sustainability

MDPI

Article

Can the New Energy Vehicle Pilot Policy Achieve Green Innovation and Emission Reduction?—A Difference-in-Differences Analysis on the Evaluation of China's New Energy Fiscal Subsidy Policy

Susheng Wang [1,2], Gang Chen [1,*] and Dawei Huang [1,3]

[1] School of Economics and Management, Harbin Institute of Technology, Shenzhen, Shenzhen 518055, China; wangss@sustech.edu.cn (S.W.); hdw@szpt.edu.cn (D.H.)
[2] Department of Finance, Southern University of Science and Technology, Shenzhen 518055, China
[3] School of Management, Shenzhen Polytechnic, Shenzhen 518055, China
* Correspondence: 13b956005@stu.hit.edu.cn; Tel.: +86-1581-5535-026

Abstract: Whether the new energy vehicle pilot policy (NEVPP) can achieve green innovation and emission reduction is an important exploration for China to achieve green and sustainable development. This research aims to empirically investigate the impact, impact mechanism, and heterogeneity characteristics of the NEVPP on urban green innovation and emission reduction based on panel data from 281 cities in China from 2004 to 2017, using difference-in-differences (DID) methods and fixed effect (FE) models. The results show that the NEVPP significantly reduces the carbon dioxide emissions of the pilot cities but significantly inhibits the green innovation, and the results are robust to the placebo test, propensity score matching DID (PSM-DID) test, instrumental variable (IV) estimation, emissions trading system (ETS), and Carbon-ETS interference test, and change of the dependent variable. In addition, further studies have shown that the NEVPP's emission reduction effects are mainly achieved by reducing energy consumption, promoting technological innovation, and adjusting industrial structure. Moreover, we found that the NEVPP performed better in the regions where the level of economic development is high, the local government has a good relationship with the market, and the level of non-state economic development is high. In general, our research results show that the NEVPP has achieved innovation and emission reduction policy effects in China, but it is also accompanied by an inhibitory effect on green technological innovation.

Keywords: NEVPP; green innovation; difference-in-differences; emission reduction; carbon emission; energy conservation; industry structure; heterogeneity

check for updates

Citation: Wang, S.S.; Chen, G.; Huang, D.W. Can the New Energy Vehicle Pilot Policy Achieve Green Innovation and Emission Reduction?—A Difference-in-Differences Analysis on the Evaluation of China's New Energy Fiscal Subsidy Policy. *Sustainability* **2021**, *13*, 8643. https://doi.org/10.3390/su13158643

Academic Editor: Mihaela Onofrei

Received: 1 July 2021
Accepted: 30 July 2021
Published: 3 August 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

In the past four decades, China's rapid economic growth has been accompanied by excessive energy consumption, pollutant emissions, and greenhouse gas emissions [1–3]. China has explored the path of green development while balancing the relationship between environmental sustainability and high-speed economic growth for a long time [4,5], such as emissions trading system (ETS) [6] and carbon-ETS [7]. However, this type of policy is mainly aimed at the production activities of industrial enterprises, ignoring the environmental problems of the transportation system in urban development [8], for example, fuel vehicles have become an important part of urban greenhouse gases and harmful pollutants (such as nitrogen oxides (NO_X) and particulate matter (PM), etc.) emissions [9]. Developed countries such as the United States, Germany, and Japan set their sights on the field of new energy transportation as early as the 1970s [10], laid out policies for the new energy automobile industry, and tried to use new energy vehicles (NEVs) to replace traditional fuel vehicles to try to solve this problem [11–13]. In recent years, China, India, Pakistan, and other countries have also begun to deploy new energy vehicle industries; various stimulus policies have been introduced to promote the development of these countries' new energy automobile industry. For example, around the year 2000, some Indian government policies that focused on the use of cleaner fuels did reduce vehicle emissions [14,15]. During 2009–2010, the Chinese government issued a series of new energy vehicle industry subsidy policies, which effectively stimulated the production and consumption of NEVs [16]. The resulting discussion and research on the effectiveness of new energy vehicle subsidy policies have received widespread attention [17].

The existing literature, and a large number of facts, support the belief that the new energy vehicle subsidy policy can significantly improve the production and sales level of NEVs in the region [18,19]. For example, Jenn et al., (2018) evaluated the impact of monetary and non-monetary incentives from federal and state governments, power operators, and many other entities on the adoption of electric vehicles. The study found that for every USD 1000 provided as a rebate or tax credit, the average sales of electric vehicles increased by 2.6% [17]. Moreover, policymakers generally accept that NEVs have great potential in terms of saving energy and emission reduction [20]. However, some scholars still question the effectiveness of the new energy vehicle subsidy policy. Doubts mainly come from three aspects. One is to question whether NEVs have a green emission reduction effect compared with traditional fuel vehicles [21]. Existing NEVs are still mainly driven by electricity and, technically, they still depend, directly or indirectly, on fossil energy that makes carbon and pollutant emissions [22]. In addition, the recycling and processing of new energy vehicle batteries and the deployment of charging piles all involve environmental issues [23,24]. The second aspect is to question whether the new energy subsidy policy itself can achieve the green development goals expected by its policymakers [25]. The effective implementation of government financial subsidy policies requires a good relationship between the government and the market and the level of development of the private economy because market-oriented competition can effectively avoid or dilute the distorting impact of subsidy policies on the market price formation process [26]. However, there are still regulatory loopholes in specific practices. Occasionally, companies and corrupt officials have conspired to obtain state financial subsidies by defrauding them, which may lead to national fiscal and tax losses and resource misallocation [27–29] and poses a greater threat to the effectiveness of the policy. The third aspect is to question the endogenous problems that may exist in the evaluation of the effect of the existing new energy automobile industry subsidy policy [30], that is, whether there is a selection bias in the selection of subsidy pilots or subsidy targets, which will greatly reduce the credibility of the policy evaluation conclusions [31].

Although existing research provides quantitative support for the emission reduction effects of new energy vehicle subsidy policies [32,33], NEVs can partly or completely get rid of the excessive dependence of TFVs on fossil fuels, and use clean green energy to, directly or indirectly, reduce the emission of greenhouse gases and air pollutants harmful to human life and health [34]. For example, Nie et al., (2015) analyzed the carbon emission reduction capabilities of NEVs by constructing a new energy vehicle urban logistics carbon emission model and calculated the total carbon emission reduction after the promotion and application of new energy vehicles. The results show that the application of new energy vehicles in the logistics industry has a certain carbon emission reduction effect. With the continuous development of new energy vehicle technology, the effect of carbon emission reduction will become more significant [35]. However, this type of research lacks in-depth research on the internal mechanism of the emission reduction effect.

Furthermore, research on the product life cycle of new energy vehicles shows that companies face huge operational risks in the early development of the new energy vehicle industry due to the high risks of technology research and development activities [36]. The government chooses to support the R&D and production activities of new energy vehicle companies through financial subsidies and other policy tools in the early stage of industrial development. On the one hand, this helps to reduce innovation costs and enhance the ability of new energy vehicle companies to resist risks [37]. On the other hand, it helps guide consumers to consume new energy vehicles and improve corporate performance [38]. This is conducive to enterprises carrying out more innovative activities [39,40] and promotes the technological innovation of the new energy industry in the core technology fields of automotive low-carbonization, informatization, intelligence, power batteries, drive motors, high-efficiency internal combustion engines, advanced transmissions, lightweight materials, and intelligent control [41–44]. For example, Xue et al., (2021) constructed a quasi-natural experiment of policy impact based on panel data of 123 new energy vehicle listed companies from 2009 to 2018 and empirically studied the impact of promotion policies on corporate technological innovation. The results show that: (1) The recommended catalog of new energy vehicles has a significant positive impact on corporate technological innovation; (2) The recommended catalog has the largest positive impact on corporate technological innovation in the economically developed eastern region, followed by the central region, and the smallest impact in the western region; (3) The positive impact of the recommended catalog on the technological innovation of state-owned enterprises is greater than that of private enterprises. Other related studies have also come to similar research conclusions: that is, the new energy vehicle pilot policy(NEVPP) has a significant positive incentive effect on innovation [35,37]. However, the above research did not link innovation and emission reduction for inspection and analysis. There is a lack of comprehensive analysis of the relationship between subsidy policy, green innovation, and emission reduction. In addition, when the same subsidy policy is implemented in different cities or regions, different degrees of spatial heterogeneity will inevitably appear [45]. However, the existing research pays little attention to the heterogeneity of subsidy policy effects caused by factors such as geographical location, government and market relations, and the development level of the private economy.

Above all, the purpose of this research is to take China's NEVPP as the research object and apply the difference-in-differences(DID) method and fixed effects model to empirically test whether the NEVPP has green innovation effects and emission reduction effects on pilot cities, and to carry out an in-depth investigation of the internal mechanism and the source of heterogeneity of the effect of the new energy fiscal subsidy policy.

