2011), and it indicates the inappropriate setting of TACs and low level of harvest compliance give rise to the failure of rebuilding stocks and the loss control of discard. Therefore, the implementation of a single-species quota in multi-species quota is problematic due to the incentive of discarding, which will reduce the economic benefit and bias estimation in the stock, then the species transformation system is introduced, but it is difficult to achieve the optimal goals(Woods, Holland, Marteinsdóttir, & Punt, 2015). For the multiple species, the substitute production across species is important in the allocation targets, and it indicates that an increase in landing in one species requires a landing increase of other species, suggesting the difficulty of substitution production across different species(Scheld & Anderson, 2017). But there is a huge challenge for the matching individual catch rate and the share of quotas in the multiple species, and it also affects the quota price.

Therefore, the three components are intertwined with each other, to affect the result of efficiency and externality. And the discussion falls on the difference among a constant TAC or dynamic TAC, a transferable quota or non-transferable quota, multi-inclusive or multi-exclusive quota. Among the three components, and each component has two statuses, there are 8 different alternatives, it is important to controlled the condition when it studies one element on the effect of multi-quota.

4.2.3 Reviews

Review 1: Extension to the existing theories and studies

Based on the above literatures, it primarily focuses on two kinds of quotas, single-species quota and multi-species quotas, then on the quota effect and important components in the theories. Lastly, it comes to the spillover and externality caused by the quota respectively. And primary elements in the study fall on the three elements of transferable quota, total allowable catch (TAC), multi-quotas coexisting.

Firstly, whether the quota can be transferable or not, the condition is different, and what effect could be on the target? it will increase and gain the external efficiency as the combination of different vessels in a transferable market(Weninger, 1998), and there is a considerable efficiency gains and cost reduction in a traded quota(Kompas & Che, 2005), while tradable or non-tradable emission quotas provide equal incentives to invest in abatement technology for firms(Hagem, 2001). Comparing to the ITQ, the IQ without a quota trade market is more rigid management mechanism(Péreau et al., 2012). But in the tradeable quota market, there is a phenomenon of concentration of a specific category of license, such as conventional vehicles, particular for the lottery.

Secondly, the available amount of quota, namely, TAC, is whether a dynamic or a fixed amount of quota. In the previous studies, generally, the single-species quota falls on the fixed quota, such as the gender quota in the legislative system. And the multi-species quotas fall on a dynamic and uncertain amount of quota, such as maritime fishing management. But when a multi-species quota connects with a constant amount of quota, what difference does it have? Previous studies demonstrated that there is a concave revenue function indicating that a constant quota will be preferable(Hannesson & Steinshamn, 1991), in the sample of imported quota distribution among different countries, a share equals to the market share before the restriction, namely, the share of free trade. But how does it determinate the quota quantity and which one is the best solution? It is contingent on the market role, importer, higher export-price elasticity exporter or a lower export-price elasticity exporter. And for the comparative welfare effect, the ranking is different among the quota allocation method(Kreinin & Dinopoulos, 1992). Additionally, when it is multi-species quotas with a dynamic quota amount, one of the target is to study the counter effect of quota on a dynamic

amount of biomass, for example, an individual quota management increases the fish density(Sullivan & Rebert, 1998), a greater increase in quota prices will reduce the fish stock (Newell, Sanchirico, & Kerr, 2005), it can reach the point of maximum social benefit with the individual transferable quotas(Chavez & Salgado, 2005). Therefore, what difference does it have when a multi-species quota connects with a constant amount of quota as an exogenous variable in the design of quota?

Thirdly, for the ITQ, its primary incentive is designed to increase the economic rent and sustainable harvest. Previously, the intention of quota is a method deployed for the rent capture, there are two methods of rent capture, quota tax is based on the price of quota and profit tax is a certain share of profit as the tax. And a prerequisite for the quota tax is a competitive quota market where the prices can be generated and known bilaterally. A profit tax and a quota tax are the two methods to collect the rent, where fishers capture the full benefits of efficiency improvements in the category of quota tax, and the regulator and fishers share the risk and benefits in the category of profit tax (Grafton, 1992). Therefore, the target is different, previously, the intention for the fishery participated in the ITQ is to maximize the economic profit, and the maximization of utility for the individuals who participate in the license quota among different choice of categories. However, for Shenzhen transport regulator, the intention is to promote one category of quota against others, therefore, it is different in term of regulator intention. But individuals who participate in the fishing quota or license quota, have the same intention to maximize the profit in the fishing quota and utility in the license quota. When the rent catch is not the primary target, with a way to incentivize the adoption of one choice among the multi-choices, such as NEVs, what result does it have?

Lastly, there is a multi-species quota with a mutual inclusive relationship, individuals can make a decision with a combination of different choices, but when the multi-species quotas are exclusive with each other, namely, individuals can only choose one of the multi-quotas, instead of a combination, what result could have?

And for my empirical study, the sample of Shenzhen is employed that adapts to the extension from the above. It can be descripted as the model of non-transferable quota, fixed and constant TAC, multi-quotas coexisting but with a multi-exclusive relationship, instead of multi-inclusive quotas. And the for the quota organizer, the license quota is to limit the total consumption of vehicles, reduce the volume of conventional ones, and promote the adoption of NEVs, instead of a simple rent catch. Therefore, integrating the extension of theory and studies with the condition of empirical study, it will be regarded as a basement to the next two reviews.

Accordingly, for the empirical study of multi-quotas, the primary components are different, it can be simplified as comparison of uncertainty TAC vs certainty TAC, transferable quota vs non-transferable quota, inclusive multi-quotas vs exclusive multi-quotas, which are the primary components in the study of quota, but in my study, the scenario is subject to a mechanism of multi-exclusive quota with a fixed TAC and a non-transferable market, which is much better to study the bilateral relationship among different sub-quotas due to the existence of fixed TAC and non-transferable market, more importantly, under the condition of full compliance.

Review 2: Actual effect on individuals' behaviors as the implementation of a multi-exclusive quota with a fixed TAC and a non-transferable market.

Naturally, the question will be raised about the whether the quota has fulfilled its initial target, and how it works under multi-exclusive quotas with a fixed TAC and non-transferable market. The previous researches focus on one category form of quota, such as effect of gender quota in legislative system and education resource. But the scenario under the gender quota in legislative system is compulsory numeric allocation, these quotas intend to increase the gender and ethnic

representation in the employment market and legislative system, which is affirmative and compulsory, but when there is only a specific number or ceiling imposed on different categories, individuals have the option to choose different one. Meanwhile, individual transferable quota primarily concentrates on multi-species quotas but with a mutual inclusive relationship. Participants can have an optimized combination among diversified species, namely, it is co-existing. When the multi-quotas are exclusive, the participant can only have one choice among different categories, each choice is similar to an information filtering and behaviors can be regarded as a collective dichotomous choice(Ben-Yashar & Kraus, 2002), what difference could it be? Does it still achieve the initial target under the multi-exclusive quotas?

Review:3 Spillover and discards under the mechanism of multi-exclusive quota with a fixed TAC and non-transferable market

Contingent on the extension of theories, under the scenario of mutual exclusive quotas with a fixed TAC and non-transferable market, is there a spillover? what externalities could have? For this part, it will primarily focus on two externalities, spillover and discards.

Firstly, on the spillover Effect, concerning the part of a single quota, for example, the racial quota on the education resources, the debate focuses on the spillover effect of lower admission standard. The quota for the disabled people in the employment market will lead to an extrusion for them. And there are phenomenon of cheating and misrepresentation in the quota and subsidy, and widening the income gap among different regions, therefore, the study on the spillover effect for a single quota cannot cover the real scenario. In the second part of multi-species quotas, it primarily focuses on the direct quota effect on specific individuals, neglecting the spillover effect, such as individuals' adverse selection. Meanwhile, when the relationship among multi-quotas has been converted from multi-inclusive into multi-exclusive, it neglects the bilateral relationship among different sub-quotas, and the bilateral relationship on the spillover.

Secondly, concerning discards, it mainly happens in the multi-species quotas, but it is difficult to study the exact mechanism effect on discarding, particular in the multiple species. Previously, in the theory of individual transferable quota, the multi-species are inclusive in the application of fishing management, fisheries can have a harvest with a combination of different species, but with a quota for a total amount or a separate quota on each species, which increases the difficulty of enforcement compliance, therefore, after the harvest and constrained by the amount of quota, the discarding happens with the target of profit maximization and extent of quota enforcement. Accordingly, the inappropriate institutional mechanism for the common property and difficulties in the testing of compliance, worsen the phenomenon of discards.

However, what will happen when a full enforcement of compliance and with clear exclusive multi-species quotas? In Shenzhen's license quota system, it has clear and controllable measures to maintain the enforcement of the license quota. From the application, checking of preconditions, publication of lottery or bidding results, licence registration, purchase of vehicles categories, which are all under the management of regulator, and the information is transparent in different operation process, and which is bind with individuals' ID number, therefore, the enforcement of license quota is much easier and better than the fishing quota. Meanwhile, the multi-species are exclusive without a substitution among different quotas in the design of mechanism, participants can only have one choice for a specific category, instead of a combination of multi-categories that increases the difficulty of enforcement. Accordingly, for the discarding in the multi-species with a mutual exclusive quota, participants can only make a decision on whether the specific category chose by themselves is accepted or not, when the previous choice is rejected by itself, it is regarded as discards.

Additionally, for the multi-species quotas in the theory of ITQ, it does not study the mutual effect of multi-quotas on the discards, due to the uncertainty and difficulty in the study of enforcement and amount estimation. Previously, for the application of fishing management, an increase in landing in one species requires a landing increase of other species, suggesting the difficulty of substitution production across different species(Scheld & Anderson, 2017), this is the substitution effect among the mutual inclusive quotas, but what is the effect on discards under the multiple exclusive quotas?

4.2.4 Hypothesis

Based on the above part of review, it extends the existing theories and studies, and the new condition of multiple exclusive quotas is confirmed. Therefore, this part plans to answer the question whether the adoption of NEVs is forced to green or not, and the spillover and discards caused by the quota. Meanwhile, for the empirical study and test of hypothesis, it will be tested from both micro-macro perspectives, where the macro-perspective refers to data collected from the authority's publication monthly, including the lottery probability, bidding, available amount of quota, and the previous application data, and where the micro-perspective refers to the data collected from the fieldwork. Additionally, from the macro-perspective, it will focus on the extrusion effect among different quotas, such as the extrusion effect of conventional vehicles on the NEVs.

Hypothesis 4 Individuals are forced to green in the adoption of NEVs under the multi-exclusive-quotas with a fixed TAC and non-transferable market.

It will test the hypothesis from both micro-macro perspectives, where micro-perspective refers to the empirical study of how many times participating in the multi-exclusive quotas based on the data of fieldwork, and the decision sequence is also important among multi-exclusive quotas to test whether it is forced or not. Additionally, macro-perspective refers to total bidding price and number of applicators as a whole in the multi-exclusive quota system.

Hypothesis 4.1 It is forced to green in the adoption of NEVs in the model of multi-exclusive-quotas, the more times participating in the lottery of conventional vehicles, the higher possibility of purchasing NEVs.

What is the effect of quota on the individuals' behaviors, particularly, under the scenario of multi-exclusive-quotas? Firstly, regarding the effect of a single quota, there is a sharp reduction from the competitors(Wolf, 1959), a steady and gradual increase for the patients with an exercise quota(Doleys, Crocker, & Patton, 1982), increases the production output and decrease the price(Lips & Rieder, 2005), a diversified effect on the electricity market, even the total output is fixed in the emission quota(Golombek, Kittelsen, & Rosendahl, 2011), a higher barrier of exiting and decreasing of total employment(Peck, 2017). While for multi-quotas, primarily in the application of fishing management, it prevents rent dissipation(Dupont, 2000), efficiency gains and associated cost reduction(Kompas & Che, 2005). Accordingly, when it is a multi-exclusive-quotas with a fixed total allowable catch, a non-transferable market and mutual exclusive quotas, it can also achieve its target.

Hypothesis 4.2 In term of macro-perspective in multi-exclusive quotas, the higher cost and smaller probability of one sub-quota, the higher rate of adoption for another sub-quota. Namely, the adoption of NEVs, is positively associated with a higher bidding price and lower lottery winning rate.

Individuals have multiple choices, the possible positive spillover effect for the adoption of NEVs is the condition that the demand of conventional ones is higher than the quota cap. Will consumers concentrate on a specific category? That always happens in the fishing industry, as the phenomenon of race to the higher value fish species. From the implication of quota in fishing market, the quota price will increase as the demand increase, initially, there is a substantial price dispersion, while the

dispersion will go down within individuals over time(Newell, Sanchirico, & Kerr, 2005). With the considerations of income elasticity of driving, price elasticity of driving, average annual income, the plate bidding mechanism has a higher welfare gain in terms of consumers surplus, which guarantees the individuals with higher preferences of driving to obtain the plate, but results in a less congestion mitigation as the successful bidders with a higher driving preference will drive more. Furthermore, contingent on the operation cost per mile to examine the mitigation effect, the lottery result in a higher traffic mitigation effect comparative to the bidding mechanism(Zhu, Du, Xiong, & Zhang, 2013). Accordingly, this part will fall on the macro-perspective to test the relationship among different sub-quotas, particularly, on the adoption of NEVs.

Hypothesis 5 There are spillover and discards caused by the multi-exclusive quotas

Due to the limitation of quota imposed on the domain of one city and prerequisites of applicators, therefore, is there an externality, such as spillover and discards?

Hypothesis 5.1 There is a spillover effect under the multi-exclusive quotas. Individuals will choose to purchase a vehicle outside the domain of imposed quota scope, this could be opposite with the initial target of reducing the volume of conventional vehicles and increasing the volume of NEVs.

There are several distortion effects giving rise to the sub-optimal of trade volume and allocation(Bogetoft, 2003), the debate among different policies on environmental protection, the emission quota brings less distortion than the emission tax(Yanase, 2007). The gender quota exerts a spill-over effect on the proportional representation, whereby it has a negative impact by preventing women from winning same seats in the next election, but with a positive impact on the gender representation by relocating to other districts(Shin, 2014). Similarly, a residential desegregation program in Singapore, namely, the ethnic housing quotas, which has a distortion effect and causes the price difference, and challenge the target of achieving the desegregation using quantity restriction(Wong, 2014). So it is imperative to establish quotas to justify the equality on the representation(Figueroa, 2015), Contingent on the Shanghai's empirical study, it indicates the existence of both welfares gain and loss, the net effect depends on the marginal externality and consumers' preference for vehicles (Xiao, Zhou, & Hu, 2017). Accordingly, there is also a spill-over effect under the multi-exclusive quotas.

Hypothesis 5.2 There is an externality of discards in the multi-exclusive quotas. The higher cost of the bidding, the higher rate of discards; The lower the lottery rate of winning a license plate, the lower rate of discarding.

Is there a discard emerged in all sub-quotas or one of them under the multi-exclusive quotas? In the theory of ITQ under a multi-inclusive quota, fishers will discard the lower value fishes under the constrain of quota(Turner, 1997). Meanwhile, the difficulties in matching quota holdings with catches, there is a combination of limits and incentives providing a sufficient flexibility to ease the risk of overexploitation for fishers(Sanchirico, Holland, Quigley, & Fina, 2006). And it is consistent with the enforcement of compliance will affect the discard(Garrity, 2011). the three primary components in the individual transferable quota are interconnected with each other, but when the TAC fixed and there is no transferable market, and it is a full enforcement and compliance, the discard will emerge in the category of sub-quota with highest cost for individuals, and the higher cost of the bidding, the higher rate of discards; The lower the lottery rate of winning a license plate, the lower rate of discarding.

Chapter 5 Sampling Design and Description Analysis

5.1 Sampling

5.1.1 Sampling Introduction

The design of sampling is based on the literature review in 3rd chapter, where elaborates the problem on data collection and methodologies for the adoption of electric vehicles. And the solution is the data enrichment and fusion combining the stated and revealed preference, instead of the solo stated preference in the current works. More specifically, the below table presents the design of sampling.

Table 19 Design of sampling

	Controlled group (Other cities)	Experiment (Shenzhen)
Stated preference (no Electrical Vehicles)	Comparison Group 1	Comparison Group 2
Revealed preference (owned Electrical Vehicles)	Comparison Group 3	Comparison Group 4

The data collection started from 23rd, May 2017 to 8th, August 2017, consisting of two groups, one is the experiment one in Shenzhen with the impose of quota, another one is the controlled group in others cities where no quota has been implemented in the cities as the preference policy to promote the adoption of NEVs. Additionally, the data collection was based on the cooperation of a NEVs dealer and charging service provider[27],named Judian, who has developed an APP as the company's customers service platform, which can be downloaded by the customers or the potential ones. The APP, charging station, which is one of the most popular APP for the E-drivers to find the charging stations, and payment for the charging fee. On the APP, individuals will not only know the locations and price, the parking and other service fee, but also the type of charging station, including the fast or slow charging, where and how many charging stations are still available for charging now, and send its application to the organization where could build a new charging station, and the service feedbacks about the charging station from the drivers.

Individuals who have installed it could receive the questionnaire notice from the APP manager. In order to control the sample, initially, the two-questionnaire links for two groups are separated. In the APP, respondents can choose the link according to the description, namely, Shenzhen, or other cities (in order to collect a clear comparison group, there is a notice above the link, "excluding Beijing, Shanghai and Guangzhou", due to the fact, as the first-tier cities, complicated but different vehicles management policies have been implemented over a long period in these cities). For the participants, it still has a probability of choosing the wrong questionnaire link, but according to the address that respondents have submitted, if it is wrong, the samples from excluded cities will be erased, with the target to control the samples from the controlled group and experiment group.

Therefore, with the consideration of contingent valuation's limitation and better closing to the real scenarios of individuals, after the description of WTP elicitation methods, where in my work, the method could be concluded as a combination of double-bounded dichotomous choices and an opened-ended question, namely, the first dichotomous choice of whether owning a vehicle is

[27] The firm's homepage: http://www.ueee.cn/, it has clear introduction on the primary business and APP in Chinese. Meanwhile, the following attached photo is the QR-code of the APP, which is a platform to provide the charging service and management of customer relationship. For the detailed information of cooperation, I upload the questionnaire link on the APP, then the colleague in the firm's customer relationship management department will promote the message to individuals every second day. The following photo is the APP's QR code to spread its APP conveniently.

presented for all subjects, then the choices between NEVs or conventional vehicles, with the target of accessing to real behaviors and avoid the potential demerits discussed in the previous part of measuring and methodology, such as the format effect, endogenous problem, and selection bias. Additionally, in the background setting of limiting the IP and allowance of solo PC and mobile phone, it can avoid the duplicate response.

With the consideration of incentive design, integrating with the current condition, the key points are illustrated as the following table.

Table 20 Introduction of the sampling

Category	Contents
Pilot survey	There are 30 samples for experiment and controlled groups totally, providing detailed feedback, including the logic, wording, questions, etc., after they finished the survey. More importantly, before the design of this round of sampling, it has a previous data collection in the end of 2015, which provides meaningful insight for this round of sampling and data collection, including the ideal platform, how to access to individuals who really purchased one electrical vehicle, what elements affect the data validity.
Incentive Type	Initially, for the pre-paid versus promised, a pre-paid incentive is the one give to everyone who receives the invitation regardless of whether they do or not. In on-line surveys, previously, vouchers are often used instead of cash, but now, with the penetration of digital finance and mobile payment in China, all the payments among different entities and individuals can be done within seconds. The voucher is not an ideal way for incentive in China now. Meanwhile, due to the challenge of incentives transition, lots of discussions focus on ways to balance the cost and efficiency. For example, a pre-paid incentive could be regarded as an obligation for recipients to fill the questionnaire, and increase the response rate. Furthermore, for the lottery versus guarantee incentive, the research generally indicates that a lottery incentive has about the same impact as a straight payment for the respondent. However, specific tests of lotteries against other types of incentives or no incentives show that lotteries are no more effective in web surveys than in other kinds of surveys. in most tests, lotteries did not significantly increase response rates over a no-incentive or alternative incentive group. In addition, previously, lotteries are thought to be generally more difficult to administer as participants often require registration. All these previous analyses subject to the limitation of payment approaches, however, as discussed in the above, it has not been a problem in China due to the penetration and integration of mobile payment in every corner of daily life. Accordingly, in the pilot survey, the incentive in my design consists of two parts, the first step is a lottery payment to all the members in different social groups with the intention to raise their attention. The essence of this approach is similar to Chinese traditional “red envelop”, but supporting by the Internet technology. According to the number of members in the group, I can set the total amount of cash and number of “red envelop” that will be divided, which could be regarded as a live competition show among members within the group, all the members could seize the chance to get the cash by a randomized amount. Meanwhile, I will send the link of questionnaire in the group, all the members can open the link and fulfill the questionnaire. Additionally, I will also send the link to all the members’ “chatting window” separately, where I can discuss with them about their questionnaire feedbacks lively. Admittedly, the majority of them would seize the cash incentive in the groups but ignore the affiliated task of filling the questionnaire, which is contradictory to the previous conclusion that a pre-paid incentive could highly increase the respond rate. Why? To a larger extent, the cash incentive is regarded as taking for granted instead of obligating to finish the task by the individual due to the fact that individuals are used to get the randomized amount of ‘red envelop’ within a social group in China, it is regarded as a small game, instead of a task to be filled. Based on the context in China and experience in the pilot survey, in the formal survey, the incentive is a guarantee and constant incentive. After it submits the questionnaire successfully, 5 RMB will be transferred to the participant by mobile phone. Participants will add the Wechat account from the firms’ customer-personnel team, then the incentive will be transferred by the firm’s colleague.

Budget	The total budget for this round of questionnaire is 15,000RMB, with the cash incentive of 5 RMB for each respondent who has submit the questionnaire. The amount of cash incentive is subject to the budget limitation and the consideration on the effectiveness of incentives, neither too high nor too low. Otherwise, individuals have motivation for cheating or no intention to fill the questionnaires. In Shenzhen, for the non-fulltime work, the minimum payment is 19.5 RMB hourly in the year of 2017. Moreover, in the pilot survey, the average time-cost is 6 minutes. Lastly, from the feedback of all samples, average cost-time is 325 seconds in the experiment group of Shenzhen, and 267 seconds in the controlled group of others cities.
Delivery Method	Which is transferred through mobile payment, Wechat. This approach was contingent on the discussion with the cooperation partner of the firm. Firstly, we can assure the correspondents have finished the questionnaires. Besides, for the partner, they can expand the potential customers and have more active mutual interaction with customers in the social platform. The incentive cash is easy to be delivered, individuals are accustomed to the effectiveness and efficiency of mobile payment in their daily life. Accordingly, the traditional voucher for the responders, it lacks strong sense of timeliness, which needs additional time to redeem the gift cards, which will sharply reduce the motivation to do the questionnaire in China.
When to Offer Incentives	In the pilot work, there is a randomized cash incentive in the group to raise their attention and interest, namely, before the survey; Furthermore, the continuous cash incentives will be delivered for the feedback after they have finished the work. For the time of incentive payment, in the formal survey after the pilot, it will be transferred after a successful submission. When individuals submit the questionnaires successfully, there is a notice, "scanning and adding the Wechat account， the cash will be transferred to you".
Quality Control	The survey software offers some functions for the quality controls, including the setting that will refrain individuals from repeating submission, such as the setting of only one submission from one mobile phone, computer or IP address. Furthermore, in the process of cash transferring, is based on the account list that is generated after respondents' submission, and adding of the firm's Wechat account, we can assure to avoid the repeated account. Besides, the amount of incentive, it could be regarded as a neutral measure as a symbolic incentive, and avoid the subject motivation to fill the questionnaire several times.
Questionn -aires	There are two questionnaires for the experiment samples in Shenzhen and controlled samples in others cities, primarily, which are the same in the questions, but with a light difference due to the different scenarios and contexts. For more details, questionnaires and web links are attached in the appendix, which is better to compare the difference and logic among the questions.

Note: the sampling is very important, the emphasis on the above table try to elaborate the key points that get the data needed in the dissertation, simultaneously, to a large extent, maintain the data validity and avoid the sampling bias by the platform, incentives, peer effect, etc.

The following table indicates the cost time for filling the questionnaires in the two samples, the mean cost time and standard deviation in the experiment group are both greater than controlled group.

