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THE ROLES OF SUSTAINABLE BATTERIES AND POLICIES IN DRIVING THE DEMAND FOR ELECTRIC VEHICLES IN CHINA

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Abstract: Despite the implementation of various measures to promote the use of Electric Vehicles (EVs) by the Chinese government and Chinese companies; the demand for EVs has yet to reach its desired target. This study investigates the determinants of EV demand including policy, facilities, and socio-economic aspects. The study employs quarterly time series data between 2010 and 2022 to estimate the relationship between EV policies, battery charging and recycling facilities, price, income, urbanisation, and population against EV ownership in China. The research found a positive correlation between the number of battery recycling companies, public charging facilities, EV prices, and EV demand. However, the three different policies studied produced mixed results. Interestingly, urbanisation was found to have a negative correlation to EV demand. This is noteworthy as most EV facilities are in urban areas, yet the demand for EVs in China is negatively influenced by urbanisation. The conclusions drawn from this study holds great significance for the future of EV demand in China. Specifically, if the Chinese government promotes EV adoption in semi-urban cities, it could have a substantial impact. The study also provides valuable insights for government and industry stakeholders. These insights can help with informed decision making and shape the trajectory of EV development in China.

Keywords: Energy vehicles, sustainability, demand, price, income, urbanisation.

Introduction

On 16th April 2023, during the G-7 meeting in Japan, progress was made with regard to renewable energy. The member countries established targets for solar and offshore wind power capacity, demonstrating their commitment to accelerate sustainable energy development. Additionally, a goal of achieving carbon neutrality by 2050 was set, highlighting the need to mitigate climate change. The meeting focused on promoting renewable energy and carbon neutrality. This outcome aligns with the promotion of photovoltaic technology (PV) and Electric Vehicles (EVs) as possible solutions.

New Energy Vehicles (NEVs) are recognised as the future of the auto industry. They bring economic benefits and contribute to the development of science and technology. EVs are powered by electricity stored in large batteries. These batteries can be charged using various charging facilities. EVs have the potential to alleviate carbon emissions, noise, and air pollution in urban areas. Many cities have implemented policies to support EVs and foster their development. However, challenges arise in constructing charging infrastructures due to space limitations and uneven distribution of charging stations, which may hinder EV promotion. Additionally, the increased power demand from EVs puts pressure on urban power systems.

In China, EV sales have declined for three consecutive years. However, it is worrying that COVID-19 has had a huge impact on the EV market and the EV sales volume in China has decreased sharply (Wen *et al*., 2021). Despite the Chinese government's efforts to promote EV adoption through policy initiatives, the impact on actual EV sales has been somewhat limited (Sina, 2020). China surpassed the United States as the largest EV market in the last five years (Askic, 2017), yet the rapid proliferation of EVs have not been met with a proportional expansion of EV infrastructure, particularly charging facilities. This discrepancy has dampened the Chinese consumers' enthusiasm for EVs, given the crucial role of charging infrastructure in shaping consumer perceptions and behaviours. The decline serves as a clear signal for China to address the underlying factors influencing the demand for EVs, which calls for a comprehensive investigation (Coffman *et al*., 2017).

Additionally, the adoption of EVs also faces barriers such as price, limited range, infrastructure availability, and technological uncertainties (Cheng & Tong, 2017). The environmental impact has raised the concern of consumers who worry about the disposal and recycling of the EV battery. Consequently, there is a growing need for studies that focus on identifying important and effective policy measures for EVs. Policymakers are actively seeking guidance for these measures based on their potential to facilitate widespread EV adoption (Hasan & Mathisen, 2021).

There have been studies conducted to understand the adoption of EVs from various aspects and disciplines; e.g., policy and subsidy aspects (Du *et al*., 2017; Wang *et al*., 2017; Zhang & Hanaoka, 2021), EVs battery market (Ou *et al*., 2019; Hsieh *et al*., 2020), climate and environmental aspects (Li *et al*., 2019; Zheng *et al*., 2020), economic and market prospects (Cheng & Midler, 2016; Wu & Chen, 2022), and marketing and consumer behaviour (Yang *et al*., 2018; Li *et al*., 2020; Ling *et al*., 2021). On the energy saving aspect, Lai and Teh (2022), Su and Teh (2022), and Su *et al*. (2023) demonstrated the advantages of a Dynamic Thermal Rating (DTR) system, especially its ability to generate more energy than a traditional battery systems and its potential for cost.

