Can the Establishment of National High-Tech Zones Promote Regional Green Development? -Empirical Evidence from Chinese Cities

Xiutian Zheng[1,*], Qingqing Lan[2]

[1]Hangzhou Normal University, Hangzhou 311121, China
[2]Wenzhou Coal Gas General Company, Wenzhou 325000, China

*Corresponding author's email: zxt1369@163.com

Abstract. Green development is a necessary requirement for high-quality economic development. China needs to adhere to an innovation-driven development strategy to provide technological support for green development. Given that National High-Tech Zones (NHTZs) serve as platforms for promoting technological innovation and industrial innovation, this paper theoretically analyzes the impact of NHTZs establishment policy on regional green development, uses green technology progress as a metric for green development, and conducts an empirical test using a difference-in-differences (DID) model. The findings suggest that the establishment of NHTZs can significantly promote regional green development. This paper provides a decision-making basis for government departments to further develop high-level NHTZs and achieve high-level urban green development.

Keywords: National High-Tech Zone, Green Development, Green Technology Progress

1 Introduction

Given the escalating ecological and environmental crisis, the implementation of green development strategies is necessary for countries and regions worldwide. China attaches great importance to green development, and has implemented a series of green development measures. Innovation is the driving force leading high-quality urban development. Establishing and continuously developing NHTZs to promote the clustered development of high-tech enterprises in a region is one of the innovative measures implemented by the Chinese government. In 2021, China's Ministry of Science and Technology issued the "Implementation Plan for the Special Action of Green Development in NHTZs" proposing to "comprehensively and deeply practice the concept of green development, implement green policies, regulations, and standards, and innovate green development mechanisms within NHTZs". NHTZs play a demonstrative and leading role in promoting technological innovation[1]. NHTZs can improve urban innovation [2]. However, whether the establishment of NHTZs can

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promote urban green development requires empirical evidence from academia. This paper focuses on the theme of the impact of the NHTZs on regional green development.

2 Theoretical Analysis and Research Hypothesis

To promote green development, a region should adhere to innovation-led green development and promote the application of scientific and technological achievements in the real economy. For example, it can rely on technological innovation to transform traditional industries, develop strategic emerging industries, and promote energy structure optimization, industrial upgrading, and green economic development.

NHTZs play an important role in boosting innovation outputs [3]. NHTZs gather a large number of scientific research platforms and innovation centers, serving not only as the source of innovation for new energy technology and information technology, but also as hubs for technology-based enterprises in fields like biotechnology and new energy technology. They are a crucial force in promoting the application of green technologies, providing multi-dimensional support for a region's green development through high-end scientific and technological achievements, high-quality market entities, and emerging industrial formats. The establishment of NHTZs can promote urban environmental governance and decrease urban air pollution, thereby enhancing the level of urban green development[4]. Under the guidance and encouragement of government departments at all levels in China, NHTZs across the country can continuously promote green development while innovating, thereby helping to achieve the transformation from technological value to economic value, and then to social and environmental value.

This paper proposes the following hypothesis.

H1: The National High-Tech Zone establishment policy has a positive effect on a region's green development.

3 Variable Selection and Model Design

3.1 Selection and Measurement of the Dependent Variable

Existing literature employs various metrics to measure green development, such as air quality and the number of green patents per capita. This paper selects the Green Technology Progress Index (GTC) as the dependent variable. This index is derived from the decomposition of the Green Total Factor Productivity index. Drawing on the research findings of references [5][6], and others, this paper calculates green development indicators. Specifically, it employs a non-desirable SBM model (SBM-Undesirable) incorporating energy inputs and undesirable outputs, combined with the Global Malmquist-Luenberger (GML) index. Using MATLAB software, the green total factor productivity of cities within the sample is calculated for the period 2005-2019. This paper will decompose the calculated green total factor productivity into a green technology efficiency index and a green technology progress index. Since the aforementioned green technology progress index is an annual chain growth rate, it

will be cumulatively multiplied with 2005 as the base year to serve as the dependent variable.

3.2 Selection of Explanatory Variables

The explanatory variable is the establishment policy of NHTZs, designated as DID when a city is approved to establish a NHTZ. This paper adopts a multi-period Difference-in-Differences (DID) approach, constructing a DID dummy variable. Cities approved to establish NHTZs between 2005 and 2019 are treated as the treatment group, excluding cities that already had NHTZs before 2005. Cities without established NHTZs as of 2019 are used as the control group. Given the variation in approval dates within the year, cities approved in the first half of the year have their DID variable set to 1 for the current and subsequent years. For cities approved in the second half of the year, the DID variable is set to 1 starting from the following year. In all other cases, the DID variable is set to 0.

3.3 Selection of Control Variables

Drawing on existing research, this paper selects the following variables as control variables. First, the level of urbanisation (URBAN), proxied by the ratio of urban construction land area to administrative area. Second, human capital (HUMAN), proxied by the logarithm of the ratio of higher education student enrollment to the total year-end population. Third, the level of fixed asset growth (FIX), measured by the year-on-year growth rate of total social fixed asset investment. Fourth, the level of financial development (FIN), proxied by the ratio of financial institution loans to GDP. Fifth, the level of openness to foreign investment (FDI). The amount of foreign direct investment actually utilised in US dollars, converted to RMB based on the annual average exchange rate announced by the China Foreign Exchange Trade Centre for the year, is divided by the GDP of the current year to serve as a proxy variable for the level of openness to foreign investment.