Table 21 the cost-time for answering questionnaires

Groups	Variable	Obs	Mean	Std.Dev.	Min	Max
Shenzhen (experiment group)	costtime	607	325.3seconds	935.4	54	22,470
Other cities (controlled group)	costtime	1,302	267.8 seconds	350.9	43	7,691

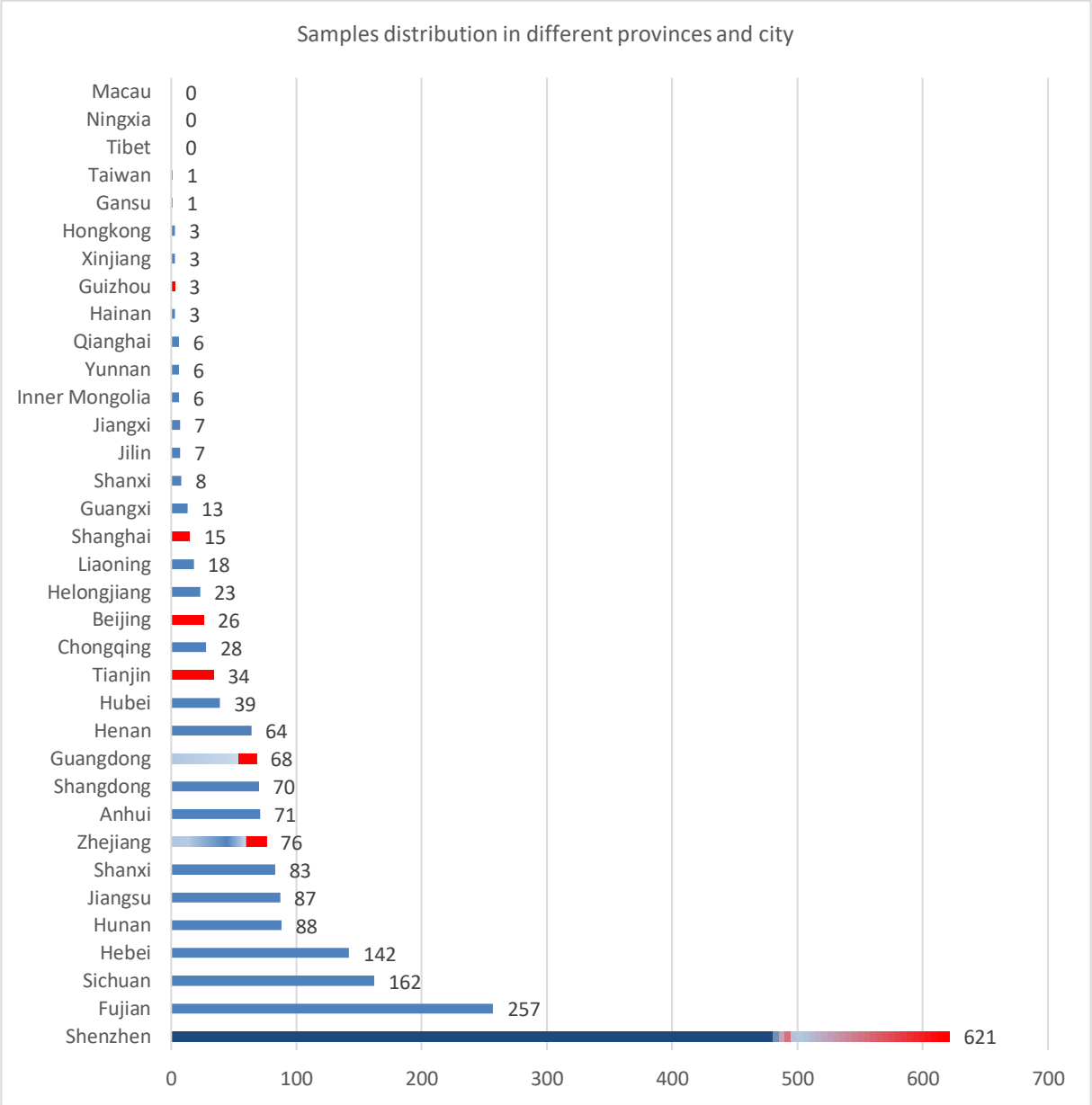
NOTE: where the observation number is the result of effective samples deleting the un-effective samples in both experiment and controlled groups. Meanwhile, within the effective samples, there are two samples that cost unexpected long time for filling the questionnaire, the reason for that is because the break in the process of filling, the individual finishes it after a long break.

5.1.2 Sampling Distribution

Initially, the samples distribution indicates as the following figure. It is presented according to level of provincial names, except for the experiment samples in Shenzhen, as a city. In the questionnaire, participants will answer the question about the city where they live, amounting to 310 cities totally,

then based on the location of cities in different provinces, it has been converted into the provincial distribution.

Figure 30 the samples distribution in the provinces level



NOTE: This figure presents the distribution of all the samples, but in order to stringent control the two groups, experiment and control groups, the red in the above chart indicates part of samples should be erased according to the requirement in the two groups, as the fact that there is diversified license plate quota deployed in the province's city. Meanwhile, the statistical report in term of the provincial level, it calculates the number contingent on the answer of one question in the questionnaire, which city do the individual live? When we know the names of cities, it is easily calculated for the provincial level.

Similar situation is not unique in Beijing, as of the third quarter of 2017, there are eight cities, Beijing, Shanghai, Guangzhou, Guiyang, Shijiazhuang, Tianjin, Hangzhou and Shenzhen, implementing restrictions on consumers' vehicles purchase. Meanwhile, six of the eight cities, Beijing, Shanghai, Guangzhou, Shenzhen, Hangzhou and Tianjin, have promulgated special preferential policies and incentives for the new energy vehicles.

Table 22 distribution of effective and un-effective samples in the controlled and experiment groups

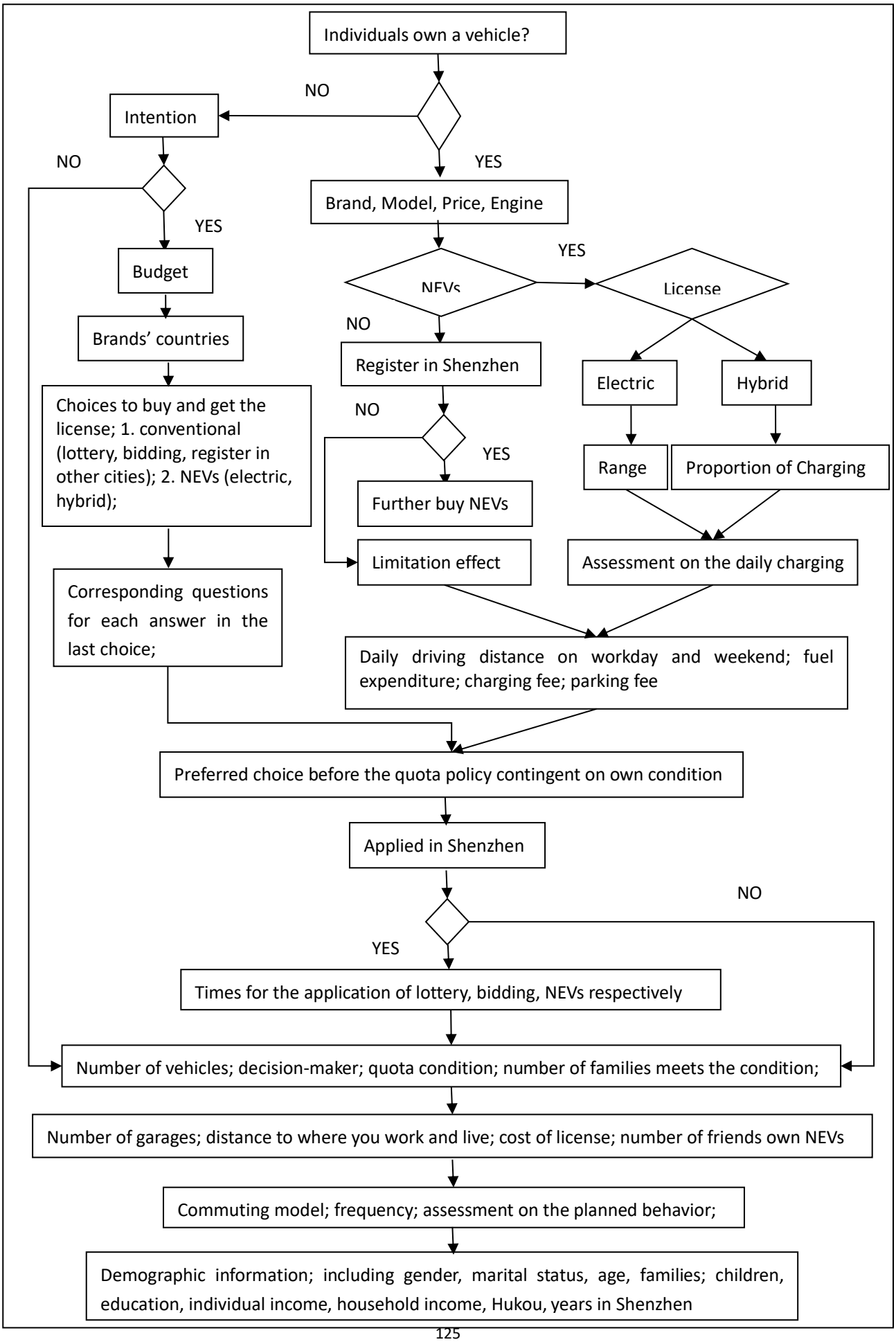
Group	Controlled group (Other cities)		Experiment (Shenzhen)		Sum
Total number	1416		621		2037
Un-effective samples	Beijing	26	Other cities	14	128
	Shanghai	15			
	Guangzhou	11			
	Guiyang	2			
	Hangzhou	26			
	Tianjin	34			
Reason	These cities have different quota for the adoption of NEVs.		These respondents filled the questionnaire of other cities, instead of Shenzhen itself.		
Effective samples	1302		607		1909

5.2 Description Analysis

Before the details of description analysis about the data in the field work and research, it is better to know the logic and guidance behind the questionnaire, the questionnaire framework is presented as the following figure. There are lots of filters and skips in the questionnaires, it is better to refer to the questionnaire website links[28] where the logic and skip have been integrated into the questions.

Figure 31 Logic and filter in the questionnaire

[28] The questionnaire link for the experiment group in English is: https://www.wjx.cn/jq/12798469.aspx
The link of Chinese version for the experiment group is: https://www.wjx.cn/jq/15181257.aspx
The English questionnaire link for the controlled group is: https://www.wjx.top/jq/13423990.aspx;
The Chinese questionnaire link for the controlled group is:
https://www.wjx.cn/pq/15044430.aspx?t=636866708954638165;


Individuals own a vehicle?
NO
YES
Intention
NO
YES
Brand, Model, Price, Engine
Budget
YES
NEVs
License
Brands' countries
NO
Register in Shenzhen
Electric
Hybrid
Choices to buy and get the license; 1. conventional (lottery, bidding, register in other cities); 2. NEVs (electric, hybrid);
NO
YES
Range
Proportion of Charging
Further buy NEVs
Limitation effect
Assessment on the daily charging
Corresponding questions for each answer in the last choice;
Daily driving distance on workday and weekend; fuel expenditure; charging fee; parking fee
Preferred choice before the quota policy contingent on own condition
Applied in Shenzhen
NO
YES
Times for the application of lottery, bidding, NEVs respectively
Number of vehicles; decision-maker; quota condition; number of families meets the condition;
Number of garages; distance to where you work and live; cost of license; number of friends own NEVs
Commuting model; frequency; assessment on the planned behavior;
Demographic information; including gender, marital status, age, families; children, education, individual income, household income, Hukou, years in Shenzhen

5.2.1 Demographic

Questions on demographics, including income, gender, age, household size, education, and marital status, etc.

Table 23 tabulate the distribution of basic demographic variables

		Shenzhen (experiment group)			Other cities (controlled group)		
		Freq.	Percent	Cum.	Freq.	Percent	Cum.
male	female	188	30.97	30.97	665	51.08	51.08
	male	419	69.03	100	637	48.92	100
	Total	607	100		1,302	100	
marital	single	176	29	29	370	28.42	28.42
	married	416	68.53	97.53	905	69.51	97.93
	divorced	13	2.14	99.67	26	2	99.92
	widowed	2	0.33	100	1	0.08	100
	Total	607	100		1,302	100	
residence	no	328	54.04	54.04	383	29.42	29.42
	yes	279	45.96	100	919	70.58	100
	Total	607	100		1,302	100	

NOTE: The marital status of divorced and widowed will be transferred to married in the empirical study, due to the fact that the percentage is too low and is convenient to generate a dummy variable where 1 represents individual has already married and 0 represents individual is still single.

From the distributions, in the samples, there is an uneven distribution in the gender, accounting for 69% and 31% for male and female in the Shenzhen samples, while 49% and 51% in the other cities sample respectively. Meanwhile, for the residence registration in the cities where are living, it is 46% of respondent' registration in Shenzhen and 54% are not in Shenzhen, which is consistent with the fact that Shenzhen as a migrant city. Adversely, the samples in the controlled groups of other cities, the percentages are 71% and 29% respectively, combing with the variables how long living in the cities, averagely, the years are 8.07 years and 17.66 years in the experiment cities Shenzhen and controlled cities respectively, more than two times of the previous one. However, for the marital status, there are similar distribution in the two samples with proportions of 68.5% and 69.5% of married and 29% and 28.42% for single in Shenzhen and other cites separately.

Table 24 the description analysis for the demographic characteristics

Sample	Variable	Obs	Mean	Std.Dev.	Min	Max	Sample	Obs	Mean	Std.Dev.	Min	Max
Shenzhen (experiment)	age	607	31.23	5.84	20	56	Other cities(controlled)	1,302	29.87	5.60	18	69
	educ	607	14.77	2.44	9	22		1,302	15.20	2.19	9	22
	income	607	4.28	2.53	1	14		1,302	3.17	1.92	1	14
	memberhhold	607	3.59	1.70	0	22		1,302	3.65	2.02	0	35
	residence	607	0.46	0.50	0	1		1,302	0.71	0.46	0	1
	livingyear	607	8.07	8.20	1	37		1,302	17.66	11.62	0	60
	precondition	607	1.09	0.75	0	6						
	numvehicles	607	1.07	0.75	0	6		1302	0.86	0.59	0	3

NOTE: For the variable of income presented in the table, previously, in the questionnaire, the different options are scale numbers, such as 6.1-9, and the unit is 1,000 RMB, but it has been transferred to an order variable, for example, 1=<3; 2=3.1-6; 3=6.1-9; 4=9.1-12; 5=12.1-15; 6=15.1-18;7=18.1-21; 8=21.1-24; 9=24.1-27; 10=27.1-30; 11=30.1-33; 12=33.1-36; 13=36.1-39; 14 is above 39. The residence is a dummy variable that 1 means the residence is in the city where lives, and 0 means no.

For the comparison of description analysis, which is consistent with the fact that average income after tax in Shenzhen is higher than samples from other cities by more than 1 grade representing

3,000 RMB as a level in the questionnaires, and a bigger gap in the Shenzhen samples. Meanwhile, the mean of residence in Shenzhen (0.46) is much smaller than controlled samples (0.71) where a dummy variable of 1 indicating the registration in the city where respondents live, otherwise it is o. And it is 17.06 years for respondents who live in the controlled group cities that is 2 times of living in the Shenzhen (8.07), which complies with the background Shenzhen is a migrant city. Meanwhile, it is similar in term of family members in the household and marital status. However, the age in Shenzhen sample (31.23) is slightly greater than controlled group (29.87), on the contrary, years for education in the controlled (15.2) is slightly bigger than the samples in Shenzhen (14.77). Moreover, the average number of vehicles in the household is 1.07 in Shenzhen samples, which is slightly higher than the sample from other cities (0.86). And the number of each household members who meet the precondition imposed in the quota in Shenzhen is 1.09.

5.2.2 Group of Individuals do not own a vehicle

This part primarily descripts the attributes for the individuals who do not own vehicle, neither conventional nor new energy vehicles.

Table 25 description analysis of nominal variables for the individuals who do not own a vehicle

variables	nominal	Shenzhen(experiment)			Other cities(controlled)		
		Freq.	Percent	Cum.	Freq.	Percent	Cum.
owncar	no car	301	49.59	49.59	617	47.39	47.39
	own a car	306	50.41	100	685	52.61	100
	Total	607	100		1,302	100	
license	no	63	20.93	20.93	139	22.53	22.53
	yes	238	79.07	100	478	77.47	100
	Total	301	100		617	100	
license_plan	no plan	8	12.70	12.70	52	37.41	37.41
	with a plan	55	87.3	100	87	62.59	100
	Total	63	100		139	100	
yearpurch_plan	No	39	12.96	12.96	128	20.75	20.75
	within 1 year	142	47.18	60.13	171	27.71	48.46
	within 3 years	63	20.93	81.06	283	45.86	94.33
	later than 3 years	57	18.94	100	35	5.67	100
	Total	301	100		617	100	
model_plan	small car	40	15.27	15.27	100	21.37	21.37
	sedans	107	40.84	56.11	204	43.59	64.96
	suv	104	39.69	95.8	159	33.97	98.93
	mpv	4	1.53	97.33	3	0.64	99.57
	others	7	2.67	100	2	0.43	100
	Total	262	100		468	100	
brand_plan	China	120	51.28	51.28	220	50.34	50.34
	Germany	66	28.21	79.49	149	34.1	84.44
	USA	15	6.41	85.9	23	5.26	89.7
	Japan	28	11.97	97.86	38	8.7	98.4

	France	3	1.28	99.15	4	0.92	99.31
	Korea	2	0.85	100	1	0.23	99.54
	Italy	0	0		1	0.23	99.77
	others	0	0		1	0.23	100
	Total	234	100		437	100	
categ_plan	conventional	185	70.61	70.61	91	19.44	19.44
	hybrid	40	15.27	85.88	340	72.65	92.09
	pure	37	14.12	100	37	7.91	100
	Total	262	100		468	100	
categplan_befqta	conventional	102	38.93	38.93			
	hybrid	105	40.08	79.01			
	pure electric	55	20.99	100			
	Total	262	100				
commuting no car	Metro	112	37.21	37.21	121	19.61	19.61
	Bus	47	15.61	52.82	249	40.36	59.97
	Internet-based model such as DIDI	34	11.3	64.12	89	14.42	74.39
	Private car	42	13.95	78.07	49	7.94	82.33
	Taxi	33	10.96	89.04	41	6.65	88.98
	Walk	15	4.98	94.02	27	4.38	93.35
	Bicycle including the shared Mobike,OFO	18	5.98	100	41	6.65	100
	Total	301	100		617	100	
commuting owns a car	Metro	57	18.63	18.63	58	8.47	8.47
	Bus	32	10.46	29.08	60	8.76	17.23
	Internet-based model such as DIDI	10	3.27	32.35	39	5.69	22.92
	Private car	187	61.11	93.46	454	66.28	89.2
	Taxi	7	2.29	95.75	36	5.26	94.45
	Walk	2	0.65	96.41	15	2.19	96.64
	Bicycle including the shared Mobike,OFO	11	3.59	100	23	3.36	100
	Total	306	100		685	100	

For the percentage of owning vehicles, more or less, it is 50%-50% in the experiment samples, while the group of owning a car is slightly higher than the one does not own by 5% (52.6% and 47.4% respectively). For the individuals who do not own a car but own a driving license, there are approximately over three quarters for both samples (79.07% and 77.47%). Furthermore, for the individuals who do not own a driving license, a majority respondent has a plan to hold a license, amounting to 87.3% in the experiment samples, while the controlled group is less than the experiment one by a quarter with (62.59%). Concerning the time for the purchasing of vehicles, 47.18%

of responders have a plan within 1 year in first group, but it is longer in the second group accounting for 45.86% with a plan within next 3 years.

Additionally, for the planned model, sedans and SUV are the most popular ones in both samples with a large majority of 80% and 77.64%. Meanwhile, for the countries indicating the sources of brands, more than three quarters referrer to China and Germany with the proportion of 79.49% and 84.44% totally for two samples respectively. However, for the planning category, for the experiment Shenzhen samples, the choice for the conventional ones is 70.61%, which consists of three choices in the questionnaire contingent on the real scenarios, firstly, lottery Conventional vehicles (or in others' families name), secondly, bidding Conventional vehicles (or in others' families name), lastly, register in other cities (Conventional). Conversely, in the samples of other cities, it is only 19.44% for the conventional ones, but with 72.65% for the hybrid ones. Lastly, for the ways of commuting, there is a different perspective in the two samples, for the individuals who do not own a car in Shenzhen, the primary choice for the commuting is metro, accounting for 37.21%, then with 15.6% for bus, 13.95% for private car. While in the samples of other cities, the bus has the biggest proportion amounting to 40.36%, then with 19.61% for the metro and 14.42% for the shared Internet-model, which indicates a better public transportation system in Shenzhen than other cities, especially for the metro. On the contrary, for the individuals who owns a car, the primary way of commuting is private car in both samples, amounting to 61.11% and 66.28% in Shenzhen and other cities respectively, which is an endogenous variable of owning a car.

Table 26 Description analysis of numerical variables for the individuals who do not own a vehicle

	Variable	Obs	Mean	S.D.	Min	Max		Obs	Mean	S.D.	Min	Max
Shenzhen	budge_plan	262	14.71	16	2	100	Other cities	352	19.10	15.44	3	180
	engine_plan	56	1.84	0.36	1.2	3		26	1.88	0.40	1.4	2.8
	range_least_no car	301	349	324	2	3000		617	455	574	0	3888
	range_least_own a car	306	385	448	2	4600		685	397	417	1	3658
	range_least_own a conv.	137	371	391	10	3000		501	375	366	2	3000
	range_least_own a nev	169	396	491	2	4600		184	457	527	1	3658

For the numerical variables of planning purchase, the planning budget in controlled group (191,000rmb) is slightly higher than experiment group in Shenzhen (147,100rmb), however, generally, the planning engine size of conventional vehicles, in the two samples is the same (1.84 and 1.88 separately), while for the least range for the NEVs, it is 455km in the controlled sample, which is higher than the experiment samples (349km). Comparatively, the least range requirement for the individuals who own a car in Shenzhen sample (385km) is higher than ones without a car(349km), conversely, in other cities (397km), which is less than ones without a car(455km). More specifically, the requirement of least ranges for ones who own a NEVs is higher than ones who own conventional vehicles in both samples.

5.2.2 Group of individuals own Conventional Vehicles

Table 27 Description analysis of nominal variables for individuals who own conventional vehicles

variables	nominal	Shenzhen (experiment)			Other cities (controlled)		
		Freq.	Percent	Cum.	Freq.	Percent	Cum.
catog_own	conventional	137	44.77	44.77	501	73.14	73.14
	hybrid	120	39.22	83.99	122	17.81	90.95
	pure electric	49	16.01	100	62	9.05	100
	Total	306	100		685	100	
model conventional	small car	32	23.36	23.36	129	25.75	25.75
	sedans	70	51.09	74.45	254	50.7	76.45
	suv	30	21.9	96.35	110	21.96	98.4
	mpv	4	2.92	99.27	7	1.4	99.8

	others	1	0.73	100	1	0.2	100
	Total	137	100		501	100	
	no	54	39.42	39.42	198	39.52	39.52
property_parking conventional	own	83	60.58	100	303	60.48	100
	Total	137	100		501	100	
	china	42	30.66	30.66	138	27.54	27.54
	germany	45	32.85	63.5	143	28.54	56.09
	usa	11	8.03	71.53	79	15.77	71.86
brand_convetional	japan	26	18.98	90.51	98	19.56	91.42
	france	2	1.46	91.97	8	1.6	93.01
	korea	11	8.03	100	35	6.99	100
	Total	137	100		501	100	
	not in SZ	50	36.5	36.5			
license_sz	in SZ	87	63.5	100			
	Total	137	100				
	no effect	16	32	32			
prohibition_driv	affect	34	68	100			
	Total	50	100				
	no	20	14.6	14.6			
nev_further	yes	117	85.4	100			
	Total	137	100				

For the individuals who own conventional vehicles, it is 44.77% in Shenzhen sample, which is less than the one in other cities (73.14%). Among these conventional vehicles, sedan is the largest part in both samples (51.09% and 50.7%), then the same to small car (23.36% and 25.75%) and SUV (21.9% and 21.96%). Furthermore, there is a same proportion in terms of owning a property of parking (60.58% and 60.48% respectively). In terms of brands, Germany has the largest proportion in both samples (32.85% and 28.54%), following by China (30.66% and 27.54%). Additionally, among these conventional owners, the licenses of 36.5% are not enrolled in Shenzhen, in which is 68% affected by the prohibition on the vehicles that are not enrolled in Shenzhen imposed by the government with the intention of easing traffic jam over the rush hours.

Table 28 Description analysis of nominal variables for individuals who own conventional vehicles

	Shenzhen (experiment)					Other cities (controlled)				
Variable	Obs	Mean	Std.Dev.	Min	Max	Obs	Mean	Std.Dev.	Min	Max
year_conventioal	137	4.24	2.96	0.5	19.5	501	4.03	2.67	0.5	17.5
price_conventional	137	19.73	16.15	2.1	100	501	15.89	11.99	2	150
engine_conventional	137	1.82	1.00	0	12	501	1.65	0.42	0	5
distance_work	137	61.49	87.48	2	500	501	53.47	87.78	0	680
distance_week	137	92.33	127.25	0	865	501	88.32	117.05	0	1000
fuel_exp	137	1013.03	963.81	0	6000	501	825.33	660.88	10	5888
park_exp	137	282.34	273.12	0	2000	501	253.12	385.52	0	3006
cost_effective	137	73.16	25.12	0	100	501	79.13	23.41	0	100
reduc_emmission	137	81.34	22.68	10	100	501	86.32	18.80	0	100

In terms of years purchased, the Shenzhen sample (4.24 years) has a slight bigger than ones in other cities (4.03 years), which is the same to variables of cost and engine size (197,300rmb vs 158,900rmb, and 1.82 vs 1.65 respectively). What is more, it is also happened concerning the variables of driving distance on workday (61.49km vs 53.47km) and weekend (92.33km vs 88.32km), the cost on the fuel (1,013rmb vs 825rmb) and parking (282rmb vs 253rmb) monthly. However, for the valuation of NEVs in the two samples, the former one is lower than the latter in terms of cost-effective (73 vs 79) and reduction of emission (81 vs 86), out of 100 totally.