The structure of this study is arranged as follows. Section 2 summarizes the background of the NEVPP in China. Section 3 introduces the empirical research design. Section 4 reports the estimation results of the benchmark model, and Section 5 analyzes the impact mechanism. Section 6 examines the heterogeneity of policy effects, Section 7 carries out different robustness tests. The last section provides the discussion and main conclusions.

2. The NEVPP in China

China is the world's largest energy consumption country and the world's largest automobile production and sales country. It faces severe challenges in strengthening energy conservation and emission reduction and leading the transformation of the traditional automobile industry. For this reason, the Chinese government has conducted many environmental policy explorations [46,47] and introduced a series of policy incentives to guide the development of the new energy automobile industry. Among these policies, the NEVPP, that has had a greater impact on the development of the new energy automobile industry, mainly includes the following three items, the specific contents of which are shown in Table 1. It should be noted that the NEVPP is composed of two parts of policies that overlap in time and city, which are pilot projects for the demonstration and promotion of energy-saving and new energy vehicles (DPENEVs) in 25 cities, and subsidies for the private purchase of new energy vehicles (SPPNEVs) that have been launched in six cities (as shown in Figure 1).

Table 1. NEVPP in China (2009–2010).

Policy Time and Document Name	Motivation	Content	Pilot Cities
In January 2009, Notice on Carrying out the Pilot Work of Demonstration and Promotion of Energy-saving and New Energy Vehicles	Expand automobile consumption, accelerate the structural adjustment of the automobile industry, and promote the industrialization of energy-saving and new energy automobiles	The central government focuses on subsidies for the purchase of energy-saving and new energy vehicles. Hybrid vehicles (including plug-in hybrid vehicles) can receive a subsidy of up to CNY 50,000 based on fuel-saving rate and maximum electric power ratio, and pure electric vehicles can receive a subsidy of CNY 60,000.	Beijing, Shanghai, Chongqing, Changchun, Dalian, Hangzhou, Jinan, Wuhan, Shenzhen, Hefei, Changsha, Kunming, andNanchang, as shown in Figure 1
In May 2010, Notice on expanding the work related to the demonstration and promotion of energy-saving and new energy vehicles in the public service field	Carry out further promotion work and accelerate the industrialization of energy-saving and new energy vehicles	According to the actual promotion of energy-saving and new energy vehicles, the financial departments of the pilot cities appropriated the subsidy funds according to the prescribed standards. The specific management measures of the subsidy funds shall be formulated by the pilot cities in light of the actual local conditions and reported to the Ministry of Finance for the record.	Tianjin, Haikou, Zhengzhou, Xiamen, Suzhou, Tangshan, Guangzhou, Shenyang, Hohhot, Chengdu, Nantong, and Xiangyang, as shown in Figure 1
In May 2010, Notice on launching the pilot program of subsidies for the private purchase of new energy vehicles	Accelerate technological progress in the automotive industry, focus on cultivating strategic emerging industries, and promote energy conservation and emission reduction	The central government will provide a one-time subsidy for new energy vehicles purchased, registered, and used by private individuals in pilot cities. The local government allocates certain funds, focusing on supporting the construction of supporting infrastructures such as charging stations, the purchase of new energy vehicles, and the repurchase of batteries. According to the standard, the maximum subsidy for plug-in hybrid passenger vehicles is CNY 50,000 per vehicle; the maximum subsidy for pure electric passenger vehicles is CNY 60,000 per vehicle.	Shanghai, Changchun, Shenzhen, Hangzhou, Hefei, and Beijing, as shown in Figure 1

The most direct economic effect of the NEVPP is the production and consumption effect of NEVs. Judging from the 2010–2018 new energy vehicle production and sales data released by the China Association of Automobile Manufacturers (as shown in Figure 2), the production of NEVs increased from 7181 in 2010 to 1,270,481 in 2018, ranking first in the world for four consecutive years. The number of new energy sales also increased from 4884 in 2010 to 1256,195 in 2018. The overall new energy vehicle production and sales data have increased in number and speed at an alarming rate. It is undeniable that China's NEVPP has made certain achievements in the production capacity and consumption of NEVs. However, official statistics did not disclose information on the urban green innovation and emission reduction effects of the pilot policy, a lack of policy evaluation on the above two aspects. Therefore, it is necessary to conduct a more in-depth analysis.

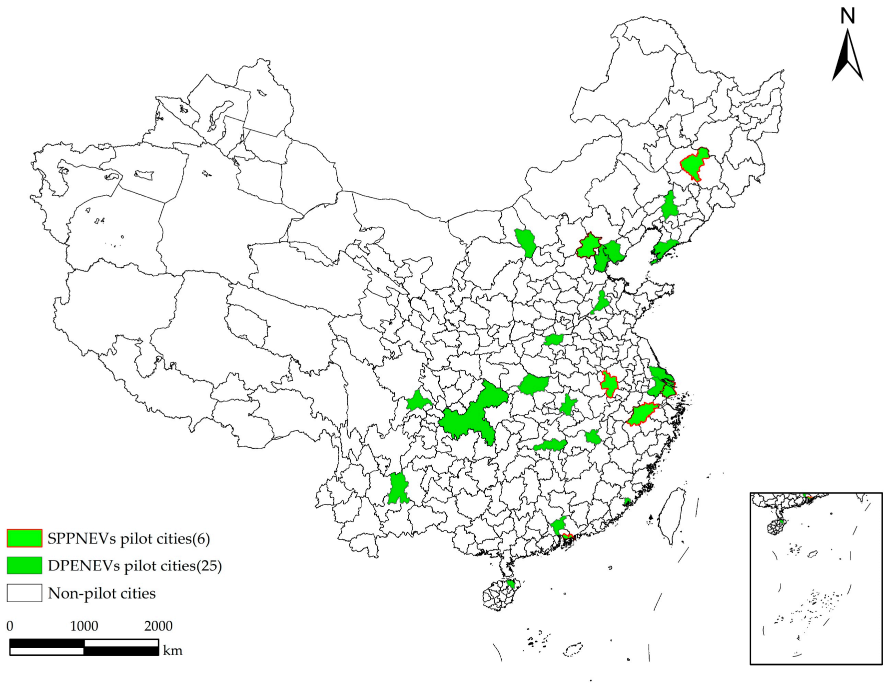


Figure 1. Distribution of NEVPP pilot cities in China.

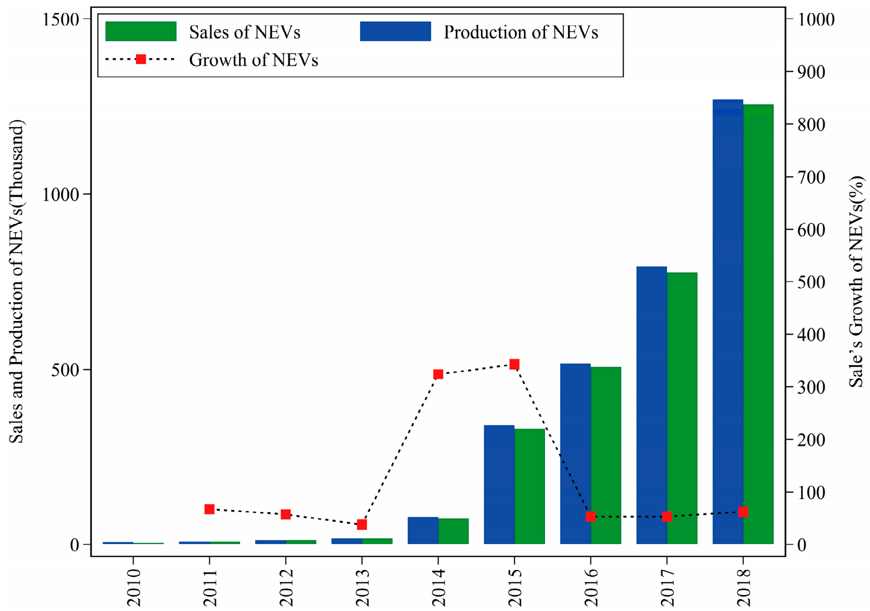


Figure 2. Sales and Production of NEVs in China from 2010–2018.

3. Research Design

3.1. Samples and Data

Considering the possible time lag between the introduction of the first batch of pilot policies and their implementation, we set the NEVPP policy time point to 2010. Coupled with the requirements of the before and after time trend analysis of the parallel trend test of the DID research method, we chose the 6 years before the policy time point, that is, 2004–2009, and the 7 years after the policy time point, a total of 14 years from 2004–2017, as the sample period for NEVPP policy evaluation. We deleted the cities whose administrative divisions were adjusted during the sample period, such as Chaohu City in Anhui Province and Longnan City in Gansu Province, etc. In addition, we deleted Hong Kong, Macao, and Taiwan regions with different statistical calibers, as well as cities in Tibet and ethnic minority autonomous regions where data samples were missing.

