Policy impact of new energy vehicles promotion on air quality in Chinese cities

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\section*{A R T I C L E I N F O}

Keywords:
“Ten Cities, Ten Thousand NEVs project”
“Difference-in-differences” method
Urban air nitrogen dioxide concentration
Chinese cities

\section*{A B S T R A C T}

We conduct a rigorous and systematic empirical study on the effect of “Ten Cities, Ten Thousand New Energy Vehicles (NEVs) project” on urban air quality. After examining the applicable conditions of the ‘difference-in-differences’ method, we demonstrate that this project meets the parallel trend assumptions, randomness assumptions and homogeneity hypothesis in terms of the impact on air quality, represented by urban air nitrogen dioxide concentration. Thus, during the whole promotion period, the promotion of new energy vehicles can reduce the concentration of nitrogen dioxide in urban air, but the effect is not significant every year of the promotion. The effect of the project evolves over time. The fact that the effect of reducing the concentration of urban air nitrogen dioxide is small is relevant to the small number of new energy vehicles, because the entire project did not attain the expected target. As a result, the promotion of new energy vehicles has become an option to improve urban air quality, especially by reducing air nitrogen dioxide concentration.

\section*{1. Introduction}

The great achievement of China’s economic advancement is made at the expense of the environment. The use of coal-based fossil fuels emitted large greenhouse gases (mainly carbon dioxide) and polluting gases. China’s urbanization process has accelerated in recent years, causing urban traffic congestion, automobile exhaust and industrial emissions, and resulting in serious decline in environmental quality (Yang et al., 2018). Seven of world’s top ten air pollution cities in 2003 are in China. Less than 1% of the whole Chinese cities meet the WHO (World Health Organization) air quality standards. According to \textit{China’s Environmental Status Bulletin}, only 84 cities meet the ambient air quality standards, accounting for only 24.9% of the total number of cities; the air quality in the rest 254 cities is unqualified. 474 cities (districts and counties) conducted precipitation monitoring, and the results show that the pH value of annual rainfall is less than or equal to 5.6 in about 19.8% of the cities, and the average acid rain frequency is 12.7%.

Automobile exhaust has become an important source of urban air pollution (Sun et al., 2018). According to a United Nations (UN) report, automobile exhaust emissions accounted for more than 60% of all the substances in air pollution in cities. The harmful substances in automobile exhaust include: solid suspended particulates, carbon monoxide, nitrogen oxides and so on. Nitrogen oxides can do great harm to the environment and human’s health (Dhondt et al., 2012). Nitta et al. (1993) and Sekine et al. (2004) provided evidence that exposure to heavy traffic was related to increased risk of respiratory symptoms, with higher concentration of nitrogen dioxide being one of the causes. Apart from its direct effect on human health, it can react with other substances to produce acid rain, and corrode materials and affects the normal growth of plants. The nitrogen oxides and hydrocarbons may even react to produce photochemical smog that has caused casualties in Tokyo and Los Angles (Lin and Tan, 2017a). Worse still, nitrogen oxides play an indispensable role in the formation of PM2.5 (particulate matter with diameter less than or equal to 2.5 µm), which is the most important factor causing haze (Lin and Tan, 2017b).\textsuperscript{1}

The concentration of nitrogen is greatly influenced by human activities and decreased during the period 2010–2015, reflecting that China’s air pollution control policy has worked in recent years, especially technical and administrative policies aimed at controlling automobile exhaust emissions (Sun et al., 2016). For example, installing a catalytic reactor in the exhaust system of a vehicle, by which the carbon

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\textsuperscript{1} Since there is no data on concentration of carbon monoxide, PM2.5 and PM10 (particulate matter with diameter less than or equal to 10 µm) for some sample cities in this research, we take the concentration of nitrogen oxides as the representative of city air quality in this paper.
monoxide can be oxidized to carbon dioxide using a catalyst, and the nitrogen oxides can be reduced to nitrogen; or adding additives to the fuel to make it burn efficiently. The administrative measures include improving the quality of the refined oil, eliminating old cars, promoting the use of public transport and so on.

Different from traditional fossil energy vehicles, new energy vehicles are driven by unconventional energy and have become one of the most important tools to reduce automobile exhaust emissions. Both the Chinese central government and local governments have adopted a series of policies to promote the use of new energy vehicles since 2009. The current types of new energy vehicles include pure electric, plug-in hybrid and fuel cell vehicles.

As the first important attempt to promote the use of new energy vehicles, China's Ministry of Science and Technology, the Ministry of Finance, National Development and Reform Commission, Ministry of Industry and Information jointly launched the "Project of promoting the application of large-scale new energy vehicles", which is also called "Ten Cities, Ten Thousand New Energy Vehicles Project" (hereinafter referred to as "Ten Cities, Ten Thousand NEVs Project") in 2009. The government plans to use financial subsidies and other measures to pilot the use of new energy vehicles in thirty cities within three years, and seeks to make new energy vehicles account for 10% of the automobile market by the end of 2012. The extension coverage includes buses, taxis, official, municipal and postal services. Because new energy vehicles are mainly fueled by electricity, their emissions can be seen as zero in the urban districts. In this way, their effects on air quality is an important and significant empirical economic issue. However, most of the existing literature on new energy vehicles in China is concentrated on the development of the new energy vehicle industry themselves, ignoring other aspects. Although the original intention of developing new energy vehicles in China is not to control air pollution, the new energy vehicles will affect air quality undoubtedly because of their cleanliness. In this paper, we attempt to investigate the impact of the policy on air quality. This kind of empirical research can quantitatively measure the extent of the impact of new energy vehicles on urban air quality and evaluate the policy of promoting new energy vehicles. These are the contributions of this research to the literature. We use the case study of the “Ten Cities, Ten Thousand NEVs Project” for the analysis.

We only analyze the nitrogen dioxide concentration because of the following reasons. First, the research period of this study is from 2005 to 2012 in which the data on Air Pollution Index (API) and Air Quality Index (AQI) are unavailable (the former is released from 2006 to 2012 and the latter is released from January 2013). Second, both API and AQI are available only for the major cities in China. That is, for some cities in our study, the API data is unavailable even from 2006 to 2012. Third, data on the concentrations of other automobile exhaust pollutants such as carbon monoxide are not released before 2013. Fortunately, data on nitrogen dioxide concentration can be obtained for the period 2005–2012 for all the cities in this study. Fourth, nitrogen dioxide is the main exhaust of vehicles. Fifth, there is no statistical data on CO₂, which is from transport energy use (Mi et al., 2017b) on Chinese city level, for each type of energy consumption of each city is unavailable. It is therefore difficult to calculate the CO₂ emissions by multiplying the amount of energy and the corresponding emission coefficient. Another way is to obtain the CO₂ emissions data by GIS spatial analysis, and the data resource is CHRED (Cai and Zhang, 2014). However, it has only released the data of two years: 2007 and 2012. Therefore, CO₂ is not used as a proxy of air quality in this paper.

The rest of this paper is organized like this: the second part is the literature review which summarizes the studies on new energy vehicles. The third part shows how we conduct the analysis. The fourth part presents the empirical results and the testing on the method suitability. The last part is the robustness check and main conclusions.
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