Supplementary Materials

Exploring carbon emission effects of national-level industrial park policies on cities in China

1. Heterogeneity Analysis

Impact of industrial park construction on city carbon emissions under different city classifications

Impact of industrial park construction on carbon emissions in cities by region

Significant regional differences exist in China in terms of the level of economic development, industrial structure, population density, etc. Therefore, the impact of regional disparity may need to be considered in the analysis. This study consulted the National Bureau of Statistics of China's Economic Belt Division Standard and divided the sample into three groups: east, central and west. The benchmark model is applied to analyze the impact of the three types of parks on city carbon emissions in the different regions, as shown in Table S1.

Table S1. Results of the regional heterogeneity analysis of the impact of park construction on city carbon emissions

	ETDZ			EIDP			LCIP		
	East	Center	West	East	Center	West	East	Center	West
TREAT	-0.0748 （0.0809）	0.2727** （0.1208）	0.8580*** （0.2033）	-0.0519 （0.0819）	-0.3484** （0.1664）	-0.1913 （0.3081）	-0.1511* （0.0858）	0.2481* （0.1355）	-0.4924** （0.2090）
Constant	0.6233*** （0.1545）	1.0145*** （0.3164）	1.3199** （0.5398）	0.5820*** （0.1537）	1.2653*** （0.3491）	1.5605*** （0.5446）	0.6038*** （0.1521）	1.0777*** （0.3119）	1.8917*** （0.5348）
N	4284	4284	4284	4284	4284	4284	4284	4284	4284
CONTROL	Y	Y	Y	Y	Y	Y	Y	Y	Y
City Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
R^2	0.5313	0.4987	0.4775	0.5343	0.4942	0.4586	0.5327	0.4982	0.4891

*p < 0.1, **p < 0.05, ***p < 0.01. The values in parentheses are standard deviations.

For the eastern region, the coefficients of ETDZ and EIDP are not significant, while the coefficient of LCIP is -0.1511 and significant at the 10% level, indicating that constructing LCIP in the eastern region can induce decreases in city carbon emission intensity. For the central region, the coefficients of ETDZ and LCIP are both positive and significant at the 5% and 10% levels, respectively. This suggests that the presence of these two types of industrial parks may increase the carbon emission intensity of the cities in the central region. On the other hand, EIDP has a negative coefficient of -0.3484, which is statistically significant at the 5% level. This finding implies that EIDP can help reduce the carbon emission intensity of cities in the central region.

Impact of industrial park construction on carbon emissions in cities with different resource endowments

Differences in resource endowments between cities can be remarkable, with some being rich in resources and heavily relying on those resources for developing the economy, e.g., via the exploitation and processing of various types of minerals, forests and other natural resources. However, some cities are scarce in resources and often need various types of resources and energy from other cities, and they bear relatively low environmental costs. These two types of cities have different development paths in the early stages of their development, and their paths for realizing the "dual-carbon goal" are very likely different.

Table S2. Results of the resource endowment heterogeneity analysis of the impact of park construction on city carbon emissions

	ETDZ		EIDP		LCIP	
	R	NR	R	NR	R	NR
TREAT	-0.5062*** （0.1588）	-1.3262*** （0.0940）	-0.6381** （0.2771）	-0.3331*** （0.0898）	-0.8463*** （0.1764）	-0.4777*** （0.0924）
Constant	1.9577*** （0.3276）	2.6407*** （0.1575）	1.3602*** （0.3789）	1.7039*** （0.1691）	1.8217*** （0.3421）	1.8101*** （0.1577）
N	4284	4284	4284	4284	4284	4284
CONTROL	Y	Y	Y	Y	Y	Y
City Fixed Effects	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y
R^2	0.4339	0.5007	0.4325	0.4942	0.4440	0.4995

*p < 0.1, **p < 0.05, ***p < 0.01. The values in parentheses are standard deviations.

The State Council defines resource-based cities as cities with the extraction and processing of minerals, forests and other natural resources as their leading industries. The difference in the degree of dependence on energy and resources in the region between such cities and non-resource-based cities is large for the development process. This may also affect the carbon emission reduction effect of the construction of industrial parks. In this study, according to the list of national resource-based cities issued by the State Council, the sample is divided into two groups of resource-based cities and non-resource-based cities, and the benchmark model regression formula (1) is applied, with the results shown in Table S2.

For resource-producing cities, the coefficients of the three types of industrial parks are -0.5062, -0.6381 and -0.8463, respectively. The results are significant at the 1% or 5% confidence level, indicating that the construction of the three types of industrial parks in resource cities can significantly contribute to reducing the intensity of city carbon emissions. LCIP has the greatest emission reduction effect, followed by EIDP. For nonresource cities, the coefficients of the three types of industrial parks are also negative and significant at the 1% level, indicating that industrial parks in nonresource cities also reduce city carbon emission intensity. However, for nonresource cities, the ETDZ has the greatest effect on promoting city carbon emission reduction.

Simply put, both EIDP and LCIP are more effective at promoting carbon reduction in resource-based cities, while ETDZ is more effective in nonresource-based cities.

Impact of industrial park construction on carbon emissions in cities with different numbers of parks

The distribution of each type of industrial park varies across cities, with some cities having only one industrial park and others having a very large number. To study whether the number of industrial parks constructed by a city affects the effect of parks in promoting carbon emission reduction, this study carries out a heterogeneity analysis with respect to the number of parks. For different types of industrial parks, cities with a single park and cities with two or more parks were considered treatment groups. The associated results are shown in Table S3.