A recent study by Gomes *et al*. (2022) highlighted that China's industrial policies to create an electric vehicle market have had mixed results with market growth, concentrated in a few cities and the requirement for coordination between demand structure policies and charging infrastructure. Thus, this study identified the key factors shaping the demand for EVs in China. It focused on the governance and policy aspects, sustainability of facilities, and the socio-economic aspects. Quantitative research methods were employed to analyse data from between 2010 and 2022. This study is the first to use quantitative methods to comprehensively analyse the impact of China's policies, EV battery recycling capabilities, and the availability of public charging facilities on EV demand. It represents a breakthrough and innovation in related research and provides valuable insights for future research in this area. The findings are intended to guide stakeholders when formulating targeted strategies to stimulate the demand for EVs and catalyse economic growth.

Literature Review

Review of past studies shows that the demand for EVs has been widely studied using theories such as the Technology Acceptance Model (Abbasi *et al*., 2021; Huang *et al*., 2021; Xia *et al*., 2022), Unified Theory of Acceptance and Technology (Dwivedi *et al*., 2019; Abbasi *et al*., 2021), Theory of Planned Behaviour (Wang *et al*., 2016; Zhang *et al*., 2018; Wang *et al*., 2022), Diffusion of Innovations Theory (Xia *et al*., 2022), and Social Cognitive Theory (Rezvani *et al*., 2015) in exploring the factors influencing EV demand.

Common economic theories such as Demand Theory has not been getting much attention. Demand, in economic terms, reflects a consumer's inclination to buy goods and services along with their willingness to pay a designated price for them. When the price of a good or service rises, there is typically a reduction in the quantity demanded. According to Demand Theory, it can be inferred that any factor influencing the price of a product or altering consumers' perceived cost of the product will inevitably affect the overall demand for the product. According to Sierzchula *et al*. (2014), Kumar and Alok (2020), and Jaiswal *et al*. (2021), a country's EV market share is closely tied to important factors such as financial incentives, the availability of charging infrastructure, and the presence of local production facilities. Therefore, with the Demand Theory, we can make simulations, considering the factors related to prices and cost on the EV's demand. The parameters of demand function including price elasticity and income can measure the degree of impact of price and income changes on the EV demand thereby, helping policymakers and enterprises understand the demand characteristics of EVs and make predictions for the EV market's share and sales.

Policy measures that incentivise car buyers have been effective in influencing voluntary EV adoption with high cash grants being particularly attractive (Lieven, 2015). Policies that consider the key concerns of consumers such as the price to pay and the opportunity cost are more likely to be successful (Egbue & Long, 2012). Recent research has placed a significant emphasis on gaining a comprehensive understanding of how the combination of policies affects the widespread adoption of sustainable technologies in the market (Kong *et al*., 2020).

Global cities aspiring to lead in sustainability must implement effective measures to promote electric mobility (Bakker & Trip, 2013). Both developed and developing countries are formulating long-term plans to replace internal combustion vehicles with EVs and generate electricity from renewable sources (Taghizad-Tavana *et al*., 2023).

Research highlights various preferred policy approaches through interviews with Nordic experts (Kester *et al*., 2018). A case study on Norway underscores the importance of contextual adaptation, recognising that not all policies yield uniform results. Policymakers are advised to re-evaluate and restructure EV policies once a certain level of adoption is achieved in the market (Hasan & Mathisen, 2021).

Tao *et al*. (2023) found a positive correlation between discounts, infrastructure subsidies, and EV sales. In the public sector, purchasing subsidies significantly impacted the adoption rate of the electric bus while in the private sector, financial incentives like subsidies and toll breaks may not have the same effect. The level of policy implementation varies based on the development status of cities, indicating a positive correlation between effective policy implementation, development status, and EV demand (Liu *et al*., 2021).

Tesoriere *et al*. (2023) assessed the potential costs of implementing financial incentives for EVs in Ho Chi Minh City, showing that early-stage incentives can yield net positive benefits. Kong *et al*. (2020) stress the importance of policy flexibility in China, suggesting that adjusting policies based on prevailing circumstances and combining complementary measures can optimise effectiveness.