The various economic output value data of the city-level control variables were all price deflated based on 2003. The data comes from the "China Statistical Yearbook", "China Regional Economic Statistical Yearbook", and "China City Statistical Yearbook" across the years. The city (green) patent authorization data comes from the China Research Data Service Platform (CNRDS) database. Urban carbon emissions were calculated by superimposing the carbon emissions of the counties under their jurisdiction.

3.2. Variables

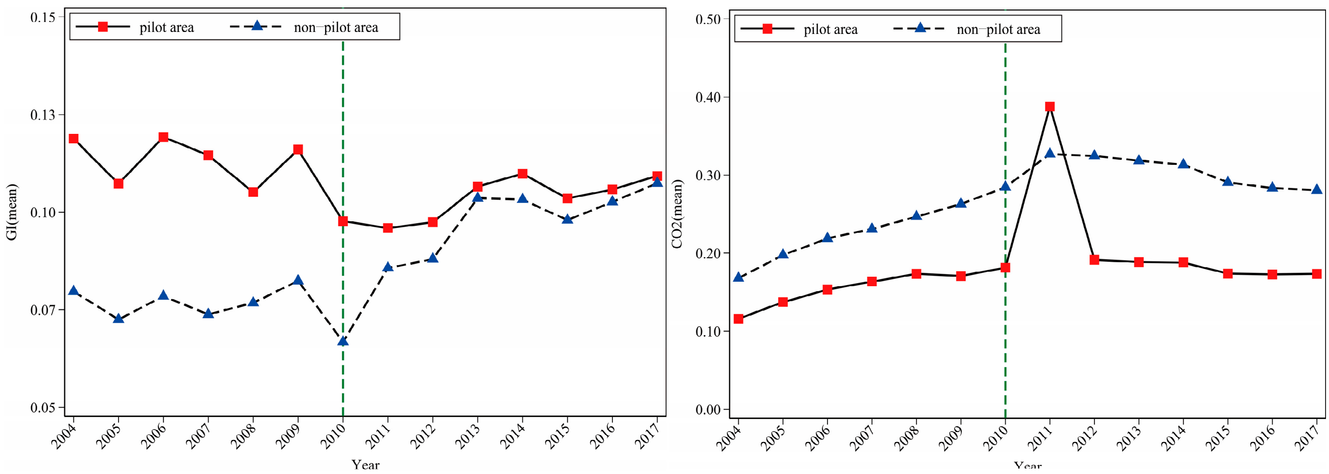
3.2.1. Dependent Variable

The dependent variables of this study are the level of urban green innovation and carbon dioxide emissions. Based on Shi and Lee (2020 [31]), urban green innovation is measured by the ratio of the number of urban green patents to the total number of patents granted. The urban carbon dioxide emission data is calculated by taking the logarithm of the total carbon dioxide emission (million tons) of the districts and counties under the jurisdiction of the city. The data of districts and counties were calculated using the apparent emission calculation algorithm.

3.2.2. Key Explanatory Variable

The key explanatory variable of this study is the dummy variable of the NEVPP, which is composed of the pilot group dummy variable and the pilot time group dummy variable. When a city belongs to the pilot group (list in Table 1 column 4), the pilot group dummy variable is 1; otherwise, it is 0.

Figure 3 shows the time series trend of urban green innovation level and carbon dioxide emissions in the treatment group and the control group cities from 2004 to 2017. It is not difficult to see that before and after the pilot policy, the changing trend of the treatment group and the control group underwent major changes. After the implementation of the pilot policy, the gap between the treatment group and the control group of the urban green innovation level was significantly reduced. The carbon dioxide emissions of the pilot cities fluctuated drastically two years after the implementation of the pilot policy. After that, the emission reduction effect was significantly better than that of the control group cities.



(**a**) (**b**)

Figure 3. Time trend graph of (**a**) green innovation and (**b**) CO_2 Emissions (mean value).

3.2.3. Control Variables

Based on the existing literature [7,30,31], we controlled for a set of variables to capture the influence factors of green innovation and carbon dioxide emissions. The control variables included economic development level (GDP per capita), population size (total population), energy consumption (logarithm of per capita industrial electricity consumption), government intervention (per capita fiscal expenditure), education expenditure (logarithm of education expenditure), industrial structure (the ratio of the secondary industry to the tertiary industry), scientific research human capital (the proportion of the number of employees in the scientific research comprehensive technical service industry in the total population).

3.3. Empirical Model

We applied DID to study the impact of NEVPP on green innovation. The panel DID model is set as follows

$$\underset{\{gi_{it},CO_{2it}\}}{Y_{it}} = \alpha_0 + \alpha_1 DID_{it} + \alpha_2 control_{it} + city_i + year_t + province_j \times year_t + \varepsilon_{it} \quad (1)$$

where the dependent variable Y_{it} denotes the urban green innovation and carbon dioxide emissions in city i at year t. The independent variable DID_{it} denotes the dummy variable of NEVPP, which equals 1 if the city i at year t is approved as the pilots, otherwise, it equals 0. $control_{it}$ denotes control variables. α_0 denotes the constant, α_1 denotes the coefficients of the independent variable, α_2 denotes the coefficients of control variables. $city_i$ is urban fixed effects absorbing all unobserved city-specific, time-invariant factors that may influence the dependent variable. $year_t$ is the year fixed effect to control for the general macroeconomic factors affecting all cities. $province_j \times year_t$ is the province individual time effect to control for unobservable factors that vary over time in each province on the estimation results. ε_{it} is a random error.

4. Empirical Analysis

4.1. Baseline Regression

As shown in Table 2, columns (1) and (2) are the average treatment effect (ATE) results estimated by the panel DID model. Columns (3) and (4) are the dynamic treatment effect (DTE) results of each year after the implementation of the pilot policy estimated by the panel DID model.

The results show that after controlling for the individual effects of the city, the time effect of the year, and the time effect of the province, the NEVPP has a significant impact on green technology innovation, and emission reduction in pilot cities. The NEVPP significantly reduced carbon dioxide emissions in pilot cities, but at the same time significantly inhibited green technology innovation in pilot cities; the coefficients are all significant at the 10% confidence level. The dynamic effect analysis results of columns (3)–(4) show that the pilot policy had a significant impact on urban green innovation and carbon emissions each year after the implementation of the policy. In terms of green innovation, from 2010 to 2017, the DTE estimation results in each year showed a significant inhibitory effect; the coefficient was significant at the 1% confidence level, and the inhibitory effect increased year by year. In terms of emission reduction, from 2010 to 2017, the DTE estimation results in each year showed a significant promotion effect; the coefficient was significant at the 1% confidence level, and the emission reduction effect increased year by year. This once again confirms the inhibitory effect of the NEVPP on the green innovation of the pilot cities and the reduction effect on carbon dioxide emissions. The inhibitory effect of green innovation is slightly different from the existing research conclusions, and the emission reduction effect is the same as the existing research.

Table 2. Baseline regression results.

	Green Innovation(GI)-ATE	CO_2 Emissions-ATE	GI-DTE	CO_2 Emissions-DTE
	(1)	(2)	(3)	(4)
DID	−0.237 * (−1.72)	−0.020 * (−1.66)		
Treat × *year10*			−0.862 *** (−3.77)	−0.261 * (−1.65)
Treat × *year11*			−0.886 *** (−3.55)	0.096 (1.23)
Treat × *year12*			−0.966 *** (−3.62)	0.138 (1.58)
Treat × *year13*			−1.106 *** (−3.98)	−0.311 *** (−2.65)
Treat × *year14*			−1.237 *** (−4.18)	−0.446 *** (−3.15)
Treat × *year15*			−1.454 *** (−4.33)	−0.667 *** (−4.35)
Treat × *year16*			−1.542 *** (−4.21)	−0.604 *** (−3.94)
Treat × *year17*			−1.601 *** (−4.21)	−0.705 *** (−4.32)
Constant	−5.887 *** (−3.36)	2.109 *** (15.96)	−5.833 *** (−3.50)	−4.330 *** (−7.25)
Control	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y
City-FE	Y	Y	Y	Y
Pro ×*year*	Y	Y	Y	Y
Obs.	3934	3934	3934	3934
Adj-R^2	0.163	0.975	0.163	0.913

Note: The parentheses are the *t*-values. *** and * represent significant levels at 1% and 10%, respectively.

