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Assessing policy influence on electric vehicle adoption in China: An in-depth study

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ABSTRACT

Electrification of transport industry in China presents several new prospects to fulfil requirements, which are necessary to encounter increasing issues of energy security, air quality, and to lower the dependence on fossil fuels. The Chinese government is paying significant attention in increasing EV market penetration and consumer adoption through numerous demonstration programs/plans with attractive transportation policies. In this study, key factors included in adoption barriers and EV policies are comprehensively reviewed, which can enhance consumer intention to adopt EVs. This research study extensively demonstrates the significant and positive impact of two distinguished types of EV policies including financial policies and preferential policies on consumer's intention to adopt EVs by implementing an extended and improved version of Theory of Planned behavior (TPB). A case study in Shanghai is performed through survey of 314 respondents, which is further evaluated by structural equation modelling (SEM) to assess the aspects of EV policies on consumer adoption. In particular, construct items of TPB including attitude, subjective norm (SN), and perceived behavioral control (PBC) are investigated in detail to present their joint impact on purchasing intention of consumers. The confirmatory factor analysis (CFA) and structural equation modelling are performed in AMOS for assessment of survey findings. The research findings from survey analysis reveal that financial and preferential EV policies have a considerable impact towards shaping the attitude of consumers and significantly related to adoption intention of EVs. However, for Shanghainese, preferential policies are more positively associated with consumer purchase intention in comparison with financial policies. Consequently, preferential policies are playing a crucial role in controlling the adoption intention of EVs in China. The principal policy suggestions for various aspects provide multifaceted perceptions for stakeholders to envision electrified transportation.

1. Introduction

In the last decade, air pollution, greenhouse gas (GHG) emissions, energy crises, and climate change are becoming the challenging issues worldwide. These critical environmental issues demand new prospects to develop a sustainable society. Fossil fuels dependence in transportation, industrial and power sectors is creating substantial environmental concerns. By 2004, significant developments in China made the transportation sector, the fourth largest automobile manufacturer and third largest automobile consumption market among all countries. Subsequently, in 2009, China surpassed the US with the continuous growth in the transportation market and became the largest transportation market in the world [1]. According to the National Bureau of Statistics of the People's Republic of China, the vehicle ownership reached 125 of every.

Thousand population in the year 2020 [2]. The Bureau further estimated that the vehicle ownership will reach 300 per thousand population in 2025 [2]. The vehicle oil consumption has increased to an

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alarming extent and it is expected to reach about 17 % of the total oil consumption, between the year 2015–2020 [2]. Due to the vast oil consumption in China, the country has ranked itself as the largest oil importer in the world. On average 6.3 million tons of daily oil import was recorded in September 2013, more than the US with 6.24 million tons [3]. International Energy Agency realized that if appropriate policies and significant measures are not taken to decrease the demand of oil till 2030, then the per year oil demand in China will go up to the threatening level of 808 million tons [4]. Total oil dependence of China with fuel consumption of automobiles is shown in Fig. 1 [5]. Furthermore, the CO_2 emissions produced by the transportation sector is intensifying the environmental concerns [6]. The emission rate of CO_2 around the world is shown in Fig. 2 [7] and the emission rate from different sectors is presented in Fig. 3 [8].

It is estimated that the value of Carbon emission for transport industry in China is around 8–10 % of total amount [9]. National Development and Reform Commission (NDRC), Development Research Center (DRC) and Tsinghua University carried out a research project together in 2009, which revealed that the transportation sector is expected to double the percentage value of GHG emissions in China by 2020 [9]. In 2016, Zhu Liu [10] conducted a research project and discussed that the 73 % of the global CO_2 emissions are produced in China from the year 2010–2012. Furthermore, the author declared that CO_2 emissions in.

China can reach up to 50 % in next decade. In 2015, president Xi Jinping announced in his speech during Paris Agreement on climate change, that China will drop emissions 60–65 % by 2030 [10]. Therefore, the need of the hour is to transform the transportation industry to help introduced to encounter the environmental problems arising in the transportation sector. Electrifying the transportation system is an emergent solution with the primary objective of achieving a green transport sector that possesses higher mileage and fuel economy with lesser GHG emissions.

The deployment of Electric Vehicles (EVs) is a promising solution to establish an eco-friendly transportation system through new standards and policies. Since 2009, the Chinese government is paying significant attention in increasing the market penetration and consumer adoption of EVs through numerous demonstration programs/plans with attractive transportation policies. Governments, policy makers and researchers are collaboratively working to enhance the EVs consumer adoption by improving the existing policy mechanism. Subsequently, the massive deployment of electric vehicles (EVs) transforms the automotive industry of China into a subsidy-based market of EVs. EVs can decrease the vehicle tailpipe emission, oil dependence and contribute to addressing environmental concerns. Globally, EVs are extensively adopted during the last decade. Overall, market share and yearly sales of Plug-in EVs can be noticed by different regions as depicted in Fig. 4 [11]. Sales of these vehicles are projected to hold 27 % of the global market of EVs by 2030. Currently, as far as the registered number of EVs are on the road, the United States, China, and Germany are leading the globe. Moreover, Fig. 5 presents the percentage of slow and fast-charging stations publicly accessible in different countries. It is evident that installed charging stations slow as well as fast in China are higher as compared to different countries.

1.1. Aims, scope and contributions

The research work has been chosen in the light of significance of electric vehicles in revolutionizing the transport sector. EV policies are playing a vital role for widespread consumer adoption. Policies as an attractive measure can directly influence the adoption rate of EVs. The scope of this paper lies within various EV policies, and consequences of these different policies on consumers intension to adopt EVs. For public awareness and new technology acceptance, the administrative regulations including financial based policies, preferential policies and other significant policies relevant to EV adoption should be explored.

Therefore, this work is mainly motivated by the necessity and demand to provide a deep insight into adoption barriers of EVs and EV policies formulated by Chinese government through theory of planned behavior for large-scale adoption of EVs in transport industry. The subject of this work is to highlight the importance and relevance of major EV policies introduced by Chinese government through various demonstration projects and benefits of EV policies for transformation of automobile industry into electrification-based transport sector. Therefore, the scientific aim of the study is to gain knowledge and awareness of Chinese EV policy framework and its significance in increasing the consumer intention to adopt EVs on large-scale.

This research intends to make a unique contribution to the area by examining the important aspects that influence the desire of potential consumers in China to adopt EVs significantly. Most of the previous studies has concentrated on customer views in the United States and different countries in Europe. Considering that, emission of greenhouse gases in China is an issue of paramount significance, therefore, the possibility to enhance the adoption uptake of electric vehicles by Chinese customers in Shanghai is an important topic of research at this time. This study extends the existing research by providing the respondent behavior of Shanghai city towards the subsidized EV policies and to what extent these policies can change the behavioral intention to adopt EVs. Firstly, this research work mainly highlights and investigates the combined impact of financial based policies and preferential policies on Shanghai consumers as compared to previous studies which merely

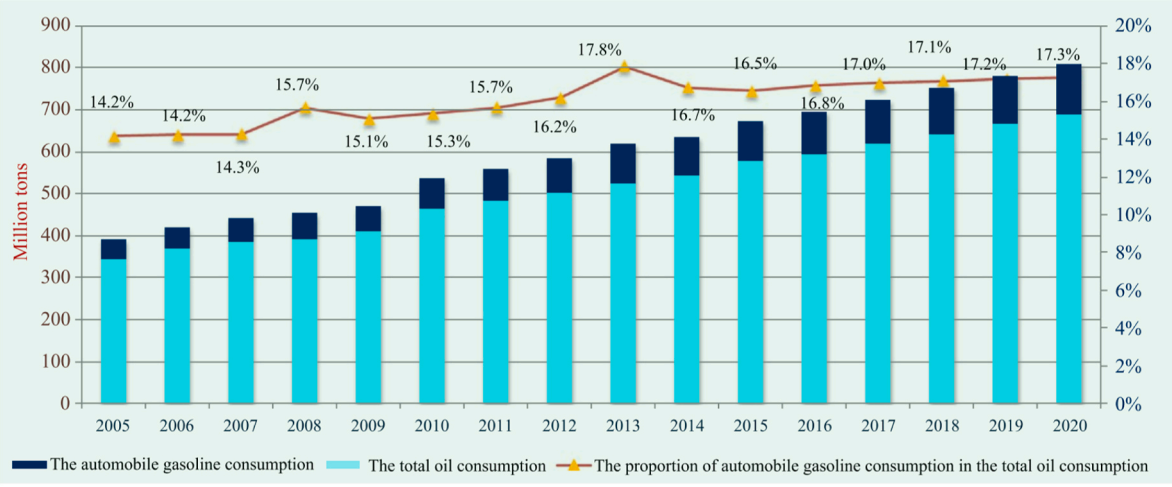

Fig. 1. China's total oil dependency with fuel consumption of automobiles.

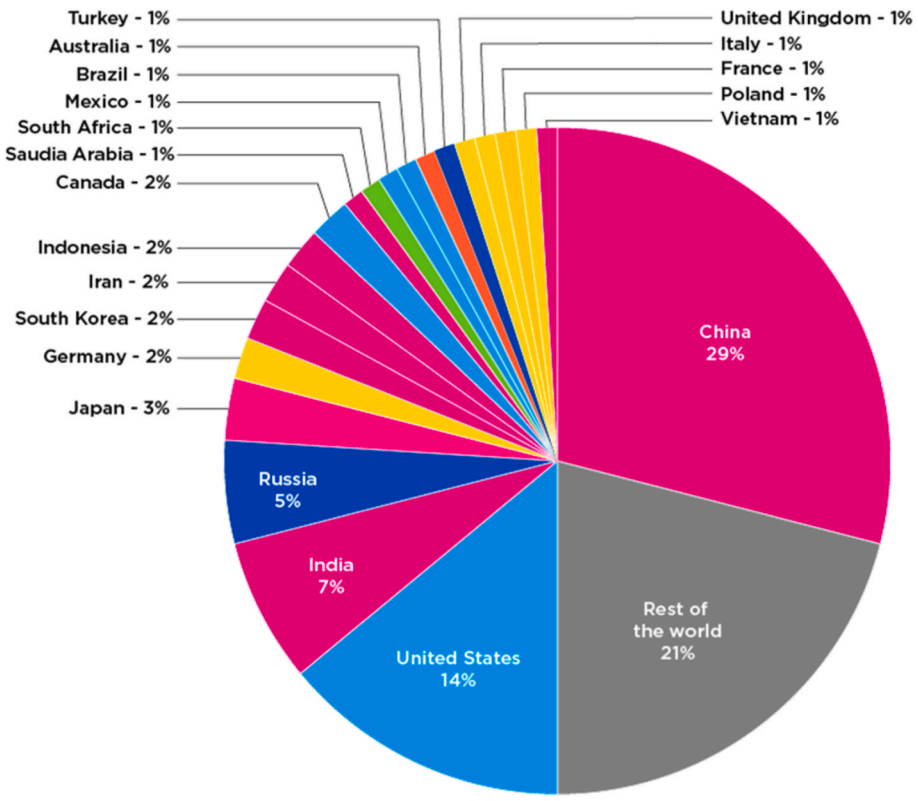

Fig. 2. Global rate of CO_2 Emissions.

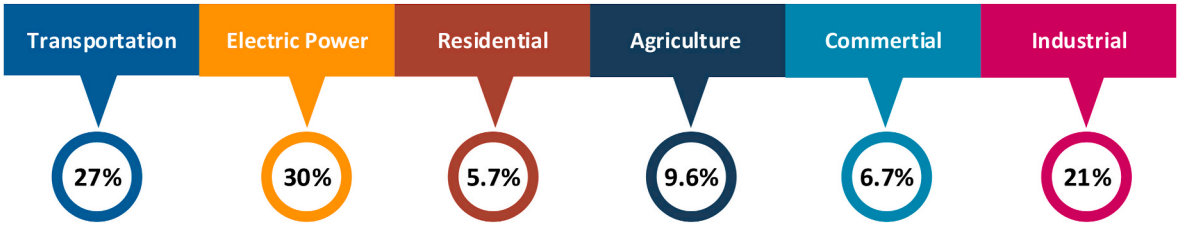

Fig. 3. Emission rate by different sectors.

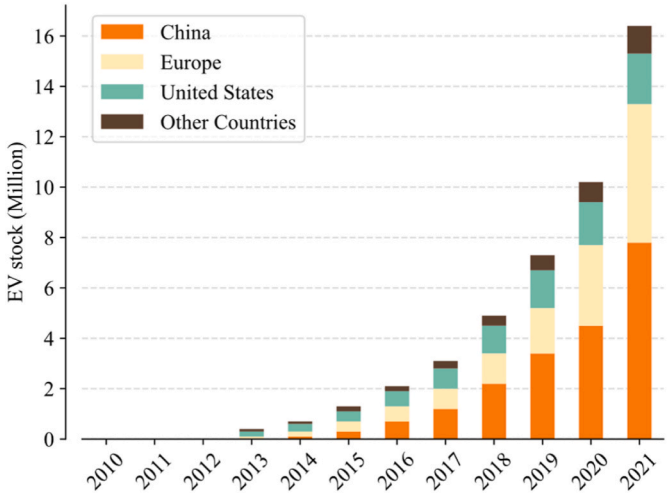

Fig. 4. Global Yearly Sales of EV for different Regions.

discussed the financial subsidies. Secondly, this research is mainly focused on EVs only and ignoring hybrid electric vehicles (HEVs). Many types of differences exist between HEVs and EVs such as: direct carbon emissions are still produced by the HEVs due to the utilization of combustion engine as compared to EVs. Adoption of HEVs by consumers require minute change in their habits in comparison with EV adoption. Consequently, the results discussed in previous studies based on adoption of HEVs may not entirely suitable for EVs. Hence, the gap is narrowed down in this work and aim to highlight the adoption of pure electric vehicles.