Wang *et al*. (2016) categorised policy measures into financial incentives, the provision of information, and convenience, with convenience policies identified as the most influential in promoting EV adoption rates. Silvia and Krause (2016) advocated for a hybrid policy approach while Hu *et al*. (2019) proposed public procurement as an effective policy instrument. Hu *et al*. (2020) demonstrated that production subsidies and infrastructure development can accelerate EV diffusion. Contrarily, Encarnação *et al*. (2018) argued that public regulations alone are insufficient for widespread EV adoption, leading to discussions on market-oriented policy instruments (Wu *et al*., 2021) and the call for a shift from government led to market-driven mechanisms (Li *et al*., 2022). From a demand theory perspective, a positive correlation is assumed between EV policies and demand.

The influence of purchasing subsidies on the promotion of electric buses in the public sector has proven significant across different phases of demonstration projects in China. Noteworthy policies in China such as the Ten Cities and One Thousand Vehicles Project (TCP), Energy Saving and New Energy Vehicle Industry Development Plan (EDP), and Notice on Improving, Promoting, and Applying Fiscal Subsidy Policies (NFP) offer financial incentives like subsidies and tax benefits. These measures contribute to enhance the affordability and attractiveness of EVs for Chinese consumers.

Between 2009 and 2012, China introduced the "Ten Cities and One Thousand Vehicles Project (TCP)" policy. This involved providing financial subsidies to develop 10 cities annually for about three years, deploying 1,000 new energy vehicles in each city for various purposes such as public transportation, rentals, and municipal services. The aim was to reach a nationwide new energy vehicle market share of 10% by 2012.

The Energy Saving and New Energy Vehicle Industry Development Plan (EDP) is designed to boost the adoption and advancement of energy saving electric vehicle technology. It includes measures like tax incentives, purchase subsidies for electric vehicles, and support for infrastructure development.

The Notice on Improving, Promoting, and Applying Fiscal Subsidy Policies (NFP) is focused on enhancing the development and utilisation of EVs in the country while refining existing fiscal subsidy policies. The policy entails several new provisions, including the gradual reduction of subsidies to zero after 2020, quicker elimination of vehicles with lower mileage, enhancement of EV technical standards, and financial rewards for companies, contributing to technological innovation and quality improvement in the EV industry.

Undoubtedly, financial assistance alleviates the economic burden on buyers, potentially impacting the demand for EVs. Therefore, the hypotheses can be formulated as follows:

H1: TCP has a positive influence on the demand for EVs.
H2: EDP has a positive influence on the demand for EVs.
H3: NFP has a positive influence on the demand for EVs.

Disposing of EV batteries can be extremely costly, especially considering their significant contribution to the overall cost of EVs and even more, if the waste contains valuable materials. Recycling presents an opportunity to reduce life cycle costs by recovering valuable materials and avoiding the expenses associated with hazardous waste disposal. Establishing a practical and efficient method for recycling batteries and other energy storage components from EVs is considered essential for the successful implementation of this new mode of transport. Reusing batteries provides a viable option as it allows recycling companies to develop cost-effective and energy-efficient methods over time (Kotak *et al*., 2021). Martins *et al*. (2021) emphasise the significance and benefits of recycling in terms of critical metal supply and highlight future trends towards a circular economy.

Improving EV battery recycling technologies can address various challenges, including environmental concerns and the overall cost (price) of EVs (Hu *et al*., 2020). It offers solutions to various issues, including environmental concerns, as well as cost related challenges associated with EVs. As the cost of EVs decreases through efficient battery recycling, automotive companies are likely to expand their EV production lines. Consequently, improving the EV battery recycling rate not only directly contributes to the growth of NEV demand, but also indirectly fuels the demand for new EVs. Consequently, the following hypothesis is derived:

H4: EV battery recycling capabilities have a positive influence on the demand for EVs.

Meanwhile, there is a mutual influence between the demand for EVs and the availability of public charging facilities with public attention serving as a crucial link in this relationship (Ma & Fan, 2020). However, the increase in demand for EV charging stations as such poses a challenge for future smart grids. The cost of electricity network expansion is considered the adaptive cost, arising from the EV diffusion and the increase of other electrical loads (Tao *et al*., 2023). EV adoption in a traditional fleet requires charging infrastructure with fewer stations that each have more charging ports (Lokhandwala & Cai, 2020).

A perfect charging facility is an important guarantee for the rapid development of EVs, especially in China (Deng & Liu, 2017). The lack of a proper charging infrastructure and the additional load placed on the national grid are important barriers to EV adoption in Saudi Arabia (Alotaibi *et al*., 2022). Literature shows that public charging infrastructure is an important factor associated with the EV uptake rate, although the direction of causality is yet unclear (Coffman *et al*., 2017). The increasing of public charging points will increase the adoption rate, especially in urban municipalities (Wu & Yang, 2020). Hence, the following hypothesis can be made:

H5: The EV charging facilities have a positive influence on the demand for EVs.

