The Impacts of Popularization of Electric Vehicles on Urban Air Pollution: Evidence from China

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Abstract. This research explores the impact of popularizing electric vehicles (EVs) on China's urban air pollution or contagion. With the rapid growth of the transportation industry and the increasing concern about air pollution, the Chinese administration has been promoting the use of EVs to mitigate the adverse effects of traditional gasoline-powered vehicles on the environment. Using empirical data collected from various cities in China, this study exploits a difference-in-differences approach to analyze the causal connection between the EV implementation and urban air quality. According to the findings, the increase in EV usage significantly and positively impacts reducing the concentration of air emissions such as PM2.5 and SO_2. Moreover, the study also finds that the magnitude of the effect varies across different types of cities with varying levels of economic development and air pollution. This research provides valuable insights into the effectiveness of promoting EVs in reducing urban air pollution in China. It has important implications for policymakers and stakeholders in other countries.

1 Introduction

Air pollution is a significant public health issue worldwide, with urban areas most affected. Transportation and industry are the main contributors to urban air pollution [1]. The combustion of fossil fuels by vehicles is a significant source of air pollution, releasing pollutants like nitrogen oxides (NOx), volatile organic compounds (VOCs), and particulate matter (PM) into the atmosphere. These pollutants have been linked to respiratory and cardiovascular diseases and cancer.

Electric vehicles are to be powered by electric motors and do not produce tailpipe emissions. Therefore, they are cleaner and more sustainable than traditional gasoline and diesel-powered vehicles. However, several factors have hindered EV adoption, including high costs of purchasing, limited driving range, and the need for infrastructure for charging [2].

In addition to the potential positive impact on public health, the widespread adoption of EVs could have economic benefits. For instance, a study by the International Council on Clean Transportation (ICCT) found that by 2030, EVs could help reduce the high demand for oil in the global market by 2.5 million barrels per day, saving $190 billion in fuel costs [3].

Another potential challenge associated with the popularization of EVs is the need for a significant increase in electricity production and infrastructure to support charging demands. It could require significant investments in power generation, transmission, and distribution systems, which could take time to implement and may face regulatory challenges [4].

2 Development history and related research progress of EVs

Guangzhou, a major city in southern China, has a long history of air pollution, primarily caused by industrial activity and transportation. The City has implemented various measures to improve air quality, including promoting EV adoption since the mid-2010s [5].

One of the significant steps the government took to promote EV adoption was introducing a pilot program for electric taxis in 2016. Under the program, the government subsidized taxi companies to purchase electric taxis, and charging infrastructure was installed across the City. The program was highly successful; by 2019, over 3,000 electric taxis were operating in the City [6].

Efforts by the government to promote EV utilization in Guangzhou have significantly impacted air quality in the City. According to a study published in the journal Environmental Science & Technology, the adoption of electric taxis in Guangzhou led to a significant reduction in air pollution, with a 34% decrease in particulate matter (PM) and a 51% decrease in nitrogen oxide (NOx) emissions [7].

The government's success in promoting EV adoption in Guangzhou has also led to the developing of a vibrant EV industry in the City. According to a report by Bloomberg New Energy Finance, Guangzhou is home to several leading EV manufacturers, including GAC New Energy and BYD Auto, among China's top EV manufacturers [8].

As of the latest research progress on the effects of popularizing electric vehicles on urban air pollution and

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the vehicle industry, several studies have been conducted globally, including in China, to investigate the potential benefits and challenges of EV adoption. Research findings suggest that widespread EV adoption could significantly reduce air pollution and improve public health but also pose challenges for the traditional vehicle industry.

One study that applied a model to evaluate the predicted effects of EV adoption on urban air pollution and the vehicle industry unravelled that increased adoption of EVs could significantly minimize air pollution and improve public health. However, the study also found that adopting EVs could pose challenges for the traditional vehicle industry, as they may lose market share to new entrants focused on EV production. Additionally, the study found that government policies, such as incentives and regulations, can significantly promote EV adoption.