To investigate the policy effects of the NEVPP in-depth, this study also took urban innovation and PM10 concentration as substitute variables for green innovation and carbon emissions. Based on Peng, Sun and Nie (2017 [48]) and Zhou and Cheng (2021 [49]), urban meteorological factors (MFs, including precipitation, wind speed, temperature, and humidity, etc., MFs data comes from China Meteorological Data Service Centre) had a significant impact on urban PM10 concentration. Therefore, we controlled the MFs regression, and built a new analysis model (Equations (2) and (3)) for estimation.

$$Innovation_{it} = \alpha_0 + \alpha_1 DID_{it} + \alpha_2 control_{it} + city_i + year_t + province_j \times year_t + \varepsilon_{it} \quad (2)$$

$$PM10_{it} = \alpha_0 + \alpha_1 DID_{it} + \alpha_2 control(withMFs)_{it} + city_i + year_t + province_j \times year_t + \varepsilon_{it} \quad (3)$$

The results are shown in Table 3. Columns (1) and (2) are the ATE results estimated by the panel DID model, and columns (3) and (4) are the DTE results for each year after the implementation of the pilot policy. Consistent with the baseline model estimation results, the ATE estimation results show that the NEVPP had a significant emission reduction effect, the coefficient is significant at the 5% confidence level; the difference is that the NEVPP also had a significant innovation effect, the coefficient is significant at the 1% confidence level. This means that the NEVPP significantly improved the technological innovation level of pilot cities, but it inhibited the city's green innovation process. Subsequent heterogeneity analysis conducted an in-depth analysis of this result.

Table 3. Regression results about Innovation and PM10.

	Innovation-ATE	PM10-ATE	Innovation-DTE	PM10-DTE
	(1)	(2)	(3)	(4)
DID	0.220 ***	−0.411 **		
	(2.61)	(−2.36)		
Treat × *year10*			1.520 ***	−1.167 ***
			(15.62)	(−13.73)
Treat × *year11*			2.018 ***	−1.398 **
			(15.42)	(−2.30)
Treat × *year12*			2.462 ***	−1.658 ***
			(17.18)	(−2.63)
Treat × *year13*			2.794 ***	−0.846 **
			(15.93)	(−2.01)
Treat × *year14*			2.893 ***	−1.048 **
			(9.39)	(−1.74)
Treat × *year15*			3.434 ***	−0.956 ***
			(11.74)	(−2.66)
Treat × *year16*			3.876 ***	−0.933 **
			(18.72)	(−2.31)
Treat × *year17*			3.887 ***	−13.673 ***
			(16.50)	(−74.81)
Constant	3.118 ***	−3.887	3.146 ***	−6.492
	(3.61)	(−0.85)	(3.56)	(−1.45)
Control	Y		Y	
Control (add MFs)		Y		Y
Year-FE	Y	Y	Y	Y
City-FE	Y	Y	Y	Y
Pro ×*year*	Y	Y	Y	Y
Obs.	3934	3525	3934	3525
Adj-R^2	0.889	0.890	0.888	0.889

Note: The parentheses are the *t*-values. *** and ** represent significant levels at 1% and 5%, respectively.

4.2. Parallel Trend Test

The key identification hypothesis of the DID model is that non-pilot areas provide effective counterfactual changes for the policy treatment effects of pilot areas [50,51], that is, before the implementation of the NEVPP, urban green innovation and carbon dioxide emissions maintain relatively stable changes, while there is a significant difference between the treatment group and the control group after the pilot implementation (as shown in Figures 3 and 4). To ensure the basic assumption is met, this study followed the parallel trend test method of DID and performed panel DID regression for the first 4 years and the last 5 years of the treatment period. The regression results show that before the implementation of the NEVPP, there was no systematic difference in the time trend between the pilot area and non-pilot area, which means it satisfies the parallel trend assumption.

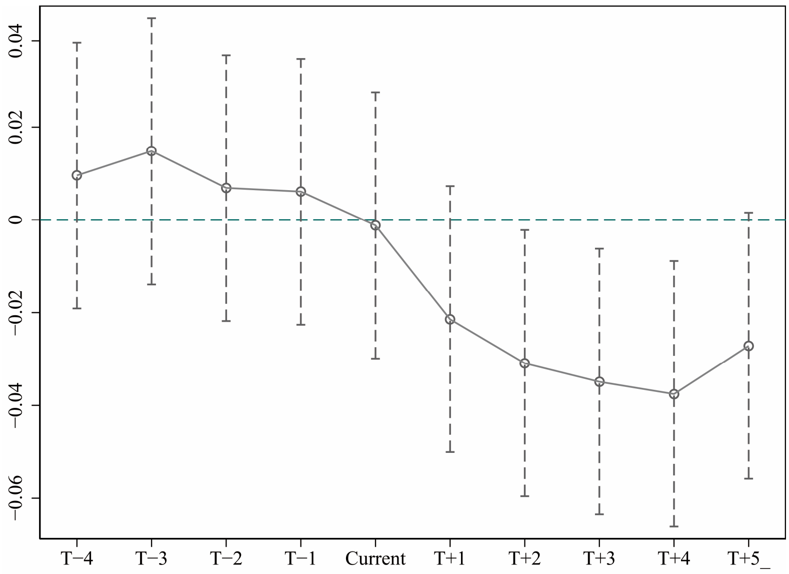


Figure 4. Parallel trend test.

5. Mechanism Analysis

As discussed in Section 1, the NEVPP may affect carbon dioxide emissions through energy conservation, innovation, and adjustment of industrial structure. We empirically tested these potential impact mechanisms.

5.1. Impact of Energy Conservation

Under the support of the NEVPP policy, new energy vehicle manufacturers in pilot cities have significantly reduced operating costs and innovation risks, and significantly improved corporate profitability. This gives these new energy vehicle manufacturers enough space to carry out more technological innovation activities, which includes the promotion of technological innovations in the new energy industry in the low-carbonization of automobiles, power batteries, drive motors, and high-efficiency internal combustion engines. Partially, or even completely, replacing traditional fossil energy consumption may directly or indirectly reduce urban fossil energy consumption, and then achieve emission reduction targets through energy conservation. Therefore, we believe that the pilot policy can achieve the policy goal of reducing carbon dioxide emissions by reducing urban energy consumption. We learnt from the practice of Wu et al. (2014 [52]), by adopting satellite night light data to simulate and measure the energy consumption of the city, and used the following model to test the mechanism:

$$CO_{2it} = \alpha_0 + (\alpha_1 DID_{it} + \alpha_3 ec_{it} + \alpha_4 DID_{it} \times ec_{it}) + \alpha_2 control_{it} + city_i + year_t + province_j \times year_t + \varepsilon_{it} \tag{4}$$

Table 4 column (1) gives the estimated results of Equation (4). It is shown that the interaction coefficient of the NEVPP DID and the energy consumption is significantly negative at the 5% level, indicating that the NEVPP can significantly reduce carbon dioxide emissions of the pilot cities by energy conservation.

Table 4. Results of the impact mechanism analysis.

	CO_2 Emissions		
	Energy Conservation	**Innovation**	**Industry Structure**
	(1)	**(2)**	**(3)**
*DID *ec*	−0.087 ** (−2.28)		
*DID *innovation*		−0.010 ** (−2.12)	
*DID *str*			−0.091 ** (−1.97)
Constant	0.681 *** (3.11)	1.539 *** (7.44)	1.122 *** (5.11)
Control	Y	Y	Y
Year-FE	Y	Y	Y
City-FE	Y	Y	Y
Pro ×year	Y	Y	Y
Obs.	3934	3934	3934
Adj-R^2	0.906	0.710	0.896

Note: The parentheses are the *t*-values. ***, ** and * represent significant levels at 1%, 5% and 10%, respectively.

5.2. Impact of Innovation

The NEVPP mainly uses various financial subsidies from central government and local government to intervene in the R&D, production, and consumption links of the new energy automobile industry. On the one hand, this can help new energy automobile manufacturers resist the huge risks of innovation in the early stage of the development of the new energy automobile industry, and promote the innovation activities of new energy automobile companies. On the other hand, it can also increase the R&D investment of enterprises by reducing costs and increasing the scale of profitability, and also increase the intensity of technological innovation activities. Both can speed up the technological innovation process of new energy vehicle manufacturers in the fields of low-carbonization, informatization, and intelligence of vehicles, as well as technological progress in the fields of power batteries, drive motors, high-efficiency internal combustion engines, advanced transmissions, lightweight materials, and intelligent control. The government's NEVPP can significantly improve the technological innovation level of new energy companies through the above two channels, thereby enhancing the city's innovation capabilities and achieving energy-saving and emission reduction goals. We use the logarithm of the number of urban patent grants to measure the level of innovation at the city level, and use the following model to test the mechanism

$$\begin{aligned} CO_{2it} &= \alpha_0 + (\alpha_1 DID_{it} + \alpha_3 innovation_{it} + \alpha_4 DID_{it} \times innovation_{it}) + \alpha_2 control_{it} \\ &+ city_i + year_t + province_j \times year_t + \varepsilon_{it} \end{aligned} \quad (5)$$

Table 4 column (2) gives the estimated results of Equation (5). The interaction coefficient of the NEVPP DID and innovation is significantly negative at the 10% level, indicating that NEVPP can improve the innovation of territorial cities, which can significantly reduce carbon dioxide emissions of the pilot cities.