5.2.3 Group of individuals own NEVs

Table 29 Description analysis of nominal variables for the individuals who own NEVs

variables	nominal	Shenzhen (experiment)			Other cities (controlled)		
		Freq.	Percent	Cum.	Freq.	Percent	Cum.
catog_own	conventional	137	44.77	44.77	501	73.14	73.14
	hybrid	120	39.22	83.99	122	17.81	90.95
	pure electric	49	16.01	100	62	9.05	100
	Total	306	100		685	100	
Model hybrid	small car	15	12.5	12.5	38	31.15	31.15
	sedans	40	33.33	45.83	53	43.44	74.59
	suv	60	50	95.83	29	23.77	98.36
	mpv	4	3.33	99.17	2	1.64	100
	others	1	0.83	100			
	Total	120	100		122	100	
proportion_charing for hybrid	less than20%	13	10.83	10.83	13	10.66	10.66
	21%-40%	34	28.33	39.17	61	50	60.66
	41%-60%	37	30.83	70	39	31.97	92.62
	61%-80%	20	16.67	86.67	7	5.74	98.36
	81%-100%	16	13.33	100	2	1.64	100
	Total	120	100		122	100	
model pure	small car	17	34.69	34.69	15	24.19	24.19
	sedans	18	36.73	71.43	20	32.26	56.45
	suv	11	22.45	93.88	20	32.26	88.71
	mpv	1	2.04	95.92	3	4.84	93.55
	others	2	4.08	100	4	6.45	100
	Total	49	100		62	100	
property_parking for NEVs	no	117	69.23	69.23	80	43.48	43.48
	own	52	30.77	100	104	56.52	100
	Total	169	100		184	100	
brand_nev	China	134	79.29	79.29	102	55.43	55.43
	Germany	20	11.83	91.12	37	20.11	75.54
	usa	2	1.18	92.31	18	9.78	85.33
	japan	6	3.55	95.86	16	8.7	94.02
	France	1	0.59	96.45	5	2.72	96.74
	Korea	4	2.37	98.82	5	2.72	99.46
	others	2	1.18	100	1	0.54	100
	Total	169	100		184	100	
categown_aftqta	conventional	104	33.99	33.99			
	pure electric	72	23.53	57.52			
	hybrid	130	42.48	100			
	Total	306	100				
categown_befqta	conventional	160	52.29	52.29			
	pure electric	61	19.93	72.22			
	hybrid	85	27.78	100			
	Total	306	100				

The percentage of NEVs in the Shenzhen sample (55.23%) is more than two time as other cities (26.86%), more specifically, the hybrid accounts for the primary component in both samples. For the model among the hybrid, half of them is SUV in Shenzhen, while in other cities, the primary part is sedan with 43.44%, but for proportion of charging in the total mileage of hybrid, such as over 60%, the Shenzhen sample (30%) is much higher than other cities (7.3%). On the contrary, for the model of pure electricity vehicles, the largest component is sedan, then followed by small car in Shenzhen samples, while, sedan and SUV are the largest proportion in other cities. Substantially, the individuals who own NEVs has much lower percentage of owning a parking property (30.77%) in

Shenzhen, which is almost half of samples in other cities (56.52%), and half of percentage for the individuals who own conventional vehicles (60%). Furthermore, in term of brands, China has the largest share in both samples (79% and 55.43%), then Germany (11.83% and 20.11%).

Table 30 Description analysis of nominal variables for the individuals who own NEVs

Variable	Shenzhen (experiment)					Other cities (controlled)				
	Obs	Mean	Std.Dev.	Min	Max	Obs	Mean	Std.Dev.	Min	Max
year_nev_hybrid	120	2.15	1.351314	0.5	7.5	122	3.172131	2.206087	0.5	11.5
year_nev_pure	49	1.704082	1.322554	0.5	5.5	62	2.064516	1.362507	0.5	8.5
price_nev_hybrid	120	22.16	18.47	2.1	170	122	20.59	19.11	1.58	120
price_nev_pure	49	13.56	7.59	4.2	36	62	13.24	10.22	3.68	70
range_nev_hybrid	120	82.03	33.48	23	300	122	70.66	32.94	23	200
range_nev_pure	49	237.71	84.88	110	468	62	239.73	114.47	40	400
distance_work	169	78.67	104.46	0	800	184	119.93	155.87	1	900
distance_week	169	134.36	183.67	0	1500	184	173.96	343.48	0	4000
fuel_exp	169	651.24	639.51	20	4000	184	851.30	820.52	0	5400
park_exp	169	338.31	304.96	0	2009	184	488.40	915.66	0	5566
cost_effective	169	74.56	27.43	0	100	184	77.30	23.05	6	100
reduc_emmission	169	82.80	25.59	0	100	184	78.57	22.98	3	100
recommendation	169	76.99	23.40	6	100	184	74.67	24.33	0	100
charging_find	169	48.89	30.79	0	100	184	69.41	24.81	0	100
charging_misused	169	75.40	27.90	0	100	184	70.68	25.13	0	100
charing_maintain	169	59.68	28.07	0	100	184	73.12	22.61	5	100

The years purchased of pure electricity (1.7 years and 2.06 years) is less than hybrid (2.15 years and 3.17 years) in both samples, additionally, the years in other cities are longer than Shenzhen sample in both pure and hybrid vehicles. What is more, the real driving rage for hybrid is 82km that is slightly bigger than other cities (70.66km), generally, the same range in both samples (237.7km vs239.7km) for pure electricity vehicles. Obviously, the Shenzhen sample is smaller than other cities in terms of the driving distance on workday (78.67km vs 119.93km) and on weekend (134.36km vs 173.96km), cost of fuel monthly (651rmb vs 851rmb) and parking fee (338rmb vs 488rmb) monthly. For the evaluation of cost-effective for the NEVs, the Shenzhen sample is smaller than other cities, while it is adverse for the reduction of emission.

Lastly, the comprehensive assessment for the charging facility, Shenzhen sample has a big variation among the four variables, and the possibility to find the charging station has the lowest perception (48.89) in Shenzhen sample, and the highest is the recommendation of NEVs to others, other cities have the same perception for the lowest and highest variables, but with a smaller variation among the four variables.

5.2.4 Behaviors on the quota in Shenzhen samples

As the announce of quota in December, 2014, and there was the first quota implemented in 2015. This part primarily focuses on the times of individuals who have participated in the license plate quota, such as the lottery for NEVs or conventional vehicles, bidding for conventional vehicles.

Table 31 Application behaviors on the quota in the experiment Shenzhen samples

Shenzhen	variables	Obs	Mean	Std.Dev.	Min	Max
no car	apply_quota	301	0.20	0.40	0	1
	lottery_conv	301	1.10	4.06	0	30
	bidding_conv	301	0.06	0.28	0	2
	lottery_pure	301	0.08	0.55	0	8
	lottery_hybrid	301	0.05	0.27	0	3
own a car	apply_quota	306	0.40	0.49	0	1

	lottery_conv	306	3.43	6.76	0	30
	bidding_conv	306	0.07	0.41	0	5
	lottery_pure	306	0.10	0.52	0	8
	lottery_hybrid	305	0.18	0.46	0	3
own a conventional car	apply_quota	137	0.24	0.43	0	1
	lottery_conv	137	1.68	4.69	0	24
	bidding_conv	137	0.02	0.15	0	1
	lottery_pure	137	0.01	0.12	0	1
	lottery_hybrid	137	0.05	0.33	0	3
own a NEV	apply_quota	169	0.53	0.50	0	1
	lottery_conv	169	4.85	7.79	0	30
	bidding_conv	169	0.11	0.54	0	5
	lottery_pure	169	0.17	0.69	0	8
	lottery_hybrid	168	0.29	0.53	0	3

NOTE: The apply_quota is a dummy variable, where 1 indicates the participation of license plate quota and 0 means no participation. Then the other four variables mean the time participating the different kind of license plate quota respectively.

The table indicates the samples data in Shenzhen for the participation of quota, generally, the times of respondents who own a car participated in the quota is three times of ones who do not own a car in the lottery of conventional vehicles (1.1 vs 3.43), but the times of participation of hybrid and pure ones are both low, although the group of owning a car is relatively higher than the one without vehicles. Similarly, the times for the group owning NEVs is more than 4 times of the ones who owning conventional vehicles, the implications behind it, possibly, because the individuals who purchase the NEVs lastly due to the participation of several time failed in the lottery of conventional ones, besides, the samples for the individuals who own conventional vehicles consist part of respondents who have already purchased the vehicles before the implementation of quota in 2015.

5.2.5 Description analysis on the charging station

Table 32 Description analysis on the charging station

Groups		Shenzhen (experiment)					other cities (controlled)				
	variables	Obs	Mean	Std.Dev.	Min	Max	Obs	Mean	Std.Dev.	Min	Max
no car	workp_charging	135	6.20	8.81	0.01	50	97	10.14	15.64	0.1	108
	livep_charging	138	6.96	11.60	0.01	86	110	5.66	6.82	0.01	30
own a car	workp_charging	185	6.17	9.52	0.01	60	183	11.02	18.83	0.1	144
	livep_charging	199	6.05	9.26	0.01	68	187	5.78	12.08	0.01	86
own a conventional	workp_charging	54	7.48	9.25	0.01	50	104	12.11	21.29	0.1	144
	livep_charging	59	6.98	8.31	0.12	35	106	7.96	15.38	0.015	86
own a nev	workp_charging	131	5.63	9.61	0.01	60	79	9.59	14.99	0.3	100
	livep_charging	140	5.66	9.64	0.01	68	81	2.92	3.78	0.01	20

Contingent on the previous analysis, the sanctification of finding a charging station is lowest, this table indicates the detailed distance from where they work and live. Certainly, lots of respondents do not where is the charging station, but based on the exact data, firstly, for the classification of no car and owning a car, within the former one without a car, the distance from where individuals work is smaller in Shenzhen than the counterpart in other cities (6.2km vs 10.14km), while the Shenzhen sample is slightly bigger than controlled one (6.96km vs 5.66km). but for the group of owning a car, there is a big gap in the working distance (6.17km vs 11.02km), but with a similar distance for where they live (6.05km vs 5.78km). more specifically, the division of owning conventional and NEVs ones, the samples in other cities have much higher distance from working than Shenzhen samples for both conventional (7.48km vs 12.11km) and NEVs (5.63km vs 9.59km).

Chapter 6 Empirical Analysis and Results

6.1 WTP/AP and Its Disparity

6.1.1 Variables Description and Multi-Collinearity Analysis

(1) Variables Description

The table for the variables' description, includes the dependent and independent variables, meanwhile, for the independent variables, it primarily divides into the variables in terms of the perception, demographic, charging, quota, incentive/ hindered elements, which is easier and better to know the variable's interpretation.

Table 33 Description of variables

Types	Variable	Definition
Deped.	owncar	Dummy variable, where 1 indicates the individuals who own a car (including pure and hybrid vehicles, conventional ones), o represents do not own a car.
	categ_plannev	Dummy variable, the kind of vehicles you plan to buy, where 1 indicates as NEVs (including pure and hybrid vehicles) and o represents conventional ones.
	catog_ownnev	Dummy variable, the kind of vehicles you own, where 1 indicates as NEVs and o represents conventional ones.
	disparity	Dummy variable for the comparison between the actual purchase and category of planning to purchase, 1 means it change the decision and 0 means no change.
Independent		
perception	cost_effective	Valuation, 0-100, NEVs is cost-effective comparing to the conventional ones (save money overall)
	reduc_emmission	Valuation, 0-100, NEVs can reduce the green emission in the city
demographic	married	Dummy variable, marital status, where 1 indicates married and o represents as single, meanwhile, in the samples, totally, there are 42 samples are divorced and widowed, in order to simplify the study, here it is represented as married as the fact that they have get married before.
	male	dummy variable, gender, where 1 is male and o is female.
	age	your age
	educ	highest level of your education
	be_bachelor	dummy variable, 1 represents individuals' education is below bachelor, otherwise is o.
	bachelor	dummy variable, 1 represents individuals' education is bachelor, otherwise is o.
	ab_bachelor	dummy variable, 1 represents individuals' education is above bachelor, otherwise is o.
	income	income monthly after tax
	memberhhold	no. of family members who are living together
	residence	Dummy variable, your registered residence (Hukou) in the city where you live, 1 is yes and o is no.
	livingyear	How many years have you lived in the city
	numvehicles	number of vehicles in your household
	licensepay	maximum cost of license plate that you have willingness to pay
	range_least	the least requirement for the range of NEVs
	yearpurch_plan	plan to purchase a car and when
	budge_plan	plan to purchase a car, your budge unit 10,000 RMB
	year_own	How many years have already purchased the vehicles
	license	dummy variable, whether own a driving license for the individuals who do not own a car, 1 is yes, and 0 is no.

charging	no._charging	It equals to 0,1,2, representing know nothing about where has the charging station, one of charging station (either work or live place), and both work and live places;
	workp_charging	dummy variable, know the charging place where you work, 1 is yes,0 is no.
	livep_charging	dummy variable, know the charging place where you live,1 is yes, 0 is no.
	interworkd	Interaction term, dummy variable whether know the location of charging time the distance of charging from where you work.
	interlived	Interaction term, dummy variable whether know the location of charging time the distance of charging from where you live.
quota	apply_quota	dummy variable, have you ever applied to the plate license,1 means yes, o is no.
	lottery_conv	Interaction term, dummy variable whether apply to the quota time the numbers of application of lottery for the conventional vehicles.
	bidding_conv	Interaction term, dummy variable whether apply to the quota time the numbers of application of bidding for the conventional vehicles.
	lottery_pure	Interaction term, dummy variable whether apply to the quota time the numbers of application of lottery for the pure electric vehicles.
	lottery_hybrid	Interaction term, dummy variable whether apply to the quota time the numbers of application of lottery for the hybrid vehicles.
	numapp_total	Total application times in the quota system
	numapp_conventional	Total application times for conventional vehicles in the quota system
	numapp_nev	Total application times for NEVs in the quota system
Incentive/ hindered elements	Incentive/ hindered elements	These are the questions that the respondents should write by themselves separately, including the incentive policies in your city, and hindrance elements in your city, contingent on the writing words, I divide the answers into several parts of the following variables.
	inceunknown	dummy variable, I do not know the incentive policies.1 is yes, 0 is no.
	noincetive	dummy variable, there is no incentive policies, 1is yes,0 is no.
	incepurchase	dummy, incentives police for purchasing, including subsidy, tax, etc. 1 is yes, 0 is no.
	incedriving	dummy variable, incentives in the driving, such as charging, 1 is yes, 0 is no.
	hinderunknown	dummy variable, I do not know any hindrance, 1 is yes, 0 is no.
	nohinder	dummy variable, there is no hindrance, 1 is yes, 0 is no.
	hindercharging	dummy variable, the hindrance of charging, 1 is yes, 0 is no.
	hindersubsidy	dummy variable, the hindrance of subsidy, 1 is yes, 0 is no.
	hinderawareness	dummy variable, the hindrance of awareness,

The variables of residence, it could be only considered the comparison between the residence registering in the cities where they live, as the fact that it would contaminate the effect of controlled group and experiment group, due to the migration, particular for the samples in the experiment group of Shenzhen. If the correspondents' residences are not in Shenzhen and only with a short working period, it is highly possible to migrate to another city, such as the city where they come from, accordingly, the quota in Shenzhen will not be regarded as an element for their choices, which is not consistent with the expectation of two different samples, control and experiment. Therefore, it is better to only consider the samples that register in Shenzhen.

(2) Multi-Collinearity Analysis

In order to better understand the coefficient of correlation in the experiment and controlled groups, it has been divided into four segments, which is a 4 comparison-groups elaborating in the design of sampling. Namely, individuals who plan to purchase and have already owned in the experiment group of Shenzhen, similarly, plan to purchase and have already owned in the controlled group of other cities' samples, which provides a better insight on the mutual coefficient relationship for the empirical studies.

Table 34 Correlation coefficients for individuals who plan to purchase NEVs in the experiment Shenzhen sample

e(V)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1-cost_effective	1																			
2-reduc_emmission	0.4140*	1																		
3-married1	0.02	0.02	1																	
4-male	-0.07	0.07	0.03	1																
5-age	0	0.03	0.54*	0.17*	1															
6-educ	0.07	0.03	-0.14*	-0.25*	-0.22*	1														
7-income	0.13*	0	0.06	-0.03	0.03	0.37*	1													
8-memberhhold	0.1	0.02	0.21*	-0.03	0.11*	-0.24*	0.11*	1												
9-residence	0.12*	-0.05	0.12*	-0.27*	0.01	0.27*	0.27*	0.14*	1											
10livingyear	0.12*	0.01	0.23*	-0.16*	0.25*	0.05	0.31*	0.22*	0.41*	1										
11-licensepay	-0.01	-0.06	-0.12*	0	-0.12*	0.10*	0.31*	0.01	-0.01	0.11*	1									
12-range_least	-0.09	-0.04	0.02	-0.03	0.07	-0.18*	-0.16*	-0.03	0.03	0.13*	-0.12*	1								
13-license	0	0.09	0.30*	0.11*	0.19*	-0.05	0.05	-0.03	0.17*	0.11*	-0.13*	0.09	1							
14-yearpurch_plan	0.03	0.04	-0.15*	-0.05	-0.02	-0.08	-0.19*	-0.13*	-0.27*	-0.24*	-0.02	-0.04	-0.22*	1						
15-budge_plan	0.08	0.01	0.01	-0.01	0.05	0.26*	0.53*	0.11*	0.21*	0.29*	0.34*	-0.13*	0.03	-0.1	1					
16-workp_charging	0.13*	0.17*	0.35*	0.16*	0.27*	-0.30*	-0.18*	0.13*	-0.08	0.09	-0.23*	0.1	0.17*	0	-0.1	1				
17-livep_charging	0.1	0.14*	0.29*	0.12*	0.26*	-0.30*	-0.23*	0.09	-0.15*	0.04	-0.21*	0.08	0.18*	0.03	-0.1	0.79*	1			
18-interworkd	0.06	0.09	0.16*	0.06	0.08	-0.10*	-0.08	0.03	-0.05	-0.01	-0.12*	0.06	0.04	0.12*	0	0.44*	0.32*	1		
19-interlived	0	-0.13*	0.19*	-0.02	0.08	-0.15*	-0.08	0.04	0.02	-0.04	-0.14*	-0.09	0.13*	0.01	-0.1	0.34*	0.39*	0.22*	1	
20-apply_quota	-0.06	-0.06	0.09	0.05	0.02	-0.07	0.02	-0.01	0.23*	0.14*	-0.01	0.04	0.19*	-0.14*	0.05	0.07	0.08	0.04	0.13*	1

NOTE: Where the * denotes that the correlation coefficient is significant at the 10% level or better.

Table 35 Correlation coefficients for individuals who own NEVs in the experiment Shenzhen sample

e(V)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1-cost_effective	1																	
2-reduc_emmission	0.56*	1																
3-married	0.02	0.10*	1															
4-male	0.00	0.01	0.09	1														
5-age	-0.02	-0.00	0.36*	0.17*	1													
6-educ	-0.09	-0.01	-0.00	0.01	-0.04	1												
7-income	-0.13*	-0.09	0.04	0.19*	0.08	0.39*	1											
8-memberhhold	0.04	0.06	0.23*	0.00	0.26*	-0.25*	-0.11*	1										
9-residence	0.00	-0.0579	-0.10*	-0.02	-0.01	0.39*	0.22*	-0.08	1									
10-livingyear	0.09	0.0886	0.14*	0.18*	0.24*	0.07	0.02	0.10*	0.28*	1								
11-licensepay	-0.02	-0.06	-0.06	0.08	-0.08	0.18*	0.17*	-0.17*	0.06	0.03	1							
12-range_least	0.03	0.00	-0.01	-0.10*	0.03	0.01	-0.05	0.01	-0.04	-0.02	-0.00	1						
13-year_own	0.02	-0.02	0.04	-0.19*	0.08	-0.13*	0.00	0.14*	-0.11*	0.01	0.00	-0.02	1					
14-workp_charging	0.06	-0.00	0.07	0.16*	0.08	-0.10*	-0.05	-0.03	-0.05	0.01	-0.02	0.09	-0.16*	1				
15-livep_charging	0.09	0.09	0.06	0.21*	0.06	0.00	-0.05	-0.00	0.02	0.07	-0.01	0.14*	-0.23*	0.65*	1			
16-interworkd	0.02	0.02	-0.02	0.05	-0.04	-0.11*	0.03	-0.02	-0.04	-0.01	-0.01	0.03	-0.02	0.37*	0.26*	1		
17-interlived	0.02	0.04	0.04	-0.02	-0.05	0.01	-0.03	-0.04	-0.00	0.02	-0.11*	0.04	-0.02	0.31*	0.33*	0.34*	1	
18-apply_quota	-0.06	-0.00	-0.07	0.19*	0.04	0.09*	0.09*	0.05	0.16*	0.01	0.14*	-0.04	-0.31*	0.09	0.13*	0.05	-0.14*	1

NOTE: Where the * denotes that the correlation coefficient is significant at the 10% level or better.

Table 36 Correlation coefficients for individuals who plan to purchase NEVs in controlled other cities samples

	1	2	3	4	5	6	7	9	10	11	12	13	14	15	16	17	18	19
1-cost_effective	1																	
2-reduc_emmission	0.61*	1																
3-married1	0.07	-0.02	1															
4-male	-0.05	-0.06	0.01	1.00														
5-age	0.01	0.01	0.56*	0.12*	1.00													
6-educ	0.01	0.08*	-0.19*	0.07	-0.19*	1.00												
7-income	0.01	-0.01	0.09*	0.12*	0.03	0.14*	1.00											
9-residence	0.08*	0.04	0.06	0.01	0.08*	0.07*	0.17*	1.00										
10-livingyear	0.11*	0.01	0.19*	-0.08*	0.21*	-0.16*	0.04	0.60*	1.00									
11-range_least	-0.01	-0.03	-0.15*	0.05	-0.13*	0.02	-0.07	0.08*	0.09*	1.00								
12-inceunknown	0.00	0.03	-0.05	-0.14*	-0.07	-0.06	-0.02	0.01	0.02	0.05	1.00							
13-noincetive	-0.06	-0.15	0.14*	0.07	0.08*	-0.06	0.09*	0.06	0.09*	0.03	-0.60*	1.00						
14-incepurchase	0.05	0.08*	-0.06	0.08*	0.01	0.11*	-0.05	-0.07	-0.10*	-0.08*	-0.47*	-0.33*	1.00					
15-incedriving	0.03	0.11*	-0.09*	0.04	-0.01	0.05	-0.05	-0.02	-0.05	-0.02	-0.19*	-0.11*	-0.07*	1.00				
16-hinderunknown	-0.01	-0.01	-0.03	-0.11*	-0.03	-0.21*	0.01	0.00	0.03	0.04	0.53*	-0.33*	-0.23*	-0.08*	1.00			

17-nohinder	-0.01	-0.12*	0.17*	0.00	0.09*	-0.03	0.05	0.08*	0.10*	0.00	-0.32*	0.61*	-0.23*	-0.13*	-0.59*	1.00				
18-hindercharging	0.02	0.16*	-0.13*	0.11*	-0.03	0.26*	-0.02	-0.05	-0.16*	-0.03	-0.21*	-0.23*	0.47*	0.11*	-0.37*	-0.35*	1.00			
19-hindersubsidy	-0.02	0.00	0.01	0.12*	0.01	0.06	-0.03	-0.04	-0.01	0.03	-0.09*	-0.08*	0.11*	0.20*	-0.14*	-0.13*	-0.08*	1.00		
20-hinderawareness	0.01	-0.03	-0.09*	-0.02	-0.07	0.07	-0.07	-0.03	-0.02	-0.05	-0.04	-0.11*	0.13*	0.10*	-0.17*	-0.16*	-0.08*	-0.04		
21-workp_charging1	0.09*	0.03	0.01	0.05	0.06	-0.04	0.00	-0.04	0.03	-0.07	0.00	-0.11*	0.11*	0.04	-0.08*	-0.01	0.03	0.14*		
22-livep_charging1	0.14*	0.09*	0.03	0.07	0.12*	-0.05	-0.01	-0.04	0.07	-0.11*	-0.04	-0.08*	0.12*	0.05	-0.09*	-0.02	0.07	0.12*		
23-interworkd	0.08*	0.00	-0.03	0.05	0.00	-0.01	0.07	0.06	0.07	-0.03	-0.08*	-0.02	0.09*	0.06	-0.06	0.01	-0.01	0.06		
24-interlived	0.13*	0.06	-0.03	-0.03	0.08*	-0.01	0.00	0.05	0.08*	-0.06	-0.05	0.00	0.07	-0.01	-0.10*	0.06	0.02	0.01		
	20	21	22	23	24															
20-hinderawareness	1.00																			
21-workp_charging1	0.06	1.00																		
22-livep_charging1	0.02	0.79*	1.00																	
23-interworkd	0.09*	0.49*	0.34*	1.00																
24-interlived	0.05	0.49*	0.60*	0.36*	1															

NOTE: Where the * denotes that the correlation coefficient is significant at the 10% level or better.

Table 37 Correlation coefficients for individuals who own NEVs in the controlled other cities sample

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1-cost_effective	1																				
2-reduc_emmission	0.58*	1																			
3-married	0.10*	0.03	1																		
4-male	-0.02	0.01	0.01	1																	
5-age	0.06*	0.07*	0.34*	0.19*	1																
6-educ	-0.02	0.07*	-0.07*	-0.05	-0.12*	1															
7-income	-0.05	-0.08*	0.07*	0.01	0	0.24*	1														
8-residence	0.11*	0.02	0.01	-0.05	0.10*	0.07*	0.10*	1													
9-livingyear	0.11*	0.02	0.01	0.05	0.31*	-0.16*	-0.07*	0.46*	1												
11-inceunknown	-0.04	-0.01	0.06	-0.07*	0.06	-0.09*	0.03	-0.01	-0.05	1											
12-incepurchase	0.09*	0.13*	0.05	0.11*	0	0.12*	-0.05	0.03	0	-0.44*	1										
13-hinderunknown	0.02	-0.03	0.08*	-0.06	0.01	-0.14*	0.07*	0	-0.02	0.49*	-0.23*	1									
14-hindercharging	0.05	0.16*	-0.02	0.21*	0.09*	0.09*	-0.08*	0.02	-0.01	-0.19*	0.35*	-0.44*	1								
15-hindersubsidy	-0.01	0.02	-0.06*	0.09*	-0.03	0.06	-0.01	-0.04	-0.01	-0.10*	0.10*	-0.14*	-0.12*	1							
16-hinderawareness	-0.01	0.02	-0.01	0.04	-0.01	0.03	-0.02	0.04	0.06	-0.11*	0.11*	-0.15*	-0.10*	0.013	1						
17workp_charging	0.08*	0.05	0.03	0.11*	0.08*	-0.04	-0.01	0.02	0.05	-0.08*	0.18*	-0.11*	0.08*	0.09*	0.02	1					
18-livep_charging	0.11*	0.06*	0.07*	0.11*	0.08*	-0.08*	0.02	0.03	0.07	-0.11*	0.15*	-0.08*	0.03	0.11*	0.03	0.74*	1				
19-interworkd	-0.04	-0.04	0	-0.03	0	-0.02	0.01	0.04	-0.02	-0.06*	-0.01	-0.04	0.02	0.01	-0.01	0.38*	0.29*	1			
20-interlived	0.01	0.01	0	0.02	0.06	0.03	0.00	0.05	-0.01	-0.05	0.07*	-0.06	0.06	-0.01	0.02	0.27*	0.37*	0.23*	1		
21-incepurchase	0.09*	0.131*	0.04	0.11*	0	0.11*	-0.04	0.03	0	-0.44*	1.00*	-0.23*	0.34*	0.10*	0.11*	0.18*	0.15*	-0.01	0.07*	1	
22-hindercharging	0.05	0.16*	-0.03	0.21*	0.09*	0.09*	-0.07*	0.01	-0.01	-0.20*	0.35*	-0.45*	1.00*	-0.13*	-0.10*	0.08*	0.02	0.02	0.06	0.35*	1

NOTE: Where the * denotes that the correlation coefficient is significant at the 10% level or better.

