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Will the Low-carbon City Pilot Policy Achieve Regional Emission Reduction?

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Abstract

In order to address climate change and promote green and low-carbon development, the Chinese government has implemented a pilot policy for low-carbon cities since 2010 and has continuously expanded the scope of the pilots. Taking the second batch of low-carbon pilot policies as an example, this paper uses difference in difference method to study the impact of low-carbon pilot policies on reducing urban carbon emission intensity based on the panel data of prefecture level cities from 2006 to 2019. It is found that the construction of low-carbon cities has a positive effect on reducing carbon emissions,and this conclusion is still valid under the robustness test. Based on this conclusion,this paper argues that China should further promote low-carbon pilot policies and actively explore the development model of low-carbon cities, especially to improve the livable and green urban environment.

Keywords

Low-carbon Pilots; Carbon Emissions; Double Differential; Low-carbon Cities.

1. Introduction

Accompanied by continued economic development and the continuous consumption of fossil energy, the issue of global climate change has attracted widespread concern and attention from the scientific community, governments and the international community, forcing mankind to be exposed to multiple risks such as stagnant economic development, impaired health, shortages of food and water resources, the frequent occurrence of extreme weather, and rising sea levels, especially for developing countries such as China, which has a more vulnerable climate. The Chinese government is vigorously promoting green and low-carbon development in order to actively address climate change. In order to control the level of carbon emissions, the Chinese government has proposed a "double-bound" national contribution target under the framework of the Paris Agreement: in terms of total carbon emissions, carbon emissions will peak in 2030 and efforts will be made to reach the peak as soon as possible; in terms of intensity, carbon emissions per unit of GDP will be reduced by 60-65% by 2030 as compared to the level in 2005. In order to realize the dual-control goal of carbon emission reduction. In recent years, the Chinese government has not only promoted national cooperative emission control actions as in the past, but also spared no effort to carry out carbon emission reduction practices at the national, regional and industry levels, such as building a national carbon emissions trading market and implementing pilot low-carbon cities.

There are about the policy effects of China's low-carbon city pilot, scholars mainly focus on two major effects:First, it is believed that the low-carbon city pilot policy has a significant environmental effect, that is, to reduce environmental pollution and improve air quality. Song Hong et al. (2019)[1] take the low-carbon city pilot policy as a "quasi-natural experiment", and argue that the construction of low-carbon cities significantly reduces urban air pollution by reducing corporate emissions and upgrading the industrial structure. Zhou Di et al. (2019)[2]

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utilized the second batch of low-carbon city pilots to conduct a study, and found that the low-carbon pilot policy has a significant and sustained role in promoting the reduction of carbon emission intensity in cities. Wang Huaxing and Shi Daqian (2019)[3] conducted a study using the first two batches of low-carbon city pilots and found that the construction of low-carbon cities would significantly reduce haze pollution. Secondly, it is believed that the low-carbon city pilot policy has significant economic effects, i.e., promoting economic development, enhancing total factor productivity, facilitating foreign investment and promoting the transformation of industrial structure.Yang et al. (2019)[4] found that the low-carbon city pilot policy significantly promotes China's regional economic development through the study of China's low-carbon city pilots.Cheng et al. (2019)[5] utilized the second batch of low-carbon city pilots to conduct a study, and found that the construction of low-carbon city pilots significantly enhances green total factor productivity. Gong Mengqi et al. (2019)[6] took foreign direct investment as the object of research and found that the low-carbon city pilot policy significantly increased foreign direct investment in China.

Foreign scholars are more consistent that low-carbon city policies will reduce environmental pollution and improve health. For example, the study of Wolff (2014)[8] found that the low-carbon city policy in the European region will significantly reduce atmospheric pollution and improve air quality. Pilot urban policies promote green innovation of enterprises to a certain extent. Chen Qifei et al. (2020)[9] utilized the first two batches of low-carbon city pilots to conduct a study and found that low-carbon city pilot policies would promote industrial structure transformation. However, foreign research on the policy effects of low-carbon city pilots mainly focuses on developed countries and regions, and little literature has considered the construction of low-carbonized cities in the vast number of developing countries.

This paper takes the second batch of low-carbon pilot policies as an example, based on the panel data of prefecture-level cities from 2006 to 2019, and adopts the double-difference method to study the effect of low-carbon pilot policies on reducing the intensity of urban carbon emissions. It is found that low-carbon city construction has a positive effect on reducing the level of carbon emissions, and this conclusion still holds under the robustness test. Based on this conclusion, this paper argues that China should further promote low-carbon pilot policies and actively explore the development model of low-carbon cities, especially to enhance livable and green urban environments.