In recent years, global economic trends have witnessed an increase in the urban population. Based on the World Urbanisation Prospect 2018, 68.4% of the world's population is projected to live in urban areas by 2050 (United Nations Ministry of Economy and Social Affairs, 2024). As urbanisation advances, the population tends to become more educated; this is often associated with higher income levels among urban residents. This demographic is inclined toward embracing cutting-edge technologies, including the adoption of EVs. The urban lifestyle marked by brief commutes and frequent short-distance travel, harmonises effectively with the existing range capabilities of many EVs. This alignment positions EVs as a convenient and fitting choice for urban mobility. However, urbanisation is negatively associated with EV demand in Northern Europe (Sovacool *et al*., 2019).

At the same time, urbanisation brings new challenges to urban transport infrastructure (Nykvist & Whitmarsh, 2008; Pavone *et al*., 2012). Given the current structure of transport systems, Battery EVs (BEV) can be the choice for future mobility (Bruglieri *et al*., 2014; Wappelhorst *et al*., 2014; Boyacı *et al*., 2017). Therefore, considering the population density, degree of urbanisation, and economic changes in China, the relationship between urbanisation and EV demand may be hypothesised as follows:

H6: Urbanisation influences the demand for EVs.

China's relaxation of its two-child and three-child policy has increased the demand for a second car within families. Growing environmental awareness among car owners has fuelled interest in the environmental benefits of EVs, leading to increased support and purchases. EVs offer higher energy efficiency and lower exhaust emissions compared to traditional vehicles, appealing to consumers who prioritise sustainability and view EVs as a future oriented trend. EVs embody innovative technological advancements in the automotive industry, including advanced battery technology and intelligent driving systems. This attracts interest from existing car owners, seeking a more advanced and intelligent driving experience.

In recent years, more drivers have been using EVs as either their primary or a secondary vehicle. Most households are larger and people with more children prefer EVs to supplement the family fleet (Graham-Rowe *et al*., 2012; Schuitema *et al*., 2013; Nayum & Klöckner, 2014; Noppers *et al*., 2015). So, assume that the number of people who already own a car is positively correlated with the demand for EVs.

H7: The number of the population with cars influences the demand for EVs.

Demand theory suggests that the quantity demanded of a product is determined by its price, considering the income constraint of consumers. Numerous studies have demonstrated that the adoption of EVs is influenced by the price of EVs and the purchasing power of consumers (Vilchez *et al*., 2019; Liao, 2022). Among the barriers to adoption, the price of EVs is more significant factor than the EV range (Adepetu & Keshav, 2017). Moreover, the demand for EVs among low and middle-income households is price elastic.

Given the price sensitivity of different consumer categories, this study aims to examine the impact of several substitutional incentive policies to continue stimulating the preference for EV adoption even after the phase-out of purchase subsidies. Four substitutional incentive policies, namely mileage subsidies, congestion fee discounts, parking fee discounts, and bus lane driving permissions are proposed to address the discontinuation of purchase subsidies.

The incentive effect of the purchase subsidy policy on price-sensitive consumers is found to be 1.6 times higher compared with price-insensitive consumers. To prevent a decline in the adoption rate of EVs resulting from the removal of purchase subsidies, the recommended subsidy amounts for mileage, parking fees, and congestion fees are 0.93 CNY/km, 4.43 CNY/hour, and 16.09 CNY/time, respectively (Lu *et al*., 2022). It is worth noting that a subsidy implemented in one country can lead to increase innovation, lower prices, and greater adoption of EVs in other regions.

Wang *et al*. (2017) emphasised that financial incentive policy measures are the most crucial in promoting the adoption of EVs. Bruckmann *et al*. (2020) found that EV ownership is predicted by factors such as technology affinity, high income, and living in one's own house. Lieven (2015) discovered a higher penetration of EVs in countries with high purchasing power. Additionally, theoretical frameworks suggest that personal carbon trading and tradable driving credit schemes can alter consumers' EV preferences through both economic and psychological motivations (Li *et al*., 2022).