According to previous research studies on TPB, various types of research tasks are accomplished depending on the researcher requirements. After the extensive literature, it is analyzed that previous studies did not comprehensively evaluate the purchase intention of Chinese consumers for actual EV adoption based on financial as well as preferential policies measures. The previous studies majorly analyzed the effect of policies based on financial measures only. The combined impact of financial and preferential policies on changing the attitudes towards purchase intention to adopt EVs has not been fully examined. To understand the significance of large-scale deployment of EVs, this research is an attempt to develop more extensive understanding of the combined impact of financial and preferential policies on shaping the attitudes towards purchase intention to adopt EVs, which has not been

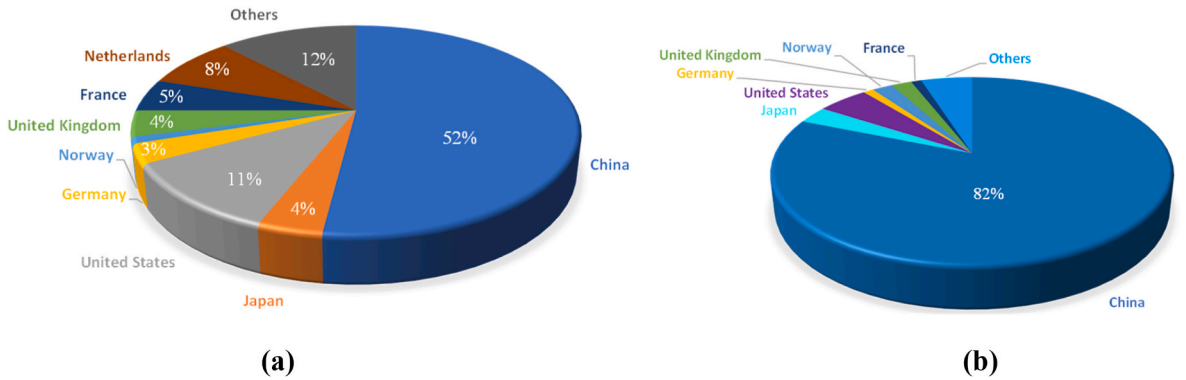

Fig. 5. Charging stations availability: (a) Slow charging points (b) fast charging points.

investigated previously. The prime motivation behind this research is to examine the relationship of two major types of policy frameworks with consumer purchasing intention to adopt electric vehicles. Therefore, this study will explore the prime research question.

➢ How do policy measures matter for consumer purchasing intention to adopt electric vehicles?

This research work aims to explore the influence of government policies towards shaping the attitude to adopt EVs. It is necessary to conduct this research in order to evaluate the influence of policy measures on the consumer adoption. This study is further focused on the two main categories of policy measures which are based on financial and preferential policies. It analyzes the relative effect of both financial and preferential policy mechanism on the consumer intention to adopt EVs. This article brings a new look to the existing literature by highlighting substantial barriers relevant to EV adoption through comprehensively discussing EV policy framework in China. Based on the comprehensive analysis, this study brings valuable addition to the existing literature in the areas of academics, engineering, public policy and the stakeholders of the automobile industry, providing complete assistance for the future developments in this field. Furthermore, this study has completed the following research tasks as well.

- ❖ Analyze the relationship between adoption barriers and incentive policies
- ❖ Comprehensive analysis of Chinese EV policy framework and global barriers for EV adoption
- ❖ Highlight the key factors involved in Chinese EV policy framework
- ❖ Detail analysis of constructs items involved in mechanism of TPB
- ❖ Evaluating the linkage between subsidized policies and consumer intention to adopt EVs
- ❖ Analyze the relationship between intention and actual consumer adoption through a case study in Shanghai

The deployment of EV on large-scale has become a global need due to air pollution, greenhouse gas emissions, energy crises, and climate change. Attractive EV policies can have a substantial impact towards widespread EV adoption and ultimately achieving the goals of environmental concerns. This work can support policy makers by suggesting different possibilities to make improvements in EV policy mechanism for large-scale deployment of EVs as well as widespread EV consumer adoption. It is foreseen that the work presented in this paper would be a useful addition and a valuable source of information for researchers studying the subsidized EV policy mechanism through theory of planned behavior.

1.2. Organization

The remainder of the manuscript is prepared as follows: Section 2 effectively analyzes the major barriers to the widespread adoption of EVs. Section 3 thoroughly investigates various EV policies, including financial incentive policies, infrastructure development, investment-based research and development (R&D) policies, and preferential policies. Section 4 sheds lights on the framework development of the research work through the extended version of TPB. Moreover, hypothetical relationship between the construct items is presented along with the design of questionnaire based on the construct items of TPB and financial and preferential policies. Section 4 effectively examines the collected responses from participants obtained through both online and offline surveys. The confirmatory factor analysis (CFA) and structural equation modelling are performed in AMOS for the assessment of survey findings. Section 5 discusses the data results based on the extended framework of the TPB. Section 6 offers the policy suggestions according to the extensive analysis of existing framework of Chinese EV policies. Finally, section 7 presents the concluding observations, limitations and future directions based on the research findings of this study.

2. EV consumer adoption barriers

Electrifying the transportation sector is a most promising solution to handle environmental issues effectively [12]. However, electric vehicles as an innovative technology facing hindrance due to some barriers that prevents its widespread adoption. This section will provide detailed review of practical issues which cause reluctance in massive EV adoption.

2.1. Financial issues in widespread EV adoption

It is quite understandable that emerging and innovative technologies are often compared badly with the existing products in terms of price. Therefore, in the case of EVs, purchasing price, higher battery cost and higher cost of maintenance are the major financial hurdles in the massive adoption of EVs [13,14]. Therefore, many studies concluded from the survey results that higher purchasing cost of EV is one of the chief barriers in large scale adoption of EVs as compared to the gasoline vehicle [15]. The authors in Ref. [16] conducted a research study in UK and outcomes showed that the long payback period as well as the higher purchase cost related to EVs are the major hurdles in consumers' inclination to adopt EV. Another research study conducted in Ref. [17] including data from 30 countries suggested that EV purchase price and the market share are negatively correlated with each other. The major cause of higher price of the EVs is due to lithium ion batteries; lithium ion battery capacity increases the driving range of an EV, but it also rises purchase price of the EVs [17–19].

Lower maintenance and fuel cost of EVs make it more beneficial even

with high initial cost and high cost of batteries [20]. It is observed that per mile cost of EVs is roughly 50 % less in comparison with gasoline automobiles with reference to prices of fuels and current available power [21]. The propulsion system of EV motors is considerably less complex as compared to combustion engine vehicles [22]. This leads to easy propulsion of EV motors and cost of motor is reduced [23]. However, the study conducted by Ref. [24] concluded that irrational behavior of consumers is observed, while taking the decision to purchase EV, as fuel economy is not incorporated in their purchase decision. Similarly, the study performed by Ref. [25] revealed that economy of fuel is not a major factor in making purchase decision of consumers, and no rational analysis on financial basis is performed by the consumers when making their final decision to purchase the vehicle. The study implemented by Ref. [23] observed the consumer's thoughts on EV maintenance cost by conducting a survey between twenty one major cities of America. The authors revealed that majority of the consumers believed that maintenance cost of EVs is comparatively higher than the gasoline automobiles [26]. This is due to the fact that consumer did not have a clear understanding about the maintenance cost and fuel cost which leads to addition of barriers in EV adoption.

2.1.1. Performance issues in EV adoption

Performance of a vehicle substantially matters while making purchase decision of vehicle [27]. Here performance refers to the evaluation of internal features of EVs such as safety in driving EV, the driving range of EV, battery life of EV, acceleration feature, charging interval and reliability [28,29]. Many research scholars claimed in their studies that driving range of an EV and the overall EV performance is a topmost hurdle that sets back the consumer's attitude from adopting electric vehicle [30]. These issues proved to be true at the time of battery dropping down while driving EV, particularly when journeys got suddenly prolonged and it was not predictable that how far the remaining battery could take the car driver [27,31]. In another study, respondents are given the opportunity to use EVs for some certain time and the results showed that most respondents were not satisfied by the performance of the EVs [32]. Furthermore, the study implemented by Ref. [33] also showed consistent findings, that EV range anxiety arose many concerns of EV drivers especially for longer journeys [34].

The studies performed in Refs. [31,35] found that numerous drivers in UK after using EVs for seven days said that the EV power is not up to the mark and they faced difficulties due to prolonged charging hours. Many respondents were also concerned with safety issues while driving EVs [35]. The study conducted in Ref. [36] also found such outcomes in their study that faculty members, administration staff and students of the technological university in US were greatly concerned about the driving safety and reliability of EVs.

2.1.2. Infrastructural issues in EV adoption

The study performed by Refs. [16,37] concluded that the charging infrastructure has similar kind of importance for EVs as fuel stations have for gasoline automobiles, lack of sufficient charging infrastructure is a barrier in largescale EV adoption in major cities. Therefore, development of charging infrastructure is essential at various necessary places as shown in Fig. 6, in order to support EV adoption. The study described by Ref. [32] recommended the necessity of largescale public EV charging stations and the opportunity of charging an EV at work, through an experiment of stated choice undergone in Denmark. Likewise, a survey conducted in Norway exposed that with the availability of EV support infrastructure, the EV market can flourish and become competitive [38]. The consumer preference of opportunity of overnight EV charging at home was found in a study conducted by Ref. [39]. This preference of possibility of charging-at-home will not merely provide convenience to EVs owners but also it ensures security of their vehicle and its charging port [40].

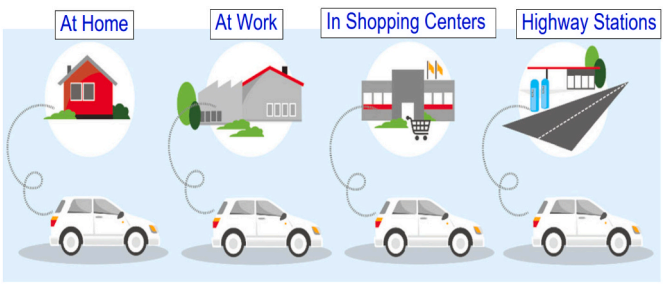

Fig. 6. Requirement of charging infrastructure at various places.

2.1.3. Overall issues on consumer adoption

Various significant incentive-based EV policies are introduced by the government to increase the EV consumer adoption. EV policies and consumer adoption are correlated with each other, therefore, the factors involved in consumer adoption should be examined carefully to make more reliable and efficient EV policies [41,42].

The key factors which can significantly influence the consumer adoption are classified into internal and external factors. Internal factors of EVs include price and battery performance, whereas, external factor of EV include fuel prices as well as charging stations [43,44].

As far as internal and external factors are concerned, the substantial impediments which can prevent the EV consumer adoption and large scale deployment of EVs include requirement of high charging time, higher cost of EV battery as well as operational cost with comparatively higher purchasing price and availability of charging stations [45]. The study conducted by Ref. [31] concluded that people are reluctant to pay higher initial cost required by EVs. As vehicle users believed that superior performance parameters should be realized after paying the high cost. Various research studies from the literature suggested that the fuel cost is less with electricity, however, the higher purchasing cost with other added expenses including home chargers etc. Still prevent the higher adoption [46,47].

The other major limitation factor which can have a significant impact on the EV consumer adoption is inadequate electric driving range as concluded by different research studies from literature [48,49]. The studies conducted by Refs. [50,51] revealed that limited battery range is a considerable issue for a large scale deployment of EVs. The results are obtained by performing a web-based survey [51]. One group of researchers suggested that Plug-in hybrid EVs (PHEVs) are more desirable and preferable in comparison with pure EVs or battery EVs (BEVs) as concluded by studies [50]. On the other hand, the other group of researchers examined that pure EVs/BEVs are more preferred as compared to PHEVs if appropriate number of charging locations are available and there is continuous development on infrastructure of EV charging. The study also suggested that the issue of battery range can be addressed in a better way by providing the number of charging stations.

Several research studies also highlighted the significance of charging time as a key factor towards consumer adoption [52,53]. Limited development in charging infrastructure is also counted as a significant barrier towards widespread EV adoption. Advancement is charging infrastructure must be required to overcome the major issues of vehicle users [54]. Giving higher priority towards the development of charging infrastructure can strengthened the EV transportation market [9,43,55]. The results obtained from the implemented methodology in study [56] reveals that EVs sales are considerably increased based on model of vehicle. In research study [57], the authors recommended that gasoline prices have more influence on adoption rate of EVs in comparison with policies incentives. The studies in Refs. [17,58] concluded that development in EV charging infrastructure have a significant impact to increase the EV adoption.

In summary, it is concluded that financial attributes (higher purchasing cost and fuel cost), infrastructure development (facility of charging locations), and technical attributes (charging time and electric driving range) plays a considerable role in extensive deployment of EVs

as well as become significant factors for widespread EV consumer adoption [43,59–61]. The substantial issues for large scale deployment of EVs and widespread consumer adoption are presented comprehensively in Fig. 7 and Table 1.

2.1.4. EV policies and consumer adoption

Various analytical strategies can be observed in overall policy structure of EVs. The state of research regarding the policy mechanism of EVs can be discussed with two different perspectives. According to the first one, mathematical modeling and analysis are utilized to analyze the EV policy structure. A cost benefit analysis is thoroughly performed with detail evaluation of EV policy structure by employing conventional primary models in study by Ref. [79]. The study concluded that different studied policies are inefficient for future development. The efficacy of energy policy act is evaluated by employing the econometric methods in study by Ref. [56]. The results obtained from the implemented methodology reveals that EVs sales are considerably increased based on model of vehicle. In research study [57], the authors recommended that gasoline prices have more influence on adoption rate of EVs in comparison with policies incentives. The study [17] concluded that development in EV charging infrastructure have a significant impact to increase the EV adoption.

The second prospective emphases on the actions and the concepts recommended by the policy makers rather than implementing a mathematical methodology. Substantial policy measures are discussed in a study [80] to enhance the acceptance of EVs. A workshop is conducted with different policy experts to perform analysis of different policy factors. An appropriate combination of two feasible policies are suggested to increase the mobility of EVs. How effectively the national security agenda utilize by the policy entrepreneurs is discussed in study by Ref. [81]. The literature related to policy entrepreneurship is used as a theoretical parameter to endorse the desired energy policy. The study conducted by Ref. [82] evaluated the impacts introduced by policy measures on consumer acceptance of EVs. Agent-based model is

Table 1
Significant issues for widespread EV adoption.