6.1.2 Empirical Results for Hypothesis 1

For this hypothesis, firstly, it plans to test that there is a difference between the public and private goods in the estimation variation of WTP, and the private good's variation is smaller than a public good. Secondly, it plans to test that in the two groups of samples, controlled group without license plate quota is regarded as a higher substitutability, while Shenzhen as an experiment group with the impose of quota, is regarded as a less substitutability sample, therefore, it is also applied to hypothesis that variation in experiment group is higher than the controlled group. Based on the target, the meta-analysis will be deployed to compare the studies that have been done previously, in terms of the average WTP, standard variation, the methodology collecting and eliciting the data etc., which will provide a minimal guidance regarding such issue. Meanwhile, the meta-analysis refers to a tool for analyzing based on the accumulated knowledge on this topic from diversified fields. The presence of systematic and identifiable variation of WTP is essential to the validity of WTP, where the systematic set covers the attributes of the studied objects, policies sites and context in the ways to collect the data. The quality and comparability are important for the meta-analysis, but a certain degree of heterogeneity is desirable to compare the effect of different scenarios and contexts. For example, the payment vehicle in some question surveys, refers to the voluntary payment, revealing the reduced WTP amount as the voluntary payment (Johnston et al., 2005). However, in a meta-regression analysis on the WTP for the renewable energy, it finds that a large number of studies do not report the standard error or relating equivalent dispersion statistics of the WTP estimation(Ma et al., 2015),which raises concerns about the validity of WTP estimation. And this is one reason there are only limited researches listing in my work to comparing the dispersion of WTP estimation between private and public goods.

Due to the diversified products or perceived services, scenarios, contexts and currencies etc., it is not easy to compare the variability across different samples simply, then a simple statistical term of coefficient of variation referring to a relative variability, is introduced in the comparison of WTP estimation between public and private goods. Where the sample only refers to individuals who do not own vehicles, with the purpose of collecting the estimation of WTP.

Table 38 Comparison of coefficient of variation for the WTP in my research

Samples	Obs	Mean	Std.Dev.	Min	Max	S.D./ Average
Experiment-Shenzhen	262	14.71	16.03	2	100	1.09
Controlled-Other cities	352	19.10	15.44	3	180	0.81
Total	614	17.22	15.83	2	180	0.92

NOTE: Where the unit for the WTP is 10,000 RMB, and the samples only refer to individuals who do not own vehicles but have a willingness and plan to purchase, only under this condition is there an estimation of willingness to pay (WTP) from individuals.

Table 39 Literature comparison of disparity on the distribution of WTP

Literatures	Topics	Average WTP	S.D.	
(Torero, Chowdhury, & Galdo, 2003)	WTP for the telephone service	0.178	0.113	0.63
		0.405	0.265	0.65
		1.128	0.506	0.45
(Jaeger & Harker, 2005)	Evaluation of novel kiwifruit	1.051	0.900	0.86
(Shlay et al., 2005)	WTP for child care	2.338	1.657	0.71
(van den Berg et al., 2005)	informal caregivers	7.84	4.43	0.57
(King, Tsevat, Lave, & Roberts, 2005)	WTP for a Quality-Adjusted Life Year	105,800	167,700	1.59

(Whitehead, 2006)	Improving WTP for water quality Improvements	75.95	70.57	0.93
(Shih et al., 2007)	WTP for diagnose of diabetes	468.9	327.7	0.70
(Nellthorp et al., 2007)	WTP for Noise Changes into Transport Appraisal	252	289	1.15
(Andersson, 2008)	WTP for Car Safety	12.64	2.69	0.21
(Cawley, 2008)	WTP to reduce childhood obesity	92.55 60.19	68.16 66.65	0.74 1.11
(Schwarzinger et al., 2009)	Asymptomatic spouse for WTP questions	44.6	28.4	0.64
(Khwaja, 2010)	WTP for health insurance	24,947(1991) 39,435(2008)	15,584(1991) 24,635(2008)	0.62 0.62
(Yu, Gao, et al., 2014)	WTP for the “Green Food”	0.404 2.555	0.204 1.404	0.50 0.55

Note: this is a review on the previous works of willingness to pay, in term of the average valuation, variation and S.D./ Average, but for different research subjects.

For the first part of this hypothesis, the private good’s coefficient variation is smaller than a public good in term of the WTP estimation due to a clear reference and tradeable market. Where in my research, as a private and tradeable good of vehicle, the coefficient variation is 0.92. Superficially, to a larger extent, it is higher than parameters listed in above table as the combination of literatures, which has an adverse conclusion to the previous hypothesis. But some other condition, such as scenarios and method of data collection, are not controlled in the comparison. Firstly, the definition of public goods is ambiguous and difficult to set the scope in the practice, although it could be regarded as a public good when there is no alternative in individuals’ perception(O’Brien & Viramontes, 1994; Ryan, 1996; Dranitsaris, 1997; Bala et al., 1999; Eastaugh, 2000; Sach, 2004), while the topics listed in the literatures, such as telephone service, children care, water quality, car safety, childhood obesity, health insurance, etc., it is a challenge to define it either as a private or public good according to the definition and practice in the previous literatures. More importantly, the way of collecting the data is a much higher weight element in the estimation of WTP.

The modes of collecting the data are diversified presented in the table of literatures, such as open-ended, dichotomous choice, factorial survey analysis, double-bounded dichotomous choice, combination of open-ended and closed-ended, allowing respondents to pick a number or an interval from a list of given values. Therefore, there are different drawbacks for previous presented methods of collecting data, such as the starting point bias for the dichotomous way and closed-ended(Cameron & James, 1987; Gafni, 1998;Eastaugh, 2000; Veronesi, Alberini, & Cooper, 2011), due to the diversified ways of data collection, it would give rise to the different estimation of WTP, accordingly, it cannot draw the conclusion that the private good has an either higher or lower variation contingent on the presented tables.

However, based on the comparison data of coefficient of variation in my research, the second part of this hypothesis indicates that variation in the experiment group is higher than the controlled group as the fact that there is a higher substitutability in the controlled group than the experiment group due to the existing of quota imposed by the authority in the experiment group. Which is consistent with the hypothesis that coefficient of variation is 1.09 and 0.81 in the sample of experiment and controlled group respectively, namely, the disparity in the experiment group is higher than the counterpart in the controlled group. Besides, for both the

two groups, the ways of data collection are the same, so it also has the possibility to compare the variation between the groups.

In a nutshell, two groups of comparisons in term of coefficient variation, public and private goods, controlled and experiment groups, it cannot draw any conclusion for the former group comparison due to the ambiguous clarification of public or private good in the presented literatures and the diversified collection models in their studies. But it is consistent with the second part of first hypothesis that the coefficient variation in the experiment group is higher than the counterpart in the controlled group. Namely, the less substitutability, the higher variation.

6.1.3 Empirical Results for the Hypothesis 2

The second hypothesis focus on the test that the function mechanism between WTP and AP is different. Previously, the studies only focus on the mechanism of WTP in terms of the income, perception, psychological and moral perspectives. But this part of hypothesis not only challenges the validity of WTP, but more importantly, studies the discrepancy and difference in the function mechanism between WTP and AP. It will be divided into three sub-hypothesises.

(1) Hypothesis 2.1 The higher green perception of the new energy vehicles, the higher WTP. But this positive relationship for WTP is not applicable to the AP.

For this sub-hypothesis, primarily, it focuses on the effect of perception on the WTP and AP, after that, it will also study the formation mechanism of perception, namely, the variables of perception will be also being the dependent variables.

Table 40 Comparison of perception in different groups

Samples	Experiment group (Shenzhen)				Controlled group (other cities)			
Dependent Var.	plan nevs		own nevs		plan nevs		own nevs	
	1	2	1	2	1	2	1	2
cost_effective	0.012		0.002		0.014		-0.002	
	(3.66)**		(0.59)		(4.87)**		(0.85)	
reduc_emmission		0.015		0.002		0.007		-0.01
		(3.58)**		(0.61)		(2.30)*		(4.24)**
income	-0.053	-0.034	0.03	0.03	-0.038	-0.035	0.032	0.026
	(1.66)	(1.08)	(0.95)	(0.93)	(0.93)	(0.87)	(1.3)	(1.05)
_cons	-1.184	-1.67	-0.124	-0.148	-0.07	0.403	-0.582	0.157
	(4.46)**	(4.23)**	(0.45)	(0.49)	(0.28)	(1.46)	(2.88)**	(0.68)
N	262	262	306	306	468	468	685	685

NOTE: This Table presents the results of effect of perception in terms of "willingness to pay" and "actual payment" between experiment and controlled groups, namely, a dummy variable as the plan to purchase of NEVs and have already owned NEVs in the two groups. Meanwhile, the assessment for the variable of cost_effective and reduc_emmission in the questionnaires, respondents can choose any number of values in a scroll slider over 0-100 in the questionnaire. Besides, it is integrated with the income, with the purpose of setting variable of income as an important part in the empirical analysis. (* $p<0.05$; ** $p<0.01$).

For the empirical study presented in the above table, which supports the hypothesis that there is a higher WTP for the NEVs with a higher green perception of it. For the planning to purchase NEVs, the perception of cost effective and reduction of emission are both statistically significant in both experiment and controlled groups, with the additional one point of emission reduction, is associated with a 0.015 and 0.007 increase in the probability of purchasing NEVs at the level of 1% and 5% in the experiment and controlled samples respectively, which is analogous to the variable of cost-effective, indicating the perception of reducing the cost overall for NEVs. It is also consistent with conclusion in the theory of planned behavior (Ajzen & Fishbein, 1977), and the perception of higher quality and security food plays a positive role in the WTP of organic food(Krystallis & Chryssohoidis, 2005). There is a same conclusion on the adoption of the modified genetic food, the higher negative perception is associated with a clear detrimental effect on the adoption of modified genetic food(Kimenju & De Groote, 2007), but these conclusions only concentrate on the perspective of willingness, instead of actual payment.

But for samples of actual owning NEVs, it is not statistically significant, except for the variable of reduction emission in the controlled group, which is significant at the level of 1% and one-

point increase is associated with a 1.1% lower probability of owning a NEVs. Accordingly, to a larger extent, it can draw the conclusion that there is no statistically significant relation between the green perception of NEVS and the AP, except the variable of reduction emission in the controlled sample. Why do not the perception variables have a statistical relation with the actual payment of NEVs? Firstly, as the empirical result presented in the table, truly, for the perception, there is no effect on the behavior of actual purchasing, due to more important determinants, such as challenges imposing by attributes of NEVs, policies imposed by the government. Additionally, there would be an endogenous problem in the dataset, namely, a reverse relationship between the dependent variable and independent variables, more specifically, in the group of individuals who have already owned vehicles (dependent variable), it would have a reverse effect on the perception (independent variable). And the solution is to look for an instrument variable constructing a relation with the independent variable but absent relation with the dependent variable in a two-stages regression.

Interestingly, the variable of income is not statistically significant for all groups, neither planning to purchase NEVs nor owned NEVs for both experiment and controlled groups. Namely, with the increase of income, there is no positive or negative statistically significant relation on the WTP and actual payment for the NEVs. Basically, the previous literature indicates the higher income, the higher willingness to pay, such as healthcare intervention (Bala et al., 1999), the health care(Ethgen et al., 2003), certified food (Angulo & Gil, 2007), forest property right and security(Linde-Rahr, 2008), green electricity(Zhang & Wu, 2012). Even though there are lots of debate about the effect of income on the consumers' WTP, such as risk-reverse, environmental Kuznets curve. It is reasonable and feasible for the empirical results that there is no any statistically significant relation between the income and planning purchase and actual owning NEVs, neither positive nor negative. With the increase of income, the consumption will increase for some products, while some products will experience the decline, which is contingent on the goods' characteristics(Horowitz & McConnell, 2000). The category of NEVs, is only regarded as a substitution of a conventional vehicle for consumers, more importantly, until now, the marketing competence of conventional vehicles is much stronger than the NEVs, otherwise, there would be no subsidy and others incentive policies for the adoption of NEVs. Accordingly, due to fact the existing of market structure for NEVs, the substitution and income effect are both weaker than conventional ones. Contingent on the previous literature on the effect of income, with the increase of income, it is positively related with the WTP and actual payment, but only for the stronger market performance, conventional vehicles, rather than the weaker one, NEVs. Accordingly, the income is a necessary but insufficient condition for the adoption of NEVs.

Therefore, based on the previous empirical analysis and test, it supports the hypothesis that the higher green perception is positively related with the WTP, but for behaviours of individuals' actual payment, it does not exist. Namely, there would be a phenomenon of "trap of subjective willingness". It could be also regarded as the different effect mechanism between WTP and AP. However, there is no enough evidences to extend it, indicating that there is a same conclusion for all common market or only this special case study of NEVs. Accordingly, it also connects to the studied object in the hypothesis 1, private or public goods with different attributes for the studied object, is it applicable to all of them? This if one point for further study.

In this hypothesis, the perception is a primary independent variable to test the relation with WTP and AP, nevertheless, what is the effect mechanism for the formation of perception?

Accordingly, variables, as the perceptions of cost-effective and reduction of emission, will also be regarded as dependent variables to study effect of independent variables on it, such as demographic information, own a car or not (NEVs or conventional ones), etc.

Table 41 Cost-effective perception of NEVs in different samples

Dependent variable, is the cost-effective, namely, it saves cost comparing to the conventional ones.										
Panel A	Experiment (Shenzhen)					Controlled (other cities)				
	1	2	3	4	5	1	2	3	4	5
owncar	4.453					1.975				
	(2.06)*					(1.55)				
categ_plannev		12.592					13.298			
		(3.55)**					(5.30)**			
catog_ownnev			1.402					-1.829		
			(0.46)					(0.91)		
age<=25				2.576					-4.364	
				(0.69)					(1.86)	
Age[26,29]				-2.074					-2.932	
				(0.66)					(1.36)	
Age[30,35]				3.928					0.659	
				(1.30)					(0.31)	
below_bachelor				-4.021					5.258	
				(0.96)					(2.44)*	
bachelor				-8.274					5.501	
				(2.09)*					(2.62)**	
income<=3(000)				1.008					2.487	
				(0.14)					(0.81)	
3.1-6(000)				-3.642					3.832	
				(0.94)					(1.59)	
6.1-9(000)				-3.916					5.237	
				(1.14)					(2.13)*	
9.1-12(000)				-4.244					3.030	
				(1.37)					(1.18)	
price_own					-0.157					0.003
					(1.63)					(0.04)
dist_work					0.029					0.002
					(1.53)					(0.22)
dist_week					0.005					-0.012
					(0.49)					(2.36)*
fuel_exp					-0.002					0.001
					(0.79)					(0.59)
park_exp					-0.002					0.001
					(0.36)					(0.53)
N	607	262	303	607	306	1,302	468	685	1,302	685

NOTE: This table presents the results of OLS regression, and the dependent variable in panel A is the cost_effective, and panel B is reduc_emmission, meanwhile, the independent variables are the dummies indicates different status and parameters for the driving experiences. Additionally, when age >=36, education >bachelor (master and PhD) and income >=12.1, they are omitted variable.

Owning a car is positively related with the perception of cost-effective by 4.45 at the level of 5% in the experiment samples, while it cannot reject the null hypothesis in the controlled samples. Meanwhile, for the group of planning to purchase, planning to purchase NEVs are both positively associated with the dependent variable both at the level of 1%, which is

consistent with the previous table for the relationship between the perception of cost-effective and planning purchase for both group samples. However, for the groups of owning a car, owning a NEVs is not statistically significant for both samples. In terms of education, age and income, the dummy variables for different classifications of groups in the experiment samples, basically, which are not statistically significant, except the dummy variable of bachelor. While in the controlled samples, there is a slight increase of cost-effective perception with the increase of education, from 5.258 to 5.5 at the significant level of 5% and 1% separately. Accordingly, it cannot draw the conclusion that the higher education, income and age, are associated with a higher perception of cost-effective. Lastly, for the driving experience, including the driving distance on the workday and weekend, the fuel and parking cost, which are not statistically significant, except for the variable of driving distance on the weekend, which is negative associated at the level of 5%.

Table 42 Reduc_emmission perception of NEVs in different samples

Dependent variable, is the reduc_emmission, namely, it reduces the emission.										
Panel B	experiment (Shenzhen)					Controlled (other cities)				
	1	2	3	4	5	1	2	3	4	5
owncar	1.277					4.204				
	(0.65)					(3.65)**				
categ_plannev		11.455					5.645			
		(3.67)**					(2.35)*			
catog_ownnev			1.463					-7.754		
			(0.52)					(4.50)**		
age<=25				-0.978					-6.095	
				(0.29)					(2.87)**	
Age[26,29]				-1.776					-5.227	
				(0.62)					(2.68)**	
Age[30,35]				3.761					-2.169	
				(1.37)					(1.12)	
below_bachelor				-0.021					-2.581	
				(0.01)					(1.32)	
bachelor				-1.274					1.718	
				(0.35)					(0.90)	
income<=3(000)				-7.078					5.000	
				(1.12)					(1.80)	
3.1-6(000)				-2.427					8.350	
				(0.69)					(3.82)**	
6.1-9(000)				-0.181					6.177	
				(0.06)					(2.78)**	
9.1-12(000)				0.072					6.544	
				(0.03)					(2.81)**	
price_own					-0.219					-0.043
					(2.48)*					(0.74)
distance_work					0.001					-0.014
					(0.06)					(1.63)
distance_week					-0.001					-0.009
					(0.11)					(1.93)
fuel_exp					0.002					0.001
					(0.88)					(1.24)
park_exp					-0.006					-0.000

					(1.22)					(0.10)
N	607	262	306	607	306	1,302	468	685	1,302	685

Similarly, regarding to the perception of reduction of emission, for the variable of planning to purchasing the NEVs, it is both statistically significant at 1% and 5%, comparing to purchase the conventional vehicles, the ones who plan to purchase NEVs have a higher score of perception by 11.45 and 5.645 in experiment and controlled samples. Owing a vehicle is associated with 4.2 score higher than the individuals without vehicles at the level of 1%. But for actual owning vehicles, conversely, owning NEVs is 7.7 scores lower than the ones owning conventional vehicles at the significant level of 1%. Furthermore, for the remaining variables, generally, it is not statistically significant in the experiment samples, while in the controlled samples, with the increase of age, the decrease has a slowdown trend from -6.095 to -5.227 at the level of both 1%. Additionally, it is positively related with the variable of age, with the increase of income, there is a slowdown tread then with a slight increase at the level of 1%. Lastly, for the driving characteristics, except the price of owning vehicles is negative associated with the perception of reduction emission at the level of 5%, the others variables are all not statistically significant in both samples. Accordingly, for the perception formation, the perception of cost-effective is analogous to reduction emission.

Table 43 Spatial effect on the perception of NEVs in the different samples

Panel A: dependent variable: cost_effective, namely, it saves cost comparing to the conventional ones.								
	Experiment (Shenzhen)				Controlled (other cities)			
	plan nevs		own nevs		plan nevs		own nevs	
workp_charging	6.701		3.281		4.321		6.093	
	(1.82)		(0.98)		(1.39)		(2.81)**	
interworkd	0.024		-0.002		0.136		-0.104	
	(0.09)		(0.01)		(0.90)		(2.10)*	
livep_charging		6.480		5.248		5.128		6.708
		(1.80)		(1.57)		(1.61)		(3.12)**
interlived		-0.143		-0.022		0.531		-0.134
		(0.76)		(0.13)		(1.39)		(0.95)
N	262	262	306	306	489	489	685	685
Panel B: dependent variable: reduc_emmission, namely, it reduces the emission.								
	Experiment (Shenzhen)				Controlled (other cities)			
	plan nevs		own nevs		plan nevs		own nevs	
workp_charging	7.858		-0.483		2.064		3.148	
	(2.44)*		(0.16)		(0.71)		(1.66)	
interworkd	0.059		0.075		-0.052		-0.065	
	(0.24)		(0.40)		(0.37)		(1.48)	
livep_charging		10.519		4.071		4.768		3.069
		(3.41)**		(1.32)		(1.61)		(1.63)
interlived		-0.548		0.041		0.021		-0.025
		(3.35)**		(0.27)		(0.06)		(0.20)
N	262	262	306	306	489	489	685	685

NOTE: This table presents the OLS regression results, dependent variables are the perception of NEVs, cost_effective and reduc_emmission, which is a discrete value over 0-100. And independent variables are the spatial element about the charging stations and distance from where they live and work.

Interestingly, for the test of accessibility of charging station on the perception, it is only statistically significant for the perception of cost-effective in the controlled sample who have already owned vehicles, while for the perception of reduction emission, which is only

significant in the experiment sample for the individuals who plan to purchase NEVs. Apparently, for the significant groups, knowing the specific charging station is positive with the perception and the distance from the charging station in the work or live place, is negative with the level of perception.

(2) Hypothesis 2.2: There are several sub-hypotheses about the effect of past experience on the WTP and AP. Firstly, in the controlled samples without the quota, the living years and registered resident do not have effect on individuals WTP for NEVs; while samples in the experiment imposing the quota, the longer of living years and registered resident, the higher WTP for the NEVs. Secondly, the higher driving cost, the higher WTP for NEVs, besides, the higher performance requirement on the NEVs is associated with a lower WTP for NEVs, and a higher willingness to pay the external fee, such as the license of premium, is related to a higher WTP. But this relationship for WTP is not applicable to the actual payment.

Prior to the behavioral study between the binary choices of NEVs and conventional ones, it is reasonable to analyze samples who own a vehicle, where it does not distinguish the conventional or NEVs, accordingly, it could be also regarded as a comparison benchmark for the adoption of NEVs. Accordingly, for this part of testing on the past experience, it will cover different variables representing the past experience, but the dependent variable is different, initially, it is a dummy variable representing the individual owning a vehicle or not, then the dependent variable consists of two groups, namely, planning to purchase NEVs or conventional ones for individuals who do not own a vehicle, and owned a NEV or conventional one for individuals who have already owned vehicles.

Table 44 Comparison of individuals who own a car or not in the two samples

Samples	Experiment group (Shenzhen)						Controlled group (other cities)		
Dependent variable	own a car, yes or no			own a car (after quota)			own a car, yes or no		
	1	2	3	1	2	3	1	2	3
married	0.645			0.535			0.86		
	(5.23)**			(3.86)**			(10.52)**		
male	0.493			0.744			0.215		
	(4.24)**			(5.41)**			(2.99)**		
memberhhold	0.003			-0.02			-0.012		
	(0.11)			(0.48)			(0.7)		
residence	0.564			0.734			0.306		
	(5.24)**			(6.03)**			(3.87)**		
livingyear		0.018			0.018			0.013	
		(2.88)**			(2.60)**			(4.25)**	
educ			0.053			0.079			0.011
			(2.26)*			(2.91)**			-0.64
age			0.042			0.042			0.055
			(4.57)**			(4.01)**			(8.36)**
income			0.008			0.01			0.094
			(0.34)			(0.4)			(4.74)**
N	607	607	607	502	502	502	1,302	1,302	1,302
Prob > chi2	0	0.004	0	0	0	0	0	0	0
Pseudo R2	0.0929	0.01	0.031	0.1214	0.0099	0.0359	0.0792	0.0101	0.0593

NOTE: This table presents the results of a Probit regression, the dependent variable is a binary variable equal to 1 if the respondent owns a car, and o represents no car. Meanwhile, yes or no car (after quota), the data for this part has excluded 105 samples who have purchased the vehicles before the quota, namely, before January, 2015. The policy of quota in Shenzhen was promulgated at 18:00, on 29th, December,2014, which taken effect

immediately. * p<0.05; ** p<0.01.

As shown in the above table, for the individuals' demographic variables, the coefficients of relationship are in most cases significant at the 1% level and economically meaningful, such as the marriage status, the married with a 64.5% higher possibility owns a car comparing to single, in the controlled group, which is much higher (86%). Meanwhile, for gender, comparing to female, men have a higher (49.3%) possibility of owning a car, which is the same to the residence, and the years have lived here, both significant for three groups at the level of 1%. It is also happened to the variable of age, with the increase of 1 year, it has a higher chance of 4.2%,4.2% and 5.5% respectively. However, there is a difference between the experiment and controlled groups in terms of education and income, in the experiment group, one additional year of education increases the possibility of owning a car by 5,3% and 7.9% at the significant of 5% and 1% respectively. But in the controlled group, the variable of education is not statistically significant.

Accordingly, and apparently, for the dummy variable of owning a vehicle, rather than NEVs, these variables representing the past experience consist with the previous literature and expectation, such as married, male, residence, years of living in the city, age, which are consist with the social expectation. However, it is interesting that there is a difference on the effect of income between the experiment and controlled group, it is positively associated in the controlled group without the imposed effect of quota, but it is not statistically significant in the experiment group. The possible explanation for divergence is because the imposed quota giving rise to the phenomenon that the higher income does not mean a higher possibility of owning a car, meanwhile, the imposed quota started from the first month of 2015, from the description analysis about how long individuals have purchased the vehicles, the majority of customer purchased have been covered by the quota. Additionally, it should pay attention to the dependent variable that is a dummy variable of owning a car, either NEVs or conventional one, and the effect of past experience in the above empirical table proving that is consistent with the previous literature and social expectation, but when the dependent variable is a dummy variable of owning NEVs or conventional one, what conclusion will it be on the effect of past experience?