Table S3. Results of the analysis of heterogeneity in the number of parks in terms of the impact of park construction on city carbon emissions

	ETDZ		EIDP		ETDZ	
	One	More	One	More	One	More
TREAT	-1.0733*** （0.1194）	-1.0883*** （0.1285）	-0.3943*** （0.1197）	-0.3572*** （0.1280）	-0.0177 （0.1047）	-0.4114*** （0.1413）
Constant	2.2701*** （0.1825）	2.2157*** （0.2076）	1.5821*** （0.1803）	1.5558*** （0.1857）	1.4781*** （0.1795）	1.6359*** （0.1703）
N	4284	4284	4284	4284	4284	4284
CONTROL	Y	Y	Y	Y	Y	Y
City Fixed Effects	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y
R^2	0.4846	0.5194	0.4927	0.4936	0.5023	0.4771

*p < 0.1, **p < 0.05, ***p < 0.01. The values in parentheses are standard deviations.

When only one industrial park is constructed in a city, the coefficients of the ETDZ and EIDP are -1.0733 and -0.3943, respectively. They are both significant at the 1% level, indicating that establishing one such type of industrial park in the city helps promote the reduction of city carbon emission intensity, and the ETDZ has a better effect. The regression results for LCIP are not significant, indicating that building one LCIP in a city does not induce a notable reduction in city carbon emissions. If two or more relevant industrial parks of the same type are built in the city, the coefficients of the three types of industrial parks are negative, and all of them are significant at the 1% confidence level. This indicates that constructing two or more industrial parks in a city can notably reduce city carbon emission intensity.

A comparison of the results across the industrial park types shows that when several ETDZs are built in the same city, the coefficient changes from -1.0733 to -1.0883, which is a small increase in the absolute value and indicates that this type of industrial park has a certain clustering effect on city carbon emissions. For the EIDP, an increase in the number of parks constructed in a city caused the coefficient to change from -0.3943 to -0.3572, a decrease in magnitude. This indicates that there is no cluster effect of the impact of this type of industrial park on city carbon emissions. For LCIPs, an increase in the number of constructions in a city changes the regression coefficient from being nonsignificant to a 1% significance level of -0.4114. This finding implies that LCIP has a clustering effect on promoting a reduction in city carbon emission intensity. Taken together, it is not necessary to introduce multiple ETDZs and EIDPs in the same city to reduce carbon emissions. However, increasing the number of LCIPs affecting real-world conditions could contribute positively to city carbon emission reduction.

2. Robustness Test

PSM test

To address potential selection bias for cities implementing industrial park policies, the propensity score matching (PSM) method was used. Figure S1 shows that differences in covariates between the treatment and control groups were reduced substantially after matching, with all standard errors within 10%, indicating effective matching. The new sample was reanalyzed, and Table S4 shows that the core coefficients for the three types of industrial parks remained negative and significant at the 1% level, confirming the robustness of the original results.

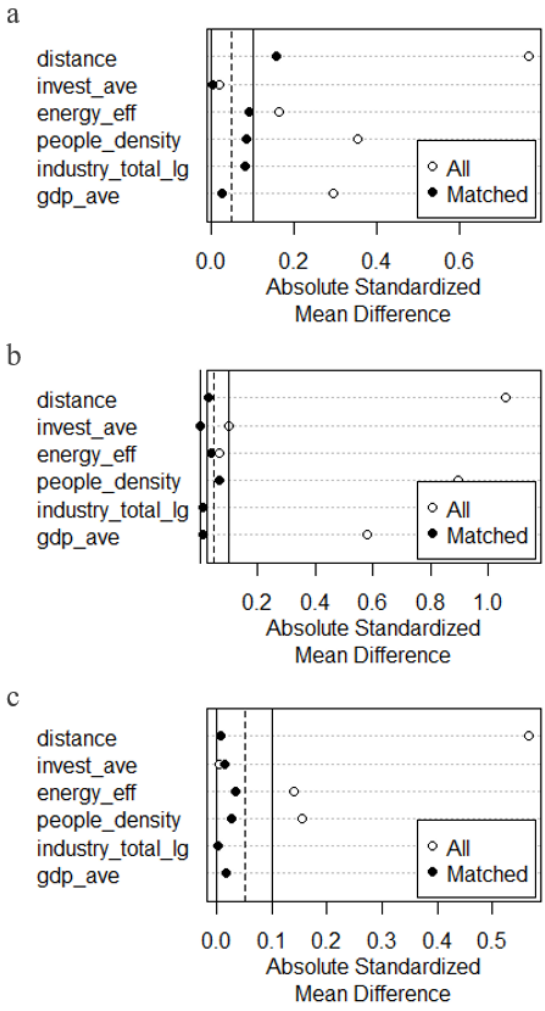

Figure S1. Absolute standardized mean difference before and after PSM matching – ETDZ(a), EIDP(b), and LCIP(c)

Table S4. Results of PSM analysis of the impact of park construction on city carbon emissions

	ETDZ		EIDP		LCIP	
	（1）	（2）	（3）	（4）	（5）	（6）
TREAT	-1.1545***	-1.0273***	-0.3949***	-0.3838***	-0.4504***	-0.5067***
	（0.0576）	（0.0660）	（0.0450）	（0.0380）	（0.0499）	（0.0735）
CONSTANT	2.2756***	2.4225***	1.5870***	0.8431**	1.6425***	1.7835***
	（0.1784）	（0.2024）	（0.1945）	（0.2709）	（0.1863）	（0.3138）

N	4284	4284	4284	4284	4284	4284
CONTROL	Y	Y	Y	Y	Y	Y
City Fixed Effects	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y
R^2	0.4986	0.4947	0.4986	0.7078	0.4986	0.6053

*p < 0.1, **p < 0.05, ***p < 0.01. The values in parentheses are standard errors. Columns (1), (3) and (5) show the baseline regression results of the impacts of the three types of national industrial parks on city carbon emissions, while columns (2), (4) and (6) show the regression results after PSM matching, with robust standard errors.