Type of Issues	Issues	Sources
Financial Issues	Purchase Price	[17,62]
	Battery Cost	[23,63]
	Misunderstanding of Fuel Cost/Possible Savings	[32,64]
	Misunderstanding of Maintenance Cost	[51,65]
	Re-Sale Value Anxiety	[35,66]
Performance Based Issues	Safety	[13,30,46]
	Driving Range	[30,67]
	Reliability/Unreliable Technology	[32,46]
	Charging Time	[41,51]
	Battery Life	[31,46]
	Power	[13,49,68]
	Vehicle Design	[35,68]
	Availability and lack of vehicle selection in EV market	[35,69]
Infrastructural Issues	Public Infrastructure Availability	[39,70]
	Infrastructure Availability at Work	[32,71,72]
	Infrastructure Availability at Home	[40,70]
	Public Charging Standards	[30,72,73]
	Infrastructure Availability on Highway	[16,65]
	Limited plans for long-term Future deployments	[30,69]
	Large Capital Investments for Charging Infrastructure	[30,74]
Other Adoption Issues	Consumer Knowledge	[34,35,75]
	Consumer Misperceptions	[23,69,75]
	Consumer Awareness	[35,69,75]
	Marketing Strategies	[35,76]
	Bad Experience with Dealerships	[30,58,75]
	Restrictive Usage	[49,68]
	Willingness to pay	[30,77]
	Less Share of EVs in Automobile Industry	[28,30]
	Insufficient Power Generation	[9,78]
	Too Complex Charging publicly	[28,30,72]

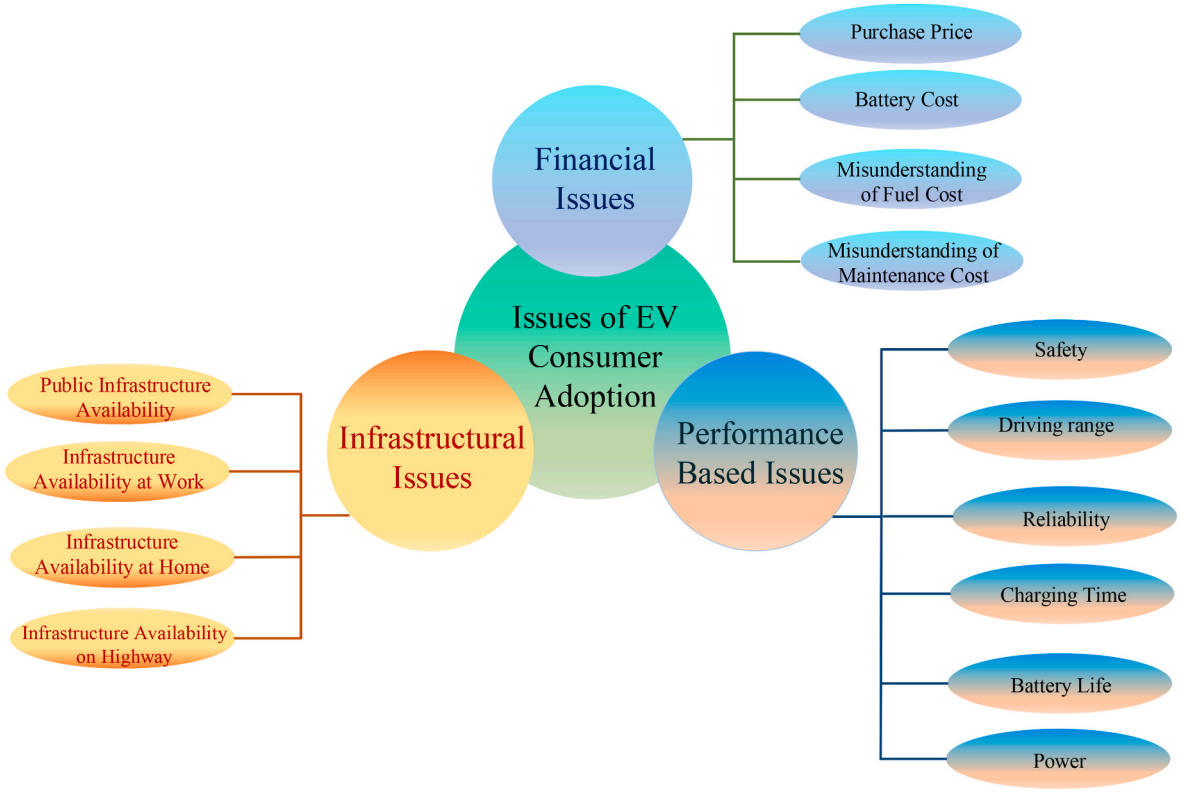

Fig. 7. Practical issues of EV consumer adoption.

implemented with four policy scenarios to enhance the EV adoption in urban areas. Key factors and major policy incentives are assessed by employing the linear regression method in study performed by Ref. [9]. The implemented method thoroughly examined the EV sales in transport market with detailed evaluation of policy incentive introduced by Chinese government.

3. Structure of EV policies in China

Chinese government has formulated numerous policy measures to ensure extensive EV consumer adoption and to support the innovative-EV technology. The leading section will be providing an extensive analysis on the Chinese EV policy mechanism including the financial, infrastructure development policies.

Investment-based research and development (R&D) policies and preferential policies, and other significant factors related to EV policies, which can increase the consumer adoption. This research is based on exploring the correlation of EV consumer intention with policy incentives for widespread adoption of EVs in China.

3.1. Categories of EV policies

Supportive governmental policies play a significant role in achieving certain goals of a nation [83]. Policies as an attractive measure can directly influence the adoption rate of EVs [84]. China has paid importance in formulating and implementing various policies for the development and widespread consumer adoption of electric vehicles [48]. Researchers have classified the EV policies into different main groups includung financial policies, infrastructure development policies and investment-based research and development (R&D) policies [85]. However, the government in China introduced some major preferential policies as well which includes some significant attractions such as preferred parking place or free parking, expedite process of getting license plate and opportunity to use high occupancy vehicle (HOV) lanes [86].

3.1.1. Financial policies

EVs have a higher price due to innovative technology and high fuel efficiency in comparison with conventional internal combustion engine (ICE) vehicles [87]. Many researchers have suggested that purchase price is a major concern of most consumers, and researchers have regarded the vehicle cost as a significant and attractive factor in consumer adoption decision [27,36,88]. For instance, the authors in study [50] conducted a survey oriented research which reveals that 50 % survey respondents showed purchasing cost a major concern and barrier in EV adoption. To cope up with the issue of purchasing cost, several financial policy measures including tax policies and direct subsidies have been introduced by the policymakers [89]. Tax incentives and fiscal subsidies are the most common forms of EV financial measures. Because EVs are eligible for regional as well as national subsidies combinedly, thus, financial policies may be examined from two viewpoints: financial policies from national government and financial measures from regional government [90]. Central and local government provide direct subsidies to consumers and the subsidy standards of local government vary from one region to another [90,91]. The subsidy mechanism of the local government could be equivalent or even more advanced than the subsidy standards of the central government [92]. Furthermore, on purchase of EVs few taxes are exempted such as value-added tax and vehicle purchase tax [93,94].

Currently, several countries have introduced incentive policies based on financial measures to stimulate the adoption rate of EVs [47,95]. In China, one of the financial policy announced by the government includes the subsidy of up to 60,000 RMB is paid by the government to any user who buy EVs [90,96]. The parameters, which decide the amount of subsidy received by each vehicle include efficiency performance of the vehicle, category of vehicle and the type of technology [97]. Financial policies for EVs mainly comprised of price subsidies and Tax exemptions. Government provide subsidies to battery clients leasing companies and vehicle manufacturing companies [98]. Subsequently, the companies sell EVs to the customers on the price after subsidy deduction [99]. The Chinese government considers that the support from financial policies will result in increasing consumer adoption which will ultimately decrease EV costs [100]. The EV financial policy mechanism in China is presented in Fig. 8. In Ireland, consumers are encourage to purchase EV by reducing the registration tax of the vehicle [101]. Similarly, road rolling tax, added value tax, and purchase tax is exempted in Norway [102]. Likewise, rebate programs have been introduced by the US government to inspire consumers to adopt EVs [103].

EV sales and consumer adoption regarding the policy incentives based on the financial measures have been discussed in several recent studies [14,47,104]. The authors in study [105] focused on the consumer motivation and divide them into two types: 1) Intrinsically motivated consumers, 2) Extrinsically motivated consumer. The study concluded that adoption of EVs can be promoted on large scale with incentives based on financial plans rather than policies based on information provision such as vehicles with energy labels. The study conducted by Ref. [106] suggested that incentives announced by the government are effective in many countries to increase the consumer adoption. The research study implemented by Ref. [107] analyzed the major factors involved in EV policies for fourteen countries and concluded that EV development and deployment can be increased substantially with tax incentives and other financial subsidies. In work [36], the authors utilized a conjoint survey for China and the U.S. to analyze the EV preferences. The study concluded that consumers are more willing to adopt gasoline vehicles in both countries, however, Chinese respondents are more willing to purchase the EV technology as compared to the Americans even same kinds of financial subsidies are announced in both countries. The research works conducted by Refs. [9, 108] suggested that to promote the EVs in similar fashion while decreasing financial subsidies, the government should introduce and formulate some indirect subsidies such as exemption from the license fee of the vehicle [109].

In light of the above discussion, it is clear that financial measures help to decrease the EV price and considerably increase the consumer intention to adopt EVs. Therefore, it is obvious to consider that if policy measures based on financial incentives are increased by the government, intention of consumers to adopt EVs is triggered.

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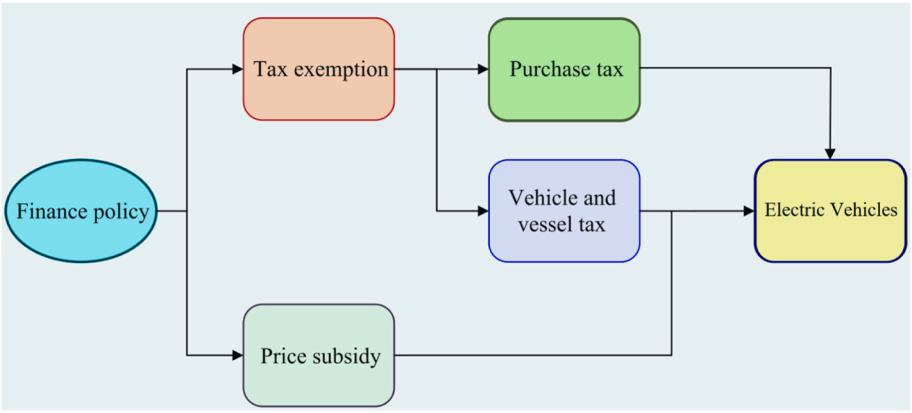

Fig. 8. Mechanism of EV financial policy subsidy in China.

help to decrease the EV price and considerably increase the consumer intention to adopt EVs. Therefore, it is obvious to consider that if policy measures based on financial incentives are increased by the government, intention of consumers to adopt EVs is triggered.

3.1.2. *Preferential policies*

The major decision of consumers to adopt EVs on large-scale is significantly influenced by the awareness of convenience obtained after using the EVs [103]. The study implemented by Ref. [13] revealed that difficulty to charge EVs is one of the major barriers for most of the consumers. Therefore, the study performed in Ref. [103] concluded that higher adoption can be observed among consumers if they are able to charge the EVs with least disruption in their daily schedules. Similarly, the authors in study [110] recommended that the opinion of consumers to adopt EVs is triggered with accessibility of charging infrastructure on bigger scale. Multiple regression method is implemented in study performed by Ref. [9] to examine the major factors, which can have large impact on sales of EVs. The study concluded that consumer's convenience can be increased, and consumer's anxiety can be decreased with availability of EV charging infrastructure, which ultimately leads to improve the acceptance rate of EVs [110]. On the other hand, reduced adoption likelihood and increased consumers inconvenience are observed with two other substantial barriers including limited charging range of EVs with long changing time [111]. Technical support policies and construction policies based on building charging infrastructure on large scale are formulated by the government in order to overcome the above mentioned issues [91,112]. The major purpose of these policies is to increase the awareness of convenience achieved after using EVs and improve customer passion for adoption of EVs [113].

It is evident that vehicles are meant for comfortability and ease for the consumers, however, on the other side, gasoline vehicles are one main cause of bringing harms to the society in shape of air pollution and congestion [89]. In order to lessen the harm to the environment brought by vehicles, numerous policy measures have been introduced regarding EVs in Shanghai and Beijing recently [101,110,114]. The major preferential policies have significant attractions such as preferred parking place or free parking, expedite process of getting license plate and opportunity to use high occupancy vehicle (HOV) lanes [9,86,97,115]. During the annual inspection of vehicle, the EV consumers also have the privilege that they are not needed to line up [47,101]. One of the policy measures include vehicle-purchase restriction as well as traffic-flow restriction, which are based on the rule of even-odd numbered license plates [116]. However, to promote the widespread adoption and to facilitate EVs, EV owners are free from restrictions of even-odd numbered license plates in Shanghai and Beijing [9,116,117]. Moreover, some other EVs preferred policies are formulated and implemented by the government, which includes rights of driving an EV on bus lanes and EV drivers also have a privilege to own a parking space in order to conveniently park [47,72]. It is worth speculating that these EV preferential policy measures will arose interest in EVs and car owners will feel these policies more convenient to adopt EVs [86].