5.3. Impact of Industry Structure

The NEVPP also affects the macro-industrial structure of the city, and affect the city's carbon dioxide emissions through industrial structure adjustment. In the pilot areas, the traditional automobile industry was affected by the new energy automobile industry policy, the operating costs of enterprises have increased significantly due to the competitive effect of NEVs. Coupled with the pressure of other types of energy-saving and emission reduction policies implemented by the city government, this has caused the auto industry capital to gradually withdraw from the traditional auto production field and invest in the new energy auto industry. This capital transfer effect will form an adjustment of the industrial structure at the industrial level. Moreover, the implementation of the new energy vehicle pilot policy also attracts the transfer of capital from other polluting industries to the green energy-saving field, which will further affect the industrial structure of the city. The green adjustment of the urban industrial structure will inevitably reduce the dependence on fossil fuel energy at the industrial level, and increase the proportion of non-fossil energy. This directly or indirectly reduces the level of urban carbon dioxide emissions. Therefore, this study believes that the new energy vehicle pilot policy can affect the city's carbon emissions by adjusting the city's industrial structure. We used the ratio of the added value of the city's secondary industry to GDP to measure the city's industrial structure, and use the following model to test the impact mechanism

$$CO_{2it} = \alpha_0 + (\alpha_1 DID_{it} + \alpha_3 str_{it} + \alpha_4 DID_{it} \times str_{it}) + \alpha_2 control_{it} + city_i + year_t + province_j \times year_t + \varepsilon_{it} \quad (6)$$

Table 4 column (3) gives the estimated results of Equation (6). The interaction coefficient between the NEVPP DID and industry structure is significantly negative at the 5% level, indicating that the NEVPP can adjust the industry structure of pilot cities, which can significantly reduce carbon dioxide emissions of the pilot cities.

6. Heterogeneity Analysis

The NEVPP is essentially a new energy automobile industry policy; the implementation of industrial policy is closely related to the economic development level of the policy area. Generally speaking, areas with a higher level of economic development have a larger market scale and more intense market competition than areas with lower levels of economic development. It is easier for industrial policies to exert their policy effects in areas with large market scale and more competitive markets.

In addition, the fiscal subsidy policy represented by the NEVPP is different from market-oriented policy tools because the fiscal subsidy policy, with obvious characteristics of government intervention itself, is one of the important reasons for the distortion of market commodity factor prices. This kind of price distortion will affect the market competition pattern. Therefore, the effective implementation of the fiscal subsidy policy is more dependent on the marketization level of the policy area than market-oriented policy tools; specifically, it depends more on the relationship between the government and the market and the level of development of the non-state-owned economy. In areas where the government has a good relationship with the market, the government's intervention in the market is relatively weak. Under the conditions of a certain level of economic development, market competition is relatively more adequate. Enterprises can take advantage of their own technological innovation under a better competitive landscape, and generate more monopoly profits; the higher the efficiency of resource allocation is, then the greater the probability of successful technological innovation and the higher the energy efficiency. Under certain conditions of output, the overall carbon emission level will be lower.

As we all know, many countries with low levels of economic development have obvious characteristics of government intervention. Strong government intervention means two possible scenarios. One is market segmentation caused by excessive competition by local governments; this is not conducive to the formation of the overall competition pattern in the region and causes the distortion of regional resource element prices, which has an adverse effect on the effectiveness of the policy. The second category is the corruption of rent-seeking rights under the collusion of government and enterprise; the main manifestation of this is that government employees use their rights to conspire with new energy automobile companies to defraud state subsidies. This causes the loss of public property and at the same time distorts regional resource element prices, which adversely affects the effectiveness of the policy.

The economic development level is divided into three groups: the eastern region, the central region, and the western region. The three northeastern provinces have fewer samples and are not listed separately, but they are combined into the eastern region for unified analysis. Secondly, according to the research of Li and Ramanathan (2018, [53]), we used the provincial marketization data disclosed by Fan Gang et al. [54]. According to the median of the government–market relationship index, the sample cities are divided into two levels, namely, regions with good government–market relations and regions with poor government–market relations. Similarly, according to the median of the non-state-owned economic development level index in the provincial marketization data, the sample cities are divided into two groups, namely, regions with a higher level of non-state-owned economic development and regions with a lower level. The heterogeneity groupings all use the data before the pilot period, and the 2009 data are used here to avoid possible selection bias.

Table 5 shows the estimated results of the heterogeneity analysis of the NEVPP based on the grouping by locations. Columns (1) and (2) are the estimation results in the eastern region, columns (3) and (4) are the estimation results in the central region, and columns (5) and (6) are the estimation results in the western region. Firstly, we examined the heterogeneous effects of NEVPP on urban green innovation in different locations. The results show that in the eastern region with a high level of economic development, the NEVPP had a significant positive effect on green innovation in pilot cities, and the coefficient is significant at the 5% level. In the central and western regions, the NEVPP did not show a positive effect on green innovation in pilot cities but showed a negative impact, and the coefficient in the western region was significant at the 10% level. This explains one possible reason for the green innovation suppression effect derived from the benchmark model regression, that is, the level of economic development is an important source of the NEVPP's green innovation effect heterogeneity. The economically developed regions have a large market and sufficient market-oriented competition. Therefore, the NEVPP policy can give full play to its green innovation effect. In economically underdeveloped areas, this promotion effect will reverse and become a negative inhibitory effect. Since there are more urban individuals in the central and western regions of China, the overall negative inhibitory effect is shown. Next, we focused on the heterogeneous effects of the NEVPP on carbon emissions in different locations. On the whole, the coefficients of the three regions are all negative, which means that they all indicate the reduction effect of the NEVPP. However, only the eastern region is significant at the 5% level, which means that the overall NEVPP emission reduction effect is mainly due to the eastern region playing a major role.

Table 5. Heterogeneity analysis results of different locations.

	East		**Central**		**West**	
	(1) GI	**(2) CO_2**	**(3) GI**	**(4) CO_2**	**(5) GI**	**(6) CO_2**
DID	0.617 **	−0.032 **	−0.187	−0.015	−0.877 *	−0.052
	(2.42)	(−2.25)	(−0.64)	(−1.20)	(−1.96)	(−1.57)
Constant	−5.406 ***	3.109 ***	−5.370 ***	2.236 ***	−5.211 **	2.086 ***
	(−2.76)	(12.50)	(−2.75)	(8.34)	(−2.52)	(17.46)
Control	Y	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y	Y
City-FE	Y	Y	Y	Y	Y	Y
Pro ×year	Y	Y	Y	Y	Y	Y
Obs.	3934	3934	3934	3934	3934	3934
Adj-R^2	0.167	0.967	0.164	0.973	0.165	0.957

Note: The parentheses are the *t*-values. ***, ** and * represent significant levels at 1%, 5% and 10%, respectively.

Table 6 shows the estimated results of the heterogeneity analysis of the NEVPP based on the grouping by government–market relations and development of the non-state-owned economy. Columns (1)–(4) are the estimated results based on government–market relations grouping, columns (5)–(8) are the estimated results grouped according to the development of the non-state-owned economy. Firstly, we will examine the heterogeneous effects of the

NEVPP under different groups on urban green innovation. The results show that in areas where the government–market relationship is good, that is, areas where the government's direct intervention in the market is low, as well as in regions with a high development of the non-state-owned economy, that is, regions where the government through state-owned units indirectly intervenes in the market with low intensity, the NEVPP exhibits a positive green innovation effect, and the regional coefficient of development of the non-state-owned economy is significant at the 1% level. This explains the other possible reasons for the inhibitory effect of green innovation derived from the regression of the benchmark model, namely government–market relations and development of the non-state-owned economy. This shows that both direct and indirect government interventions in the market will have a negative impact on the green innovation effect of the NEVPP. This result reflects the key influence of market-oriented reforms in the effect of the NEVPP policy. Secondly, we examine the impact of the NEVPP on carbon emissions heterogeneity under different groups. Similarly, the emission reduction effect of the NEVPP is significant in areas with good government–market relations and areas with a high development of the non-state-owned economy. In another group of cities, this showed a positive impact (but the result was not significant). This means that the government's direct intervention in the market and indirect intervention also affect the city's carbon emissions.

Table 6. Heterogeneity analysis results of different government and market relations, development of non-state-owned economy.