2. Model Construction and Variable Selection

2.1. Description of the Sample

The first batch of low-carbon pilot areas released by the National Development and Reform Commission in 2010 included five provinces, Guangdong, Liaoning, Hubei, Shaanxi and Yunnan, and eight cities, Tianjin, Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang and Baoding; in November 2012, the "National Development and Reform Commission on the Second Batch of Low-Carbon Provinces, Regions and Cities Pilot Low-Carbon Work Notice" also identified Beijing, Shanghai, Hainan, Shijiazhuang, Qinhuangdao, Jincheng, Hulunbeier, Jilin, Daxinganling, Suzhou, Huai'an, Zhenjiang, Ningbo, Wenzhou, Chizhou, Nanping, Jingdezhen, Ganzhou, Qingdao, Jiyuan, Wuhan, Guangzhou, Guilin, Guangyuan, Zunyi, Kunming, Yan'an, Jinchang, and Urumqi, and 29 other provinces and cities were also identified as the second batch of low-carbon pilot provinces and cities. Considering that city-based units are more representative and typical, and can explore the policy effects of low-carbon pilots in a more detailed scope, and can also avoid the empirical analysis being limited by the sample size, this paper chooses the second batch of low-carbon pilot cities as the experimental group for policy evaluation, but excludes some of the pilot cities from the treatment group because of their incomplete data. The control group cities in this paper are the other cities excluding the first,

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second and third batch of low-carbon pilot cities and provinces, and also excluded from the control group due to incomplete statistical data in some remote areas, such as some cities in Xinjiang, Tibet. The final areas for double difference analysis were 132 prefecture-level cities, of which 25 and 107 were in the experimental and control groups, respectively.

2.2. Model Building

Since the low-carbon pilot policy shock can be viewed as a quasi-natural experiment, this paper adopts the classic policy evaluation model, the double difference model, which quantifies the effect of the policy by comparing the difference between the changes before and after the policy shock in the experimental group and the control group, but the method has certain requirements for the control and experimental groups in the process of using it, i.e., it is necessary to satisfy parallel trends and develop the same dynamics before the policy shock.

$$Y_{it} = \beta_0 + \beta_1 Treat_i \times T_t + \theta X_{it} + \mu_i + v_t + \varepsilon_{it} \quad (1)$$

2.3. Variable Selection and Data Sources

The explanatory variable is the carbon emission level of each city, which is accounted for by the logarithmic value (lnicar) of each city's carbon emissions (unit: million tons). The data of carbon emissions come from CEADs (China Carbon Accounting Database), and the calculation method can be referred to its official website.

In this paper, the following control variables are selected for empirical research: (1) urban population size, measured by the logarithm of the total population at the end of the year (lnpop). Population size is an important measure of the level of carbon emissions in the city, the larger the population, the greater the consumption of energy, and the city's carbon emissions will also increase. (2) The scale of economic development, measured by the logarithm of gross regional product (lngdp) and the logarithm of per capital gross regional product (lnrgdp). The level of regional economy tends to have a certain correlation with carbon emissions (3) Scale of industrial development, measured by the number of industrial enterprises above scale (lncp). The more industrial enterprises there are, the stronger the agglomeration effect is, and the more carbon dioxide emissions will increase. (4) Industrial structure, measured by the logarithmic ratio of the value added of the secondary industry to the total value added (lnsec). A reasonable industrial structure can well control the level of carbon emissions in the city, while an imbalanced industrial structure may increase the carbon emissions of the city. (5) Education level, expressed as the logarithm of the number of students enrolled in general higher education institutions (lnsd). The education level of a region affects the environmental protection cognition of a region, and the higher the education level, the faster the rate of carbon emission reduction.

Based on the above analysis, this paper divides the 132 prefecture-level cities as follows: 25 low-carbon pilot cities as the experimental group and 107 non-low-carbon pilot cities as the control group. The time interval of the study is 2006-2019. The data were obtained from China Statistical Yearbook, China Urban Statistical Yearbook, China Environmental Statistical Yearbook, and CECN statistical database. The GDP of each region involved in the calculation of the variables is calculated using the GDP deflator, which yields the real GDP to eliminate the effects of price changes. For a few missing values, this paper uses linear interpolation and looks up statistical annual reports to supplement. Specific variable definitions and descriptive statistics are shown in Table 1, from which it can be seen that there are large differences between the experimental group and the control group, which provides a basis for subsequent research.