Local EV sales are strongly influenced by the benefits of license plate, and these benefits are different in various cities of China [112]. In Beijing, license plates of EVs are purchased based on lottery policy [116]. Each applicant can get the license plate, if and only if the numbers of applications are less than the upper limit [110]. In shanghai, every applicant revived the license plate freely [47]. Major cities of China have policy of purchase restriction for conventional vehicles. Therefore, license plate benefits can increase the EV sales substantially. Cities which did not realize the policy of purchase restriction should provide some other ways and introduce different benefits to increase EV sales and to protect the environment [9].

In China, the current practice to control the traffic congestion includes travel limitation of a vehicle at particular time as well as in specific region [118]. One of the major attractions for customers introduced by the government during early stage of EV promotion is the policy of no driving restriction or exemption of driving restriction, which increased the EV sales rapidly [73,117]. The EVs sales in major cities of China including Beijing and Shanghai verifies the great benefit of this major preferential policy. Therefore, this policy should be adopted by other cities to solve the major issues regarding urban environment [47,96].

The authors in study [119] realized in his research study that the advantages of above-mentioned EV preferential policies and vehicle-flow policies are more prominent in the major cities of China as compared to the other cities. In a survey-based study [110] conducted in Beijing, observed that the preferential policy measures for EVs and zero traffic restrictions for electric vehicles have substantial impact on the users' choice of adopting EVs. Adoption of EVs is associated with enjoying some traffic 'privileges' in comparison with internal combustion engine vehicle. The preferential policy mechanism is presented in Fig. 9.

Moreover, several economic studies assumed the rational behavior of consumers and revealed that lower prices and some added benefits can enhance the consumer intention to accept new products [119]. In essence, it is observed that preferential policies can be acknowledged as additional benefits as well as special paybacks to consumers [68,97]. Consequently, with increase in preferential policies, adoption intention can be up surged rapidly.

3.1.3. *Promotion policy of infrastructure development*

Complete charging infrastructures must be developed through infrastructural development policies by the government at various places of a city to promote the widespread adoption of EV [69,73,114,115]. The development of the charging infrastructure comprises of battery swapping stations (BSS) and facility of charging poles (CP) at various

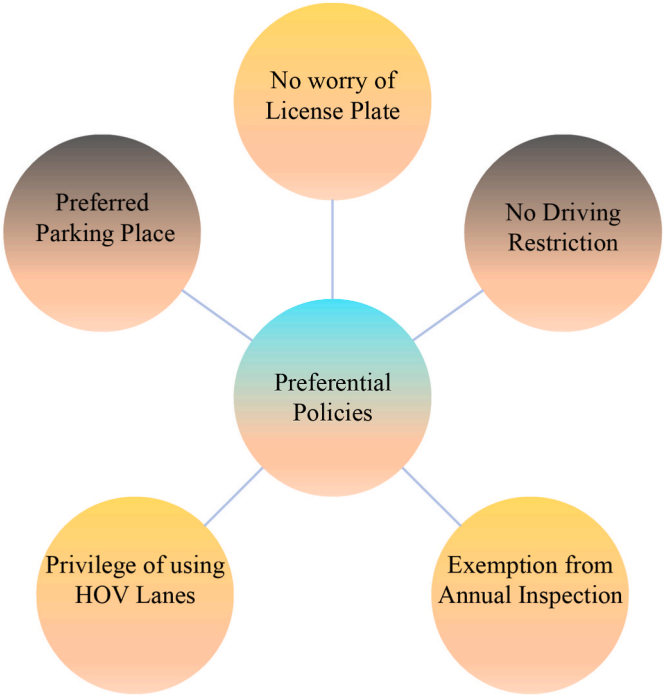

Fig. 9. Mechanism of EV preferential policy in China.

locations [41]. It also refers equipment required for EV charging including conductors and connectors [120]. Standardization of charging interface, pricing-based charging policies and infrastructure building plans are substantial subparts of infrastructure development policies [112]. The mechanism of EV infrastructural policy in China is shown in Fig. 10.

3.1.4. Mechanism of research and development policy

Many research institutions, companies and top universities are collaboratively working on various projects initiated by the Chinese government for the development and deployment of EVs [121]. The government of China has proposed a special R&D funding plan known as "863" projects [122]. The investment-based R&D policies emphasis on some significant sectors including EV platform for public support, the EV product and its essential components, the standardize charging technology and platform for grid charging. The standardize charging technology involves the process of EV charging through battery technology. The mechanism of EV research and development policy in China is shown in Fig. 11.

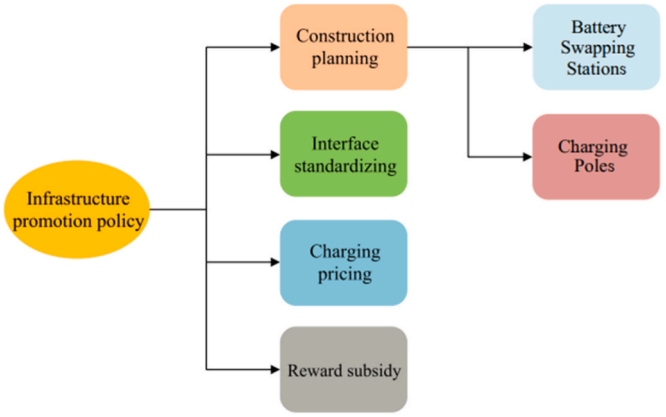

Fig. 10. Mechanism of EV infrastructural policy in China.

3.2. EV policy structure and its comparison

3.2.1. Policy structure

The overall structure of formulated EV policies in China is shown in Fig. 12. The macroscopic policies in the framework deal with collective policy measures, which are regulated by the Chinese government to achieve their specific goals for environmental safety and energy conservation. The demonstration policies highlight those measures which are expected to accelerate the acceptance and popularity of EVs for public influence and awareness. The framework explains that the major objective of subsidization and preferential policies is to provide pricing subsidies and tax exemptions in order to stimulate the adoption and consumer choice for EVs [110,123]. The objective of technical policies is to spread and flourish the EV innovative technology through collaboration with universities, relevant companies and research based institutions by government capital [78,124,125]. Additionally, the Chinese government published a number of significant policies linked to the administration of the EV and power battery industries in order to strengthen the industry's regulation. Infrastructural development policies intend to the formulation of infrastructure building plans, standardization of EV interface and charging price subsidy from utilities [60, 118].

The policies regarding EVs implemented in china are discussed in different research studies [126,127]. A life-cycle analysis is performed based on energy consumption and emission rate of EVs to make different recommendations regarding EV policies [126]. Significant uncertainties and difficulties, which prevent the needed deployment rate of EVs in China are well discussed in study by Ref. [127]. Relevant policies regarding social factors and financial incentives are thoroughly reviewed and analyzed to better understand the barriers of EV adoption.

3.2.2. Policy comparison

On comparing the EV policies of China with other countries that possess better and comprehensive policy regulations and more developed infrastructural mechanism, it can be found that the Chinese EV policy structure still holds room for further improvements [78,85,95]. Firstly, the current mechanism of Chinese EV policy including taxation and subsidies is more towards the EV consumers [112]. The manufacturer side is not getting any kind of privileges in China in comparison with other countries, where different other ways are introduced to encourage the production and reduced the cost of EVs [90]. Many support policies are formulated by the US government to encourage and assist the manufacturers. Secondly, during early stages, different countries including US, Japan, and Germany fix special kinds of funds for technology development (R &D) of EVs, and these countries are on the cutting edge as compared to China, [93,128,129]. Moreover, different kind of penalties are introduced by European union on vehicles with high carbon consumption [95]. Furthermore, different preferential policies are formulated by the Norwegian government during production stage as well as adoption stage (both for manufactures and consumers) [69]. These steps lead to enhance the EV adoption by making a tough beneficial competition between gasoline automobiles and EVs. Consequently, Chinese EV policy mechanism can be further improved for massive deployments of EVs as well as widespread EV consumer adoption.

4. Theoretical framework through Theory of Planned Behaviour

4.1. Review of theory of planned behavior

The basic mechanism which extensively defines the behavioral intention and the behavior is known as 'Theory of Planned behavior' (TPB) [83]. TPB is an extended version of Theory of Reasoned Action (TRA). The key factor for an appropriate measurement and prediction of technology diffusion behavior is based on consumer intention to purchase, as proven by various researcher [130]. Theory of Reasoned

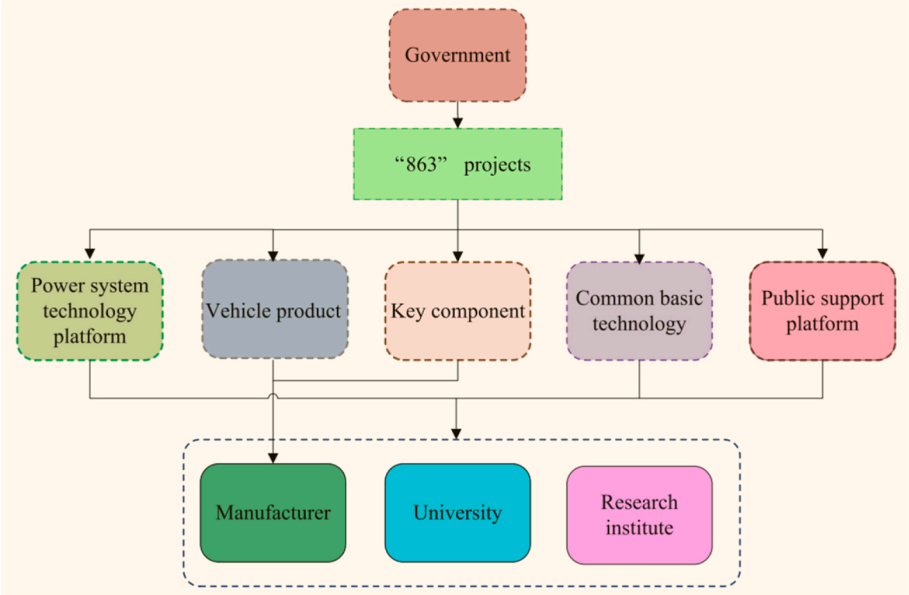

Fig. 11. Mechanism of EV research and development policy in China.

Fig. 12. Ev policies framework in China.

Action demonstrates the relationship between attitudes, beliefs, behaviors and intentions [131]. According to this theory, the intention of behavior is a function of two factors including subjective norm and the attitude towards the certain behavior. This theory works based on some assumptions which are: human beings have a rational behavior, and all the necessary and available information is used to make their final decision [132]. The actual behavioral intention is determined by attitudes of consumers towards a specific behavior. However, individually the attitude regarding certain product or its services do not determine the actual behavioral intention. Attitudes can have a positive or negative influence while performing a certain behavior. Therefore, favorable or unfavorable attitudes bring different results for making an intention. The influence of other people on the behavioral intention of an individual is referred as subjective norm. The people get influenced by the others whom they love including family members and peers. The actual behavior is determined by combining these two above-mentioned factors [131]. However, TRA has some constraints in its application as it eliminates such behaviors on which individual possess restricted willingness control. The weakness of this model is the assumption based on the individual control. Consequently, the model of TPB is formulated in

extension to theory of reasoned action to overcome its drawbacks by combining the actual behavioral control as well as perceived behavioral control [131].

The literature on EV consumer adoption related to TPB reveals that there are various added external factors, which influence EV purchase intention directly as well as indirectly [133]. The studies performed by Refs. [134,135] concluded that the EV purchase intention is affected by the attributes of EVs with major demographic factors. Furthermore, it is noteworthy to mention that these external factors are changed for different situations and are not applicable on other countries. Likewise, a number of internal factors have found influencing the one's attitude and individual purchase intentions, which includes self-identity, individual's efficacy, subjective norms as well as moral norms [134,136]. Additionally, researchers also realized that the conclusions drawn by various studies about the consumer responses towards policies incentives did not show a consistent trend. For instance, a study conducted by Ref. [97] concluded that the EV consumer adoption is positively influenced by governmental policies, financial privileges and charging infrastructure. On the other hand, the authors in Ref. [137] found that environmental concerns and the knowledge of renewable and sustainable energy can cast positive effects on EV purchase intention. The studies by Refs. [7,138] concluded that the individuals who possess positive concerns regarding environment are more inclined to adopt green vehicles. The study performed in Ref. [139] claimed that the individuals who adopt and the individuals who do not adopt holds different norms, attitudes as well as perceive innovative attributes differently. Another study conducted by Ref. [57] found that the EV adoption is triggered by increased gasoline price rather than policy incentives. The study by Ref. [140] proved through the mechanism of theory of planned behavior that the dedication of a particular area in a city would fasten the early-phase EV diffusion as compare to providing financial privileges only.

4.2. Constructs items of theory of planned behavior

The theory of planned behavior is majorly based on the assumption that intentions can directly predict the behavior [139]. According to the TPB, the major influential factors regarding behavioral intention of an individual includes attitudes and subjective norm as well as perceived behavioral control as suggested by studies [131,141]. The perceived behavioral control is added as an additional item in TPB to better explain the behavioral intentions. In order to understand the phenomena of why people choose or not choose EVs, TPB has been extensively adopted. TPB suggests that behavioral intention of an individual towards a specific behavior determines the individual's behavior. Therefore, TPB sustains a direct relationship between individual behavior and his/her behavioral intention. However, the intention is further combinedly influenced by one's attitudes, subjective norms and perceived behavioral control [131,141,142]. Subsequently, the behavioral intention is controlled and measured by consumer's attitude, his subjective norm as well as his perceived behavioral control.

The perceived behavioral control describes an intensity of difficulty or ease, which consumers perceived when the factors, which effect the behavioral performance are examined. In China, there are several provisions as well as external barriers, which greatly influence the purchasing intention of consumers that whether they should adopt EVs or not as discussed in other sections of the thesis as well. Availability of charging infrastructure at convenient places and government incentives are major influencing factors, which make the final decision of adoption. The behavioral intention to adopt EV or not is well investigated by TPB in comparison with TRA, which make it more beneficial theory in order to understand the behavioral intentions. Subjective norms and attitudes are also the part of TPB. The main framework of TPB with its construct's items and their relationship are presented in Fig. 13 [97,142]. The construct items including attitude, SN, and PBC can influence directly to each other through the intention. However, an indirect influence is observed on the behavior by attitude, SN and PBC. Moreover, a direct influence is also observed on the behavior by PBC as illustrated by the dotted arrow.