Table 45 Effect of variables in the license plate quota in the experiment group

Samples	Experiment group (Shenzhen)					
Dependent Var.	own a car, yes or no		plan nevs		own nevs	
	1	2	1	2	1	2
apply_quota	0.618		-0.011		0.79	
	(5.43)**		(0.05)		(5.17)**	
lottery_conv		0.045		0.015		0.04
		(4.25)**		(0.80)		(2.96)**
bidding_conv		-0.338		-0.231		0.021
		(1.61)		(0.57)		(0.07)
lottery_pure		-0.066		-0.067		0.992
		(0.46)		(0.30)		(2.69)**
lottery_hybrid		0.608		0.268		0.566
		(3.46)**		(0.81)		(2.98)**
N	607	606	262	262	306	306
Prob > chi2	0.000	0.000	0.85	0.79	0.000	0.000
Pseudo R2	0.0929	0.0492	0.01	0.0052	0.07	0.1

NOTE: This table presents the results of a Probit regression, the dependent variable is a binary variable equal to 1 if the respondent owns a car, and o represents no car. After that, then separately, there are two groups, there

is a dummy variable of own NEVs for individuals who have already owned a vehicle, and a dummy variable of planning to purchase NEVs for individuals who have not owned a vehicle* p<0.05; ** p<0.01.

Apparently, for the dummy variable whether applied in the quota system, the dummy variable of owning a car and owning NEVs, it is statistically significant at the level of 1%. And for the group of individuals who have not owned a vehicle, all the variables are not statistically significant, this is reasonable due to the fact that lots of individuals who have not participated in the quota.

What is the effect of past experience on the WTP and AP? What is the difference between planned behaviors (WTP) and actual behaviors (AP)?

Table 46 Comparison of individuals who plan to purchase NEVs and own NEVs between the two samples

	Experiment									controlled		
	plan nevs					own nevs				plan nevs		own nevs
	1	2	3	4	5	1	2	3	4	1	2	1
married	0.458					0.098				0.270		0.199
	(2.51)*					(0.49)				(1.97)*		(1.20)
male	0.522					0.733				-0.404		-0.142
	(2.78)**					(4.15)**				(2.99)**		(1.26)
memberhhold	-0.054					-0.023				0.015		0.016
	(0.95)					(0.53)				(0.27)		(0.56)
residence	-0.050					0.423				-0.071		-0.151
	(0.27)					(2.83)**				(0.49)		(1.02)
age		0.031					0.019				0.027	-0.024
		(2.05)*					(1.52)				(1.38)	(1.90)
educ		-0.054					0.031				0.031	-0.160
		(1.67)					(0.98)				(0.74)	(5.91)**
livingyear			0.019					0.010			-0.004	0.007
			(1.75)					(1.00)			(0.50)	(1.26)
budge_plan			-0.013					-0.001			0.009	0.006
(price_own)			(2.10)*					(0.12)			(1.13)	(1.60)
yearpurch_plan				0.116				-0.341			0.023	-0.132
(year_own)				(1.12)				(7.50)**			(0.31)	(5.23)**
income				-0.026				0.031			-0.051	0.065
				(0.79)				(0.85)			(1.03)	(2.37)*
numvehicles				-0.019				-0.075			0.065	0.162
				(0.17)				(0.59)			(0.46)	(1.16)
range_least				0.000				0.000			0.000	0.000
				(1.33)				(0.63)			(0.25)	(2.14)*
precondition				0.040				0.094				
				(0.33)				(0.85)				
licensepay					-0.074				-0.024			
					(1.71)				(0.56)			
N	262	262	262	262	262	306	306	306	306	468	352	685
Prob > chi2	0.0028	0.0111	0.0415	0.5043	0.0759	0.000	0.2031	0.000	0.5789	0.0113	0.745	0.00

Pseudo R2	0.051	0.0284	0.0201	0.0136	0.0099	0.0612	0.0076	0.1906	0.0007	0.0282	0.015	0.115					

NOTE: This table presents the Probit regress results and the dependent variable is the dummy variable, planning to purchase NEVs or not for the group of respondents who does not own vehicles but with plan to purchase, and own NEVs or not for the group of respondents who have owned vehicles. Namely, the differences between the "willingness to pay" and "actual payment" in two samples, meanwhile, please pay attention to the variables, budge_plan and yearpurch_plan are listed in the group of planning to purchasing, while price_own and year_own are represented for the groups who have owned it. * p<0.05; ** p<0.01.

Initially, for the marriage status, planning to purchase in two samples are both statistically significant at the level of 5%, which has a 45.8% and 27% higher degree to purchase NEVs comparing to the single. But it is not statistically significant in the groups of owning NEVs in both experiment and controlled samples.

Meanwhile, in term of gender, in the experiment group, both the planning and owning groups are statistically significant and positive related with the dependent variable by a higher degree of 52.2% and 73.3% comparing to female respectively. However, in the controlled samples, it is negatively related by a lower possibility of 40.4% at the statistically significant of 1%, but it cannot pass the test in the group of owning NEVs. Furthermore, in terms of members in the household and residence registration in the cities where they live, it is statistically significant in the group of owning NEVs in the experiment sample, with a higher degree of 42.3% at the level of 1%.

Simultaneously, age is statistically significant at the level of 5% by a higher degree of 3.1% with the increase of one year in the planning group of experiment sample, while education is negative associated with the group of owning NEVs in the controlled samples, which is a lower possibility of 1.6% with an additional one-year education at the significant level of 1%. Interesting, it is negative associated with the purchase budget at the significant level of 5%, indicating that there is a lower possibility of 1.3% to purchase the NEVs with one more unit budget in the planning group of experiment samples, which is consistent with the additional payment for the license, an increase of 10,000rmb accepted cost for the license is associated with a lower degree of 7.4% at the significant level of 10%.

Table 47 Results of subjective perception about the incentives and hindrance for the adoption of NEVs in the controlled group

	dependent, 1 indicates it plans to purchase nevs,0 is conventional one.									dependent, 1 indicates it owns nevs,0 is conventional one.								
	plan nevs									own nevs								
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
inceunknown	0.29									0.08								
	(2.20)*									(0.79)								
noincetive		-0.09									0.20							
		(0.65)									(1.77)							
incepurchase			-0.24									-0.25						
			(1.48)									(2.14)*						
incedriving				-0.24									-0.14					
				(0.75)									(0.88)					

hinderunknown					0.26									0.25					
					(1.82)									(2.31)*					
nohinder						0.002									0.18				
						(0.01)									(1.64)				
hindercharging							-0.34									-0.39			
							(2.04)*									(3.37)**			
hindersubsidy								-0.07									0.09		
								(0.19)									(0.39)		
hinderawareness									-0.06										-0.37
									(0.18)										(1.45)
N	468	468	468	468	468	468	468	468	468	685	685	685	685	685	685	685	685	685	
Prob > chi2	0.03	0.51	0.14	0.46	0.07	0.99	0.04	0.85	0.86	0.43	0.08	0.03	0.38	0.02	0.10	0.00	0.69	0.14	
Pseudo R2	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.01	0.00	0.00	

NOTE: The table presents the probit results, and the dependent variable is the same to the previous one, as the dummy variable indicating the planning categories of vehicles and owning categories, therefore, it is enabling to study the difference between “willingness to pay” and “actual payment”. The independent variables are categorized contingent on respondents’ feedbacks and answers in Chinese on the questionnaires, the questions in the questionnaire is shown as follow.

About the new energy vehicles policies in the city where you live. (at least write one policy, if you don't know, or there is no incentive policy in your city, please write "I don't know" and "no" respectively, including the categories: 1. Incentive policies_____; 2. Elements that hinder the adoption of NEVs you think_____.

Accordingly, based on the words in the blank, it is classified as “I do not know about the incentive, namely, inceunknown”, “there is no incentives, namely, noincetive ”, “incentives for the initial purchase, namely, incepurchase ”, etc. however, it has multi-collinearity among the classifications, so the study is presented as the separated columns.
* p<0.05; ** p<0.01.

Accordingly, for both groups, planning to purchase NEVs and owning NEVs in the controlled samples, the charging as the hindrance is statistically significant at 5% and 1% respectively, additionally, with the lower possibility of 34% and 39% to purchase NEVs and own a NEVs, comparing to the respondents who do not perceive the charging as a hindrance. Moreover, do not know the hindrance as a variable of "hinderunknown", are both positive related with the dependent variable of "planning to purchase" and "already own one" at the significant level of 10% and 5%. However, it is difficult to explain that "do not know incentives" is positive with the plan to purchase NEVs and "initial incentive to purchase NEVs" is negative with the samples who have already owned a NEVs at the significant level of both 5%.

Table 48 Times mentioned by the participants in controlled group for both incentive and hindrance elements

Groups	variables			
policyincentive	inceunknown	noincetive	incepurchase	incedriving
	518	376	304	113
policyhiderance	hinderunknown	nohinder	hindercharging	hindersubsidy
	460	425	315	49

NOTE: this description analysis is from samples in the controlled group, where participants need to write the text for the incentive and hindrance policies respectively.

Accordingly, firstly, contingent on the empirical test, it supports that the registered residence, which indicate a possible spillover effect as the fact that the quota has been implemented is within a domain of a city, the longer individuals who live in the city, the less possibility of moving out of the city, namely, the less of spillover effect, therefore, there is a higher possibility of purchased NEVs, vise verse, in the controlled cities of samples without the quota, the living years and registered resident do not have effect on individuals WTP for NEVs; Secondly, the empirical testing cannot support the hypothesis that the higher performance requirement on the NEVs is associated with a lower WTP, and a higher willingness to pay the external fee, such as the license of premium, is related to a higher WTP.

(3) Hypothesis2.3: The lower uncertainty of the charging location and the lower distance away from where individuals work or live, the higher WTP. But this relationship for WTP is not applicable to the AP.

What is the spatial affect the individual's WTP and actual payment? Due to the hindrance factor of charging possibility, the distribution of charging station is widely considered as a geographical diffusion network, which affect the individuals' perception and acknowledgement of the control factors. The independent variables primarily include the dummy variables representing yes/no as whether it knows the location of charging stations, and if yes, then the distance to the work and live places, and the interaction term among other variables.

Table 49 Spatial analysis on the adoption of NEVs for different samples

	experiment (Shenzhen)				Controlled (other cities)			
	plan nevs		own nevs		plan nevs		own nevs	
workp_charging	0.706		0.648		0.106		0.343	
	(2.49)*		(3.14)**		(0.32)		(1.94)	
livep_charging	0.209		0.811		0.125		0.599	
	(0.73)		(3.92)**		(0.39)		(3.29)**	
interworkd	-0.013		-0.012		0.003		0.001	
	(0.88)		(1.21)		(0.22)		(0.33)	
interlived	-0.034		-0.003		0.018		-0.049	
	(1.82)		(0.30)		(0.59)		(2.49)*	
worklive_charg		0.314		0.675		0.171		0.368
		(3.56)**		(7.57)**		(1.78)		(6.12)**
N	262	262	306	306	468	468	685	685
Prob > chi2	0.00	0.00	0.00	0.00	0.43	0.07	0.00	0.00
Pseudo R2	0.07	0.04	0.15	0.15	0.01	0.01	0.06	0.05

NOTE: The table presents the probit results for the adoption of NEVs, the dependent variable is analogues to previous study, namely, the dummy variable of planning to purchase NEVs and owning NEVs or not. For the independent variable, workp_charing and livep_charging represents the dummy variables whether knowing a charging station from the working place and living place, interworkd and interlived are the interaction terms indicate the distance (km), and worklive_charg indicates the number of knowing charging stations, ranging from 0-2, where 2 represents knowing the locations of both charging stations in the places of living and working, and 1 indicates one of them and o presents no of them. * $p<0.05$; ** $p<0.01$.

Generally, from the last variable of worklive_charg presented in the above table, it supports the hypothesis that higher uncertainty of charging station is positively associated with the WTP, but also in the group of actual payment, although the statistically significant is not apparent for the WTP of NEVs in the controlled group, the value of T-statistic is 1.78, which is statistically significant at the level of 10%. Where the variable of knowing the charging station refers to either in the working or living place.

Separately, knowing the charging station in the working place is positively associated with dependent variable in the experiment samples at the statistically significant of 5% and 1% separately, which are 70.6% and 64.8% higher degree of planning to purchase NEVs and owning NEVs in comparison to the respondents who do not know the location of charging station. in terms of charging station in the living place, it is statistically significant at the level of 1% for the group of owning NEVs in both experiment and controlled samples. Furthermore, for the distance away from living, in the experiment samples, the distance with one-kilometer increase is associated with a 3.4% lower possibility for planning to purchase NEVs at the significant level of 10%. While for the group of owning NEVs in the controlled samples, there is a lower possibility by 4.9% of owning NEVs with the increase of one kilometer.

Besides, concerning the interaction term of distance and a dummy variable of whether knowing the charging station, to a larger extent, it cannot support the hypothesis that lower distance away from the working or living place is associated with a higher WTP or actual payment, except for the actual payment in the controlled group, under the precondition, with the increase of one KM away from the living place, there is a 0.049 decrease in the actual payment of NEVs. Meanwhile, for the comparison of previous study, there is a an inverse "U" shape between the house price and the distance from the train station (Dubé et al., 2014), similarly, there is a 9-14% decrease of property price due to the construction of wind turbine(Sunak & Madlener, 2016), the recharging facility, the anxiety on the range, cost and the absence of knowledge and awareness are regarded as the primary hindrances to the adoption of NEVs(Brand, Cluzel, & Anable, 2017). Therefore, the primary attribute is whether knowing a charging station either in the working or living place, but the majority of additional distances are not statistically significant.

Accordingly, with the comparison and empirical results, which finds that the lower uncertainty of the charging location from where individuals work or live, the higher WTP, but this relationship for WTP is also applicable to the actual payment. However, to a larger extent, it cannot support the hypothesis about the distance that the lower distance away from where individuals work or live, the higher WTP and actual payment.

(4) Comparison and Discussion

For this part of hypothesis 2, the conclusion and comparison between the literatures and my work are presented in the following tables. In the second hypothesis, it divides into three sub-hypotheses, from the green perception, past experience and the spatial elements, more importantly, it emphasizes the difference between the WTP and AP. The following two tables present the comparison of different elements affecting the WTP, but these results of researches only fall on the perspective of willingness, instead of actual payment. This is one of the reasons raising the question on the disparity between the WTP and AP, which finds the phenomenon of a "trap of subjective willingness".

Table 50 Different factors affecting individuals' adoption of NEVs

Determinants in the literature	Relation	Sources
Environmentalism	+ or?	(Kishi & Satoh, 2005); (Diederich & Goeschl, 2011)
Environmental consideration and awareness	+	(Ozaki & Sevastyanova, 2011)
Concern about global warming	+ or ?	(Andreoni & Vesterlund, 2001)
Low emission rates	+ or ?	(Zhang, Wang, Hao, Fan, & Wei, 2013)
Past experience	?	(Verplanken & Van Knippenberg, 1998)
type of journey	?	(Choo & Mokhtarian, 2004)
Community's values and social norms	+ or ?	(Ozaki & Sevastyanova, 2011); (Godin et al., 2005)
Self-actualization, motivation	+ or— or ?	(Godin et al., 2005)
culture	?	(Fowler & Breen, 2014);(Choo & Mokhtarian, 2004)
Financial consideration	+ or?	(Mourato et al., 2004); (Ozaki & Sevastyanova, 2011); (Fowler & Breen, 2014)
Fuel economy, running cost, gasoline price	+	(Potoglou & Kanaroglou, 2007a);(Gallagher & Muehlegger, 2011)

Purchase price	+ or — or?	(Lave & Train, 1979); (Kishi & Satoh, 2005); (Gallagher & Muehlegger, 2011);(Yuan et al., 2015a); (Tran et al., 2013)
Driving performance (automatic gearbox)	+	(Adamson, 2005);(Tran et al., 2014)

NOTE: This table concludes the primary study results based on the theory of planned behaviors, in terms of three perspectives, intention and attitudes, normative and subjective norms, controls factors, which is also in term of the willingness and subject perception.

Comparing with the previous studies on the topic of adoption of NEVs, as the limitation of data, the theory to study the problem of adoption is the theory of planned behaviors, primarily on the subjective willingness. The theory of planned behavior, based on the theory of reasoned action(Ajzen & Fishbein, 1977), the conceptual framework, briefly, consists of three determinants, including behavioral beliefs, normative beliefs for the expectation of other people or social norm, control beliefs for factors that hinder or further the performance of behavior(Ajzen & Madden, 1986), and make independent contributions to the behavior study(Daigle et al., 2002).

The key factor is the individual's intention to perform a given behavior in a specific context, in which the motivational or impended factors are assured to be captured by individual's intention that affects a behavior. But for the prediction accuracy of behavior intention, it is much higher with multiple-alternatives than only one choice(Ajzen & Fishbein, 1969). An empirical study in many different behavioral domains confirms the correlation among attitude, subjective norms and control beliefs. Furthermore, the intention is a good predictor of the behavior. It pointed out that the attitude of the individual to a particular object is reflected a continuing positive or negative evaluation (Fishbein & Ajzen, 1975). Empirically, it generates an overall positive or negative attitude toward the purchasing of new energy vehicles(Aizen & Klobas, 2013). Therefore, the accurate information about behavioral beliefs is important for the attitude toward the purchasing of NEVs.

Social and psychology theory assume that intentions cause the change of behaviors, however, most of the studies only test the correlation of intention-behavior rather than causal inference, it is the same to the empirical study for the theory of planned behavior. The self-identity has a substantial impact on the intention to environmental protection behavior(Mancha & Yoder, 2015), meanwhile, the attitude toward environmental behaviors is positive with the behaviors(Tonglet et al., 2004). While the effect of past experience on the intention, it can generate an automated cognitive processes instead of elaborating decision processes when the behavior becomes habitual(Verplanken & Van Knippenberg, 1998).

For psychosocial benefits, such as self-esteem, protection and prestige, but self-esteem is associated with the type of cars(Ellaway et al., 2003).Over time, the importance of consumer characteristics such as travel attitude, personality and different lifestyle incorporate into the individual intention(Choo & Mokhtarian, 2004), which indicates higher environmental awareness led to higher willingness to the purchase of NEVs(Kishi & Satoh, 2005). So the service should be designed to accommodate the requirement by the customers(Beirão & Sarsfield Cabral, 2007), including the social-economic factors and environmental perception(Ziegler, 2012), which is also influenced by the type of journey, individual characteristics, lifestyle and the perceived performance of different transport modes.

The second determinant of behavioral intention is subjective norms, which is the individual's cognition of social pressures taking a particular action. Moreover, the perceived norms affect

the peer effect rather than the actual norms(Gardner & Abraham, 2010). Meanwhile, individual's moral obligation refers to a sense of responsibility to act and the internal state construct, which is regarded as one explanatory variable in the subjective social norm and can better predict the behavioral intention for pro-environment (Chen, 2015). In certain contexts, for the behavior change. More importantly, the self-expectations and internalized norms to adopt a given behavior (Godin et al., 2005), indicate an individual who has high moral norm scores shows a stronger intention-behavior relationship compared with those lower moral norm scores.

For environmental awareness and social norms, it indicates a non-positive willingness to pay, only a minority is willing to sacrifice particularly high amounts(Diederich & Goeschl, 2011), which is correlated with the features of subjects, including the education level, perception of climate change, but also the exogenous environmental controls, such as the meteorological conditions. Meanwhile, the beliefs of the future temperature change, the mass-media exposure and the agreement on the emission reduction, especially for the biggest emitter((Akter & Bennett, 2011), but there is no support that the moral responsibility matter for the voluntary neutrality(Bulte et al., 2005).

Besides, it finds that the price effect is robust and negative, but quantitatively weak, and the variables linking to moral responsibility dominate the price effect(Diederich, & Considine, 2011). Furthermore, the payment for the public environmental pollution is regarded as the implementation of "polluters pay", compensating to the negative externality for the public, also regarded as the altruism, such as the donation voluntary. But there is a gender difference on the altruism when altruism is expensive, women are kinder, while men are more altruistic when it is cheap, indicating the cross of demand curves for altruism between male and female(J. Andreoni & Vesterlund, 2001). Meanwhile, the individual contributions to the public good depend on the wealth and heterogeneous preferences, for the comparative static analysis, an initial level of public good, individual wealth and technology are important for the donation(Kotchen, 2009). Besides, the network theory explores human behavior in terms of the relationship among members of societies, including macro network approach and micro network approach (Park et al., 2015), which is used to examine patterns of communications between actors.

The third determinants, as perceived behavioral to a particular behavior, but it varies across behaviors and situations. Moreover, it is comprised of two components, self-efficacy, and controllability. More specifically, the measurement of perceived behavior control can ask the questions on the basis of beliefs indirectly about the ability to deal with the facilitating or inhibiting factors, or directly the capability to perform a behavior, of which the belief-base measures have a cognitive insight of behavioral control, while the majority of the studies are based on the capability, direct approach(Daigle et al., 2002). The perceived benefits of cars rely on the social-special relationship and the individual lifestyle. But the car is not just a kind of transport, also the felling of freedom, sensation, power, status, and superiority(Steg, 2005).

Early adopters are motivated heterogeneous by the financial benefits, new technology, environmental awareness and vehicles performance attributes (Tran et al., 2013). Monetary attributes includes purchase price, annual fuel, and maintenance cost, the per-capita income is significantly correlated with the purchasing NEVs, while negative with the mean age, but it is not distinguishable from zero for gender and educational attainment(Gallagher & Muehlegger, 2011). The NEVs industrialization dependent on the development of both related advanced

technologies and a mature industry chain, including the downstream supporting infrastructures (such as the charging station) and the upstream industries (such as the power cell industry). And the charging station is one of the key elements for the popularization(Yuan et al., 2015). The majority of the studies were based on the techniques of experiment design and the individual regarded as the unit of analysis, which indicates the fuel cost savings and incentives, be regarded as an incentive to households to adopt a cleaner vehicle(Potoglou & Kanaroglou, 2007). Apart from the performance attributes of NEVs, other economic instruments, such as the commuting time and costs are also important for the adoption.

It finds that with the combined package of subsidies and attributes, gasoline vehicles continue to be more attractive to the consumers in USA and China based on the choices-based conjoint surveys over 2012-2013, tax incentives are positively with hybrid vehicle adoption(Helveston et al., 2015). Meanwhile, Chinese respondents have significantly higher relative willingness-to-paying for the new energy vehicles. It find that not only the financial benefits relating to the transport policies are important to the consumers' motivation(Ozaki & Sevastyanova, 2011), but also the social norms and willingness to comply with the social norms, moreover, the additional value affect the decision making.

Table 51 Table Different factors affecting willingness to pay as the dependent variable

Elements	Topic	Literature	Conclusion.
Bad experience in the past	Public health	(Thompson et al., 1984)	+
Age and conversation club membership	Wetland protection	(Whitehead, 1990)	+
Income elasticity	Mortality and public health	(Mangnus Johannesson et al., 1993)	+
time to invest on it	Mortality and public health	(Mangnus Johannesson et al., 1993)	+
Rating of the importance of threat	Public goods	(Kahneman et al., 1993)	+
Household income	Chronic disease	(O'Brien & Viramontes, 1994)	+
Aware of negative consequence	Environmental public goods	(Guagnano et al., 1994)	+
Income	Assisted reproductive techniques	(Ryan, 1997),	+
reduction of micturition, namely, the treatment effect.	Disease of incontinence	(Johannesson, et el, 1997),	+
net income	WTP for the longevity	(Johnson et al., 1998).	+
Education	WTP for the longevity	(Johnson et al., 1998).	-
Attitude toward paying explains the variability in WTP, and the household income is significant related to the attitude.	Pollution abatement	(Jorgensen & Syme, 2000)	+
Ability to pay	Orthognathic treatment	(Smith & Cunningham, 2004)	?
Cost will dramatically decrease as the new technology diffuse; it will increase the WTP.	Dental issuance and dentin regeneration	(Birch, Sohn, Ismail, Lepkowski, & Belli, 2004)	+
Male with higher WTP, higher education and economic status	Community insurance	(Dong, Kouyate, Snow, Mugisha, & Sauerborn, 2003)	+
Age and distance to the health center	Community insurance	(Dong, et al , 2003)	-
Pay more for the kitchen garbage bags	Recycled plastic	(Anstine, 2000)	-
wealthier consumers are less likely to pay	mandatory labeling of country-of-origin	(Loureiro & Umberger, 2003)	-
Different culture and attitudes	WTP to reduce	(Alberini, Hunt, &	?

	mortality risks	Markandya, 2006)	
Information on consumers bidding behaviors	WTP for the Golden Rice (modified genetic)	(Depositario et al., 2009)	+/-

Utility regarded as the subjective value or desirability of a result of selecting an alternative, the "expected utility" theory of uncertainty was firstly proposed over two centuries ago by Daniel Bernoulli in the 18th century, which was formally developed and structured by Von Neumann-Morgenstern(VNM)(von Neumann & Morgenstern, 1944), who indicates the individuals' willingness to take risks under uncertainty, and the axioms of continuity, transitive and independence. Additionally, the satisfaction of a consumer obtaining from the purchase and use of commodities, the expected utility theory asserts that the decision maker will select the one with highest expected utility(Lichtenstein & Slovic, 1971). Then appearance of a major debate on the behavioral rationality, which begins with the case of individual choice (Machina, 1981). However, the uncertainty is regarded as the objective risk in the expected utility model(Levin, 2006).

For the different choices under the uncertainty for the willingness to pay, there is a preference ordering over a set of variables by a utility function. But dozens of experiments indicate the violation of axioms, including the independence, the contradictory decision for risk-aversion. The components for any model of consumer choice are the consumption set, feasible set, behavioral assumption and reference relation(Jehle & Reny, 2011). For each individual, when they make decision, the axioms of consumer choices are regarded as the bedrock, which are the completeness, transitivity, continuity and convexity(Jehle & Reny, 2011).