	Government–Market Relations				**Development of Non-State-Owned Economy**			
	Good		**Bad**		**High**		**Low**	
	(1) GI	**(2) CO_2**	**(3) GI**	**(4) CO_2**	**(5) GI**	**(6) CO_2**	**(7) GI**	**(8) CO_2**
DID	0.030	−0.027 ***	−0.787 **	0.014	0.478 ***	−0.020 **	−0.751 ***	0.023
	(0.29)	(−2.75)	(−2.20)	(0.44)	(2.66)	(−2.00)	(−2.79)	(0.50)
Constant	−5.584 ***	2.845 ***	−4.004	−1.888 ***	−5.031 ***	2.882 ***	−6.197 **	−1.893 ***
	(−3.25)	(23.46)	(−0.85)	(−6.71)	(−2.98)	(17.41)	(−2.13)	(−7.66)
Control	Y	Y	Y	Y	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y	Y	Y	Y	Y
City-FE	Y	Y	Y	Y	Y	Y	Y	Y
Pro×year	Y	Y	Y	Y	Y	Y	Y	Y
Obs.	1893	1375	1694	1451	2146	1847	1675	1438
Adj-R^2	0.121	0.960	0.166	0.847	0.031	0.971	0.183	0.726

Note: The parentheses are the *t*-values. *** and ** represent significant levels at 1%, and 5%, respectively.

Above all, we believe that the NEVPP's policy effects for promoting green technology innovation and emission reduction show significant heterogeneity under different economic development levels, government–market relations, and non-state-owned economic development levels, and the policy effects perform better in the regions where the level of economic development is high, the local government has a good relationship with the market, and the level of non-state economic development is high.

7. Robustness Test

7.1. Placebo Test

To further eliminate the influence of other unknown factors on the selection of pilot cities, this study conducted 999 samplings in all 281 cities, and randomly selected 25 cities as the virtual treatment group for each sampling (the original number of treatment groups was 25), and the remaining 256 cities were used as a randomized control group. We estimate the placebo test adopting the DID approach, and the results are as shown in Figure 5. Figure 5a,b are, respectively, the distribution diagrams of the coefficients of the NEVPP on green technology innovation and emission reduction in the random sampling estimation results. It was found that the t value of most sampling estimation coefficients changes within a small range, and the significance fails (that is, the pass rate is still low even under the 10% confidence level), indicating that the NEVPP did not show a significant treatment effect in the random sampling simulation. It can be considered that the conclusion of the treatment effect identified by the benchmark model estimation passed the placebo test.

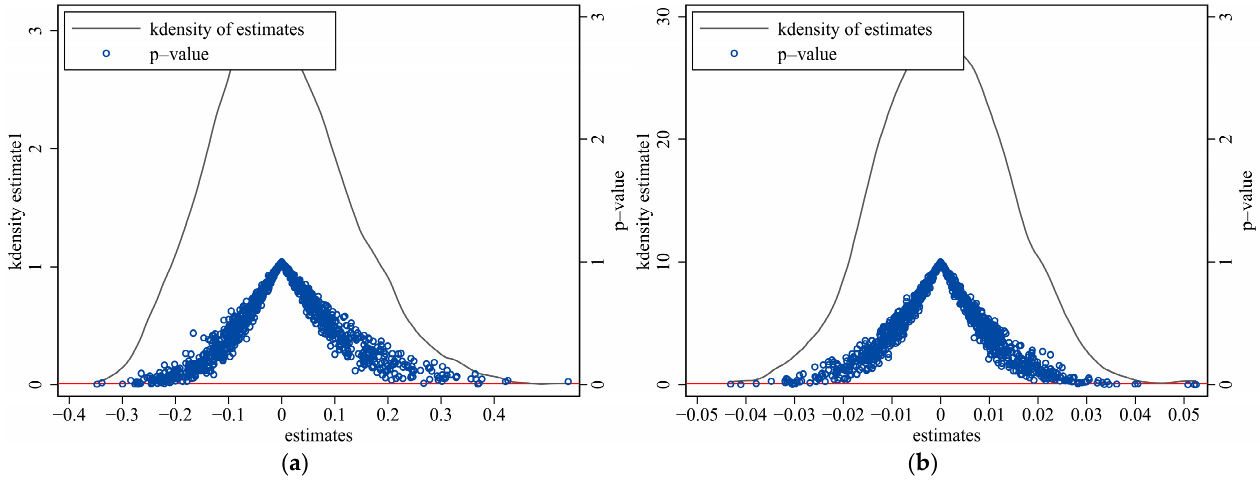


Figure 5. Figure 5a,b are, respectively, the distribution diagrams of the coefficients of NEVPP on green technology innovation and emission reduction in the random sampling estimation results. The coefficients of the NEVPP on green technology innovation (**a**) and emission reduction (**b**) in the random sampling estimation results.

7.2. PSM-DID

Although the NEVPP has a significant effect on green technology innovation and emission reduction, the result may be caused by potential selectivity bias [30,31]. Therefore, we used the propensity score matching (PSM) method to solve the problem of selective bias that may exist in the grouping, by identifying and matching to form a new treatment group and control group, and then continued to use the panel DID model to identify and evaluate the treatment effect. The results of the estimation of the PSM-DID method are shown in Table 7. This study found that the NEVPP still significantly curbs urban green innovation and significantly reduces urban carbon emissions, indicating that the research conclusions of the benchmark model are robust.

Table 7. Estimation results in PSM-DID.

	GI (PSM-DID)	**CO_2 (PSM-DID)**
	(1)	**(2)**
DID	−0.042 *	−0.101 **
	(−1.66)	(−2.18)
Constant	−0.020	−2.432 ***
	(−0.32)	(−21.31)
Control	Y	Y
Year-FE	Y	Y
City-FE	Y	Y
Pro ×year	Y	Y
Obs.	3520	3520
Adj-R^2	0.146	0.773

Note: The parentheses are the *t*-values. ***, ** and * represent significant levels at 1%, 5% and 10%, respectively.

7.3. IV Estimation

Although we adopted the PSM-DID method to overcome the possible selection bias problem, to further overcome the endogenous problem of the pilot city selection, this study used a two-stage instrumental variable method to further identify and estimate.

Drawing lessons from studies such as Xu et al., (2020) [55], especially the study of Xie et al., (2021) [30], we used the lagged term of the subsidy scale (subscalag) as an instrumental variable for the core explanatory variable; this approach satisfies the hypothesis of relevance and also satisfies the hypothesis of exclusivity. The estimation results are shown in Table 8, and are all significant. It shows that the estimation result is still robust after excluding possible endogenous selection bias.

Table 8. Estimation results in IV.

	DID	**Green Innovation**	***DID***	**CO_2 Emissions**
	(1)	**(2)**	**(1)**	**(2)**
IV(subscalag)	1.034 * (1.72)		1.257 ** (2.83)	
IV-DID		−0.259 * (−1.83)		−0.061 ** (−2.44)
Control	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y
City-FE	Y	Y	Y	Y
Pro×year	Y	Y	Y	Y
F-first stage	13.07		35.48	
Obs.	3924	3924	3924	3924
Adj-R^2	0.316	0.146	0.405	0.865

Note: The parentheses are the *t*-values. ** and * represent significant levels at 5% and 10%, respectively.

7.4. ETS and Carbon-ETS

Some scholars in existing research have analyzed the green innovation and emission reduction effects of ETS and carbon-ETS; the analysis results show that these two do have a significant impact on urban green innovation and carbon emissions [7,31]. Therefore, in order to avoid the possible confusion caused by ETS and carbon-ETS, this research constructed dummy variables of ETS and carbon-ETS, that is, if a city belongs to a policy pilot, the value is 1, otherwise it is 0. This variable was incorporated into the benchmark DID model, and then we adopted the difference-in-difference-in-differences (DDD) method to identify and estimate the model.

The results are shown in Table 9. Columns (1) and (2) are the estimated results after controlling the influence of ETS, and columns (3) and (4) are the estimated results after controlling the influence of carbon-ETS. The results show that after controlling the confounding effects of ETS and carbon-ETS, the NEVPP still significantly inhibits green innovation in pilot cities, and significantly reduces carbon emissions in pilot cities, again showing that the policy effects of the NEVPP are robust.

Table 9. Estimation results with ETS and Carbon-ETS.

	ETS		Carbon-ETS	
	(1) GI	(2) CO_2	(3) GI	(4) CO_2
DDD	−0.039 *	−0.042 *	−0.025 *	−0.196 ***
	(−1.82)	(−1.77)	(−1.69)	(−4.28)
Constant	−0.030	2.109 ***	−0.027	1.115 ***
	(−0.33)	(15.08)	(−0.30)	(5.19)
Control	Y	Y	Y	Y
Year-FE	Y	Y	Y	Y
City-FE	Y	Y	Y	Y
Pro×year	Y	Y	Y	Y
Obs.	3924	3924	3924	3924
Adj-R^2	0.026	0.975	0.024	0.899

Note: The parentheses are the *t*-values. *** and * represent significant levels at 1% and 10%, respectively.

7.5. Other Robustness Tests

With reference to previous related studies, we also considered using NO_x emissions and PM2.5 concentration as dependent variables for further robustness testing. The estimated results are shown in Table 10. The estimated results with NOx emissions and PM2.5 concentration as dependent variables are consistent with the baseline regression direction, again showing that the policy effects of the NEVPP are robust.