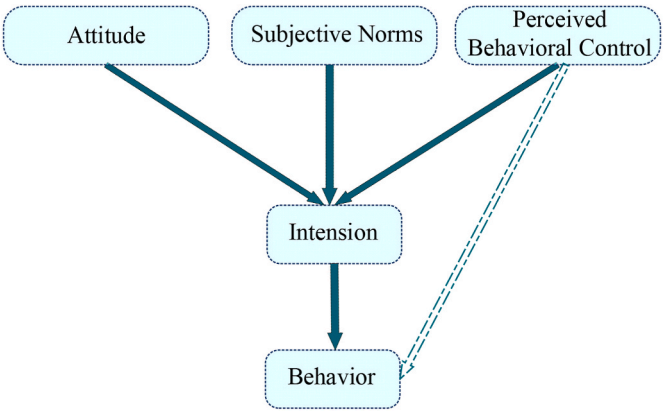

Fig. 13. Constructs items of TPB

Attitude: The attitude is described as a psychological emotion of an individual. It is actually an assessment that can either be positive or negative when a human being is engaged in a particular behavior. According to the mechanism of TPB, attitude can be measured by the feelings of a person, which are based on the assessment of benefits or disadvantages related to a specific behavior. The assessment can be favorable or unfavorable for performing a specific behavior [77]. The attitude has a direct relationship with the behavioral intention. More positive behavioral intention is observed when the attitude is more positive.

Subjective Norm: The subjective norm is described by the extent by which a person bears a social pressure to perform a specific behavior. The social pressure forces an individual to do or not to do a certain behavior. According to this point, the perception of an individual affected from external factors greatly influence the behavior of a person. In addition, the perceived beliefs of important people around the person are described as subjective norms. These significant people include peers and family members, and they can have a great impact on the final decision of an individual. The social pressure inserted by the group of those significant people on the feelings of an individual also reflects the features of subjective norms. The purchasing behavior of an individual is greatly influenced by the friends, neighbors and family member [143]. Finally, when examining the relationship among subjective norms of the people and the behavioral intention, most of the research studies verified that subjective norms have a direct influence on behavioral intention [77]. Therefore, strong intention to perform a certain behavior is observed, when people have more positive SNs.

Perceived Behavioral control: The third main construct item of TPB is perceived behavioral control. PBC actually indicates the potential difficulties perceived by an individual while performing a certain behavior [131]. Whether or not an individual is able to consume a product with ease is measured by PBC. PBC mainly relies on the importance of cost and benefits involved in a process of executing a certain behavior, which include financial burden, time and total effort required in performing the particular behavior. These irrational factors might not easily control by the individual, therefore, if the resources and opportunities are properly controlled by an individual, more ease will be observed in performing that particular behavior. Hence, the construct items of TPB model including attitude, SNs, and PBC combinedly measure the behavioral intention of an individual.

4.3. TPB extension for framework development

Previous studies as explained in the literature section suggest that TPB model is adequately open for the explanations and prediction of

additional and new constructs. It is observed that even though the model of TPB greatly helps to describe the behavioral intentions, however, research studies verified that the model of TPB can be improved and extended with the addition of more construct items. It ultimately reveals the illustrative power of the theory behind the TPB model. In this study, the model of TPB is extended with three additional construct items including financial policies, preferential policies and consumer adoption. Financial as well as preferential policies have a substantial influence in shaping the attitude of consumers. Therefore, attitude with its two influential construct items combinedly with subjective norms and perceived behavioral control contribute in making the behavioral intention of consumers to adopt EVs. The variable of consumer adoption examines the intention of consumer towards actual adoption of EVs. The behavioral intention and actual adoption are different. The behavioral intention is described as the intention of an individual to perform a certain behavior, on the other hand, the action of adoption refers to actual adoption. The behavioral intention and actual adoption are associated with each other, therefore, the attitude based on financial and preferential policies impacts the actual adoption. Furthermore, the behavioral intention helps to explore the actual adoption of EVs [7].

4.4. Research framework development through extended version of TPB

The aim of social science and psychology studies is to demonstrate and predict the existence of different behavioral patterns by constructing theories and models. To carry out an empirical analysis for the impact assessment on EV purchase intension, there is a need of a systematical approach. Theory of planned behavior has been employed for years to conduct the research for predicting behaviors on EV purchase. Additionally, the classical TPB model is adequately open for further explanations and prediction of additional and new constructs. In this research, the TPB model will be extended by measuring the effect of policy measures on the intention to adopt environmentally friendly vehicles. TPB suggests that the actual behavior or the actual adoption is determined by the attitudes, subjective norm, perceived behavioral control as well as behavioral intention and discussion on these TPB attributes are discussed below.

I. **Attitude** of a person reflects the evaluation of favorable or unfavorable outcomes of a certain behavior. Previous researches have used environmental concerns as part of attitude [59]. However, in this paper the financial policy incentives and the preferential policies are chosen as the most important and relevant factors which shapes the attitude of an individual. Financial privileges is always an essential factor that positively affect the consumer purchase intention [141]. Financial policy incentives includes tax exemption on purchase, tax exemption on vehicle and vessel are most famous incentives in order to promote the purchase of EVs in China [141]. The major preferential policies have significant attractions such as preferred parking place or free parking, expedite process of getting license plate and opportunity to use high occupancy vehicle (HOV) lanes [9].
II. **Subjective norm:** It is related to decision making capability under situation of social pressure to carry out or refrain from considering a particular behavior. Some researchers believed that technology of renewable energy can have social acceptance with support of policy privileges and market attractions [144].
III. **Perceived behavioral control:** PBC has two significant factors including perceived efficacy of an individual and capability of controlled behavior. TPB recommends that control factors which leads to encourage awareness refers to perceived behavioral control [97].
IV. **Behavioral intention:** This refers to intermittent willingness of a person to take a particular behavior. The study conducted in Ref. [145] claimed about TPB that both actual behavior and the behavioral intention holds same factors; even though behavioral intention is generally better forecasted in comparison with actual behavior. Furthermore, the study in Ref. [131] analyzed that behavioral intention directly measure the actual behavior, which is assumed to be the most truthful behavior prediction. This shows that the behavioral intention is more powerfully linked with the constructs as compared to the actual adoption. In study [146], it is concluded that it is slightly difficult to measure the rate of actual adoption. Since, the EV market in China is still growing and many people are making their minds to adopt EVs. Therefore, this research will firstly cover the measurement of behavioral intention, and afterwards the correlation between behavioral intention and actual adoption is examined. According to the study [147], attitude is the main evaluating variable for a particular behavior which can define the positive or negative influence on actual adoption behavior towards EV consumer adoption.
V. **Consumer Adoption:** The variable of consumer adoption examines the intention of consumer towards actual adoption of EVs. The behavioral intention and actual adoption are different. The behavioral intention is described as the intention of an individual to perform a certain behavior, on the other hand, the action of adoption refers to actual adoption. The behavioral intention and actual adoption are associated with each other, therefore, the attitude based on financial and preferential policies impacts the actual adoption. Furthermore, the behavioral intention helps to explore the actual adoption of EVs [7].

4.4.1. Hypothetical Relationship

According to the TPB, the major influential factors regarding behavioral intention of an individual includes attitudes and subjective norm as well as perceived behavioral control as suggested by studies [131,141]. TPB suggests that behavioral intention of an individual towards a specific behavior determines the individual's behavior. Therefore, TPB sustains a direct relationship between individual behavior and his/her behavioral intention. However, the intention is further combinedly influenced by one's attitudes, subjective norms and perceived behavioral control [131,141,142]. Subsequently, the behavioral intention is controlled and measured by consumer's attitude, his subjective norm as well as his perceived behavioral control. The model of TPB is extended with three additional construct items including financial policies, preferential policies and consumer adoption. Financial as well as preferential policies have a substantial influence in shaping the attitude of consumers. Therefore, attitude with its two influential construct items combinedly with subjective norms and perceived behavioral control contribute in making the behavioral intention of consumers to adopt EVs. The behavioral intention and actual adoption are different. The behavioral intention is described as the intention of an individual to perform a certain behavior, on the other hand, the action of adoption refers to actual adoption. The behavioral intention and actual adoption are associated with each other, therefore, the attitude based on financial and preferential policies impacts the actual adoption. Considering the foregoing discussion, the following hypothesis are presented.

H1a. Financial policy incentives will have a substantial effect on attitudes toward EV purchase intention.

H1b. Preferential policy incentives will have a substantial effect on attitude towards EV purchase intention.

H2. Individual's attitude is positively related with purchasing intention to adopt EVs.

H3. Individual's subjective norm is positively related with purchasing intention to adopt EVs.

H4. Individual's perceived behavioral control is positively related with purchasing intention to adopt EVs.

H5. Individual's behavioral intention have positive influence on EV consumer adoption.

Hypothetical relationship based on extended version of TPB attributes is illustrated in Fig. 14.

4.5. Questionnaire development

In order to test the hypothetical relationships of our proposed model based on theory of planned behavior, a structured questionnaire is developed through the extensive literature. The survey questionnaire is basically consisting of two main parts. The demographic information such as age, gender, household income, occupation, education and number of vehicles owned by the family is included in the first part of the survey questionnaire. The questions based on the constructs items of extended theory of TPB including financial and preferential policies, attitudes, subjective norms, intentions and consumer adoption are included in the second part of the questionnaire.

Participants: The questionnaire used to conduct this research study is randomly distributed among three communities including local community, research community, and business community of Shanghai city. The reasons to focus all three communities is to obtain responses from diverse demographics of Shanghai city. Moreover, each community has different approach towards green electric vehicles and governmental support to adopt EVs.

4.5.1. Data collection for case study

Data responses were obtained from Shanghai respondents during 20th September to December 20, 2022. The people of Shanghai were requested to voluntarily complete the questionnaire. At the start of the questionnaire, the time required to complete this survey and the main objective to conduct this research study were mentioned to the participants. The data collection was completed by using two mediums, which include online response collection and offline data collection. During the above-mentioned time, the link generated to complete the online survey was sent to five hundred people, whereas hundred questionnaire copies were distributed by hand. Out of 500 people, 350 people solved the online questionnaire with 70 % response rate. After examination, 223 valid responses were obtained from online data collection with valid response rate of 63.7 %. On the other hand, 91 valid responses were screened based on their completeness from offline data collection with 91 % valid response rate. Therefore, in total out of 600 questionnaire distribution through both online and offline medium, 314 useful and valid responses were used for data analysis with 52 % total useable response rate.

The demographic variables used for this research with their descriptive statistics are presented in Table 2. From the descriptive profile of the respondents as mentioned in Tables 2 and it is verified that the sample size used for this research study has good representation by covering a wide range, therefore, it is useful for further assessment. From the demographic information, it is observed that more than half of the respondents are male (56.1 %) and remaining respondents (43.9 %) are female. About 81 % respondents have age in between twenty and forty (20–40). Most of the respondents have higher education with 49.7 % holding a master's degree. Household income between ¥10,000-¥15,000 is observed for 38.7 % of the respondents. 53.2 % of the total respondents owned a vehicle. According to the report prepared by Ministry of Industry and Information Technology (MIIT) [148], it is described that citizens of china as owners of vehicle have an age in between 25 and 40 with proportion up to 55 %. The gender composition is such that males are around 58 % and females up to 42 %. Car owners with bachelor's degree or above have a percentage of 52.3 % and ¥5000-¥8000 monthly income is observed for car owners with percentage up to 33.1 %. Therefore, in this research study, the demographic

Table 2
Demographic profile of respondents.

Variable	Category	Frequency (314)	Percentage (100)
Age	Under 20	4	1.3 %
	20–30	106	33.8 %
	31–40	150	47.8 %
	41–50	38	12.1 %
	51 or above	16	5.1 %
Gender	Male	176	56.1 %
	Female	138	43.9 %
Occupation	Government Sector	30	9.6 %
	Public Institution	87	27.7 %
	Private Sector	129	41.1 %
	Self-Employed	32	10.2 %
	Others	36	11.5 %
Education	Primary School or Below	2	0.6 %
	Junior High School	4	1.3 %
	Senior High School	4	1.3 %
	Junior College	18	5.7 %
	Bachelor's Degree	86	27.4 %
	Master's Degree	156	49.7 %
	Doctoral Degree/ PHD	44	14.0 %
Monthly house hold income	Less than 5000 Yuans	15	4.8 %
	¥5000-¥10,000	99	31.5 %
	¥10,000-¥15,000	120	38.2 %
	¥15,000-¥20,000	38	12.1 %
	Above ¥20,000	42	13.4 %
Number of vehicles owned by the family	0	83	26.4 %
	1	167	53.2 %
	2	52	16.6 %

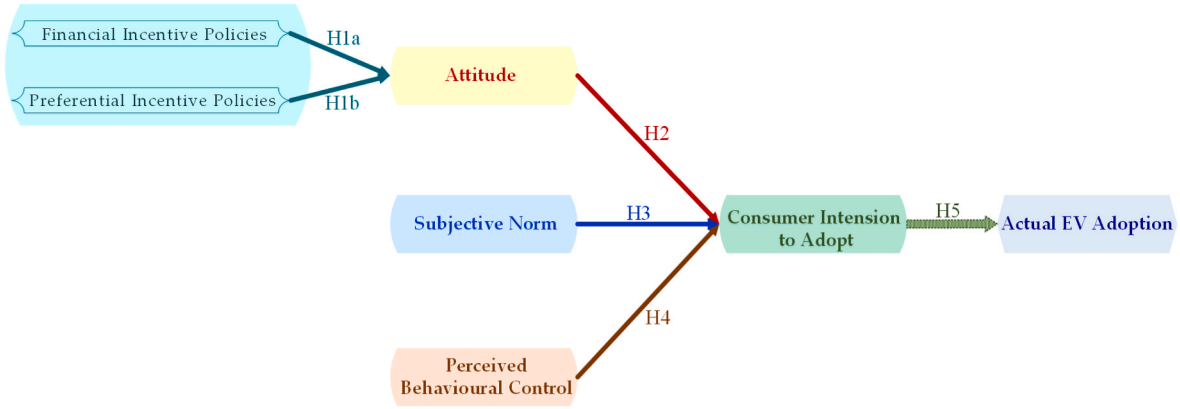

Fig. 14. Extended TPB model with hypothetical relationship.

profile of the respondents as mentioned in Table 2 is nearly consistent with the demographic profile of current Chinese owners of vehicles.