3 Research methodology

3.1 Motivation and research framework

The motivation behind the study is to investigate the potential benefits and challenges of the widespread adoption of EVs. Electric vehicles are cleaner and more sustainable than traditional gasoline and diesel-powered cars. Their widespread implementation has the potential to drastically cut down on air pollution, a significant threat to public health in cities worldwide. However, obstacles such as a lack of charging infrastructure threaten the widespread adoption of EVs [9].

3.2 Core knowledge in the field

The metrics for evaluating models in this field include measures of air pollution reduction, such as reductions in nitrogen oxide and particulate matter emissions, as well as measures of the environmental impact of EV battery production and disposal. Economic metrics, such as the cost-effectiveness of EV adoption and the potential impact on the traditional vehicle industry, are also commonly used. Other metrics include consumer adoption rates, charging infrastructure availability, and the environmental effects of electricity generation.

3.3 Data source

Commonly used data sources in this field include air quality monitoring data, vehicle sales and registration data, government policy documents, consumer surveys, and data on charging infrastructure. Data on electricity generation and the environmental impact of EV battery production and disposal are also used in this field.

3.3.1 Illustration of data analysis

Data analysis in this field typically involves developing models and methods to evaluate the potential impacts of EV adoption on urban air pollution and the vehicle industry. Therefore, this includes analyzing data on air pollution levels and vehicle emissions and exploring the potential impact of EV adoption on the traditional vehicle industry. Additionally, it may involve examining the factors influencing consumer adoption of EVs, such as government policies and consumer attitudes. Figure 1 shows EV sales and charging facilities increased for half a decade between 2015 and 2020 in Guangzhou, China.

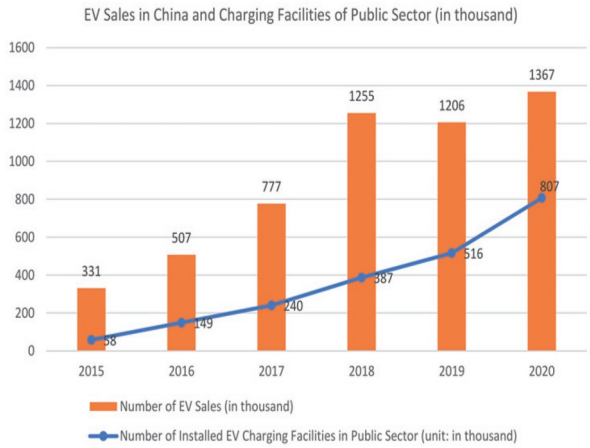

Fig. 1. EV sales as well as charging facilities.
Source: https://www.mdpi.com/vehicles/vehiclestml

From the above, it is evident that sales of Electric Vehicles are tremendously increasing in terms of thousands from 2015 to 2018, then slightly decreased with almost 300 sales due to COVID-19, and later improved in 2020, and this shows that urban air pollution will be practically reduced by 19 %. The vehicle industry will keep on making its production and sales.

Figure 2 tries to show the data for the emissions made by gasoline, diesel, and petrol vehicles from 2009 to 2016 before the official launch of EVs in 2015 and get adapted with the residents in Guangzhou, China. The considerable number of cars and the rapid growth has contributed to the increasing atmospheric pollution. For example, many on-road automobiles used 95 million tons of gasoline and 172 Mt of diesel in 2013. Similarly, the number is projected to shoot up continually due to the increase in cars. Understandably, diesel or gas fuel combustion in vehicle engines emits different types of dangerous chemicals like CO, HC, NOx, and PM emissions have remained high in Guangzhou, China [10].