Actually, the condition of uncertainty, based on certain information, is almost normal for the decision-making. The utility function is defined the consumer's preferences over the consumption set, given the different constrains, such as prices, income, etc., to maximize the utility. Meanwhile, the individuals could be divided into risk averse, risk neutral and risk loving in light of the different attitude to risk. While for the comparison, the expenditure function is essential for the decision making, refers to the level of expenditure the consumer should pay to maintain a given level of utility, obviously, it is the minimum point of expenditure and maximum of the utility for individual consumption.

Decision making is closely related to psychology (Grether & Plott, 1979), and the perception of utility and awareness of consequence lead to the positive or negative effect on the decision(Stern, Dietz, Abel, Guagnano, & Kalof, 1999). But it fails to capture three important elements that characterize decision making: (1) the nature of uncertainty in choice; (2) Effect of context, where individual is highly sensitive to contextual variables and changes in context that affect the evaluation of risk; (3) Dependence between probabilities and payoffs(Einhorn & Hogarth, 1988), and the perception of all these attributes also plays essential role in the decision making(Bahamonde-Birke & Ortúzar, 2014).

But in this paper, individuals' decision making is associated with the subjective probability for different choices of which kind of vehicle they will prefer in the quota, which is consistent with the cardinal utility theory. While normally, individuals who are risk-aversive are eager to join in the gambles, partly, because people tend to add higher probability to the result they expect intuitively(Quiggin, 1982). The expected-utility hypothesis has rich empirical content with the decision-making, and there exists a function that contains all the information relating to the predicting behavior. But the performance attributes rank the top(Zhang et al., 2013).

Meanwhile, the way is to calculate the expected values for alternatives and choose the one with highest expected value(Friedman & Savage, 1952). There are two fundamental factors for a utility function: (1) how much do the individual like each of the alternative? (2) What are the probabilities for a successful outcome of each alternative? But the utility function of a given subject is almost impossible to measure directly(Becker, DeGroot, & Marschak, 1964).

In order to understand consumers' behavior, the modeling and measuring of its preferences are critical, which often include the risk as one variable, in my study for the adoption of NEWs, the required range can be interpreted as one indicator of risk, the higher required range, the smaller risk tolerant. Moreover, a utility of income function for the specific group of low-income consumers, with a convex, namely, risk-seeking, but for the adoption of NEVs, the variable of income is only a necessary but not sufficient one, which means that there are other variables outweigh the importance of income in the willingness to pay and actual payment.

6.1.4 Empirical Results for the Hypothesis 3

In this testing of hypothesis, it primarily concentrates on the mechanism behind the disparity of WTP-AP. For the disparity in the theory of commitment cost, the three elements, uncertainty, learning opportunity and reversibility, have its own problem imbedded in the hypothesis. Firstly, the uncertainty only refers to the monetary value, neglecting the uncertainty of utilization. Secondly, both the learning opportunity and reversibility are under the hypothesis of zero-cost. Which is the common problem in the experiment study to simulate the scenarios of WTP, such as the demerits in the choices of incentive category, chosen object, absent of cognitive effort for participants, etc. Due to these problems in the theory of commitment cost to study the disparity, this hypothesis is divided into two sub-hypotheses. Firstly, it extends the uncertainty from monetary value to utilization, secondly, it expands the learning with zero cost to learning with cost in the repeated times.

The samples data will only cover individuals who have jointed the bidding or lottery in Shenzhen's quota, simultaneously, who has purchased a vehicle finally. With this possibility to study the disparity between the choices of WTP and the actual payment lastly in the quota system, accordingly, the disparity refers to the difference between the final category of actual payment and initial planned category of WTP. Simply, there are two kinds of categories for each candidate in the quota system, namely, NEVs and conventional vehicles, a dummy variable is introduced where it is 1 when the candidate change its choice and 0 when it is the same to the final choice. More specifically, concerning the comparison in the data source, the actual payment is the final category of vehicle that each candidate has purchased, while the category of WTP refers to the choice with largest times of the bidding or lottery in the quote mechanism.

Table 52 Samples distribution for participating in the quota and owning vehicles in the experiment sample

Quota apply	Individuals owning vehicles			Individuals without vehicles		
	Freq.	Percent	Cum.	Freq.	Percent	Cum.
NO	183	59.8	59.8	241	80.07	80.07
YES	123	40.2	100	60	19.93	100
Total	306			301		

Where there are 60 individuals who without vehicles also submit the application in the quota system, but they will not include in the samples of disparity study due to the absence of actual purchase finally. Meanwhile, from the above table for the group of owning a vehicle, there are 183 individuals who purchased it before the implementation of quota in Shenzhen.

Table 53 Tabulate the distribution of categories of actual purchase, planning purchase and disparity

	Catog_ownnev		wtp_new		Disparity	
Category	Freq.	Percent	Freq.	Percent	Freq.	Percent
0	33	27%	108	88%	44	36%
1	90	73%	15	12%	79	64%

NOTE: The 1 and 0 represent the NEVs and conventional vehicles respectively for the category, while for the disparity, which is a dummy variable elaborating the changed purchase and same one separately between the actual purchase and planning purchase.

There are 88% candidates with the planning to purchase conventional vehicles, but due to the imposition of quota and times of failure in the bidding or lottery, finally, there are 64% candidates have changed their previous purchase plan, namely, it is presented as the disparity equaling to 1. Accordingly, for this hypothesis, it will test how the learning opportunity with embedded cost and the utilization uncertainty affect the disparity between the actual purchase and planning purchase, namely, the dependent variable of disparity. Accordingly, it is the description analysis for the data in this hypothesis.

(1) **Hypothesis 3.1:** the higher uncertainty of utilization, the higher disparity between the WTP/AP.

For this hypothesis, the higher uncertainty of utilization, the higher disparity between the WTP/AP, which focus on the test of relationship between uncertainty and disparity. Previously, in the theory of commitment cost, the uncertainty only refers to the value, neglecting the actual utilization, which is also a drawback in the previous study that the selected product in the experiment is so simple that participants do not have cognitive efforts to think about the real value and potential problems in the process of utilization rigorously. In the field work and research setting, the product is a vehicle, with a clear price and market value reference, instead of ambiguous price benchmark. However, the uncertainty falls on the utilization process that affects the driving range, and the variable about whether knowing the charging station closing to either where individuals live or work is selected.

Table 54 description analysis on the variables of utilization certainty

Variable	Obs	Mean	Std.Dev.	Min	Max
no_charging	123	1.39	0.81	0	2
workp_charging	123	0.66	0.48	0	1
interworkd	123	4.27	8.87	0	60
livep_charging	123	0.73	0.44	0	1
interlived	123	2.67	4.28	0	20

Where the no_charging equals to 0,1 and 2 representing know nothing about where has the charging station, one of charging station (either work or live place), and both work and live places respectively. Averagely, more individuals know the charging station in the places where they live (0.73) than where they work (0.66). And the distance away from the living place(2.67KM) is smaller than it from the working location(4.27KM).

Table 55 Effect of utilization uncertainty on the disparity of WTP/AP

Dependent: disparity	1	2	3
no._charging	0.699(4.56)**		
workp_charging		0.955(3.58)**	
interworkd		-0.013(-0.92)	
livep_charging			1.315(4.43)**

interlived			-0.019(-0.61)
_cons	-0.573(2.39)*	-0.18(-0.93)	-0.516(2.25)*
N	123	123	123

From the result in the table, with the increasing certainty of utilization, namely, knowing more charging stations in different places, increases the disparity between the WTP/AP. Knowing one more charging station, the disparity will increase by 0.699, either working or living places. Separately, knowing the charging station in the location of working, it will increase by 0.955, and knowing a charging station closing to living has a larger impact on the disparity, amounting to 1.315. But both for the interaction terms between the dummy variable whether know the charging station in the working and living and the distance away to living or working cannot pass the significant statistics test. Accordingly, knowing more charging station, refers to a lower uncertainty of utilization, but it is associated with a higher disparity between WTP/AP, which is contrary to the hypothesis and previous study on the uncertainty of value.

Based on the theoretical framework of commitment cost, the uncertainty only refers to the monetary value that is uncertain to consumers, but it neglects the uncertainty of products' utility itself. The utilization could be decoded as the endowment effect that refers to the value of goods that have been in consumers' possession for short-term, while for the long-term, it could be explained by the sentimental attachment or the improved technology(Kahneman et al., 1990). And there will be no endowment effect when the purchase of the good is for re-sale, instead of the utilization, this phenomenon particularly exists in the experiment that traded object is not for real utilization, but only regarded as a transfer of token for cash as a predetermined price before the experiment(Kahneman et al., 1990).

Nevertheless, there is a problem about the conception and definition of a good value, in these experiments, it only refers to the assessment of monetary value, but more importantly, a good for a consumer, it has the endowment effect embedded in the product itself(Lusk, 2003). And it will decrease due to the less uncertainty on the good's value, less information gathered, more impatient, easier revising the previous transaction and the flexibility on timing of purchasing(Zhao & Kling, 2001).Previously, concerning the disparity between the WTP/WTA, it finds that there is no WTP/WTA divergence due to no uncertainty about the token's value, when the token is not cashed at a predetermined amount, such as contingent on a lottery of cash transfer, then the divergence will increase(Kahneman et al., 1990); Besides, the choice consistency is positively correlated with the choice certainty(Brouwer et al., 2017), implying that the higher certainty, the higher consistency over different times. Namely, the higher uncertainty of value, the higher disparity.

Therefore, integration with the previous studies, when the focus of uncertainty moves from the value to the utilization, it cannot reach the same conclusion.

(2) **Hypothesis 3.2**: the more learning opportunity with a delayed cost, the higher disparity between the WTP/AP.

For this sub-hypothesis, the more learning opportunity with a delayed cost, the higher disparity between the WTP/AP, which emphasize the relationship between the disparity and times of learning opportunity, but the cost is embedded in learning opportunity. The delayed cost includes the subjective failed sense monthly, the delayed endowment effect of the product that should have benefited. The divergence between the early trials in this experiment probability come from the misconception about the rules and lack of market

experience(Coursey, Hovis, & Schulze, 1987). Definitely, with the increasing learning opportunity, it will reduce the choice complicity, and the participants will be more familiar with the mechanism behind the choice, however, does it increase the disparity?

Table 56 Participation times in the quota system for different categories

Variable	Obs	Mean	Std.Dev.	Min	Max
lottery_conv	123	8.528455	8.396257	0	30
bidding_conv	123	0.178862	0.6406006	0	5
lottery_pure	123	0.252033	0.8056511	0	8
lottery_hybrid	122	0.45082	0.6441403	0	3

Undoubtedly, for individuals who have participated in the quota, averagely, the largest is the lottery for the conventional vehicles (8.53), which is also consistent with the data in the previous table that there are 88% individuals with the initial intention of purchasing conventional vehicles. The second largest is the lottery for the hybrid vehicles, as an alternative to avoid the potential drawback of total electricity vehicles and the remedy to tackle with the imposed quota simultaneously. And the least is the time that joints the bidding for the conventional ones due to large amount of external expense.

Table 57 How does times of learning opportunity affect the disparity of WTP/AP

Disparity	1	2	3
numapp_total	0.056(3.39)**		
numapp_conventional		0.05(3.16)**	
numapp_nev			0.377(2.20)*
_cons	-0.095(-0.53)	-0.035(-0.21)	0.152(-0.98)
N	122	123	122

Due to the existence of multi-collinearity and generating omitted variable on application times among conventional, NEVs and the total one, therefore, the hypothesis testing is separated among the independent variables, all the three independent variables support the hypothesis that the increasing times of learnings in the application, it increases the disparity between the actual purchase and category of initial plan. More specifically, with one more time of participation, there is a 5.6% higher possibility to change its initial planning. Which is contrary to the study that the disparity will decrease as the increase of repeated times(Zhao & Kling, 2001; Kling, List, & Zhao, 2013; Isoni, 2011).

What elements contribute to the difference, firstly and importantly, it falls on the cost of the learning opportunity. In this research, learning costs are diversified, such as the cost for uncertainty and longer waiting, negative mood due to the failure of bidding or lottery, urgent demand for the vehicle, time value of the deposit monthly, etc. which is consist with the real practice, instead of the assumption of zero cost in previous studies. Meanwhile, with the increasing of learning opportunity, the complicity of decision making fades away, it will reduce the disparity(Brouwer et al., 2017), but the disparity refers to the difference of value estimation. Furthermore, in previous study, it find little difference between inexperienced and experienced buyers(Parcell, Franken, Cox, Patterson, & Randle, 2010), and the continuous learning leads to the fade away of choice complicity so that it reduce the disparity (Brouwer et al., 2017). It is reasonable to draw that the choice complicity will fade away with the increasing of learning, but hypothesis for the conclusion of reducing the disparity is still contingent on the zero-learning cost.

The quota imposed by the government exerts tremendous effect on the choice of NEVs, with

different cost and possibility referring to diversified choices, such as lottery, bidding, etc. initially, the participants only have a subjective perception about the effect of quota, but over the process of purchasing vehicles in the quota mechanism, the participation can be regarded as the learning opportunity once a month. But in the previous theoretical framework, after the learning opportunity, the delayed purchasing is the decision made by themselves, namely, to a larger extent, consumers can control the result by themselves, but in this research and empirical data collection, after the effect of learning, the result is determined by the all participants in the market, instead of the participant himself/herself. Which is an extension for the commitment cost with the hypothesis that the delayed purchase is zero cost.

There is a debate regarding times participation of lottery and bidding in the quota as a variable to describe the reversibility, but actually, the reversibility refers to individuals who have already owned the property right of the product, then it is possible for them to return product. While in the times of bidding or lottery, participants haven't owed the property that they want, accordingly, next round of participation cannot be regarded as a time of reversibility, it could be only regarded as times of learning opportunity with a real understanding of the quota, and more importantly, it demonstrates the existing of cost for the learning opportunity, instead of zero cost in the theory of commitment cost. Furthermore, the goods used in experiments are not urgently used by the participants, comparing to the real market, the consumers are seeking actively to purchase the good that they want.

Therefore, concerning the empirical studies, the empirical test cannot support the hypothesis that the higher uncertainty of utilization, the higher disparity between the WTP/AP. Actually, with the increase of knowing the charging station, it indicates a higher certainty of utilization, instead of uncertainty, with a higher possibility to change the decision individual has made. Besides, for the second sub-hypothesis, the empirical test supports that it has a higher disparity between WTP/AP with a higher learning opportunity embedded with a learning cost.

6.1.5 Discussion

Based on the previous three research hypotheses, initially, it studies the mechanism of WTP, then it focuses on the disparity between the WTP and AP on the adoption of NEVs, meanwhile, the mechanism behind the disparity. Generally, it is a scenario of uncertainty with multi-choices under different constrains, while consumers' behaviors are similar to a discrete choice model based on a comprehensive evaluation of attributes, including the refueling infrastructure, policy incentives, and regulation and socio-economics demographics, in terms of a set of choices, namely, alternatives. The discrete choice model has been applied to simulate the scenarios and willingness on the adoption of NEVs, as a problem, instead of the real behaviors due to the tremendous gap between the willingness and real behaviors. However, the data for the consumers' preference in the previous literatures only presents the WTP for one of the multiple alternatives under the discrete choices model, as the fact that there is a giant gap between the WTP and the actual payment in the market. Therefore, the discussion focuses on how the WTP works in the method of discrete choice.

So how do people make a decision among multi-attribute alternatives when no alternative dominates? Therefore, the discrete choice model is proposed, and the key problems are to measure the different weights and values assigned to the attributes. The procedures, including the generation of choice option, identification of attributes, assignment of attributes levels and construction of choice combination set(Hensher, Rose, & Greene, 2005), used to measure attributes of the alternatives, assessing the stated preferences and trade-offs toward the

choice decision between new energy and conventional vehicles. Accordingly, the method of discrete choice experiment is used to select a reduced sample of choices, namely, a “fractional factorial” design, rather than the “full factorial” choices for the respondents.

However, it is highly contingent on the context factors. For the decision-making, individual intends to maximize its expected utility, while the preference reversal phenomenon also exists under the uncertainty as for the preference to a higher probability of winning. Specifically, for empirical discrete choice model on the adoption of NEVs, primarily, it concentrates on the coordination among transportation ways, parking fee, time on the way, gender, distance, holiday, personality, purpose, alternative transportations(Eppstein, Grover, & Marshall, 2011). For example, the experience from Austria(Bahamonde-Birke & Hanappi, 2016) indicates that the green-minded individuals are more easily accept the NEVs, while, the policies incentives, such as the one-year-ticket of parking, could not increase the willingness, but the reliability and the availability of charging stations are much more important for the consumers instead of the engine. Obviously, individuals with high environmental-conscious have higher willingness to pay more for low-emission vehicles(Daziano & Bolduc, 2011) based on the hybrid choice model, improved batteries with longer driving range would significant increase the willingness of electric vehicles in California(Daziano, 2013); For the government role in the promotion of NEVs, a comprehensive strategies , such as the market and demonstration support, R&D for a long-term perspective, were employed by the Japanese government(Åhman, 2006). In USA for the registration of hybrid-electric vehicles, there is a strong relationship between the hybrid adoption and the price of gasoline, but the relationship between the government’s incentive policies and adoption is much weaker than expected, notwithstanding the payments upfront appears to have enough incentive to the individuals’ adoption(Diamond, 2009), meanwhile, the individuals with higher technology enthusiasts, capability to sort out the different performances between NEVs and conventional vehicles, appear to be the early adopters(Egbue & Long, 2012). Furthermore, the providing of expected fuel cost for different kinds of NEVs and increase of gasoline price could enhance the market penetration(Åhman, 2006); Based on the discrete choice experiment, the driving range, charging time and fuel cost savings are most important(Hidrue, Parsons, Kempton, & Gardner, 2011), simultaneously, which also suggest that the mass market should be contingent on the dramatic decrease of battery cost without subsidy.

While in term of the methodology in the literature, the popular one is the discrete choice experiment. The choice-based approach is more realistically as a true buying scenario, in which you only choose one product rather than rank several(Huber et al., 1992). For the adoption of NEVs, relieves of tax, reduction of monetary cost and the low emission rate would be regarded as an incentive for the adoption, while, the policies, such as free parking, and the driving permission to public bus lanes, etc., are not significant (Potoglou & Kanaroglou, 2007). Comparing with the citizens in USA and Japan, it finds that the consumes in USA are more sensitive to the fuel cost, and the increased subsidies for purchase price have a significant effect on the adoption of alternative fuel vehicles (Tanaka, Ida, Murakami, & Friedman, 2014). Basically, the previous study of NEVs’ adoption, deploys the discrete choice model to simulate the practical scenario, which is contingent on McFadden’s utility theory, indicating each individual faces a finite options and prefer to the alternative that maximizes its utility(Zhu, 2013). It finds that the WTP is much lower than the average price premium of alternative fuel vehicles(Liu, 2014).

Accordingly, the discrete choice model is another hypothetical version of willingness to pay,

and the only difference is that combinations of alternatives have been provided to the participants. Several attributes are included in the choice model, and presented to individuals to make a choice among different combination of choice set. But how does the individual perceive the diversified choice sets of attributes combination? Is it the same information processing as we expected before the design? The research indicates that ignoring certain attributes exists to tackle the perceived complexity of choice experiment(Hensher, Rose, & Greene, 2005). Meanwhile, the increase of complexity will compromise the consistency of choices set. More importantly, there is a tradeoff between the statistical and cognitive efficiency in the design of discrete choice experiment(Johnson, 2006). Besides, it is a huge challenge to construct an experiment with an absence of substitution among diversified attributes. And the range in each attribute has a strong effect in the result, and the attribute level is unbalanced in the practical experiment, which give rise to the collinearity and loss of orthogonality. Practically, in the experiment, individuals will prefer to large sums of amount to avoid the non-price attributes(Hensher, Greene, & Rose, 2006). Accordingly, with the consideration and focus on the disparity between WTP and AP, and the demerits in the discrete choices model, it is not an ideal methodology.

6.1.6 Conclusion

Concerning the previous researches on the WTP over 40 years, initially, the concept of WTP is deployed as a framework in numerous fields, gradually, there is a debate on the validity of WTP and another concept of WTA was introduced to study the validity and reliability, then there is a theoretical framework of commitment cost to study the disparity. But there are still lots of problems, firstly, the product or service chosen in its study, a private or public good, to a larger extent, the attributes of the studied and chosen product will reversely affect consumers' behaviors, even in the laboratory experiment, the chosen product will affect the validity. Secondly, the WTA is introduced to study the validity and disparity, but it is still another hypothetical version of accepting payment, instead of the actual payment. Thirdly, the theoretical framework of commitment cost to study the disparity and consistence in the laboratory experiment, but demerits are still there, as the fact that there is no cognitive effort on the studied chosen product in the decision making, and there are three elements in the theory, such as uncertainty, it only refers to the uncertainty of monetary value, neglecting the utilization uncertainty, this problem also stems from the chosen product. Meanwhile, the zero-learning cost is embedded in the hypothesis. Accordingly, the hypothesis in this research is conducted from these three perspectives, including a public or private good, different effect mechanism on WTP/AP, and the disparity between WTP/AP.

For the first hypothesis, there is a difference between the public and private goods in the estimation variation of WTP, and the private good's variation is smaller than a public good. Additionally, it is also applied to hypothesis that variation in experiment group is higher than the controlled group. After the meta-analysis, it cannot draw the conclusion that the private good' variation is smaller than a public good due to the ambiguous clarification of public or private good in the literatures and the diversified data collection models, therefore, it need further work on the building of strict comparison groups between the public and private good. But for the second part of this hypothesis, it is consistent with the hypothesis that the coefficient variation in the experiment group is higher than the counterpart in the controlled group.

The second hypothesis, the function mechanisms between WTP and AP are different. It not

only focuses on the effect mechanism of WTP based on the previous literature review, but also compares the effect mechanism and difference with the behaviors of actual payment for the NEVs, in a nutshell, is the conclusion on the WTP also applicable to the AP? More specifically, the conclusions for the second hypothesis consists of three sub-ones.

The first sub-hypothesis in the second one, the higher green perception of the new energy vehicles, the higher WTP, but this positive relationship for WTP is not applicable to the actual payment. Which focuses on the effect of perception on the WTP and AP. And there are two variables deployed to represent the perception, namely, the cost-effectiveness indicates the NEVs save money as whole comparing to the conventional one, and the reduction emission, accordingly, it is a combination of both economic-cost and environmental perspectives. From the empirical testing, it supports that the higher green perception of the NEVs, the higher WTP, but this positive relationship for WTP is not applicable to the AP, which indicates the different effect mechanism between the WTP and AP in terms of perception, and there is a phenomenon of the trap of subjective willingness. Besides, it found that the income is a necessary but insufficient condition for the adoption of NEVs.

The second sub-hypothesis, contingent on the empirical test, it supports the hypothesis that in the controlled samples without the quota, the living years and registered resident do not have effect on individuals WTP for NEVs; But samples in the experiment group imposed the quota, it cannot support that the longer of living years and registered resident, the higher WTP for the NEVs, however, for the AP in the experiment group, the registered residence is associated with a higher possibility of owning NEVs. Meanwhile, it also cannot support the hypothesis that the higher performance requirement on the NEVs is associated with a lower WTP, and a higher willingness to pay the external fee, such as the license of premium, is related to a higher WTP. Therefore, in terms of past experience, this is the different effect mechanisms between WTP and AP.

The third sub-hypothesis, it supports the hypothesis the higher certainty of the charging location, the higher WTP, this is applicable to both WTP and AP. But for the distance away from the working or living places, it cannot draw a sole conclusion that the lower distance away from where individuals work or live, the higher WTP, but for the distance away from the living place in the experiment group of WTP and controlled group of AP, with the increase of distance, there is a negative association with the WTP and AP at the significance level of 10% and 5% respectively.

The third hypothesis, contingent on the theory framework of commitment cost for the disparity of WTP/AP, the first sub-hypothesis, the higher uncertainty of utilization, the higher disparity between the WTP/AP. But the empirical test cannot support it, when the focus of uncertainty moves from the monetary value to the utilization, it cannot reach the same conclusion. It extends the previous scope and conclusion of commitment cost, due to the utilization is strongly connected with the product or service chosen in its study and laboratory experiment, which is also demonstrated the importance and necessity of category of product raised in the first hypothesis, public or private good. For the second sub-hypothesis, the more learning opportunity with a delayed cost, the higher disparity between the WTP/AP. And the empirical test supports the hypothesis, importantly, it extends and breaks the previous precondition of zero learning cost, an extension with a learning cost embedded in behaviors.

6.2 Quota

6.2.1 Variables Description

This part primarily focuses on the effect of multi-exclusive quotas and the corresponding externalities of the spill-over and discard, namely, whether the adoption of NEVs is forced or not, and the possible side effect caused by the quota. And the data of both micro-macro perspectives will be deployed in the empirical study.

Table 58 Description of variables on the quota

Types	Variable	Definition
Deped.	spillover_plan	Plan to purchase vehicles and register in other cities for the individuals who do not own vehicles
	spillover_own	Have already purchased vehicles and registered in other cities
	catog_ownnev	Dummy variable, the kind of vehicles you own, where 1 indicates as NEVs and o represents conventional ones.
	biddiscard	Number of discards for the bidding of conventional vehicles monthly in the multi-exclusive quota.
Indep.	bidprice	average bidding price for conventional vehicles monthly in the multi-exclusive quota
	lotteryno	Number of applicators for conventional vehicles monthly in the multi-exclusive quota
	nevno	Number of applicators for NEVs monthly in the multi-exclusive quota
	lottery_conv	Interaction term, dummy variable whether apply to the quota time the numbers of application of lottery for the conventional vehicles.
	bidding_conv	Interaction term, dummy variable whether apply to the quota time the numbers of application of bidding for the conventional vehicles.
	lottery_ nev	Interaction term, dummy variable whether apply to the quota time the numbers of application of lottery for both pure electric and hybrid vehicles.
	inter_lc_ln	Interaction term between times of participation in the lottery of conventional vehicles and lottery of NEVs.
	inter_lc_bc	Interaction term between times of participation in the lottery of conventional vehicles and bidding of conventional vehicles.
	inter_ln_bc	Interaction term between times of participation in the lottery of NEVs and bidding of conventional vehicles.
	inter_ln_bc_lc	Interaction term among times of participation in the lottery of NEVs, lottery of conventional vehicles and bidding of conventional vehicles.