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Table 1. Descriptive statistics for variables

variable	Variable Meaning	Full Sample(1848)		Experimental group samples(350)		Control Group Sample(1498)	
		mean	sd	mean	sd	mean	sd
lnicar	Log of carbon intensity	3.4677	0.9186	3.6189	0.9926	3.4324	0.8971
lnpop	Log of year-end population	5.9709	0.6877	6.1702	0.6331	5.9244	0.6918
lngdp	Log of GDP	16.4929	0.9527	16.9856	1.2139	16.3778	0.8405
lnrgdp	Log of GDP per capital	10.5386	0.6803	10.7485	0.7101	10.4895	0.6639
lnsec	Logarithm of the proportion of secondary industry	3.8582	0.2509	3.7797	0.2513	3.8766	0.2474
lncp	Logarithm of the number of industrial enterprises above large scale	6.7717	1.0250	7.1549	1.2869	6.6821	0.9316
lnsd	Logarithm of the number of students enrolled in general higher education institutions	10.6761	1.2659	11.4653	1.4194	10.4917	1.1524

3. Empirical Analysis

3.1. Parallel Trend Test

In order to accurately identify the role of low-carbon pilot policies in driving urban carbon emission performance, before estimating the double difference model, this paper examines whether the samples satisfy the parallel trend assumption, i.e., whether the trends of carbon emission intensity in the experimental and control groups were the same before the low-carbon pilot policies. An important prerequisite assumption for the validity of the double-difference method is the convergence assumption, i.e., the trends in air quality in low-carbon cities and other cities should have been parallel if the low-carbon city pilot policy had not been implemented. In order to test this, this paper draws on Jacobson et al. (1993) and utilizes event analysis to conduct the test of parallel trends.

In this paper, the parallel trend is examined by setting up a corresponding dynamic effects model by taking the 2012 policy release time as the midpoint, moving the policy window forward and backward respectively, and analyzing the policy effect of carbon emission reduction through the change of the coefficients of the core explanatory variables, with the dynamic equations as follows.

$$Y_{it} = \beta_0 + \sum_{k=-5}^{k=7} \beta_k Treat_i \times T_k + \theta X_{it} + \mu_i + v_t + \varepsilon_{it}$$

Estimates and 95% confidence intervals for the parameters are plotted in Figure 1. Where the horizontal axis indicates the number of years before and after the low carbon city pilot, and the vertical axis indicates the estimated treatment effect coefficients. As can be seen from Figure 1, none of the estimates of the parameters can reject the original hypothesis of zero before the low-carbon city pilot, which indicates that there is no difference between the carbon emission performance of the experimental group of cities and the control group of cities before the low-carbon city pilot, proving that the double-difference method in this paper satisfies the common trend hypothesis. In addition, it can be seen that the treatment effect in the first year after the policy cannot reject the hypothesis of zero, indicating that there is a certain hysteresis of the policy. The treatment effects corresponding to the post-policy years other than the first year are all negative at the 5% significance level and decrease year by year, indicating that the carbon reduction effect of the low-carbon pilot policy increases year by year.

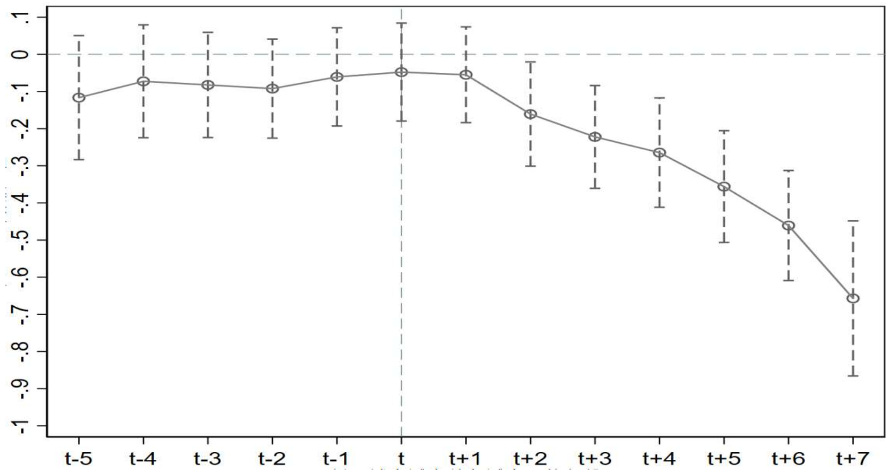

Figure 1. parallel trend test

3.2. Result of Model

Table 2. Regression results of the impact of pilot low-carbon city policies on carbon emissions