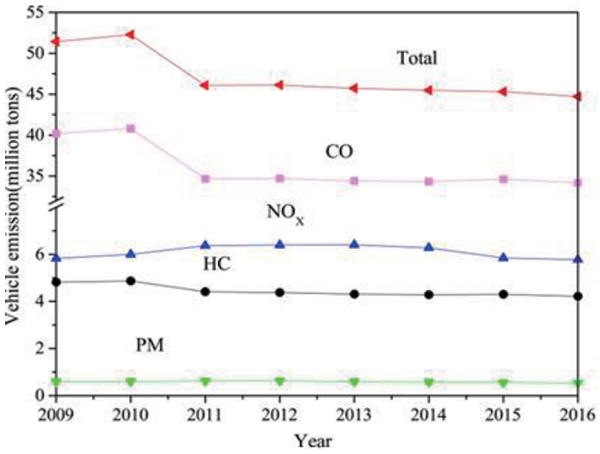

Fig. 2. Data for the emissions made by gasoline, diesel, and petrol vehicles.
Source: https://www.ncbi.nlm.nih.gov/pmc/articles

3.3.2 Elements informing patronage of electric vehicles in Guangzhou, China

Understanding consumer behavior is vitally essential for promoting EV adoption and is also a crucial analytical aspect of this study. Before choosing, most consumers compare EVs with traditional fuel vehicles in many ways. These include price, driving range, charging infrastructure, vehicle performance, and government incentives. Generally, the central and local governments' incentives and charging infrastructure are essential factors encouraging consumers to purchase electric vehicles.

Figure 3 below shows the purchase level of EVs, and it shows that from 2011 to almost 2014, there was a slow purchasing level of such EVs, but from 2015 to 2018, the demand levels of EVs significantly increased at higher rates of almost 85%.

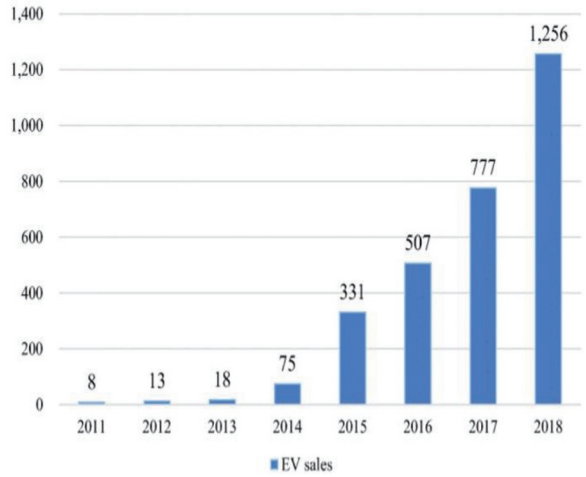

Fig. 3. EV sales versus the number of buyers.
Source: https://media.springernature.com

4 Empirical analysis and discussion

4.1 Life cycle environmental assessment

The environmental impacts of products over their whole lifespan can be estimated through the life cycle assessment approach. In this paper, this study utilizes three types of vehicles for analysis, including Toyota Corolla Luxury 2019 (a kind of conventional vehicle), Nissan Leaf 2019 (a type of battery electric vehicle), and Toyota Corolla double engine E+ Pioneer 2019 (PHEV) (a kind of Plug-in hybrid electric vehicle). Table 1 shows detailed parameters of three types of cars.

Table 1. Parameter comparison of nine vehicle models.

Model	Battery Capacity (Km/hr.)	Driven Range (km)	Top Speed (Km/hr.)
Audi e-Tron	95	402	199
BMW i3	42.2	246	149
Chevrolet Bolt EV	60	383	144
Fiat 500 e	24	135	136
Tesla Model X	100	465	249
VW e-Golf	38.5	201	149
Nissan LEAF	40	241	144
Jaguar i-PACE	90	376	199
KIA Soul EV	30	176	-

After data processing and analysis, the results of air pollutant emissions for nine types of vehicles can be achieved. Specifically, in terms of air pollutants like CO_2, VOCs, and nitrous oxides, electric vehicles produce fewer emissions than conventional vehicles. However, concerning PM2.5 and sulfur dioxide, Electric cars emit more pollutants than traditional vehicles.