NOTE: Where the four variables descripting the macro-perspective, when there is a f added in the end of each variable, bidpricef, lotterynof, nevnof, biddiscardf, which refers to the firm's behaviors in the multi-quotas system.

6.2.2 Empirical Results for Hypothesis 4

Hypothesis 4 Individuals are forced to green in the adoption of NEVs under the multi-exclusive-quotas with fixed TAC and non-transferable market.

For this part of hypothesis, it is based on the extension of existing theory, to compare the condition of uncertainty TAC vs certainty TAC, transferable quota vs non-transferable quota, multi- inclusive-quotas vs multi- exclusive-quotas. It primarily plans to answer the question whether the adoption of NEVs is forced or not in the multi-exclusive quotas with a fixed TAC and non-transferable quota market. Besides, it will deploy two perspectives, micro and macro-ones, where the micro perspective deploys the variables of times joining in the system of multi-exclusive quota, while the macro perspective will depend on the whole operation condition, such as the amount of application in lottery of conventional vehicles, NEVs, the bidding price, etc. therefore, the sub-hypothesis is also contingent on the two-perspectives.

1)**Hypothesis 4.1** it is forced to green in the adoption of NEVs in the model of multi-exclusive-quotas, the more times participating in the lottery of conventional vehicles, the higher possibility of purchasing NEVs.

The sample in this part to test the hypothesis that whether the adoption of NEVs is forced or with a willingness, will subject to individuals who have purchased vehicles after the implementation of quota. And in term of micro-perspective in the multi-exclusive quotas, individual who joined the quota and got a license finally have made different choices over this period. In order to study whether the adoption of NEVs is forced or not, the decision sequence is important. If this hypothesis of forced adoption is true, then it means that individual has tried different choices before it had made a final decision on the adoption of NEVs. Accordingly, in the empirical study, the independent variables are not only about the separated times participating in the multi-exclusive quotas, more importantly, the interaction term with each other.

Table 59 Effect of multiple exclusive quotas on the adoption of NEVs

catog_ownnev	1	2	3	4	5
lottery_conv	0.029				
	(1.75)				
bidding_conv	0.021				
	(0.07)				
lottery_nev	0.602				
	(3.41)**				
inter_lc_ln		0.177			
		(2.84)**			
inter_lc_bc			0.097		
			(0.72)		
inter_ln_bc				0.328	
				(1.16)	
inter_ln_bc_lc					0.102
					(0.59)
_cons	0.038	0.264	0.564	0.572	0.563
	(0.18)	(1.83)	(4.54)**	(4.56)**	(4.53)**
N	122	122	123	122	122

NOTE: This table presents the effect of multiple exclusive quotas on the adoption of NEVs, the dependent variable is a dummy one where 1 refers to the NEVs, and 0 refers to conventional ones. The former three variables represent application times in the lottery of conventional vehicles, bidding of conventional vehicles, and lottery of NEVs. Meanwhile, the latter four variables represent the interaction term among each other, where lc represent the lottery of conventional one, ln represents the lottery of NEVs, and bc refers to the bidding of conventional ones. * p<0.05; ** p<0.01.

Separately, application times in the lottery of NEVs and lottery of conventional ones are statistically significant at the p value of 1% and 10% respectively, indicating that the more times it participates in the lottery of conventional ones, the higher possibility it chooses to purchase the NEVs. But in term of data analysis and based on this result, it cannot support individuals are forced to choose NEVs.

Why the interaction term is necessary? Because these variables, application times in the lottery or bidding for NEVs or conventional ones are separately with each other. While for an individual's decision making, it will choose different categories quota over time. For example, an individual participates the lottery of conventional vehicles for 8 times, but lastly, it chooses

the category of NEVs in the setting of multi-exclusive-quotas. Besides, in order to test whether the adoption process of NEVs is forced or not, the sequence of decision making is important. Forced by quota means that the initial target is not NEVs, but finally individual chooses the category of NEVs. Furthermore, the lottery probability of NEVs is 100%, it means individual will get a NEVs license undoubtedly. Additionally, according to the license quota mechanism, it cannot further join the lottery of conventional vehicles when individual get a NEVs license, therefore, it is the last time to apply the lottery of NEVs among multi-applications for individuals who lastly purchase NEVs. Accordingly, from the result in the above table, the interaction term between the lottery of conventional ones and lottery of NEVs is statistically significant at the level of 1%, it demonstrates that an individual chooses to purchase NEVs lastly, but before it, it has tried times of lottery for the conventional vehicles. Which supports the hypothesis that the adoption of NEVs is forced by the impose of multi-exclusive-quotas, although there are freedoms for individuals among the multi-exclusive-quotas.

Previously, the gender quota exerts an influence in the diffusion(Caul, 2001) and a diffusion of candidate gender quota with the emerging notion of equality and representation(Krook, 2006), an informality advantage for women in the gender representation in the electoral system(Piscopo, 2016), which supports the quota effect, but it is contingent on a single quota mechanism, instead of a multi-quotas providing a choice for the participants. While for the multi-inclusive quotas in the fishing management, it has a challenge on the enforcement, therefore, a mechanism of multi-quotas converts into a single-species quota is regarded as a good alternative(Ulrich et al., 2002). it demonstrates that it has achieved the ecological and economic goal simultaneously(Péreau et al., 2012), but with a uncertainty TAC and a dynamic fish stock.

Which is consistent with the conclusion in Hypothesis 3.2, indicating that the more learning opportunities with a delayed cost, the higher disparity between the WTP/AP, indicating individual has changed its initial choice, namely, the discrepancy between WTP/AP, to another perspective, it has been forced to change its initial preference in the learning process of multi-exclusive-quotas.

2)Hypothesis 4.2 In term of macro-perspective in multi-exclusive quotas, the higher cost and smaller probability of one sub-quota, the higher rate of adoption for another sub-quota. Namely, the adoption of NEVs, is positively associated with a higher bidding price and lower lottery winning rate.

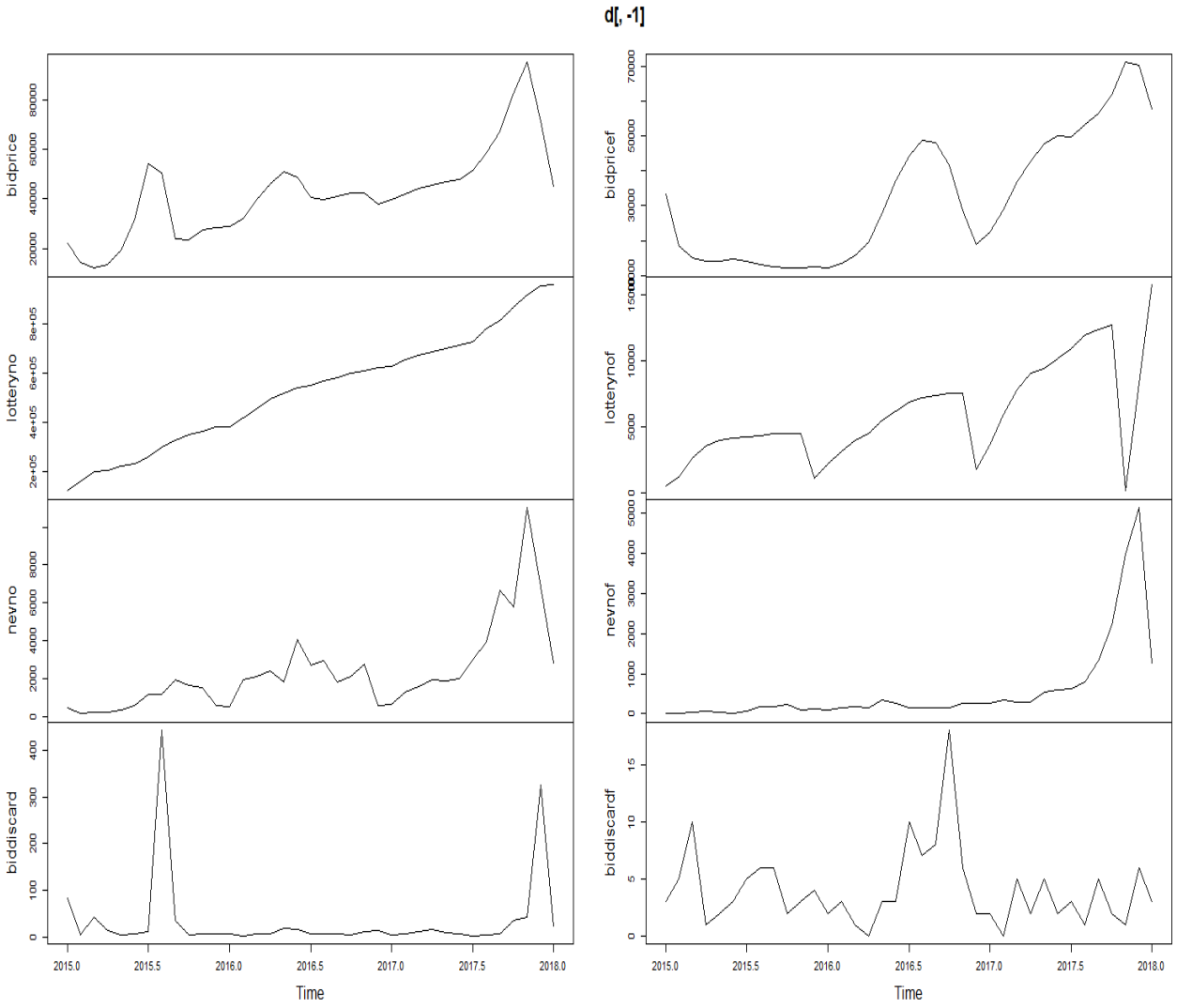
From a macro-perspective, for all individuals who joined in the multi-exclusive quotas, what are the relationships among different sub-quotas in the multi-exclusive quotas? There are two separated license groups, individuals and firms. To a larger extent, they have the same mechanism, except for the different amount of TAC, and individual can only choose one sub-quotas monthly, while for firms, it could have a combination among multiple quotas when it has several license credits according to the tax scale in Shenzhen. For example, a firm has 6 granted licenses, the firm can choose 3 granted licenses for lottery conventional ones, 2 granted license for bidding and 1 for NEVs simultaneously, therefore, for the firm's choice, it is not a multi-exclusive quota, which could be regarded as a multi-inclusive quota and allocate the granted license among different quota categories. But it is different to the inclusive in the fishing industry, where it means one fish quota can be exchanged and equivalent to another one. Generally, it can also be regarded as multi-exclusive and multi-inclusive for individuals and firms respectively.

Table 60 Description analysis about the different variable in the multi-exclusive quotas

	Variable	Obs	Mean	Std. Dev.	Min	Max
individuals	bidprice	45	45601	18277	12091	95103
	lotteryno	45	623973	298698	122574	1126789
	nevno	45	3079	2672	164	11033
	biddiscard	45	32	79	2	443
firms	bidpricef	45	35563	20244	12101	76075
	lotterynof	45	8996	7435.15	130	25078
	nevnof	45	1175	1924.171	5	9200
	biddiscardf	45	4	3.25716	0	18

The month TAC for the conventional vehicles of both lottery and bidding are constant, therefore, the fixed variables are not presented in the above table of description analysis and the next figure of the time series chart. and the ceiling for the NEVs has been deleted.

Figure 32 Distribution of different variables in the multi-exclusive quotas over Feb. 2015 to Oct. 2018



NOTE: The amount of TAC monthly is not presented here, due to a constant variable over time, which supports part of the condition in the research setting as multi-exclusive quotas but with a constant TAC and non-

transferable market. In the left of the above figure is the individuals' distribution in the multi-exclusive quotas. And in the right of the above figure is the firms' distribution, but it is only regarded as multi-inclusive quotas, instead of multi-exclusive due to the firm can choose multiple sub-quotas simultaneously when it has several license credits. Besides, it is a time series dataset, there would be an autocorrelation within one variable, but it is only four years, so in the empirical study, it will be regarded as panel data. And it is plotted by the software of R.

The above figure indicates the trend of different sub-quotas for both individuals and firms. In the group of individuals, the number of applicators in the lottery of conventional vehicles grows constantly and steadily. While for the trend of bidding price, it has an increasing trend generally. More specific trends are demonstrated in the above figure. However, the purpose of previous mechanism design is contingent on the revenue-maximizing, but to a large extent, the target of Shenzhen's quota policy doesn't rest on the profit-orient, conversely, the indirect incentive for the adoption of NEVs as the increasing potential cost for the traditional ones, more important, the authority (seller) promulgates coordinated measures to prevent the skyrocketing and enormous fluctuation, for example, the release of average price at 11am and 1pm on the bidding day, the offer should not exceed 2 time of the average price of the previous month.

Furthermore, the next part will elaborate the relationship among different variables in the multi-exclusive quotas for the individuals and multi-inclusive quotas for the firms.

In the multi-exclusive quotas, and the dependent variable is the application number of NEVs, namely, nevno. Meanwhile, concerning the independent variables in the multi-quotas, due to the constant and fixed amount of the total allowable catch (TAC), namely, the available amount of license in each quota category is constant, except for the NEVs (there is no ceiling in the application of NEVs), the price in the bidding(bidprice) and the application number of individuals in the lottery (lotteryno) are better represented the other two sub-quotas.

Table 61 Results of the NEVs adoption among multi-exclusive quotas in the macro-perspective

nevno		nevnof	
bidprice	0.076	bidpricef	0.009
	(4.35)**		(0.69)
lotteryno	0.004	lotterynof	0.164
	(3.40)**		(4.71)**
_cons	-2,691.648	_cons	-612.603
	(5.24)**		(1.40)
R2	0.79	R2	0.47
N	45	N	45

NOTE: This table presents the relationship among sub-quotas in the system of multi-exclusive quotas, and the dependent variable is the application number of NEVs as the research target, the right column presents the results of firms' behavior. However, the license quota for the firms is a separated system, it is similar to individuals one, but it cannot be named as multi-exclusive quotas, as the fact that a firm could have different granted number of the license according to the firm scale. * p<0.05; ** p<0.01.

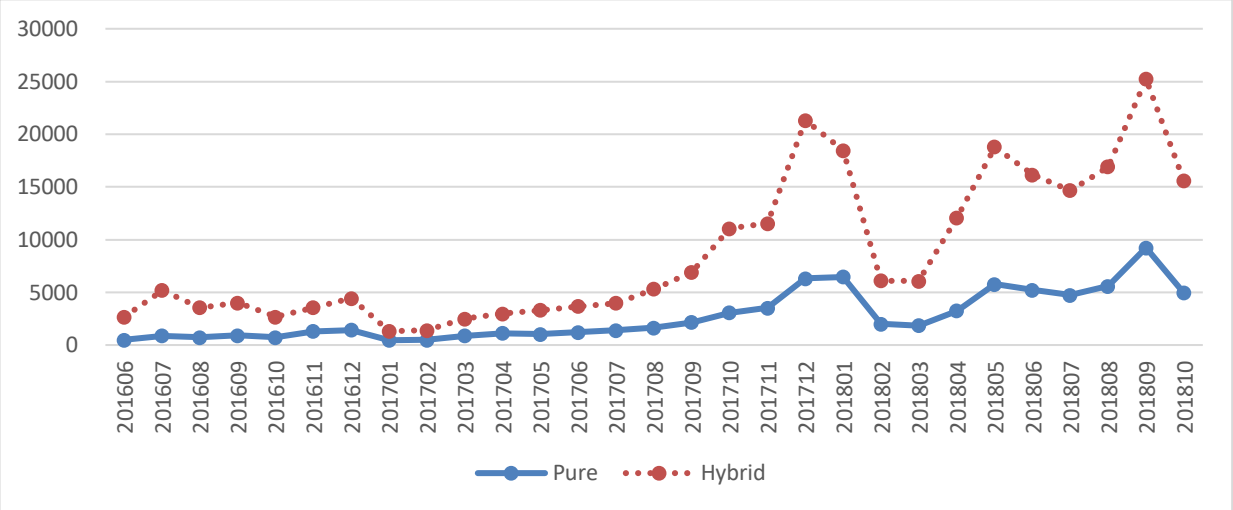
From the above result, it indicates that the variables of other sub-quotas, the bidding price and number of application, are both positive related with the adoption of NEVs in the multi-exclusive quotas in term of the macro-perspective, namely, the higher bidding price and more lottery applicators, the higher adoption of NEVs, due to the exclusive relationship among different sub-quotas and the fixed amount of available TAC monthly in the lottery and bidding of conventional vehicles, but an un-ceiling amount for NEVs, accordingly, the increase of NEVs is forced by the higher bidding price and lower lottery probability of conventional ones . Which is also consistent with the expectation and the result in last sub-hypothesis deploying the times

participating in multi-exclusive quotas in term of the micro-perspective.

However, in the separated firm's multi-inclusive quota, only the number of applications in the lottery is statistically significant at the level of 1%, and the bidding price is not associated with the adoption of NEVs.

Integrating the study of micro-macro perspective, we can draw the conclusion the adoption of NEVs is forced by the design of multi-exclusive quotas. Therefore, regarding individuals, particularly, the hybrid vehicle is regarded as a good remedy to offset the effect of multi-exclusive quotas, due to the free and 100% probability of getting a license in the quota, besides, to avoid the present potential constrains and demerits of pure electric vehicles, such as limited driving range. Which can be confirmed in the below figure that the amount of hybrid vehicles is always higher than pure electrics, sometimes is more than 2 times.

Figure 33 Pure electric and hybrid vehicles in Shenzhen quota system monthly



Note: there is no classification between pure and hybrid vehicles over Feb. 2015 to May 2016, so it is not presented here. Meanwhile, the number is the total application amount of both individuals and firms.

Accordingly, the increase in the NEVs, the majority belongs to the hybrid vehicles, but what could be the real utilization scenario? Is there a concern that owners of hybrid vehicle primarily use the conventional fuel with a higher emission? The next table presents the comparison of charging proportion for hybrid vehicles between samples of Shenzhen and other cities.

Table 62 Proportion of charging in the total mileage of driving for the hybrid vehicles

	Shenzhen			other cities		
percentage	Freq.	Percent	Cum.	Freq.	Percent	Cum.
less than20%	13	10.83	10.83	13	10.66	10.66
21%-40%	34	28.33	39.17	61	50.00	60.66
41%-60%	37	30.83	70	39	31.97	92.62
61%-80%	20	16.67	86.67	7	5.74	98.36
81%-100%	16	13.33	100	2	1.64	100.00
Total	120	100		122	100.00	

Although the adoption of NEVs is forced, however, from the implication of above table, the percentage of charging in the total mileage in the sample of Shenzhen is much better than the other cities. For example, in Shenzhen, the experiment sample, the charging proportion of more than 60% in the mileage driving amounts to 30%, while in other cities, the proportion is only 7.4%. The reason contributing to this different gap would be the accessibility of charging

facility, which would be demonstrated by the description analysis of distance from the work and live places in last chapter, the distance away from the working and living places in Shenzhen is smaller than it in other cities. Accordingly, due to the existence of multi-exclusive quotas, individuals are forced to adopt the NEVs, and particularly, the hybrid vehicles are regarded as a remedy to offset the effect. But importantly, it is on a trajectory of virtuous cycle, with the forced increase volume of NEVs, there is an incentive for the construction of charging facility, while the improvement of charging facility, which will also ease the important hindrance of NEVs.

6.2.3 Empirical Results for Hypothesis 5

In this hypothesis, it primarily focuses on the two externalities, spillover effect and discards, elaborating whether it happens and what attributes contributes to it in the multi-exclusive quotas.

1)Hypothesis 5.1 there are spillover effect in the multi-exclusive quotas. Individuals will choose to purchase a vehicle outside the domain of imposed quota scope, this could be opposite with the initial target of reducing the volume of conventional vehicles and increasing the volume of NEVs.

For this hypothesis, it primarily focuses on the spillover effect caused by the quota, generally, which is opposite to initial targets and counteract the positive effect. For example, individuals will plan to purchase vehicles in other cities that is not subject to the limitation of quota, but it increases the traffic volume and congestion in Shenzhen. To test this hypothesis in the empirical study, it deploys the data collected in the survey. Meanwhile, it will divide into two groups, the spillover effect for the group of planning purchase and having purchased.

Table 63 Distribution of spillover effect caused by the quota

Dummy	Shenzhen	spillover_plan		spillover_own		spillover_own after the quota	
		Freq.	Percent	Freq.	Percent	Freq.	Percent
0	yes	240	91.60	256	83.66	179	88.61
1	no	22	8.40	50	16.34	23	11.39
	Total	262	100.00	306	100.00	202	100.00

NOTE: Where the spillover_plan refers to the group of individuals who do not own a car, and spillover_own refers to the group of individuals who have already owned a car, besides, the difference between the spillover_own and spillover_own after the quota, the latter group indicates individuals who purchase vehicles after the implementation of quota, which is a better group to study the spillover effect.

From the description analysis, 8.4% of individuals who do not own a car plan to register in other cities, while for the actual register in other cities after the implementation of quota, it is higher than the former one amounting to 11.39%, which is even under the precondition of limitation policy to avoid the potential spillover, such as the driving prohibition for non-Shenzhen license over the rush hours. Accordingly, there is a spillover effect due to the imposed multi-exclusive quotas for both individuals of planning purchase and having already purchased. This negative spillover effect, is opposite to the conclusion that within a quota constrained import category, it increases the imported quality(Aw & Roberts, 1986), but similar to an oligopsony market power for the importing firms(McCorriston, 1996). Additionally, it is also consistent with the distortion effects in the trade allocation(Bogetoft, 2003) and emission tax(Yanase, 2007), meanwhile, a price discrimination in the Singapore community caused by the ethnic quota(Wong, 2014). But the condition is a multi-exclusive quota with a fixed TAC and non-

transferable market. When there is an increase of the aggregate TAC, it will lower the production as it will lower the marginal price (Sumner & Wolf, 1996), and a higher initial TAC is positive associated with a larger vessel investment(Tanaka, Higashida, & Managi, 2014), when the TAC is a fixed variables, then it can be regarded as an exogenous variable and does not take into consideration in the function. But in term of individual's attributes, how do these elements affect the spillover effect?

Table 64 Elements affect the spillover effect under the condition of quota

	spillover_plan			spillover_own		
male	-0.084			0.021		
	(0.35)			(0.07)		
age	0.037			-0.023		
	(1.87)			(1.03)		
income	-0.046			-0.088		
	(0.99)			(1.35)		
residence		-0.391			-1.306	
		(1.57)			(4.55)**	
livingyear			-0.029			-0.033
			(1.53)			(1.86)
_cons	-2.269	-1.254	-1.206	-0.124	-0.665	-0.944
	(3.55)**	(9.47)**	(8.00)**	(0.17)	(4.35)**	(5.41)**
N	262	262	262	202	202	202

NOTE: Where the dependent variables are the spillover_plan and spillver_own, indicating the group of individuals who do not own a car but plan to purchase and group of individuals who have already owned a car. Meanwhile, these are dummy variables that 1 means register the car in other cities, namely, there is a spillover effect, and 0 refers to no spillover effect and register it in Shenzhen. Furthermore, the group of owning a car only refers to individuals who have purchased a car after the implementation of quota in the year of 2015, instead of all individuals who owned a car, which is better to study the quota effect.

Implications from these results, for individuals who do not own a car but plan to purchase it, there is no variable with a significant statistical test, but there is only the variable of age indicating that the higher age is associated with a higher percentage at the level of 10%. However, after the implementation of the quota, obviously, individuals whose residence are in Shenzhen, are less likely to purchase a car in other cities at the significant level of 1%, and which is reasonable for the individual who lives longer in Shenzhen, less possible to register a car in other cities due to the impose of quota, but it is only at the level of 10%.

Table 65 Effect of driving prohibition for non-Shenzhen license over the rush hours

	Freq.	Percent	Cum.
no effect	16	32.00	32.00
affect	34	68.00	100.00
Total	50	100.00	

NOTE: This group of individuals consist of ones who have owned vehicles but not register in Shenzhen, so there is a driving limitation in the rush-hour for these groups of individuals, with the target of avoiding the spillover effect that all individuals would purchase and register in other cities due to the impose of license plate quota.

Due to the existing of spillover, there is a corresponding supporting policy of a driving limitation for the vehicles registered in other cites over the rush hours of 7:00-9:00 in the morning and 5:00-7:00 in the afternoon on the workday, but this limitation has been implemented from the

starting of the quota, therefore, this spillover effect still happens notwithstanding the precautionary measures have been imposed.

2)Hypothesis 5.2 The higher cost of the bidding, the higher rate of discards, the lower the lottery rate of winning a license plate, the lower rate of discards in the multi-exclusive quotas.

From the macro-perspective of multi-exclusive quotas, discards only appear on the sub-quota of bidding, rather than the sub-quotas of lottery for conventional vehicles and NEVs. Which is reasonable due to the much smaller probability of winning a license in the sub-quota of lottery for conventional vehicles, and finally forced of adoption of NEVs after several tries of other sub-quotas, individuals will not discard in these two sub-quotas. Which is consistent with the discards in the fishing management(Turner, 1997), the discarding is profit maximizing and cost minimizing for the firm(Hatcher, 2014). But the fishing management, although there is an enforcement for the compliance, it is much more difficult to control the compliance in the multi-inclusive quotas. But the multi-exclusive quota for the plate license, there is a total transparent management process, which is much easier to monitor the compliance.

But what is more important? It is the mutual relationship between the compliance and discards, on the theory of ITQ in the application of fishing management, it is regarded as a multi-inclusive quota, due to the dynamic TAC and challenge of tracking, which exerts tremendous challenge on the enforcement of compliance, which affects the variable of discards. But when it is a multi-exclusive quota, and integrating with a transparent information tracking system in Shenzhen license quota, it has a feature of perfect information. The applicator can make their own decision, comparably, to a larger extent, the supply of TAC monthly is fixed under the control of transportation authority, although there would be a slight change as the amount of previous month pass on the next month. Generally, the number of bidders is uncertain. Therefore, under this multi-exclusive quota, the applicators are competed with each other among different solutions maximizing their expected and self-perceived utility, and the discard is a second-choice contingent on the one of multiple sub-quotas individuals have made.