Certain policy interventions and business models have successfully increased EV adoption rates among low and moderate-income households in existing markets. Martins *et al*. (2021) project a worldwide increase in the number of vehicles from 1.3 billion to 2 billion by 2030 with most of the demand coming from BRICS countries. They also highlighted a correlation between the number of vehicles in use and Gross Domestic Product (GDP). Hence, the following hypotheses could be derived:

H8: The price of EV negatively influences the demand for EVs.

H9: Income positively influences the demand for EVs.

The correlation of the hypotheses can be simplified using the proposed research framework as shown in Figure 1.

Methodology

The Dependent Variable (DV) of the study is the demand for EVs. The indicator used for the DV is the quarterly data of the total number of EV sales in China (in units). There are eight

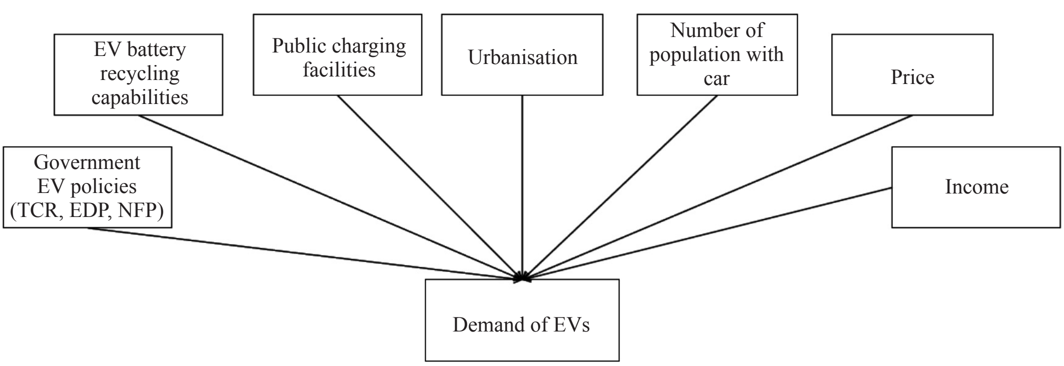

Figure 1: Proposed research framework

Note:
TCP = Ten Cities and One Thousand Vehicles Project.
EDP = Energy Saving and New Energy Vehicle Industry Development Plan.
NFP = Notice on Improving, Promoting, and Applying Fiscal Subsidy Policies.

independent variables for the study. The study utilises quarterly data from 2010 to 2022. Table 1 presents the abbreviations and data sources of all variables.

From 2010 to 2022, the Chinese government implemented three major EV policies initiated in 2009. The first was the "Ten Cities and One Thousand Vehicles Project" that aimed to deploy 1,000 EVs in the public sector across 10 pilot cities. However, 13 pilot cities were initially selected, later expanding to a total of 25 cities across three batches. The second policy, the "Energy Saving and New Energy Vehicle Industry Development Plan" of 2012 that focused on advancing energy-efficient and new energy vehicles to reduce pollution, emissions, and energy consumption. It outlined plans to accelerate research and production, promote EV use in public transport, enhance the industry chain, provide policy support, and strengthen international cooperation. The third policy, enacted in 2020, titled "Notice on Improving, Promoting, and Applying Fiscal Subsidy Policies", maintained stable subsidies for pure EVs, moderately reduced subsidies for plugin hybrid EVs, and significantly increased subsidies for fuel cell vehicles, now included in the scope of new energy vehicle subsidies. All time-series data were converted to logarithmic form to increase uniformity.

The demand for EVs is modelled as a function of *TCP*, *EDP*, *NFP*, *NFC*, *BRC*, *PRC*, *NPC*, *UBN*, and *INC* and any error or noise terms that may be presented. Equation 1 presents the time-series model specification of the study.

Table 1: Variables, abbreviations, and data sources

Variables	**Abbreviation**	**Sources of Data**	**Type of Data**
Demand of EVs	DD	China Association of Automobile Manufacturers (2024)	Quarterly data: Count of unit EVs sold in China
Ten Cities and One Thousand Vehicles Project	TCP	Liu *et al.* (2021) State Council (2012) Yu (2021)	TCP, EDP, and NFP are dummy variables. The year with the policy will take the value of 1 and 0 otherwise
Energy Saving and New Energy Vehicle Industry Development Plan	EDP		
Notice on Improving, Promoting, and Applying Fiscal Subsidy Policies	NFP		
Battery recycling capabilities	BRC	Huajing Industry Research Institute (2022)	Quarterly count of battery recycling companies
Public charging facilities	PCF	Cheng (2021)	Quarterly count of public charging facilities
Urbanisation	UZN	National Bureau of Statistics (2022)	Urbanisation ratio
Income	INC	Li *et al.* (2022)	Quarterly income per capita of the population
Price	PRC	Parker *et al.* (2021)	The average price of an EV in China (Quarterly data)
Populations with cars	NPC	Statista Research Department (2023)	Number of households with at least one car (Quarterly data)

$$DD_t = \beta_0 + \beta_1 TCP_t + \beta_2 EDP_t + \beta_3 NFP_t + \beta_4 PCF_t + \beta_5 BRC_t + \beta_6 UBN_t + \beta_7 INC_t + \beta_8 PRC_t + \beta_9 NPC_t + e \quad (1)$$

where:

DD	=	Demand for EVs (sales volume)
TCP	=	Ten Cities and One Thousand Vehicles Project Policy (dummy variable)
EDP	=	Energy Saving and New Energy Vehicle Industry Development Plan
NFP	=	Notice on Improving, Promoting, and Applying Fiscal Subsidy Policies
PCF	=	Public charging facilities (unit)
BRC	=	Battery recycling capabilities (number of recycling companies)
UBN	=	Urbanisation (ratio)
INC	=	Income (RMB)
PRC	=	Price (RMB)
NPC	=	Number of populations with cars

Data from *DD*, *PCF*, *BRC*, *UBN*, *INC*, *PRC*, and *NPC* are converted into natural logarithms for standardisation. The log transformation of data is often used to reduce the skewness of a measurement variable (Lee, 2020). Hence, the model for estimation is presented in Equation 2.

$$lnDD_t = \beta_0 + \beta_1 TCP_t + \beta_2 EDP_t + \beta_3 NFP_t + \beta_4 lnPCF_t + \beta_5 lnBRC_t + \beta_6 lnUBN_t + \beta_7 lnINC_t + \beta_8 lnPRC_t + \beta_9 lnNPC_t + e \quad (2)$$

Results

Table 2 presents descriptive statistics of the variables of the study. The total number of observations is 52.

Table 3 shows the correlation matrix for the variables. As per Gujarati (2004), it is common to observe correlation among regressors in time series data if it is not perfect. However, removing the independent variable *lnINC* yields a Variance Inflation Factor (VIF) below 10, leading to its exclusion from the regression.

Therefore, the model's estimation process involved excluding income as an Independent Variable (IV). Diagnostic tests were carried out to assess for potential problems such as serial correlation and heteroskedasticity. The Breusch-Pagan or Cook-Weisberg test for heteroskedasticity reveals that the probability (Prob > chi^2) is not significant, indicating the absence of heteroskedasticity issues in the estimation. Given the utilisation of high frequency data in this estimation, it is recommended to perform the LM test for autoregressive conditional heteroskedasticity (ARCH). Results from the LM test for ARCH indicate no presence of ARCH effects. Subsequently, Durbin's alternative test for autocorrelation and the Breusch-Godfrey LM test for autocorrelation were executed to examine the model for serial correlation. The findings indicated no evidence of serial correlation issues in the model.

Table 2: Summary of descriptive statistics

Variables	Obs.	Mean	Min.	Max.	Std. Deviation
lnDD	52	10.8329	6.92363	14.691	2.416234
lnPCF	52	9.230745	4.51086	12.4002	2.070766
lnBRC	52	6.250847	4.33073	9.41451	1.427915
lnPRC	52	11.56761	10.9682	12.1007	0.357097
lnNPC	52	18.09462	17.4485	18.5691	0.3577676
lnUBN	52	56.59038	49.2	63.6	4.585795
lnINC	52	10.04942	9.435082	10.51551	0.3334446
TCP	52	0.2307692	0	1	0.4254356
EDP	52	0.6923077	0	1	0.4660414
NFP	52	0.1538462	0	1	0.3643213

Table 3: Correlation matrix

	lnPCF	*lnBRC*	*lnPRC*	*lnNPC*	*lnUBN*	*TCP*	*EDP*	*NFP*
lnPCF	1.0000							
lnBRC	0.8382	1.0000						
lnPRC	0.9228	0.8792	1.0000					
lnNPC	0.9098	0.8849	0.9889	1.0000				
lnUBN	-	0.9203	0.9880	0.9934	1.0000			
TCP	0.8164	-0.5759	-0.7430	-0.7818	-0.7476	1.0000		
EDP	0.0733	-0.2973	0.1186	0.1160	0.0325	-0.4260	1.0000	
NFP	0.5096	0.8371	0.5408	0.5445	0.6065	-0.2335	-0.6396	1.0000

Table 4 presents the outcomes of the multiple regression estimation that was performed using Stata. The R^2 illustrates that at least changes in demand for 96% of EVs can be explained by the explanatory variables employed in the model. Moreover, the Prob > F-value is less than 0.1, implying that the regression model provides a better fit to the data than a model that contains no independent variables. Essentially, this implies the reliability of the independent variables (*Xs*) in predicting the dependent variable (*Y*).