4.5.2. Constructs with measurement items

The questionnaire survey used to test the hypothetical relationship is initially developed in English language. It is broadly acknowledged by the research community that significant effect on the response of the people is observed even with the minute change in the wording of questionnaire items. Consequently, some assistance is taken from Chinese professionals who are also good in English language to develop the Chinese version of the English questionnaire. Afterwards, Chinese version of the questionnaire is translated into English to verify that it is free from any semantic discrepancy. Later, the final version of the questionnaire in Chinese language is used to collect data from respondents.

Likert Scale: Except for demographic items, the process of measurement for questionnaire items is based on 7-point Likert scale. The seven responses of the Likert scale are: 'Strongly disagree', 'disagree', 'Slightly disagree', 'neutral', 'Slightly agree', 'agree', and 'Strongly agree'. The Likert scale is selected as from 1 to be "Strongly Disagree" and 7 to be "Strongly Agree". Higher degree of agreement with measurement/questionnaire item is observed from the respondent, if the response of the respondent moves from five to seven.

Measurement items: The measurement items based on TPB variables including attitudes, SNs, and PBC are revised based on this study requirements [7,97,101]. The response of the respondents in terms of theirs attitudes, subjective norms and perceived behavioral control towards intention to adopt EVs is measured according to the extent of agreement from 1 to 7 Likert scale. The survey questionnaire is comprised of thirty-seven questions with first six questions correspond to demographics and other thirty-one measurement items (7–37) are used to explore the respondent's intention to adopt EVs based on financial and preferential policies. The measurement items are carefully selected and adopted from the previous studies which are relevant to our research model. Many countries have designed a set of policies (financial and preferential) for extensive EV consumer adoption. We have selected those significant policies that are most common in many countries as well as in China.

The distribution of thirty-one questions are performed as: attitudes (3-measurement items), subjective norms (6-measurement items), perceived behavioral control (4-measurement items), intention (5-measurement items), financial policies (5-measurement items), preferential policies (4-measurement items), and adoption (4-measurement items). The constructs and measurement items with detailed statements and their sources for exploring consumer intention to adopt EVs are presented in Table 3.

Table 3
Constructs with measurement items.

Constructs	Item No.	Measurement Items	Source
Attitude	3	➢ In the long-term, I think buying an EV is more cost-effective than owning a conventional vehicle ➢ I think buying an EV is a good decision ➢ I think an EV offers more advantages to our society than a car with a combustion engine	[134]
Subjective Norm	6	➢ I think people around me thought that I should adopt an EV in the near future ➢ I think if I purchase an EV, then most people who are important to me would also buy an EV. ➢ I think people's opinion I value the most when I make my decision to adopt EV near future ➢ Most people who are important to me would like to own an EV themselves ➢ Most people who are important to me would be glad to see me in an EV ➢ Government encourages people to purchase EV	[149, 150], [7]
Perceived Behavioral Control	4	➢ I think the price of EV is important to me and I can afford it when I decide to adopt ➢ I am confident that it is easy to repair EV when it does not work ➢ I think I can find where to buy EV if I wanted to buy ➢ I am confident that it is easy to maintain and operate an EV	[134, 150], [7]
Intention	5	➢ I intent to purchase EV car because it has lower price than conventional car ➢ I intent to purchase EV over the conventional car because I feel the product quality of EV is better ➢ I intent to purchase EV car, because I will play a great part in helping the environment when I drive EV. ➢ I intend to purchase EV because I feel more comfortable driving an EV rather than a conventional car. ➢ Overall, I intend to buy EV in near future	[7,138]
Financial Policies	5	➢ I know well about the financial subsidy policy for purchasing an EV ➢ I know well about the Tax exemption policy for purchasing an EV ➢ Exemption from road tolling is valuable to me to adopt an EV ➢ Exemption from value added tax is useful to me to adopt an EV ➢ In the process of buying a car before, I heard about relevant government incentive policy for EV	[97, 101]
Preferential Policies	4	➢ To purchase an EV has no worry of even license plate rule ➢ To purchase an EV has no worry about parking because of free Parking or preferred parking place ➢ To purchase an EV has the privilege of using High Occupancy Vehicle Lanes ➢ EVs are not required to line up when conducting the vehicle annual inspection is attractive to me to adopt an EV	[97, 101]
Adoption	4	➢ I believe that innovation gives more control over my daily life ➢ I believe that the adoption of EV makes my life easier	[7]

(continued on next page)

5. Data analysis and results

In this section, the collected responses of participates obtained from online and offline survey are examined effectively by analyzing the whole data. Initially, the suitability of original items is measured by IBMM SPSS tool. Afterwards, the confirmatory factor analysis (CFA) and structural equation modelling are performed in AMOS for the assessment of survey findings. The main purpose of the data analysis is to verify the hypothesis used for the research study.

5.1. Descriptive analysis and structure equation modelling

5.1.1. Descriptive statistics

The descriptive statistics of all the measurement items including mean, mode, minimum and maximum response score of each construct, and their standard deviations are presented in Table 4.

5.1.2. Structural equation modelling

For the purpose of analyzing data in social science studies, the

Table 3 (*continued*)

Constructs	Item No.	Measurement Items	Source
		➢ I am enjoying to figured out how to use EV ➢ I feel like I am overly dependent on EV	

Structural Equation Modelling (SEM) is extensively adopted method based on its several benefits. The relationship between observable and unobserved variables is computed by implementing the SEM [151]. In SEM, different observable indicators are used to compute latent/unobserved variable. The extent of fitting is also computed with different indicators by performing SEM. Statistically, SEM combines multiple sequential models in one platform. Generally, the SEM is comprised of two sub-models: 1) Measurement Model, 2) Structural Model [13]. SEM is flexibly suitable for conducting both type of research methods including inductive and deductive, which can be used for confirmation of theory [152].

In measurement model, latent variables are defined by utilizing one or more observable constructs. On the other hand, in structural model, the relationship among latent variables is computed [13]. Structural modelling often discussed as path analysis. With combination of CFA and path analysis, better data analysis is observed in SEM for quantitative studies [13]. In this research, SEM accuracy is estimated by using the maximum likelihood estimation.

In this study, two stage process is implemented to perform the data analysis through SEM, and statistical software AMOS 23.0 is used to examine that whether the fitting model of the collected data is in accordance with proposed theoretical framework. Firstly, the adequacy and quality of the measurement model is examined by conducting the confirmatory factor analysis (CFA). In this process, the evaluation factors of the construct items are ensured through construct reliability and construct validity. The construct reliability includes Cronbach Alphas and composite reliability. On the other hand, the construct validity includes the convergent validity, and discriminant validity. Secondly, the hypothesis relationship between the construct items of extended theory of planned behavior is verified by implementing SEM. Afterwards, the impact of financial and preferential policies is quantified to analyze the consumer intention to adopt EVs.

5.2. Measurement model

Firstly, the original items must be judged whether they are suitable or not to perform the factor analysis. In order to confirm that if the variable is appropriate or not for the analysis, statistical tests are provided by the SPSS tool (Statistical software package). In this study, SPSS v23.0 is used to perform the Kaiser-Mayer-Olkin (KMO) and Bartlett Sphericity test. The obtained value of KMO test was 0.902, which is higher than the standard criteria of KMO (value of KMO >0.7). The significant value of P was 0 in case of Bartlett Sphericity test. Therefore, the original items are appropriate for factor analysis as suggested by the abovementioned tests. The test values are presented in Table 5.

The adequacy, quality, validity and reliability of construct items of the measurement model is examined by conducting the confirmatory factor analysis (CFA). The evolution factors based on validity and reliability are examined before testing and verifying the research hypothesis. Firstly, the factor loading of all the construct items is examined, and the value of loading must be higher than the bench mark value of 0.7. The construct item must be dropped, if the value is less than the bench mark value [153]. Afterwards, construct reliability and construct validity are analyzed.

5.2.1. Construct reliability

The internal consistency of measurement indicators for each

Table 4
Descriptive statistics of measurement items.

Questions/Measurement Items	Mean	Mode	SD	Min	Max
7. **In the long-term, I think buying an EV is more cost-effective than owning a conventional vehicle**	5.27	6	1.560	1	7
8. **I think buying an EV is a good decision**	5.24	6	1.444	1	7
9. **I think an EV offers more advantages to our society than a car with a combustion engine**	5.37	6	1.457	1	7
10. **I think people around me thought that I should adopt an EV in the near future**	4.49	5	1.621	1	7
11. **I think if I purchase an EV, then most people who are important to me would also buy an EV.**	4.26	5	1.358	1	7
12. **I think people's opinion I value the most when I make my decision to adopt EV near future**	4.85	6	1.480	1	7
13. **Most people who are important to me would like to own an EV themselves**	3.56	4	1.341	1	7
14. **Most people who are important to me would be glad to see me in an EV**	4.10	4	1.290	1	7
15. **Government encourages people to purchase EV**	5.96	6	1.015	1	7
16. **I think the price of EV is important to me and I can afford it when I decide to adopt**	5.50	6	1.362	1	7
17. **I am confident that it is easy to repair EV when it does not work**	4.13	5	1.561	1	7
18. **I think I can find where to buy EV if I wanted to buy**	5.83	6	1.081	2	7
19. **I am confident that it is easy to maintain and operate an EV**	4.51	5	1.387	1	7
20. **I intent to purchase EV car because it has lower price than conventional car**	4.35	6	1.741	1	7
21. **I intent to purchase EV over the conventional car because I feel the product quality of EV is better**	3.71	4	1.544	1	7
22. **I intent to purchase EV car, because I will play a great part in helping the environment when I drive EV.**	5.43	6	1.438	1	7
23. **I intend to purchase EV because I feel more comfortable driving an EV rather than a conventional car.**	4.23	5	1.439	1	7
24. **Overall, I intend to buy EV in near future**	4.54	6	1.570	1	7
25. **I know well about the financial subsidy policy for purchasing an EV**	4.23	5	1.508	1	7
26. **I know well about the Tax exemption policy for purchasing an EV**	4.29	5	1.572	1	7
27. **Exemption from road tolling is valuable to me to adopt an EV**	4.08	5	1.502	1	7
28. **Exemption from value added tax is useful to me to adopt an EV**	4.31	5	1.465	1	7
29. **In the process of buying a car before, I heard about relevant government incentive policy for EV**	5.11	6	1.358	1	7
30. **To purchase an EV has no worry of even license plate rule**	5.75	6	1.337	1	7
31. **To purchase an EV has no worry about parking because of free Parking or preferred parking place**	4.21	5	1.709	1	7
32. **To purchase an EV has the privilege of using High Occupancy Vehicle Lanes**	3.92	5	1.657	1	7
33. **EVs are not required to line up when conducting the vehicle annual inspection is attractive to me to adopt an EV**	3.80	4	1.728	1	7

(*continued on next page*)

Table 4 (*continued*)

Questions/Measurement Items	Mean	Mode	SD	Min	Max
34. **I believe that innovation gives more control over my daily life**	6.04	6	1.066	1	7
35. **I believe that the adoption of EV makes my life easier**	5.13	6	1.500	1	7
36. **I am enjoying to figured out how to use EV**	5.58	6	1.302	1	7
37. **I feel like I am overly dependent on EV**	4.29	5	1.529	1	7

Table 5
Kaiser Meyer Olkin (KMO) value and Bartlett's test.

Measured Item	Values	Standard
KMO	0.902	Greater than 0.7
Approx. Chi Square	3329.347	–
Bartlett's Test: Df	275	–
Sig (p)	0.000	P < 0.001

construct is measured through construct reliability. The values of Cronbach's Alphas and composite reliability are always used to examine construct reliability of measurement items [154]. **Cronbach's Alphas**: It reflects that to what extent items in a group are closely related to each other, which shows the internal consistency. **Composite reliability**: It describes to what extent the items in a group are presenting the unobserved variable [154]. The value of Cronbach's Alphas and composite reliability should be greater than the benchmark value of 0.7 [152,153,155].

5.2.2. Construct validity

It describes the degree of measurement scale, which exactly indicate and explain the constructs under examination [156]. Convergent validity and discriminant validity are used to analyze the construct validity. **Convergent validity**: It explains the extent by which two or more measurement items associated with the construct, which possess the theoretical relationship with each other. The convergent validity is measured by the value of Average variance extracted (AVE).

Average variance extracted: It determines the amount of variance, which is obtained by the constructs in relevance with the amount of variance because of measurement error [154]. The criteria to analyze the convergent validity is that the value of AVE should exceed the standard value of 0.5 i.e. AVE>0.5 [154]. **Discriminant validity:** It measures the extent by which the items are differentiated among the construct. The discriminant validity is measured by analyzing the correlation between constructs and the square root of AVEs. According to the benchmark, the correlation between constructs must be less than the square root of AVEs [154,157].

The results of confirmatory factor analysis, which include validity and reliability of constructs are presented in Tables 6–8. In Table 6, the values of Cronbach's Alphas for all constructs is greater than the standard value of 0.7. Similarly, the values of composite reliability are exceeding the benchmark value in Table 7. The evaluation factors of construct reliability follow the benchmark criteria. Therefore, these factors support in reliability of the measurement model. In Table 7, the range of AVE scores exceed the standard value of 0.5, which verifies the convergent validity. In the same way, the correlation between constructs is less than the square root of AVEs, which ensures the discriminant validity as mentioned in Table 8. The evaluation factors of construct validity meet the benchmark criteria. Therefore, these factors support in construct validity of the measurement model.