Table 66 Discards in the multi-exclusive quotas

biddiscard		biddiscardf	
bidprice	0.003	bidpricef	0.000
	(2.44)*		(0.54)
lotteryno	-0.000	lotterynof	0.000
	(2.08)*		(0.06)
_cons	-1.469	_cons	3.454
	(0.05)		(3.40)**
R2	0.13	R2	0.01
N	45	N	45

This above table presents the result of discards in the multi-exclusive quotas, for the individuals' groups, both the other two sub-quotas are statistically significant, where the higher bidding price is associated with a higher rate of discards, inversely, the bigger number of applicants for the lottery of conventional vehicles, the less the discards. However, in the group of firms, no variables pass the hypothesis test. Previously, the multi-inclusive quotas in the theory of ITQ for the application of fishing management, a discard always happens due to the incentive to maximize its profit and minimize its cost under the TAC constrain of quotas(Turner, 1997), it will even worsen due to the challenge in the enforcement of compliance, this is why the full compliance coverage and mortality accounting would reduce the discard(Branch et al., 2006).

But in my samples, it can be regarded as a full compliance as the fact that all the processes, including the application, bidding or lottery, vehicle registration after winning a license in the quota, are all transparent and can be tracked.

The increasing amount of quota decreases the discard simply(Macdonald et al., 2014), and quota price is affected by the introduction of penalty, while the discard is independent to the introduction of discard ban. However, it is under a scenario of dynamic TAC. when it is a foxed TAC and non-transferable market, these are exogenous variables, therefore, the only attributes affecting the rate of discards is the interaction among different sub-quotas in the multi-exclusive mechanism. There is a substitution among the sub-quotas in the multi-inclusive quotas, but there is a challenge to set the exchange rate, and the impropriate exchange rate will lead to the discard.

6.2.4 Discussion

This part, primarily focuses on the treatment effect of multi-exclusive quotas on the individuals' behaviors, and the methodology in the empirical study deploys the times participating in different sub-quotas for the micro-perspective and bidding price and applicator numbers in the macro-perspective. In my fieldwork of survey, there are treatment group and non-treatment group contingent on whether the treatment of quota imposed in the sample, however, why is the methodology of treatment effect not deployed in this part of empirical study? The simple answer for this discussion is the problem of sample in the two groups. Theoretically, the requirements for this methodology, indicate that the sample in the two groups should be randomized with only a difference of whether treatment imposed or not(McFadden, 1984). However, in my samples of the two groups (Shenzhen and other cities), the explanatory variables, including the education, income, work experience, environmental awareness, age, past experience, structural of household members, etc., could be regarded as two layers of samples due to the different economic backgrounds, instead of randomized. Additionally, the propensity-score matching is deployed to study the treatment effect. The treatment effect is computed by taking the average of the difference between the observed and potential outcomes for each subject, but based on the similarity samples in terms of independent variables in the treatment group and non-treatment group. For example, if the independent variables include income, education and gender in the propensity matching score, and dependent variable is a dummy variable that it whether adopts NEVs or not, the treatment effect will compare the dependent variable between the treatment and non-treatment groups by soliciting the samples with the same value in terms of the three independent variables, apparently, it has a same income in the propensity matching between the two groups, such as 8000RMB/month, but which has a big different economic implication to individuals in the two samples of groups. Accordingly, the groups can be regarded as two layers of samples, instead of a randomized one when the two groups combine together.

The methodology of treatment effect is to evaluate the causal effect of a treatment on the outcome, here the implication of variables, y_1 indicates the outcome under the treatment, y_0 represents the outcome without treatment, d indicates the treatment itself, including the value of 0 and 1, indicating without and with treatment respectively, y_1-y_0 is the treatment effect, x is a set of observed characteristics. Due to the effect between different sample groups and timing of treatment, generally, there are several variables to assess the treatment effect, A statistical causal inference model is deployed to such a case involving a simple situation of program participation versus nonparticipation, including the average treatment effect, ATE= E

$(y_1|d=1)-E(y_0|d=0)$, average treatment effect on treated, ATET = $E(y_1|x,d=1)-E(y_0|x, d=1)$ $=E[(y_1-y_0)|x, d=1]$, average treatment effect on untreated, ATEUT= $E(y_1|x,d=0)-E(y_0|x, d=0)=E[(y_1-y_0)|x, d=0]$. Combining the different treatment effect, the propensity match score is deployed for the analysis of treatment(McFadden, 1980), the propensity match score provides a solution for the evaluation, particular for the non-experimental or observational data, reducing multidimensional covariates to a one-dimensional score called a propensity score. Additionally, it resamples and matches non-treated samples to treated ones on probabilities of receiving treatment.

Table 67 Framework for the study of treatment effect

Groups	Experiment Group(d=1)		Controlled Group(d=0)
	Before Quota Owned(y=1)	After Quota Owned(y=1)	Owned(y=1)
ATET	ATET	ATE	ATEUT
	without(y=0)	without(y=0)	without(y=0)

The framework of matching method consists of an outcome variable for different units, a dummy variable indicating participation, and set of other characteristics that are regarded as exogenous variables are not affected by the intervention(Essama-Nssah, 2006). Matching has become a popular way to study the causality treatment effect in diverse fields that involve a treatment, with a basic idea to find a group of non-participants in the controlled sample who are similar to the participants in the experiment sample in terms of all pre-treatment characteristics, namely, the exogenous variables. Accordingly, with the consideration of both requirement of samples in the two groups and the propensity matching score in the study of treatment effect, this is why this methodology is not deployed to study the treatment effect of multi-quotas.

6.2.5 Conclusion

Based on the literature review on both single and multiple quotas, it extends the study to a mechanism of multi-exclusive quotas but with a constant TAC and absent of transferable market. Contingent on this scenario, it focuses on two questions, whether the adoption of NEVs is forced or not, and externalities. Meanwhile, it integrates the micro-macro perspectives in the empirical study. Accordingly, it finds that the adoption of NEVs is forced to green in the model of multi-exclusive-quotas, the more times participating in the lottery of conventional vehicles, the higher possibility of purchasing NEVs. Additionally, in term of macro-perspective in multi-exclusive quotas, the higher cost and smaller probability of one sub-quota, the higher rate of adoption for another sub-quota. Namely, the adoption of NEVs, is positively associated with a higher bidding price and lower lottery winning rate.

Meanwhile, in term of externalities, it finds that there is a spillover effect under the multi-exclusive quotas, which counteract the initial target of reducing the volume of conventional vehicles and increasing the volume of NEVs. Besides, there is an externality of discards in the multi-exclusive quotas. The higher cost of the bidding, the higher rate of discards; The lower the lottery rate of winning a license plate, the lower rate of discarding.

Chapter 7 Summary and Conclusions

7.1 Summary and Conclusion

This research, raises the research questions about the “trap of subjective willingness” and disparity between WTP and AP. Lastly, it tests these research questions empirically. Accordingly, this research integrates the macro-perspective, including the history, environment, economic, politics, industry reform, with the micro-perspective to dig into individuals’ behaviours, providing a comprehensive insight, where it not only has a big picture on the evolution process in the longitudinal historical spectrum, but also a micro-world on its function mechanism.

The literature review elaborates the researches and methodologies deployed on the adoption of electrical vehicles, which presents the two perspectives for the further works. Firstly, the data enrichment and fusion provide the insight for the design of sampling and data collection, combining the stated and revealed preference. Secondly, it raises the disparity between the willingness to pay and actual payment academically. Therefore, based on the further literature review on the disparity, it has elaborated 5 hypotheses, primarily on the disparity mechanism between willingness to pay and actual payment, and the behaviors under the multi-exclusive quota. Integrating with the empirical study, where the data collection is under the sampling design of data enrichment, the empirical results are presented as the following.

For the first hypothesis, there is a difference between the public and private goods in the estimation variation of WTP, and the private good’s variation is smaller than a public good. Additionally, it is also applied to hypothesis that variation in experiment group is higher than the controlled group. After the meta-analysis, it cannot draw the conclusion that the private good’ variation is smaller than a public good due to the ambiguous clarification of public or private good in the literatures and the diversified data collection models, therefore, it need further work on the building of strict comparison groups between the public and private good. But for the second part of this hypothesis, it is consistent with the hypothesis that the coefficient variation in the experiment group is higher than the counterpart in the controlled group.

The second hypothesis, the function mechanisms between WTP and AP are different. The first sub-hypothesis in the second one, the higher green perception of the new energy vehicles, the higher WTP, but this positive relationship for WTP is not applicable to the actual payment (AP). And there are two variables deployed to represent the perception, namely, the cost-effectiveness indicates the NEVs save money as whole comparing to the conventional one, and the reduction emission, accordingly, it is a combination of both economic-cost and environmental perspectives. From the empirical testing, it supports that the higher green perception of the NEVs, the higher WTP, but this positive relationship for WTP is not applicable to the AP, which indicates the different effect mechanism between the WTP and AP in terms of perception, and there is a phenomenon of the “trap of subjective willingness”. Besides, it found that the income is a necessary but insufficient condition for the adoption of NEVs. The second sub-hypothesis, it supports the hypothesis that in the controlled samples without the quota, the living years and registered resident do not have effect on individuals WTP for NEVs; But samples in the experiment group imposed the quota, it cannot support that the longer of living years and registered resident, the higher WTP for the NEVs, however, for the AP in the experiment group, the registered residence is associated with a higher possibility of owning NEVs. Meanwhile, it also cannot support the hypothesis that the higher performance requirement on the NEVs is associated with a lower WTP, and a higher willingness to pay the

external fee, such as the license of premium, is related to a higher WTP. Therefore, in terms of past experience, this is the different effect mechanisms between WTP and AP. The third sub-hypothesis, it supports the hypothesis the higher certainty of the charging location, the higher WTP, this is applicable to both WTP and AP. But for the distance away from the working or living places, it cannot draw a sole conclusion that the lower distance away from where individuals work or live, the higher WTP, but for the distance away from the living place in the experiment group of WTP and controlled group of AP, with the increase of distance, there is a negative association with the WTP and AP.

The third hypothesis, contingent on the theory framework of commitment cost for the disparity of WTP/AP, the first sub-hypothesis, the higher uncertainty of utilization, the higher disparity between the WTP/AP. But the empirical test cannot support it, when the focus of uncertainty moves from the monetary value to the utilization, it cannot reach the same conclusion. It extends the previous research scope and conclusion in the commitment cost theory, due to the utilization is strongly connected with the product or service chosen in its study and laboratory experiment, which is also demonstrated the importance and necessity of category of product raised in the first hypothesis, public or private good. For the second sub-hypothesis, the more learning opportunity with a delayed cost, the higher disparity between the WTP/AP. And the empirical test supports the hypothesis, importantly, it extends and breaks the previous precondition of zero learning cost, an extension with a learning cost embedded in behaviors.

The fourth hypothesis, based on the literature review on both single and multiple quotas in the theory of individual transferable quota, it extends the study to a mechanism of multi-exclusive quotas but with a constant TAC and absent of transferable market. It finds that the adoption of NEVs is forced to green in the model of multi-exclusive-quotas, the more times participating in the lottery of conventional vehicles, the higher possibility of purchasing NEVs. Additionally, in term of macro-perspective in multi-exclusive quotas, the higher cost and smaller probability of one sub-quota, the higher rate of adoption for another sub-quota. Namely, the adoption of NEVs, is positively associated with a higher bidding price and lower lottery winning rate.

The fifth hypothesis, in term of externalities, it finds that there is a spillover effect under the multi-exclusive quotas, which counteract the initial target of reducing the volume of conventional vehicles and increasing the volume of NEVs. Besides, there is an externality of discards in the multi-exclusive quotas. The higher cost of the bidding, the higher rate of discards; The lower the lottery rate of winning a license plate, the lower rate of discarding.

7.2Future Research

Theoretically, regarding the theories deployed, firstly, the commitment cost theory, there are three attributes, uncertainty, learning opportunity and reversibility. This research has extended the domain and relaxed the strict hypothesis for the former two attributes, uncertainty, learning opportunity, taking into consideration of product utilization uncertainty, rather than the solo uncertainty of monetary value, and a delayed cost for the learning opportunities. But what effects do the third attribute of irreversibility have for the relaxation of hypothesis? Meanwhile, for the quota in this research, the simulation of the practical NEVs market is banded with a set of treatments, such as the non-transferable quota, total allowable catch and multi-exclusive-quotas. However, when it changes the design of the practical policy, with a setting of transferable quota, no cap of total allowance catches and multi-inclusive-quotas, how does it work?

Regarding the adoption of new energy vehicles, the integrated trend of electrification,

intelligence, networking and sharing as the "new four modernizations" of automobiles, are leading to revolution on the road and smart cities. The essence of this change is that the car changes from mechanical to intelligent, and the fundamental driving force and the disruptive power is the information technology. Many high-tech companies are challenging traditional car companies with autonomous driving technology combined with ecological settings such as sharing and intelligence, which causes the change in the value chain and new business models. It is necessary to test the behavioral mechanisms under different business model.

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Appendix

Questionnaire 1: Adoption of New Energy Vehicles in Shenzhen as the Experiment Group[29]

I am a Ph.D. student, Yang Liu, at Bonn University. The purpose of the research is to study the individual's behavior in the adoption of new energy vehicles. This is an academic research and all respondents are chosen randomly. The survey is anticipated to take 5 minutes. Please be assuring that all your filling information in the survey will only be used for academic research and will be treated confidentially.
We highly appreciate your participation.

1. Do you own a car?

ο No ο Yes

2. Do you have a valid permission of driving license above C level?

ο Yes ο No

3. Do you have the plan to get a driving license?

ο No ο Yes

4. Do you have the plan to purchase a car and when?

ο No ο Yes, within the next 12 months

ο Yes, within the next three years ο Yes, but later (not within the next three years

5. Which way do you prefer to buy and get a plate license contingent on your own condition and quota requirements?

ο Lottery Conventional vehicles(or in others' families name)
ο Bidding Conventional vehicles(or in others' families name)
ο Register in other cities(Conventional)
ο NEVs(Hybrid vehicles)
ο NEVs(Pure electric vehicles)

6. You plan to purchase a car, your budge is(_____)？ (Unit: 10,000 RMB)

ο Yes, the budget is _____
ο I haven't decided yet

7. The model of car you prefer is ( ).

ο Small car ο sedans ο SUV ο mpv ο Others

8. which country do the brands you prefer belong to?

ο China ο Germany ο USA

ο Japan ο France ο Korea

ο Italy ο others _____ ο I haven't decided yet.

9. If you plan to purchase a conventional vehicle, the engine size you prefer to is (___)？

ο engine size _____ * ο I haven't decided yet

ο KM _____ * ο I haven't decided yet

11. Which way do you prefer to buy and get a plate license before the implementation of quota in Shenzhen?

ο Conventional vehicles ο NEVs(Pure electric vehicles) ο NEVs(Hybrid vehicles)

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[29] The questionnaire link for the experiment group in English is: https://www.wjx.cn/jq/12798469.aspx
The link of Chinese version for the experiment group is: https://www.wjx.cn/jq/15181257.aspx
The links is better to understand the logic and skip for the relationship among questions, meanwhile, the Chinese version of the questionnaire is identical in presentation and content, it adds one question of Wechat account in the questionnaire when individuals finish it, and ask participants to join the Wechat account of firm's marketing team, which is better and necessary to transfer the incentive cash. Meanwhile, this is one requirement from the firm in the negotiation, which is not only for the transferring of incentive in my research, but also beneficial to strengthen a closer customer relationship for the firm.

12. What kind of vehicles do you own now?

○ Conventional Vehicles ○ Hybrid vehicles ○ Pure electrical vehicles

13. The model of your car is ( ).

○ Small car ○ sedans ○ SUV ○ mpv ○ Others

14. Is your plate license registered in Shenzhen ( )?

○ Yes ○ No

15. If it doesn't register in Shenzhen, Does the prohibition of driving affect your daily life during the rush-hours of 7:00-9:00am and 5:00-7:00pm in Shenzhen ( )?

○ Yes ○ No

16. In the quota, it is allowed and motivated by the government to further buy a NEW when you own a conventional vehicle in Shenzhen, do you have the willingness?

○ Yes ○ No

17. What was the year, the brand, model, price and engine size of the last vehicle you purchased?

Which year_____

Brand: _____

Money you spent when you bought the car(unit:10,000): _____

Engine size: _____ notice：according to the factors of your vehicles you purchased

18. What was the year, the brand, model, price and engine size of the last vehicle you purchased?

Which year_____

Brand: _____

Money you spent when you bought the car(unit:10,000): _____

Reliable range(only battery charging): _____ notice：according to the factors of your vehicles you purchased

19. What is the proportion of charging in the total mileage of your driving ( )?

○ Less than20% ○ About 21%-40% ○ About 41%-60% ○ About 61%-80% ○ About 81%-100%

20. These questions refer to your perception of NEVs and correspondent service.

From 0 with the meaning of "I fully disagree" to 100 "I fully agree. [0---100]

I will recommend others to purchase NEV. _____

It is easy to find an empty spot in a charging station. _____

The parking places for NEVs are often misused by conventional vehicles. _____

The charging station is well maintained. _____

21. Do you own a property right of a parking place nearby the place where you live ( )?

○ NO ○ YES

22. Your average daily driving distance on workday is(_____) kilometers？

23. Your average daily driving distance on one of the weekend is(_____) kilometers？

24. Your total monthly average fuel (and/or Charging) expenditure is(_____)RMB?

25. Your monthly expense on parking fee is (_____) RMB?

26. These questions refer to the perception of NEVs.

From 0 with the meaning of "I fully disagree" to 100 "I fully agree. [0--100]

The NEVs can save money compared to a conventional car of the same size. _____

NEVs help to reduce the emissions in the big cities to a large degree _____

27. Which way do you prefer to buy and get a plate license after the implementation of quota in Shenzhen?

○ Conventional vehicles ○ NEVs(Pure electric vehicles) ○ NEVs(Hybrid vehicles)

28. Which way do you prefer to buy and get a plate license before the implementation of quota in Shenzhen?

○ Conventional vehicles ○ NEVs(Pure electric vehicles) ○ NEVs(Hybrid vehicles)

29. After the quota policy in Shenzhen, have you ever applied to the plate license? ( )

○ Yes ○ No

30. How many times do you apply in each kind of ways to get a plate license in Shenzhen?(Please fill all the choices you have made)

□ Lottery Conventional vehicles _____ *
□ Bidding Conventional _____ *
□ Lottery (Pure electric vehicles) _____ *
□ Lottery(Hybrid vehicles) _____ *

31. How many families members (including yourself) do they meet the precondition simultaneously for the application of license ( )?if yes, how many?

○ 0 ○ 1 ○ 2 ○ others _____ *

32. The total number of vehicles in your household (including yours) is ( )?

○ 0 ○ 1 ○ 2 ○ Yes, the number is _____ *

33. After the full charging of pure electric vehicles, how many kilometers of continuous reliability could meet your demand at least (_____)KM?

34. At the places where you work, the distance to your nearest charging station is ( )KM?

○ Distance _____ * ○ Unknown

35. At the places where you live, the distance to your nearest charging station is ( )KM?

○ Distance _____ * ○ Unknown

36. Under the quota in Shenzhen, the highest cost of plate license you have willingness to pay is (_____)?

37. The commuting model you use most frequently is ( )?

○ Metro ○ Bus
○ Internet-based model, such as Didi ○ Private car
○ Taxi ○ Walk
○ Bicycle(including MobiKe, OFO)

Thank you so much for your help. Please answer these last few demographic questions for statistical purposes and then we'll be finished. Your responses will be kept confidential, and there is no way to identify you according to your responses.

38. Your gender is ( )?

○ Male ○ Female

39. Your marital status is ( )?

○ Single ○ Married ○ Divorced ○ Widowed

40. Your age is_____ ？

41. The number of your household members who are living together (including yourself) is (___) ?

42. The highest level of your education is( )？

○ Secondary education ○ Graduated high school or Vocational Training
○ University Education(High level Vocational education) ○ University Degree (Bachelors)
○ Masters Degree ○ Doctoral Degree

43. Your income monthly after tax is ( )?(Unit： 1,000 RMB)

○ 3 and below ○ 3.1-6 ○ 6.1-9 ○ 9.1-12
○ 12.1-15 ○ 15.1-18 ○ 18.1-21 ○ 21.1-24
○ 24.1-27 ○ 27.1-30 ○ 30.1-33 ○ 33.1-36
○ 36.1-39 ○ Above 39 _____ *

44. Is your registered residence (Hukou) in Shenzhen?

○ Yes ○ No

45. How many years have you lived in Shenzhen?

○ less than 1 years
○ other years _____ *

Questionnaire 2: Adoption of New Energy Vehicles for the Controlled Group (Other Cities)[30]

1. Do you own a car?

○ No ○ Yes

2. Do you have a valid permission of driving license above C level?

○ Yes ○ No

3. Do you have plan to get a driving license?

○ No

○ Yes, how many years later _____

4. Do you have plan to purchase a car and when?

○ No ○ YES how many years later _____ *

5. You plan to purchase a car, your budge is(_____)？(Unit: 10,000 RMB)

○ Yes, the budget is _____

○ I haven't decided yet

6. The model of car you prefer to is ( ).

○ small car ○ Sedans ○ SUV ○ MPV ○ others _____

7. The brand you tend to is from which country?

○ China ○ Germany ○ USA

○ Japan ○ France ○ Korea

○ Italy ○ others _____ * ○ I haven't decided yet.

8. What kind of car do you prefer to buy?

○ Conventional vehicles ○ NEVs(Hybrid vehicles) ○ NEVs(Pure electric vehicles)

9. If you plan to purchase a conventional vehicle, the engine size you prefer to is(___)？

○ engine size _____ * ○ I haven't decided yet

10. What kind of car did you own?

○ Conventional vehicles ○ NEVs(Hybrid vehicles) ○ NEVs(Pure electric vehicles)

11. The model of your car is ( ).

○ small car ○ Sedans ○ SUV ○ MPV ○ others _____

12. What was the year, the brand, model, price and engine size of the last vehicle you purchased?

Which year_____

Brand: _____

Price(Actual Payment,unit:10,000): _____

Engine size(if your car is NEV, please fill the reliability range, only after the full battery charging): _____

notice：according to the factors of your vehicles you purchased

13. What is the proportion of charging in the total mileage of your driving ( )?

○ Less than20% ○ About 21%-40% ○ About 41%-60% ○ About 61%-80% ○ About 81%-100%

14. These questions refer to your perception of NEVs and correspondent service.

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[30]The English questionnaire link for the controlled group is: https://www.wjx.top/jq/13423990.aspx;
The Chinese questionnaire link for the controlled group is:
https://www.wjx.cn/pq/15044430.aspx?t=636866708954638165;

From 0 with the meaning of "I fully disagree" to 100 "I fully agree. [0---100]

I will recommend others to purchase NEV. _____

It is easy to find an empty spot in a charging station. _____

The parking places for NEVs are often misused by conventional vehicles. _____

The charging station is well maintained. _____

15. If you want to purchase another car, the choice you prefer is?

○ Conventional vehicles ○ NEVs(Pure electric vehicles) ○ NEVs(Hybrid vehicles)

16. Do you own a private parking place ( )?

○ NO ○ YES

17. Your average daily driving distance on workday is(_____) kilometers?

18. Your average daily driving distance on one of the weekend is(_____) kilometers?

19. Your total monthly average fuel (and/or Charging) expenditure is(_____)RMB?

20. Your monthly expense on parking fee is (_____) RMB?

21. Perception of NEVs: From 0 with the meaning of "I fully disagree" to 100 "I fully agree. [0--100]

New energy vehicles are cost-effective comparing to the traditional counterpart; _____

New energy vehicles can reduce the emission in the city; _____

22. About the new energy vehicles policies in the city where you live.(at least write one policy, if you don't know, or there is no incentive policy in your city, please write "I don't know" and "no" respectively.

Incentive policies: _____

Elements that hinder the adoption of NEVs you think: _____

23. The total number of vehicles in your household is ( )?

○ 0 ○ 1 ○ 2 ○ others _____ *

24. After the full charging of pure electric vehicles, how many kilometers of continuous reliability could meet your demand at least (_____)KM?

25. At the places where you work, the distance to your nearest charging station is ( )KM?

○ Unknown ○ Distance _____ *

26. At the places where you live, the distance to your nearest charging station is ( )KM?

○ Unknown ○ Distance _____ *

27. The commuting model you use most frequently is ( )?

○ Metro ○ Bus

○ Internet-based model, such as Didi ○ Private car

○ Taxi ○ Walk

○ Bicycle(including MobiKe, OFO)

Thank you so much for your help. Please answer these last few demographic questions for statistical purposes and then we'll be finished. Your responses will be kept confidential, and there is no way to identify you according to your responses.

28. Your gender is ( )?

○ Male ○ Female

29. Your marital status is ( )?

○ Single ○ Married ○ Divorced ○ Widowed

30. Your age is_____ ？

31. The number of your household members who are living together(including yourself) is (___) ?

32. The highest level of your education is( )？

ㅇ Secondary education　　ㅇ Graduated high school or Vocational Training

ㅇ University Education(High level Vocational education)　　ㅇ University (Bachelors)

ㅇ Master　　ㅇ Doctoral

33. Your income monthly after tax is ( )?(Unit： 1,000 RMB)

ㅇ 3 and below　ㅇ 3.1-6　　ㅇ 6.1-9　ㅇ 9.1-12

ㅇ 12.1-15　　ㅇ 15.1-18　　ㅇ 18.1-21　ㅇ 21.1-24

ㅇ 24.1-27　　ㅇ 27.1-30　　ㅇ 30.1-33　ㅇ 33.1-36

ㅇ 36.1-39　　ㅇ Above 39 _____ *

34. The city where you live and how many years have you lived here?

the name of the city: _____

how many years: _____

Hukou is in the city where you live now?(1 indicates yes, 0 means no) _____