Table 10. Estimation results with NOX emissions and PM2.5 concentration.

	NO_X Emissions	PM2.5 Concentration
DID	−0.319 **	−0.303 **
	(−2.34)	(−2.16)
Constant	9.675 ***	8.700 ***
	(11.49)	(2.84)
Control	Y	
Control (with MFs)		Y
Year-FE	Y	Y
City-FE	Y	Y
Pro×year	Y	Y
Obs.	3796	3392
Adj-R^2	0.347	0.346

Note: The parentheses are the *t*-values. *** and ** represent significant levels at 1% and 5%, respectively.

8. Discussion and Conclusions

8.1. Discussion

To achieve green innovation and reduce urban carbon emissions, the Chinese government has carried out more policy explorations, among which the NEVPP plays an essential role. Based on the panel data of 281 cities in China from 2004–2017, we explored the policy effect of NEVPP on green innovation and emissions reduction.

Our research results show that, compared with non-pilot cities, China's new energy vehicle subsidy pilot cities have had significant innovation effects and emission reduction effects, which are consistent with previous research conclusions [32,39]. However, the green innovation effect expected in this study did not appear; instead, a significant inhibitory effect appeared, which is significantly different from the existing researches, such as [56]. As described in the introduction, we believe that the reason for this different result may be related to the heterogeneous source of policy effects. The heterogeneity analysis results of Section 6 showed that the overall average suppression effect and the partial promotion effect of green innovation existed simultaneously, indicating the following possible messages: the eastern region and regions with high levels of non-state-owned economic development did not play a leading role. Instead, they were negatively restrained by the central and western regions and regions with a high proportion of the state-owned economy, which makes ATE appear as a restraining effect. In terms of emission reduction effects, advantageous regions showed obvious leading roles. The above conclusions not only refute the negative views of some scholars on the effectiveness of China's market-oriented reforms [57] but also confirm the important role of the market economy in improving the allocation of resource elements and the urgency of market-oriented reforms in backward areas [58].

Additionally, our analysis explores the mechanism that the NEVPP may affect carbon dioxide emissions through energy conservation, technological innovation, and industrial structure adjustment. This verifies the important role of technical efficiency in industrial structure upgrading, green innovation, and emission reduction [7]. The government should make full use of policy tools such as the NEVPP to encourage new energy companies to R&D advanced technologies. For example, the government can try to link NEVs low-carbon technology R&D with the carbon trading market and send a clear signal to the market to guide companies to invest in low-carbon technology.

8.2. Conclusions

In general, from the perspective of the current policy treatment effects, the NEVPP has achieved the expected goals of the policy; it has completed emission reductions while partially increasing green innovation, and realizing green and sustainable development. The effective implementation of the NEVPP not only provides a powerful reference for China to use subsidy policy to achieve environmental and economic sustainable development but also provides experience support on the NEVPP tools for other countries.

Although this research has provided some valuable findings and enlightenment for government decision making and research in the field of new energy vehicles, it inevitably has some limitations. On the one hand, our research is limited to city-level data in mainland China and does not involve other developing or emerging market countries. Therefore, whether the results of policy effect identification can be extended to these regions needs further empirical testing. On the other hand, due to the wide scope of the NEVPP subsidies, our research did not classify and identify the subsidy objects. For example, to classify and examine the heterogeneity characteristics of the subsidy policies for different types of new energy vehicles, such as battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs), on the impact mechanism of green innovation and emission reduction. In addition, our research did not carry out further analysis of the subsidy policy decline. Further research can attempt to start from the perspective of subsidy policy decline and examine the mechanism of policy decline on green innovation and emission reduction effects.

Author Contributions: Conceptualization, G.C., S.W. and D.H.; methodology, G.C.; software, G.C.; validation, G.C. and D.H.; formal analysis, G.C. and D.H.; data curation, G.C. and D.H.; writing—original draft preparation, G.C.; writing—review and editing, G.C. and S.W.; visualization, G.C. and D.H.; supervision, S.W.; project administration, G.C., S.W. and D.H.; funding acquisition, G.C. and D.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Ministry of education of Humanities and Social Science project (No. 17YJCZH063), Shenzhen Philosophy and Social Sciences Planning 2020 Project (No. SZ2020B012).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data available on request due to restrictions privacy. The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Vennemo, H.; Aunan, K.; Lindhjem, H.; Seip, H.M. Environmental pollution in China: Status and trends. *Rev. Environ. Econ. Policy* **2009**, *3*, 209–230. [CrossRef]
2. Lu, Z.N.; Chen, H.; Hao, Y.; Wang, J.; Song, X.; Mok, T.M. The dynamic relationship between environmental pollution, economic development and public health: Evidence from China. *J. Clean. Prod.* **2017**, *166*, 134–147. [CrossRef]
3. Chen, S. Environmental pollution emissions, regional productivity growth and ecological economic development in China. *China Econ. Rev.* **2015**, *35*, 171–182. [CrossRef]
4. Wu, H.; Hao, Y.; Ren, S. How do environmental regulation and environmental decentralization affect green total factor energy efficiency: Evidence from China. *Energy Econ.* **2020**, *91*, 104880. [CrossRef]
5. Wu, H.; Li, Y.; Hao, Y.; Ren, S.; Zhang, P. Environmental decentralization, local government competition, and regional green development: Evidence from China. *Sci. Total Environ.* **2020**, *708*, 135085. [CrossRef]
6. Yan, Y.; Zhang, X.; Zhang, J.; Li, K. Emissions trading system (ETS) implementation and its collaborative governance effects on air pollution: The China story. *Energy Policy* **2020**, *138*, 111282. [CrossRef]
7. Hu, Y.; Ren, S.; Wang, Y.; Chen, X. Can carbon emission trading scheme achieve energy conservation and emission reduction? Evidence from the industrial sector in China. *Energy Econ.* **2020**, *85*, 104590. [CrossRef]
8. McDonald, B.C.; De Gouw, J.A.; Gilman, J.B.; Jathar, S.H.; Akherati, A.; Cappa, C.D.; Jimenez, J.L.; Lee-Taylor, J.; Hayes, P.L.; McKeen, S.A.; et al. Volatile chemical products emerging as largest petrochemical source of urban organic emissions. *Science* **2018**, *359*, 760–764. [CrossRef]
9. Zhang, L.; Wang, L.; Chai, J. Influence of new energy vehicle subsidy policy on emission reduction of atmospheric pollutants: A case study of Beijing, China. *J. Clean. Prod.* **2020**, *275*, 124069. [CrossRef]
10. Wu, Y.; Zhang, L. Can the development of electric vehicles reduce the emission of air pollutants and greenhouse gases in developing countries? *Transp. Res. Part. Transp. Environ.* **2017**, *51*, 129–145. [CrossRef]
11. Hayashida, S.; La Croix, S.; Coffman, M. Understanding changes in electric vehicle policies in the US states, 2010–2018. *Transp. Policy* **2021**, *103*, 211–223. [CrossRef]
12. Åhman, M. Government policy and the development of electric vehicles in Japan. *Energy Policy* **2006**, *34*, 433–443. [CrossRef]
13. Egnér, F.; Trosvik, L. Electric vehicle adoption in Sweden and the impact of local policy instruments. *Energy Policy* **2018**, *121*, 584–596. [CrossRef]
14. Vidhi, R.; Shrivastava, P. A review of electric vehicle lifecycle emissions and policy recommendations to increase EV penetration in India. *Energies* **2018**, *11*, 483. [CrossRef]
15. Mishra, D.; Goyal, P. Estimation of vehicular emissions using dynamic emission factors: A case study of Delhi, India. *Atmos. Environ.* **2014**, *98*, 1–7. [CrossRef]
16. Sun, X.; Liu, X.; Wang, Y.; Yuan, F. The effects of public subsidies on emerging industry: An agent-based model of the electric vehicle industry. *Technol. Forecast. Social Chang.* **2019**, *140*, 281–295. [CrossRef]
17. Jenn, A.; Springel, K.; Gopal, A.R. Effectiveness of electric vehicle incentives in the United States. *Energy Policy* **2018**, *119*, 349–356. [CrossRef]
18. Yao, J.; Xiong, S.; Ma, X. Comparative analysis of national policies for electric vehicle uptake using econometric models. *Energies* **2020**, *13*, 3604. [CrossRef]
19. Sierzchula, W.; Bakker, S.; Maat, K.; Van Wee, B. The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy* **2014**, *6*, 183–194. [CrossRef]
20. Zhao, M.; Sun, T.; Feng, Q. A study on evaluation and influencing factors of carbon emission performance in China's new energy vehicle enterprises. *Environ. Sci. Pollut. Res.* **2021**, 1–14. [CrossRef]
21. Wu, Y.; Yang, Z.; Lin, B.; Liu, H.; Wang, R.; Zhou, B.; Hao, J. Energy consumption and CO_2 emission impacts of vehicle electrification in three developed regions of China. *Energy Policy* **2012**, *48*, 537–550. [CrossRef]
22. Tan, R.; Tang, D.; Lin, B. Policy impact of new energy vehicles promotion on air quality in Chinese cities. *Energy Policy* **2018**, *118*, 33–40. [CrossRef]
23. Li, J.; Ku, Y.; Liu, C.; Zhou, Y. Dual credit policy: Promoting new energy vehicles with battery recycling in a competitive environment? *J. Clean. Prod.* **2020**, *243*, 118456. [CrossRef]
24. Ren, X.; Zhang, H.; Hu, R.; Qiu, Y. Location of electric vehicle charging stations: A perspective using the grey decision-making model. *Energy* **2019**, *173*, 548–553. [CrossRef]
25. Gohoungodji, P.; N'Dri, A.B.; Latulippe, J.M.; Matos, A.L. What is stopping the automotive industry from going green? A systematic review of barriers to green innovation in the automotive industry. *J. Clean. Prod.* **2020**, *277*, 123524. [CrossRef]
26. Qu, L.; Li, Y. Research on industrial policy from the perspective of demand-side open innovation—A case study of Shenzhen new energy vehicle industry. *J. Open Innov. Technol. Mark. Complex.* **2019**, *5*, 31. [CrossRef]
27. Liu, Y.; Dong, F. Using geographically temporally weighted regression to assess the contribution of corruption governance to global PM 2.5. *Environ. Sci. Pollut. Res.* **2021**, *28*, 13536–13551. [CrossRef]
28. Liu, Y.; Dong, F. Haze pollution and corruption: A perspective of mediating and moderating roles. *J. Clean. Prod.* **2021**, *279*, 123550. [CrossRef]
29. Liu, Y.; Dong, F. Corruption, economic development and haze pollution: Evidence from 139 global countries. *Sustainability* **2020**, *12*, 3523. [CrossRef]