varibale	model			
	-1.0000	-2.0000	-3.0000	-4.0000
effect	-0.2500**	-0.3600***	-0.2500***	-0.2410***
	[0.1069]	[0.0762]	[0.0279]	[0.0275]
lnpop		-1.7610***		0.2660***
		[0.1426]		[0.0919]
lngdp		2.6410***		-0.0180
		[0.1482]		[0.1524]
lnrgdp		-1.8640***		-0.1610
		[0.1626]		[0.1361]
lnsec		0.9370***		0.2660
		[0.0713]		[0.1778]
lncp		-0.3420***		0.0282
		[0.0281]		[0.0341]
lnsd		0.0125		0.0034
		[0.0200]		[0.0312]
constand	3.245***	-11.3000***	3.4910***	2.6480
	[0.0329]	[0.4776]	[0.0079]	[2.7010]
urban fixed effect	no	no	yes	yes
time fixed effect	no	no	yes	yes
Standard errors in brackets				
* p<0.1, ** p<0.05, *** p<0.01				

Table 2 presents the regression results of the impact of pilot low-carbon city policies on carbon emissions. There are no fixed effects in columns (1) and (2), city time double fixed effects are added in columns (3) and (4), no control variables are added in columns (1) and (3), and control variables are added in columns (2) and (4). This paper finds that the estimated coefficients of the low-carbon city pilot are negative and statistically significant at least at 5% in all regression results regardless of whether the model includes control variables or not, and whether city and

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time fixed effects are controlled, indicating that the low-carbon city pilot policy generally helps to reduce the level of carbon emissions, implying that the low-carbon city pilot policy exerts the expected carbon emission reduction effect. This finding is more consistent with the existing literature, which recognizes the positive effects of low-carbon city pilot policies.

3.3. Robustness Check

In order to avoid systematic bias in the comparison trends of the selected experimental and control groups and to cope with the endogeneity problem caused by self-selection, this paper will introduce the PSM-DID method (Double Difference Propensity Score Matching) for further testing. In this paper, six observable variables such as log of regional gross domestic product per capital (lnrgdp), log of total population at the end of the year (lnpop), and log of the share of secondary industry (lnsec) are used to match the experimental and control group cities. Specifically, based on the above matching indicators, a logit model is used to estimate the propensity scores, and Kernel Matching is used to determine the weights, and the Common Support condition is imposed.PSM requires that there is no significant difference between the experimental group and the control group in terms of the observable variables after matching. PSM requires that there is no significant difference between the experimental group and the control group in terms of observable variables after matching, otherwise it indicates that the method chosen for matching is inappropriate and the kernel matching estimation is invalid. In order to test the matching effect in this paper, the balance test of all variables before and after propensity score matching is given in Tables 3 and 4. It can be seen that all the control variables in the experimental and control groups are significantly different at the 1% significance level before matching, while there is no significant difference in the remaining variables after matching except for lnpop which is still different at the 10% level. Therefore, it can be concluded that the observable variables selected in this paper are suitable and the matching method is appropriate, and the kernel matching estimation is reliable.

Table 3. Balance test for all variables before propensity score matching

Variable(s)	Mean Control	Mean Treated	Diff.	t	Pr(T>t)
lnicar	3.2450	3.5570	0.3120	4.3100	0.0000***
lnpop	5.9030	6.1530	0.2500	4.3600	0.0000***
lngdp	16.0220	16.6100	0.5880	8.0300	0.0000***
lnrgdp	10.1560	10.4020	0.2470	4.5600	0.0000***
lnsec	3.9350	3.8380	-0.0970	5.0800	0.0000***
lncp	6.6050	7.1350	0.5300	6.1000	0.0000***
Lnsd	10.3400	11.3000	0.9600	9.3600	0.0000***
*** p<0.01; **p<0.05; * p<0.1					