In conclusion, results obtained from measurement model ensure the reliability and validity of proposed model. Subsequently, in this research, extremely reliable and valid constructs are used.

5.3. Structural model

In the structural model, multicollinearity, model fitness, and path analysis also referred as hypothesis testing are observed**.**

5.3.1. Multicollinearity

In data analysis, multivariate assumptions of multicollinearity are also measured. Multicollinearity perhaps not a major issue because lower values of correlations between constructs are observed as shown in off-diagonal items of Table 8. Moreover, the collinearity tests based on values of variance inflation factors (VIFs) are performed. The obtained results reveal that the value of VIF is smaller than 10, and the value of tolerance is greater than 0.1, which confirms no multicollinearity [152].

5.3.2. Model fitness

To check the model fitness, several evaluating indicators can be observed to examine the extent of fitting for proposed model. Generally, three fit measures are used, which further have various evaluating indicators to assess the model fitness. The three fit measures are: 1) Absolute fit measures, 2) Incremental fit measures and 3) Parsimonious fit measures [152,153,155,158,159].

Absolute fit measures: These measures include the four evaluating indicators, which are: goodness-of-fit (GFI), adjusted goodness-of-fit (AGFI), root mean square residual (RMR), and root mean square error of approximation (RMSEA). The benchmark values of these evaluating indicators are: GFI≥0.9, AGFI≥0.9, RMR <0.5, and RMSEA <0.1.

Incremental fit measures: Similarly, these measures also include four evaluating indicators, which are: normalized fit index (NFI), comparative fit index (CFI), incremental fit index (IFI), and relative fit index (RFI). The benchmark values of these evaluating indicators are: NFI≥ 0.9, RFI≥ 0.9, CFI≥ 0.9, and IFI≥ 0.9.

Parsimonious fit measures: The assessment factors for these measures are: parsimony goodness-of-fit (PGFI), parsimony normal fit index (PNFI), parsimony comparative fit index (PCFI), and CMIN/DF. The benchmark values of PGFI, PNFI, and PCFI is greater than 0.5. The value of CMIN/DF lies between 1 and 3 [97].In addition, **Tucker Lewis Index** (TLI) is also observed to assess model fitness, which has the standard criteria as: TLI≥0.9 [134].

In AMOS, after giving the data into the model, the obtained results for model fitness are shown in Table 9. The obtained results reveal that all the evaluating indicators including RMSEA, CFI, TLI, GFI, NFI, RMR, PGFI, PNFI, CMIN/Df fulfill the standard criteria, which indicates that adaptability measure of the overall model meet the benchmark values, and proposed model has good external quality.

In conclusion, it is summarized that theoretical framework adopted to conduct this research work holds the fitness criteria and corresponds with the actual survey data, therefore, the external quality of the proposed model is quite high.

Table 6
[a]Reliability Test based on Cronbach's Alphas.

Measured Item	Attitude	SNs	PBC	FP	PP	Intention	Adoption	Total Items	Standard Criteria
Cronbach's Alpha	0.907	0.873	0.812	0.864	0.849	0.921	0.867	0.926	**>0.7**

[a] (SN, PBC, FP, and PP are subjective norms, perceived behavioral control, financial policies, and preferential policies respectively.).

Table 7
Results for composite reliability and convergent validity of measured model.

Constructs	Item Numbers	Factor Loadings	Composite Reliability (CR)	Average Variance Extracted (AVE)	Standard Criteria
Attitude	AT1	0.83	0.885	0.765	• Factor Loading >0.7 • Composite Reliability >0.7 • AVE >0.5
	AT2	0.91			
	AT3	0.75			
Subjective Norm	SN1	0.77	0.802	0.675	
	SN2	0.78			
	SN3	0.70			
	SN4	0.84			
	SN5	0.82			
	SN6	0.71			
Perceived Behavioral Control	PBC1	0.71	0.845	0.713	
	PBC2	0.82			
	PBC3	0.85			
	PBC4	0.86			
Intention	IN1	0.83	0.912	0.801	
	IN2	0.87			
	IN3	0.77			
	IN4	0.73			
	IN5	0.86			
Financial Policies	FP1	0.80	0.819	0.776	
	FP2	0.96			
	FP3	0.75			
	FP4	0.72			
	FP5	0.81			
Preferential Policies	PP1	0.83	0.896	0.798	
	PP2	0.86			
	PP3	0.88			
	PP4	0.84			
Adoption	AD1	0.79	0.924	0.805	
	AD2	0.82			
	AD3	0.85			
	AD4	0.89			

Table 8
[a]Results for discriminant validity measured model.

Constructs	Mean	SD	FP	PP	AT	SN	PBC	IN	AD
FinPolicies	4.26	1.12	**0.893**						
PrePolicies	4.18	1.40	0.239	**0.885**					
Attitude	5.23	1.23	0.145	0.214	**0.874**				
SubNorm	4.06	1.15	0.262	0.351	0.479	**0.821**			
PreBehCon	4.40	1.21	0.277	0.312	0.375	0.422	**0.844**		
Intention	5.27	1.18	0.307	0.337	0.385	0.401	0.423	**0.894**	
Adoption	4.45	1.27	0.187	0.234	0.255	0.287	0.352	0.411	**0.897**

[a] (The square root of AVEs is presented in the diagonal bold items, whereas, correlation between the constructs are illustrated in off-diagonal elements.).

Table 9
Results for discriminant validity measured model.

	Indicators	Standard Criteria	Obtained Results	Opinion
Absolute Fit Measures	X^2	P > 0.05	0.187	**Yes**
	GFI	≥0.9	0.918	**Yes**
	AGFI	≥0.9	0.894	**Approaching**
	RMR	<0.5	0.026	**Yes**
	RMSEA	<0.1	0.081	**Yes**
Incremental Fit Measures	NFI	≥0.9	0.929	**Yes**
	CFI	≥0.9	0.955	**Yes**
	IFI	≥0.9	0.936	**Yes**
	RFI	≥0.9	0.898	**Approaching**
Parsimonious Fit Measures	PGFI	>0.5	0.637	**Yes**
	PNFI	>0.5	0.666	**Yes**
	PCFI	>0.5	0.718	**Yes**
	CMIN/DF	<3	2.7	**Yes**
Tucker Lewis Index	TLI	≥0.9	0.901	**Yes**

5.3.3. Path analysis

In this study, structural equation modelling is used to examine the impacts of financial and preferential policies on consumer intention to adopt EVs. Each variable has a certain extent of influence, which can be analyzed by significance of related path coefficient. The statistics of hypothesized structural model are presented in Table 10. The obtained results reveal that all the variables in proposed model of extended theory of planned behavior are significantly and positively related to each other as shown in Table 10. The results obtained from SEM validate the correctness of all the proposed hypothesis **H1a**, **H1b**, **H2**, **H3**, **H4**, **and H5**. The significance **(P)** and beta **(β)** values provide support for all the hypothesis for this research study. The beta and p values of hypothesis **H1a**, **H1b** confirms that financial and preferential policies have a substantial effect in shaping the attitude towards consumer's intention to adopt EVs. In the same way, the hypothesis based on basic constructs of TPB including attitude, subjective norm, and perceived behavioral control **(H2, H3, H4)** are verified and have a positive relation towards consumer intention. Moreover, the hypothesis **H5** validates that

Table 10
[a]: Statistics of hypothesized structural model.

Hypothesis	Hypothesized Path	Beta (β)	Significance (P)	St. Error	t-value	Test Results
H1a	FinPolicies → Attitude	0.298	[b]	0.029	5.87	**Supported**
H1b	PrePolicies → Attitude	0.381	[b]	0.046	9.18	**Supported**
H2	Attitude → Intention	0.809	[b]	0.084	16.162	**Supported**
H3	SubNorm → Intention	0.612	[b]	0.087	13.370	**Supported**
H4	PreBehCon → Intention	0.193	[b]	0.031	4.146	**Supported**
H5	Intention → Adoption	0.498	[b]	0.019	18.452	**Supported**

[a] Note.
[b] $P < 0.001$.

behavioral intention of consumers have substantial positive influence on consumer EV adoption.

According to the research conducted by Ref. [160], the authors recommended that the structural model should be assessed with significance P, beta values as well as values of R^2 and corresponding t-values. The significance P and beta values are presented in Table 10, which meet the standard criteria and validates the proposed hypothesis. Bootstrapping process with 5000 bootstrap samples is performed to get the t-values and values of R^2. Corresponding t-values and values of R^2 are illustrated in Table 10, and Table 11. According to Ref. [160], the corresponding recommended measures of R^2 with value of 0.67 is considered to be substantial, 0.33 to be moderate, and 0.19 to be weak. The results obtained for corresponding t-values and R^2 values meet the benchmark criteria according to the studies conducted by Refs. [160, 161] as mentioned in Table 11. The structural model implemented in AMOS 23.0 is presented in Fig. 15. Subsequently, the findings of structural model validate that the attitude has significant impact toward shaping the consumer intentions, and there is a considerable impact of purchasing intention of consumers on the actual adoption of EVs.

6. Discussion and policy implications

6.1. Discussion of results

This research study extensively demonstrates the significant and positive impact of two distinguished types of EVs policies, which are financial policies and preferential policies on consumer's intention to adopt EVs in Shanghai city. These two EV policies are formulated by the Chinese government for the largescale deployment of electric vehicles. Nevertheless, the present study further reveals through the path analysis of research model that the significant and positive effect of preferential policies is stronger and higher than the effect of financial policies on consumer intention to purchase EVs. This shows that the preferential policies hold more weightage for consumers in process of making decision regarding EV adoption. Such kind of research findings are very significant according to the current situation of automobiles in China.

Currently, one of the major hurdles in the development and expansion of EVs in different cities of China is inadequate charging infrastructure. Consumers will be more inclined towards EVs when they realize that the Chinese government is giving preferences to EVs by deployment of enough charging stations and making consumers easy to charge their vehicles. Furthermore, finding appropriate parking space to park, requirement of following the traffic flow restrictions which includes even-and-odd number license plates etc. Have immensely increased the difficulties for the car owners due to the increase of private motorized automobiles. On the other hand, the governmental preference and privileges for EVs make EV drivers free from all these troubles and let them relish the privileges. Hence, attributes along with features of preferential policies for EVs make them more attractive for the Chinese consumers.

Table 11
Squared multiple correlations (R^2).

Construct	R^2	Standard Criteria
Attitude	0.585	$R^2 = 0.67$ (Substantial)
Intention	0.815	$R^2 = 0.33$ (Moderate)
Adoption	0.820	$R^2 = 0.19$ (Weak)

On the other hand, the significance and positive impact of financial policies is also considerable on shaping consumer's attitude towards purchasing intention of EVs. This kind of result could be perceived as obvious. However, it is important to measure the extent by which it effects purchasing intentions of consumers in comparison with other set of EVs policies. Consumers make their decisions on the basis of price of the product and it is observed that the consumers tend to make choice in favor of low purchasing costs. This is general attitude of consumers during the purchase of innovative and newly introduced technological product, so is the case with EVs. EV purchase brought some advantages and privileges for its owner in comparison with the purchase of an ordinary vehicle. Initially, the monetary incentive on purchase of EV is provided by local and central government, which results in lowering the purchase cost. Furthermore, the maintenance costs of EVs is not a current issue because EVs have been recently deployed in China and it is a new technology. Furthermore, the usage cost of an EV is much lower than the usage cost of a conventional vehicle, because the charging price is lower as compared to the cost of petrol and diesel. Moreover, taxes are a heavy burden on individuals who owns a conventional vehicle, the owners of EVs enjoys freedom from tax as well as exemption of road tolling fee, which makes the purchase of an EV attractive to the people. Therefore, lower maintenance costs and usage costs, exemptions from road tolling and vehicle tax and subsidy payment in favor of EVs by the Chinese government makes EVs cost-effective and an influential purchase adoption decision. Through a demographic control factor, 'number of vehicles owned by the family' it is found that this control variable has a significant and positive relation with EVs intention and adoption.

Chinese consumers prefer to keep traditional automobile as their first choice to purchase and they possess intention to adopt EV as their second choice or may be third which is also concluded by Ref. [162]. Furthermore, the incentives and privileges of owning an EV mainly, tax exemption, no road tolling, financial subsidies and low usage and maintenance cost seems to be more beneficial for the consumers who already owns a traditional vehicle as their first choice. EV cost effectiveness drives them to value the advantages, which an EV can bring. The study described in Ref. [74] highlighted the importance of charging infrastructure for EVs to upsurge the adoption rates. Inadequate availability and less development in EV charging infrastructure are major issues for widespread EV adoption. The study performed in Ref. [163] evaluated the efficacy of different policies provided by the Chinese government by considering the opinions of several EV users. The work suggested that the viewpoints of EV users can offer distinctive

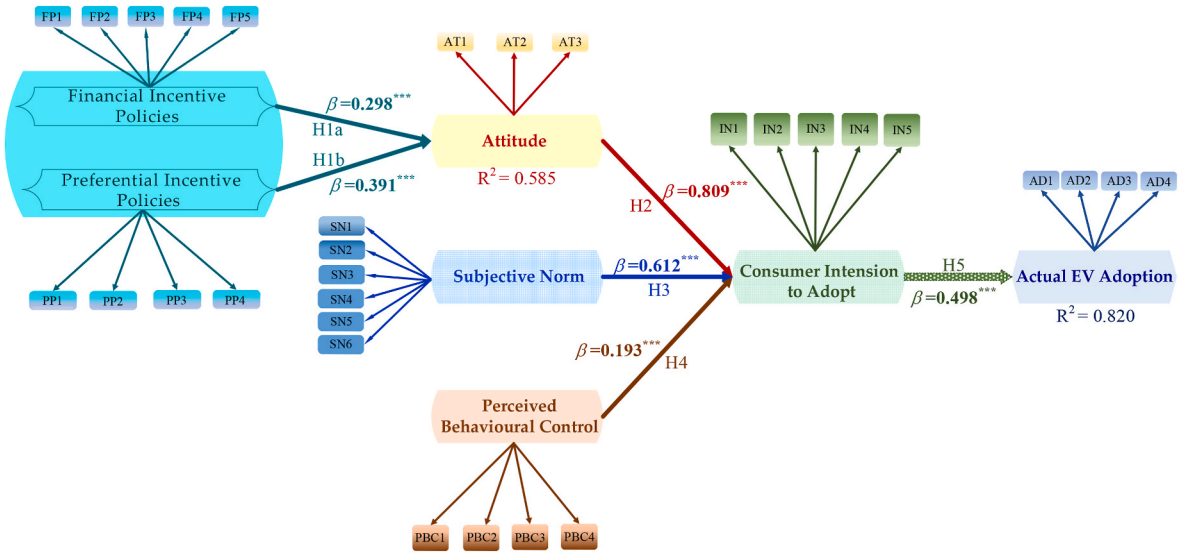

Fig. 15. The structural model.

perceptions into the execution and effectiveness of different policy benefits, and it can help to improve the policy design in the future.