As depicted in Table 4, except for *lnNPC*, *TCP*, and *EDP*, all other variables demonstrate statistical significance. Specifically, *lnBRC*, *lnUBN*, and *NFP* exhibit significance at 10% level while *lnPCF* and *lnPRC* are significant at 5% level. The results highlight that a 1% increase in the number of public charging facilities (*lnPCF*) corresponds to a 0.4% rise in EV demand, all else being constant. This positive correlation aligns with existing literature, notably the findings of Levinson and West (2018). Nonetheless, the elasticity of public charging facilities is less than one, indicating less importance of *lnPCF* in influencing the EV demand. Furthermore, the analysis indicates a positive correlation between *BRC* and EV demand, in which a 1% increase in the number of battery recycling companies will bring 0.75% demand for EVs. The result is consistent with the previous research conducted by Martins *et al.* (2021). Otherwise, the price of electric

Table 4: Estimation results

Variables	Coefficient	Standard Error
lnPCF	0.3663**	(0.1296)
lnBRC	0.7570*	(0.3495)
lnPRC	5.3035**	(1.7892)
lnNPC	3.3919	(3.1387)
lnUBN	-0.4846*	(0.2823)
TCP	-0.2018	(0.4419)
EDP	-0.5188	(0.4377)
NFP	-1.2422*	(0.6624)
Constant	-91.9843**	(43.357)
Obs.	52	
R^2	0.9612	
F (8, 43)	133.32	
Prob > F	0.0000	

Note: The asterisks ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.

vehicles (*PRC*) exhibits a positive correlation with EV demand. Both *UBN* and *NFP* exhibit a negative correlation with the demand for electric vehicles.

Discussion

Surprisingly, the Price of Electric Vehicles (*PRC*) exhibits a positive correlation with EV demand, indicating an increase in demand as the price rises. This finding diverges from conventional demand theory, which typically posits an inverse relationship between demand and price. One plausible explanation lies in the continuous improvement of EV technology since its introduction to the public, contributing to a consistent upward trajectory in prices. Moreover, the literature suggests that consumers hold elevated expectations for vehicles and for some, EVs are still perceived as luxury items. Symbolic factors such as social status play a role in shaping perceptions, potentially elucidating the observed positive correlation between price and EV demand (Simsekoglu, 2018).

Interestingly, there is a noteworthy contrast in the correlation between *UBN* and *NFP* with EV demand. Both *UBN* and *NFP* exhibit a negative correlation with the demand for electric vehicles, aligning with the existing literature (Kester *et al*., 2018). Urbanisation and car ownership are generally positively correlated (Yang *et al*., 2017), but whether urbanisation and car demand are ultimately positively or negatively correlated is determined by many other factors. The first is urban environmental indicators. Urban population density has an impact on car ownership and travel. The impact on demand depends on the specific situation (Beesley & Kain, 1964). Secondly, public facilities such as road infrastructure in towns will also affect the demand for cars (Zhao, 2011; Guerra, 2014; Schwanen & Wang, 2014). Finally, large cities often impose high import duties, vehicle registration fees, parking fees, road taxes, and vehicle quotas that limit car ownership, as is the case in Singapore and Hong Kong (Lam & Tam, 2002), and therefore, also affect car demand. It can be concluded that the negative correlation between *NFP* and EV demand may come from traffic congestion caused by excessive population density, the shortage of public charging facilities causing long EV charging queues, or the city's quota or purchase restriction policies.

On the other hand, *NFP* is negatively correlated with EV demand, which diverges from the initial hypothesis. This discrepancy can be attributed to policy adjustments, specifically price subsidies. Literature suggests that despite policy changes, the favourable oil price for gasoline vehicles still gives them an edge over EVs, providing a reasonable basis for the observed negative correlation of *NFP* (Sovacool *et al*., 2019).