Table 4. Balance test for all variables after propensity score matching

Weighted Variable(s)	Mean Control	Mean Treated	Diff.	t	Pr(T>t)
lnicar	3.4030	3.3510	-0.0520	0.8800	0.3776
lnpop	5.9560	6.0240	0.0680	1.7100	0.0876*
lngdp	16.2790	16.2940	0.0150	0.2600	0.7965
lnrgdp	10.3110	10.2650	-0.0460	1.0600	0.2910
lnsec	3.8760	3.8770	0.0010	0.0800	0.9377
lncp	6.7450	6.8410	0.0960	1.2700	0.2027
lnsd	10.8980	10.9930	0.0960	1.1100	0.2661
*** p<0.01; **p<0.05;	* p<0.1				

Combining the above analysis and the set econometric model (2) , to further test whether the pilot low-carbon city policy has an obvious improvement effect on the carbon emission level of the pilot city, the regression results are shown in Table 5. By comparing the empirical results of DID and PSM-DID, it can be seen that the sign and size of the coefficients of the main variables after using PSM-DID are basically consistent with the results of the benchmark regression model. And the regression coefficients all pass the 5% significance level test, which once again verifies the robustness of the estimation results.

Table 5. PSM-DID estimation results

treat	coefficient	standard error	z	P value	95%CI	
Diff-in-Diff	-0.2580	0.0850	-3.0200	0.0030***	-0.4246	-0.0914
lnpop	-5.2755	1.0946	-4.8200	0.0000***	-7.4209	-3.1301
lngdp	5.0722	1.1213	4.5200	0.0000***	2.8744	7.2699
lnrgdp	-5.1933	1.2106	-4.2900	0.0000***	-7.5661	-2.8205
lnsec	-1.5799	0.4927	-3.2100	0.0010***	-2.5456	-0.6142
lncp	0.1493	0.1618	0.9200	0.3560	-0.1678	0.4665
lnsd	0.4021	0.1236	3.2500	0.0010***	0.1599	0.6443
_cons	1.8243	2.8037	0.6500	0.5150	-3.6709	7.3195

4. Conclusion

Accurately evaluating the effects of low-carbon pilot policies is of great significance for pilot cities to better carry out low-carbon pilot work and further promote low-carbon pilot policies. In this paper, the impact of the second batch of low-carbon pilot policies on the carbon emission performance of cities is investigated using panel data of 132 prefectural-level cities in China from 2006 to 2019, and the double-difference method is applied. The results found that the low-carbon pilot policy has a significant and sustained driving effect on the reduction of carbon emission intensity in low-carbon pilot cities, and this conclusion still holds after the robustness test.

Based on the above findings, the policy implications derived from this paper are:

(1) Low-carbon pilot policies should be further promoted and the development model of low-carbon cities should be actively explored. On the one hand, low-carbon pilot regions should further summarize and explore the experience of low-carbon development, such as developing appropriate low-carbon ecological technologies and adopting more reasonable and greener production and living styles, including green transportation, green buildings, green consumption, etc., in order to play a benchmarking role and make pioneering experience for the exploration of the nation's full-scale low-carbon cities; on the other hand, the government should promote the low carbon pilot region's "On the other hand, the government should give further policy support and theoretical guidance to the low-carbon pilot areas, and form a set of clear and effective low-carbon policies and institutional mechanisms, such as the introduction of clear construction goals, implementation means, assessment indicators and acceptance criteria for low-carbon cities, so as to promote low-carbon pilot policies in a more friendly way.

(2) The key to promoting the carbon emission reduction effect of the pilot low carbon cities is to promote the scientific and technological research and development and technological innovation of enterprises. The government, enterprises and the society should pay special attention to the important role of scientific and technological research and development and technological innovation in the effect of the low carbon city policy. The government, enterprises and society should pay special attention to the important role of scientific and technological research and technological innovation on the effect of low carbon city policy. It should

continuously increase the investment of all enterprises in research and development, encourage enterprises to carry out technological innovation, continuously update the production process, and promote enterprises to realize green development.

(3) Establish a low-carbon industrial system and create a green low-carbon industrial chain according to local conditions. The carbon emission reduction effect of low-carbon city construction mainly comes from the reduction of electric power consumption and the improvement of technological innovation level, while the role of the conduction path through the optimization of industrial structure is limited. Therefore, local governments should create low-carbon industries in line with their own advantages according to the industrial characteristics of the region, and actively create low-carbon agriculture, develop energy-saving industries and cultivate low-carbon service industries, so as to make optimizing the industrial structure one of the most important ways to curb carbon emissions.

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