30. Xie, Y.; Wu, D.; Zhu, S. Can new energy vehicles subsidy curb the urban air pollution? Empirical evidence from pilot cities in China. *Sci. Total Environ.* **2021**, *754*, 142232. [CrossRef]
31. Shi, D.; Li, S.L. Emissions Trading System and Energy Use Efficiency—Measurements and Empirical Evidence for Cities at and above the Prefecture Level. *China Ind. Econ.* **2020**, *9*, 5–23. Available online: http://ciejournal.ajcass.org/Magazine/Show?id=75822 (accessed on 9 June 2020).
32. Li, F.; Ou, R.; Xiao, X.; Zhou, K.; Xie, W.; Ma, D.; Liu, K.; Song, Z. Regional comparison of electric vehicle adoption and emission reduction effects in China. *Resour. Conserv. Recycling.* **2019**, *149*, 714–726. [CrossRef]
33. Faria, M.V.; Baptista, P.C.; Farias, T.L. Electric vehicle parking in European and American context: Economic, energy and environmental analysis. *Transp. Res. Part. Policy Pract.* **2014**, *64*, 110–121. [CrossRef]
34. Nie, K.; Xie, D.F.; Li, W. Construction and analysis of new energy vehicle urban logistics carbon emission Model. *J. Hunan Univ.* **2015**, *42*, 134–140.
35. Xue, X.S.; Fang, H.; Yang, Z. Research on the Impact of New Energy Vehicle Promotion Policy on Enterprise Technological In-novation—Based on PSM-DID Method. *Sci. Sci. Manag. Sci. Technol.* **2021**, *42*, 63.
36. Jiang, C.; Zhang, Y.; Bu, M.; Liu, W. The effectiveness of government subsidies on manufacturing innovation: Evidence from the new energy vehicle industry in China. *Sustainability* **2018**, *10*, 1692. [CrossRef]
37. Yu, F.; Wang, L.; Li, X. The effects of government subsidies on new energy vehicle enterprises: The moderating role of intelligent transformation. *Energy Policy* **2020**, *141*, 111463. [CrossRef]
38. Wang, X.; Li, Z.; Shaikh, R.; Ranjha, A.R.; Batala, L.K. Do government subsidies promote financial performance? Fresh evidence from China's new energy vehicle industry. *Sustain. Prod. Consum.* **2021**, *28*, 142–153. [CrossRef]
39. Dong, F.; Liu, Y. Policy evolution and effect evaluation of new-energy vehicle industry in China. *Resour. Policy* **2020**, *67*, 101655. [CrossRef]
40. Zhao, Q.; Li, Z.; Zhao, Z.; Ma, J. Industrial policy and innovation capability of strategic emerging industries: Empirical evidence from chinese new energy vehicle industry. *Sustainability* **2019**, *11*, 2785. [CrossRef]
41. Cicconi, P.; Germani, M.; Landi, D.; Mengarelli, M. Virtual prototyping approach to evaluate the thermal management of Li-ion batteries. In Proceedings of the 2014 IEEE Vehicle Power and Propulsion Conference (VPPC), Coimbra, Portugal, 27–30 October 2014.
42. Cicconi, P.; Landi, D.; Germani, M. A Virtual Modelling of a Hybrid Road Tractor for Freight Delivery. *Am. Soc. Mech. Eng.* **2016**, *50664*, V012T16A028.
43. Liu, Z.; Hao, H.; Cheng, X.; Zhao, F. Critical issues of energy efficient and new energy vehicles development in China. *Energy Policy* **2018**, *115*, 92–97. [CrossRef]
44. Yuan, X.; Liu, X.; Zuo, J. The development of new energy vehicles for a sustainable future: A review. *Renew. Sustain. Energy Rev.* **2015**, *42*, 298–305. [CrossRef]
45. Liu, M.; Liu, L.; Xu, S.; Du, M.; Liu, X.; Zhang, Y. The influences of government subsidies on performance of new energy firms: A firm heterogeneity perspective. *Sustainability* **2019**, *11*, 4518. [CrossRef]
46. Muldavin, J. The paradoxes of environmental policy and resource management in reform-era China. *Econ. Geogr.* **2000**, *76*, 244–271. [CrossRef]
47. Wu, J.; Deng, Y.; Huang, J.; Morck, R.; Yeung, B. *Incentives and Outcomes: China's Environmental Policy*; National Bureau of Economic Research: Cambridge, MA, USA, 2013.
48. Peng, L.S.; Sun, H.; Nie, F.F. The Evolution of Temporal and Spatial Pattern and Influencing Factors of the Air Pollution in China. *J. Environ. Econ.* **2017**, *2*, 44–59.
49. Zhou, Z.L.; Cheng, X.F. Spatial heterogeneity of influencing factors of PM2.5 in Chinese cities based on MGWR model. *China Environ. Sci.* **2021**, *41*, 2552–2561.
50. Qiao, Z.; Li, Z. Do foreign institutional investors enhance firm innovation in China? *Appl. Econ. Lett.* **2019**, *26*, 1125–1128. [CrossRef]
51. Marcus, M.; Sant'Anna, P.H.C. The role of parallel trends in event study settings: An application to environmental economics. *J. Assoc. Environ. Resour. Econ.* **2021**, *8*, 235–275.
52. Wu, J.S.; Niu, Y.; Peng, J.; Wang, Z.; Huang, X.L. Research on energy consumption dynamic among prefecture-level cities in China based on DMSP/OLS Nighttime Light. *Geogr. Res.* **2014**, *33*, 625–634.
53. Li, R.; Ramanathan, R. Exploring the relationships between different types of environmental regulations and environmental performance: Evidence from China. *J. Clean. Prod.* **2018**, *196*, 1329–1340. [CrossRef]
54. Fan, G.; Wang, X.; Zhu, H. *NERI Index of Marketization of China's Provinces 2011 Report*; Economic Science Press: Beijing, China, 2011; pp. 273–283.
55. Xu, L.; Zhang, Q.; Wang, K.; Shi, X. Subsidies, loans, and companies' performance: Evidence from China's photovoltaic industry. *Appl. Energy* **2020**, *260*, 114280. [CrossRef]
56. Lu, Y.; Liu, Q.; Li, J.H. The impact of government subsidies on the green innovation capability of new energy automobile companies. In Proceedings of the IOP Conference Series: Earth and Environmental Science, Harbin, China, 22–24 January 2021; Voume 680, p. 012113.

57. Allen, F.; Qian, J.; Qian, M. Law, finance, and economic growth in China. *J. Financ. Econ.* **2005**, *77*, 57–116. [CrossRef]
58. Zeng, W.; Li, L.; Huang, Y. Industrial collaborative agglomeration, marketization, and green innovation: Evidence from China's provincial panel data. *J. Clean. Prod.* **2021**, *279*, 123598. [CrossRef]