The data indicates that the *TCP* has minimal influence on EV demand due to its focus on public vehicles. Given that most EV demand stems from private cars, the impact of *TCP* remains limited. Similarly, the *EDP* fails to significantly affect EV demand as it is a long-term plan with effects not readily apparent within a decade.

The *lnNPC* representing the number of people who own cars appears unrelated to EV demand. Whether consumers possess a car or a second vehicle seems to have little bearing on their inclination to purchase an EV. The finding from Pimenta and Piato (2016) aligns with the idea that higher prices of EVs compared to conventional fuel vehicles, contribute to the lack of clear advantages; thus, minimising their impact on demand.

Implications of the Study

The study offers valuable insights for industry stakeholders, governments, and policymakers, shedding light on the factors influencing EV demand from both market and policy perspectives. This knowledge can inform the refinement of policies to promote greater EV adoption. The positive relationship between the proliferation of public charging facilities and EV demand suggests that enhanced accessibility and speedier charging options can boost consumers' willingness to purchase EVs.

Given the observed negative correlation between urbanisation and EV demand, policymakers might consider directing their efforts toward suburban areas by bolstering charging infrastructure in those regions. China is poised to increase government investments in electric vehicles in the future. Addressing concerns like carbon emissions is expected to drive a continuous rise in the EV market share (Yuan *et al*., 2015). Increased government support and investment are anticipated to contribute to the stabilisation of EV prices. Consequently, this trend is likely to make EVs more affordable for a growing segment of the suburban population.

Furthermore, the rise in the number of battery recycling companies signifies a reduction in battery recycling costs and technological maturation. This advancement not only elevates the recycling rate of EVs but also contributes to a decline in the overall cost of owning an EV. Recycling of scrapped batteries reduces purchase costs, thereby amplifying consumer interest in EVs. As such, these findings offer practical insights that could guide strategic decisions and policy adjustments in the dynamic landscape of EV demand.

Conclusions

This study examines the impact of China's EV policies, charging facilities, battery recycling capabilities, price of EVs, urbanisation, and the number of populations with cars in China. Studies have shown that for every 1% increase in public charging facilities (*lnPCF*), EV demand will increase by 0.4%. Similarly, for every 1% increase in battery recycling capabilities (*lnBRC*) and price (*lnPRC*), EV demand will increase by 0.75% and 5.3%, respectively. On the contrary, urbanisation (*lnUBN*) and the notice on improvement in the financial subsidy policies for the promotion and application of EVs (*NFP*) has a negative impact and a corresponding decrease in EV demand of 0.5% and 1.2%, respectively.

Looking ahead, China aims to further amplify the market share and demand for EVs. There is a need to intensify the development of public infrastructure for EVs by increasing investment in public charging facilities. Simultaneously, efforts should be directed towards advancing Tesla's fast charging mode to reduce EV charging times, optimising the utilisation of public charging facilities. In addition to traditional public charging facilities, EVs are green alternatives to traditional cars and environmental protection is also an important factor in the demand for EVs.

In existing studies, wind power generation can be combined with electric charging strategies, which cannot only provide flexible loads for microgrids but also reduce charging costs through wind power, a renewable and cheap power source, thereby increasing demand (Song & Teh, 2024). Additionally, the introduction of pertinent policies is essential to incentivise the establishment of battery recycling companies and encourage government investment in battery recycling technology. This approach not only elevates the recycling rate of electric vehicle batteries but also contributes to a reduction in manufacturing costs for EVs. Consequently, this cost reduction can lead to a more affordable market price for EVs, expanding accessibility to a broader consumer base.

Limitations and Suggestions for Future Study

Finally, it is important to acknowledge the limitations of this study. The exclusive reliance on data from China raises the concern that the findings may not necessarily generalise to other countries. In addition, some other factors may affect the demand for EVs. For example, in areas where the power grid is underdeveloped, the low cost of energy such as wind and solar energy may also affect the demand for EVs in the region (Ganjei *et al*., 2022). Additionally, there is potential for a more granular breakdown of the demand factors by using disaggregated data.

Future research could delve into a more detailed analysis of each factor, exploring specific aspects contributing to the observed correlations. For instance, investigating whether the negative correlation between urbanisation and electric vehicle demand is attributed to road infrastructure issues, public transportation facility challenges, environmental concerns, or other factors could provide deeper insights. Furthermore, recognising the inherent uncertainties in factors such as future international politics or financial crises is crucial. Subsequent research endeavours should consider and explore these unpredictable elements to enhance the comprehensiveness and robustness of the findings.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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