Finally, a cross-country comparison is added to provide a clear understanding of policy effectiveness across various regions.

6.1.1. *Cross-country comparison*

1) Norway:

Norwegian has the most comprehensive set of policies in order to promote electric vehicles. Norway leads the world in electric vehicle adoption rate [61]. In 2022, around 80 % of the new car sold in Norwegian automobile market were EVs, and EVs have already supplanted more than 20 % of the passage cars, or vehicles with up to seven seats [164]. The government of Norway has a plan to only restrict to selling electric cars by 2025. Norway's share of the EV market grew dramatically to 79.3 % in 2022 and previously it was 64.5 % in 2021. More than 80 % of the passenger cars are been charged at home which shows their successful home charging schemes. The Norwegian government provides a set of incentives and subsidies to promote EVs in comparison with conventional vehicles such as exemption from registration tax, VAT, traffic congestion fees, annul vehicle tax, and road tolls. In case of Norway both financial and preferential policies have contributed to the success of EV adoption.

2) United States of America (USA):

The majority of greenhouse gas emissions in the United States are caused by transportation sector, with direct carbon emissions making up around 16 % of overall emission [165]. Despite governmental support, the adoption of EVs has not kept pace with expectations. The federal government of US is working to ensure that by 2030, 50 % of all new cars sold in the country will be zero-emission automobiles. For this purpose, US government introduced financial as well as other incentive which includes exemption from sales tax, reduced tax on car licenses and availability of Carpool lanes in order to maximize the EV adoption.

3) United Kingdom (UK):

A study showed that 34 % of the total carbon emissions are from the automobile industry in UK. In recent times, according to new set of policies the government United Kingdom has shown a target of all new passenger vehicles to be ZEV (zero-emission vehicle) by the year 2035. In order to facilitate ZEV, the UK government is expected to install 300,000 ZEV for public by the year 2030. A variety of government initiatives have also been put in place to lower the price of driving and maintaining an EV. A variety of government initiatives have also been put in place to lower the price of driving and maintaining a ZEV. The subsidies are provided to the consumers living in apartments up to $2500 for mini-vans and $5000 for big vans till 2025. In addition, $350 is waived off from the cost of home based EV charging points [35,166].

4) Europe:

The Europe Union is leading a motivated path towards making Europe world's 1st climate-neutral continent till the year 2050. Automobile industry has been a major sector on the target to decarbonize mentioned in the 2015 Paris agreement. While financial and preferential policy incentives play a substantial role in maximizing the EV uptake, the emphasis now lies more on giving charging infrastructure a top priority. Tax rebate is available for ZEV and the discounts are progressively increasing for the year 2026–2035. Battery electric vehicles will get 60 % discount and on the other hand hybrid electric vehicles will receive 35–50 % discount [49,166].

The policies of electric vehicles in China are categorized by substantial government subsidies, stringent manufacturing quotas, and extensive infrastructure investment. In contrast, the USA stresses on federal tax incentives along with state-level initiatives, while the UK emphasizes bans on new fossil fuel car sales by 2030 and offer grants for EV purchases. Norway leads with high EV adoption through substantial tax exemptions and benefits, whereas Australia lags with less comprehensive national policies and incentives.

In summary, it is concluded that both financial and preferential policies have substantial impact on the consumer intention to adopt EVs. However, the research finding reveal that preferential policies have more considerable impact on behavioral intention to adopt EVs in comparison with financial policies. Therefore, more preferential policies should be formulated to enhance the widespread EV adoption.

6.2. *Policy implications*

This research work adequately demonstrates the significance of policies and their role, which cannot be denied the popularization of EVs in China mainly in Shanghai city. As this research is a case study of Shanghai city, therefore, the policy implications are mainly for Shanghai. However, as Shanghai is one of the major and most important

cities of China, therefore, to some extent these results can bring the policy implications for the policy in China. Currently, policies are playing a role of pillars for the deployment of EVs in the Chinese transportation market. However, the current framework of EV policies is in transition mode. At present, the EV market is flourishing and EV sales graphs are showing increasing trends in Shanghai. It is understandable and obvious that the purchase of EVs is driven due to the benefits and incentives offered by the Chinese government in shape of EV deployment policies. Nevertheless, it is pleasant to realize that now the consumers have started showing rational behavior towards EVs in the transportation market.

For achieving the real development of EVs on its own, government, manufacturers as well as consumers need to make combined efforts to decrease the manufacturing cost, deploy adequate amount of charging stations with the support mechanism of EV preferential policies. Furthermore, it is required to aware the consumers about the necessity of EV by educating them about environmental concerns of the nation. Currently, the policy mechanism in Shanghai is more consumer-based, in order to lower the purchase cost of EVs and increase consumer attention, the need of the hour is to focus on supporting manufacturers and research and development organizations to work on lowering the manufacturing cost.

Furthermore, like other countries such as Norway, where putting heavy taxes on conventional vehicles and continue lowering taxes on EVs can be a driving force to adopt EVs. No driving restrictions policy based on the even-and-odd number license plates in Shanghai is another influential incentive for the consumers, therefore, promoting this privilege more and more would be extremely beneficial in the cities, which are facing severe traffic congestion and huge traffic load. Additionally, to reap the full benefits from EVs, emission exhaustive energy-generating nations must decarbonize their power production sources. Therefore, it is suggested to policymakers and government to must consider using renewable energy sources in their energy production.

On the other hand, experience with dealer, resiliency for charging infrastructure, and marketing techniques are among the least researched areas, although they all have significant policy consequences. For example, the lack of EV models available at a dealership limits not only a potential purchaser's ability to observe and test the experience, but information gap is also created. Moreover, the response of sales manager, the extensive delivery time, the dealership margin, and other factors combinedly create substantial difficulties that must be measured while developing dealership regulations. Likewise, marketing approaches face challenges such as a less confidence in advertising campaigns along with less attention on cultural and environmental viewpoints. Consequently, it is recommended that to enhance adoption of EVs, various marketing techniques should emphasis on increasing confidence in advertising campaigns, involving cultural values, and public marketing initiatives [69]. Table 12 summarizes several significant policy recommendations after a comprehensive analysis of various studies for different groups of stakeholders with considerations of different important parameters for widespread adoption of EVs.

The finding of this research work highly suggests that the growth and development of EVs is policy driven and with the decrease of policies this growth will be affected substantially. Therefore, to ensure EV development it is necessary to introduce and strengthen the cross-subsidy framework. The transport industry of EVs in China mainly in Shanghai city can be transformed by the interactions and combinations of cross subsidy framework. Moreover, deployment of preferential policies including no driving restriction, free parking or preferred parking space and so on are the promising features that ensures immense EV uptake and these policies should be offered incessantly.

7. Conclusion and future prospects

Considering the great pressure to encounter increasing issues of energy security, air quality, and sustainable energy systems, electrification

Table 12
Policy recommendation for different stakeholders.

Type of Parameter	Stakeholder	Policy Recommendations
Customer Perception	Government and Policymakers	Environmental safety concern and attention plans for users Pay attention to the psychological attributes of potential users Consumer heterogeneity should be considered while making policy decisions Consider EVs as indicators of "social prestige" and "pro-environmental identity" Exclusion of perceived risks associated with resale, performance, examining etc.
Economic Perception	Policymakers and Manufacturers	Emphasis on reducing cost of battery and technological advancements. Increase customer inclination to pay for EVs as well as services for charging Attention on lowering total cost of possession from the viewpoint of users.
Infrastructure Upgradation	Policymakers, Government and Service Providers	New charging solutions like as V2G and smart grid should be prioritized Infrastructure for fast charging should be prioritized Availability of Charging points at home, in the workplace, and in the community Infrastructure upgradation in densely inhabited areas Locations of charging stations are optimized to reduce range anxiety Prioritize the robustness of charging infrastructure
Government Regulations and Policies	Government and Policymakers	Fuel economy regulations, mandate zero-emission, and so on Buying incentives such as discounts, subsidies and tax exemptions should be extensively used More attention on usage incentives such as free parking, access to bus lanes, and toll-free travel Government laws to discourage the use of gasoline-powered vehicles
Perception of Environment Safety	Policymakers, Government and Energy Providers	Switching to renewable energy sources for power generation Nations with more carbon emissions-based power generation sources put more emphasis on decarbonization of grids to obtain environmental benefits of EVs
Performance and Design of Vehicle	Manufacturers	Attention to functional features such as top speed, range, and acceleration EVs are being designed to enhance ride comfort, reliability, and ease of usage.
Marketing Perception	Franchises and Dealerships	More electric vehicle models are available for viewing and testing at dealerships. Improve sales strategies and commission for different models of EVs Marketing and advertising initiatives should be improved. There shouldn't be any waiting period for different models of EVs
Socio-Demographic Aspects	Policymakers and Government	Middle-aged and young people should be targeted as possible consumers

(continued on next page)

Table 12 (*continued*)

Type of Parameter	Stakeholder	Policy Recommendations
		Users with a greater income and more education are targeted Depending on demographical variables, emphasis on multi-vehicle families, home size, gender, prior automobile owners, and so on

of transport industry in China presents several new prospects and solutions to fulfil the requirements, which are necessary for eco-friendly environment. The massive deployment of electric vehicles (EVs) transforms the automotive industry of China into a subsidy-based market of EVs through attractive policy mechanism formulated by the Chinese government. The main goal of this research is to explore how policy measures influence the behavioural intensions of consumers to adopt EVs in Shanghai city. In this study, the key factors included in EV policies are thoroughly analyzed, which are enhancing the EV consumer intention to adopt EVs. Major barriers for widespread EV adoption are also discussed in detail. In this study, it is explored that by what means the inspiration and awareness regarding EV policies greatly influence consumer purchasing intention through the mechanism of Theory of Planned behaviour (TPB). This research study extensively demonstrates the significant and positive impact of two distinguished types of EV policies including financial policies and preferential policies on consumer's intention to adopt EVs by implementing an extended and improved version of TPB. A case study in Shanghai is performed through survey of 314 respondents, which is further evaluated by operationalizing the TPB mechanism in structural equation modelling (SEM) to assess the aspects of EV policies on consumer adoption. The confirmatory factor analysis (CFA) and structural equation modelling are performed in AMOS for the assessment of survey findings. The outcomes of data analysis reveal that the basic construct items of TPB including attitude, subjective norm (SN), and perceived behavioural control (PBC) have significant effect on behavioural intention of consumers. The results obtained from the survey analysis after evaluating it through SEM reveal that financial and preferential EV policies have a considerable impact towards shaping the attitude of consumer intention in Shanghai city.

Moreover, it is observed that financial policies and preferential policies are significantly related to adoption intention of EVs, however, preferential policies are more positively associated with consumer purchase intention in comparison with financial policies. Consequently, it is concluded that the preferential policies are playing a crucial role in controlling the adoption intention of EVs and these policies should be offered incessantly. In future, more preferential policies should be formulated to enhance the widespread EV adoption. Furthermore, after analysing the structural model, it is observed that there is a considerable impact of purchasing intention of consumers on the actual adoption of EVs.

Furthermore, to some extent, the outcomes of this research not only create certain theoretical contributions to the literature, but also deliver some findings of applicability to the Chinese government. The outcomes can support policy makers by suggesting different possibilities to make improvements in EV policy mechanism for large-scale deployment of EVs as well as widespread EV consumer adoption. It is foreseen that the work presented in this paper would be a useful addition and a valuable source of information for researchers studying the subsidized EV policy mechanism through theory of planned behaviour.

This research study does not cover distinction between the brands and kinds of electric vehicle, however, it is assumed that the perceptions and reactions of consumers towards different types of EV brands and types are unlike and diverse. Therefore, succeeding research could target studying the perceptions and reactions of consumers towards certain EV brand or type, in shaping consumer intention to adopt EVs. Moreover, cross countries research work can be performed in future studies to augment the conclusions.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Nomenclature

AGFI	Adjusted goodness-of-fit
AVE	Average variance extracted
BEVs	Battery Electric Vehicles
BSS	Battery swapping stations
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CMIN/DF	Minimum Discrepancy Function by Degrees of Freedom divided
CP	Charging poles
CR	Composite Reliability
DRC	Development Research Center
EVs	Electric Vehicles
FP	Financial Policy
GFI	Goodness-of-fit
GHG	Greenhouse gas
HEVs	Hybrid electric vehicles
HOV	High occupancy vehicle
ICE	Internal combustion engine
IFI	Incremental fit index
KMO	Kaiser-Mayer-Olkin
NDRC	National Development and Reform Commission
NFI	Normalized fit index
PBC	Perceived Behavioral Control
PCFI	Parsimony comparative fit index
PGFI	Parsimony goodness-of-fit
PHEVs	Plug-in hybrid Electric Vehicles
PNFI	Parsimony normal fit index
PP	Preferential Policy
R&D	Research and Development
RFI	Relative fit index
RMR	Root mean square residual
RMSEA	Root mean square error of approximation
SEM	Structural Equation Modelling
SN	Subjective norms
TLI	Tucker Lewis Index
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
V2G	Vehicle to grid
VIF	Variance inflation factors

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