Based on this study, two suggestions can be proposed regarding reducing air pollutant emissions from EVs Firstly, the production of materials and manufacturing of batteries for EVs needs to be located in regions equipped with highly renewable energy utilization. Secondly, the power plant for producing electricity should be environmentally friendly upgraded.

4.2 The effect of subsidy policy

The paper uses the following economic Model to explore how the EV subsidy policies relate to sales in this study.

$$EV_{it} = \alpha + \beta Policy_i + \gamma Time_t + \delta Time_t * Policy_i + \lambda Z_{it} + \varepsilon_{it} \quad (1)$$

In Model (1), where $_{it}$ refers to the natural logarithm of the number of electric vehicles bought by private users in the City in year t, policy refers to the dummy

variable equal to one in the treatment group. In contrast, zero in the control group signifies the EV subsidy policy. In the years following City, I implement the EV subsidy program, the value of time is 1, while in all other years, it is 0. The coefficient designates how the EV subsidy incentive policy influences EV sales, the standard DID estimator, and the interaction term Time*Policy is the time variable. The EV subsidy policy positively affects its sales if the value is positive and statistically significant. Z_{it} indicates a vector of time-varying city-level control variables. $_{It}$ refers to the residual error term.

The explanation for each variable is above, which is a kind of Multiple Linear Regression using a difference-in-differences approach for testing subsidy policies' impact on EV sales.

Moreover, this study applies the propensity score matching method for comparing the control and treated groups with similar characteristics to remove the covariates' effect. In this case, the paper analyzed cities with similar socio-economic characteristics.

Regarding the active effects of the EV subsidy policy on EV sales, this considers the policy implementation from one year to another as the base time. Before the implementation of the policy, the policy coefficients were around 0 with no evident trend. However, after the procedure was executed, the coefficients significantly increased over time, implying that the subsidy policy assumes an increasingly crucial role in EV sales.

What's more, EVs have some stations. First, producers must enlarge the battery capacity of EVs because the one-time driving journey is only about several kilometers, much shorter than conventional cars. In this case, the current EV is tentatively suitable for the short distance within a city. Otherwise, recharging long-distance driving from exhausting electricity is hard because charging piles only exist in some places. Second, the vehicle weight of EVs is not as heavy as that of CVs, leaving some potential safety hazards because driving EVs is more floating than driving CVs at high speed. These two technical problems are relatively emergent for producers to break through.

Last but not least, considering the hedonic valuation, the driver in Guangzhou reflected that the reason for them to buy EVs is mainly due to the subsidy policies, which help them to decrease the cost during driving operation, not mainly for environmental protection. It is primarily because Guangzhou's original and essential environmental quality is acceptable for drivers living in this city, which is optional for further improvement. Especially after the negative influence of the pandemic, the Chinese government has implemented a subsidy policy on all kinds of vehicles to stimulate production and consumption.

Therefore, a subsidy policy is also an excellent method for government to stimulate EV sales and popularize EV usage for people. Combined with the formal research, policymakers are advised to make reasonable plans for distributing the production ratio between different types of vehicles based on the current situation and scenario.

5 Conclusion

This study investigates the potential benefits and challenges of popularizing electric vehicles on urban air pollution and the vehicle industry. It includes evaluating the environmental and health benefits of EV adoption and exploring the challenges and opportunities for the traditional vehicle industry. Additionally, it focuses on factors influencing consumer adoption of EVs, such as government policies and consumer attitudes.

Based on the findings of this study include promoting the development of charging infrastructure, particularly in areas with high traffic volumes. This can help to address range anxiety and encourage consumers to adopt EVs Additionally, policies that incentivize the purchase of electric vehicles, such as tax credits or rebates, can help to reduce the upfront cost of EVs and make them more accessible to a broader range of consumers.

Furthermore, governments and relevant industry stakeholders should work together to promote the standardization of charging technologies and interoperability of setting networks, which can help increase consumer confidence and encourage EV adoption.

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