To examine the green development effects of the establishment policy for NHTZs, this paper specifies the following regression model.

$$GTC_{it} = \delta_0 + \delta_1 GTC_{it-1} + \delta_2 * DID_{it} + \delta_3 * CONTROL_{it} + \eta_i + \gamma_i + \varepsilon_{it} \quad (1)$$

4 Empirical Results and Analysis

4.1 Descriptive Statistics of Variables

This paper examines the establishment of NHTZs between 2005 and 2019. Data for all indicators were obtained from the China City Statistical Yearbook, the China Statistical Yearbook, annual statistical bulletins of various cities, and statistical yearbooks of provinces and municipalities. After the approval of the Yangling High-tech Zone in July 1997, China temporarily suspended the approval of new NHTZs. The approval process resumed after 2007. To reflect changes before and after the establishment of

NHTZs, and considering data availability, the time span was set from 2005 to 2019. To mitigate the impact of outliers, continuous variable data were subjected to winsorization at the 1st and 99th percentile levels. Missing data were supplemented using interpolation methods. Indicators involving price factors were adjusted to constant 2000 prices using the GDP deflator. The sample includes a final set of 213 prefecture-level and above cities for empirical analysis, after excluding cities with significant missing data and those affected by administrative division adjustments. Within the full sample, the treatment group comprises 94 cities and the control group 119 cities.

Table 1. Descriptive statistics for the variables

Variable	Obs	Mean	Sd	Min	Median	Max
GTC	3,195	0.827	0.166	0.395	0.826	1.379
DID	3,195	0.180	0.384	0	0	1
URBAN	3,195	0.969	1.069	0.0235	0.577	6.277
HUMAN	3,195	4.249	0.969	0	4.271	6.441
FIX	3,195	19.71	17.89	-34.61	18.40	74.14
FIN	3,195	0.836	0.411	0.285	0.722	2.405
FDI	3,195	1.688	1.686	0.0169	1.125	8.116

As shown in Table 1, the minimum value for the dependent variable, green technological progress, is 0.395, and the maximum value is 1.379, indicating a substantial range. Furthermore, the mean of this indicator is 0.827, which is below 1, suggesting that green technology requires further development and improvement. The mean value for the explanatory variable, DID (Difference-in-Differences) is 0.18.

4.2 Parallel trends test

To assess the applicability of a difference-in-differences (DID) model, a critical prerequisite is to verify the existence of a common trend between the treatment and control groups prior to policy implementation. Figure 1 offers a visual inspection, suggesting that the treatment and control groups exhibit parallel trends before the establishment of NHTZs.

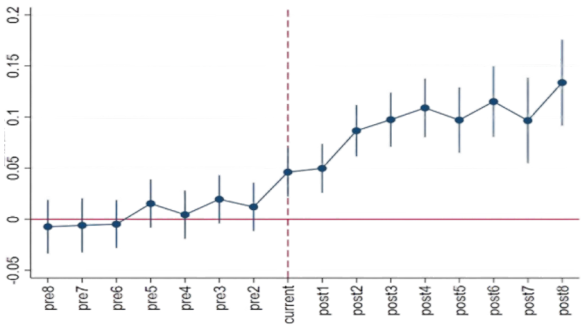

Fig. 1. Result of the parallel trends test

4.3 Regression results

The DID coefficient for green technology progress (GTC) is significantly positive in Table 2, indicating that the establishment of NHTZs significantly promotes regional green technology progress. This finding suggests a positive green development effect, thereby validating Hypothesis H1.

Table 2. Regression results

	GTC
DID	0.0327***
	(4.4035)
L.GTC	0.5488***
	(17.6432)
URBAN	0.0085***
	(2.6381)
HUMAN	-0.0069
	(-1.1656)
FIX	0.0001
	(1.1032)
FIN	0.0007
	(0.0809)
FDI	-0.0021
	(-1.1988)
Constant	0.3494***
	(8.8980)
Year	YES
City	YES
N	2982
R-squared	0.5472

4.4 Robustness Checks

(1) Robustness Check Based on Propensity Score Matching (PSM)

Significant differences exist between cities approved for the establishment of NHTZs and those that have not been approved. This heterogeneity may influence the effect of NHTZ establishment on green technology progress. Therefore, a propensity score matching (PSM) approach can be employed for robustness testing.

Table 3. Regression results under Propensity Score Matching

	Nearest PSM neighbors matching（1:1）	Kernel matching
	GTC	GTC
DID	0.0517**	0.0640***
	(2.3829)	(4.6109)
URBAN	0.0076	0.0093**
	(1.1577)	(2.0440)
HUMAN	0.0013	-0.0054
	(0.1247)	(-0.6954)
FIX	0.0003	0.0005***
	(0.9787)	(2.7405)
FIN	0.0100	0.0063

	(0.4695)	(0.4909)
FDI	-0.0056	-0.0072**
	(-0.8582)	(-2.1059)
Constant	0.9876***	0.9990***
	(16.1231)	(32.8366)
Year	YES	YES
City	YES	YES
N	789	3039
R-squared	0.4783	0.4098

Table 3 presents the results obtained using the PSM-DID method, matching variables selected from the following four dimensions: population, level of openness to the outside world, manufacturing agglomeration, and level of economic development. After balancing the covariates, regression estimation was performed. The results further confirm the promoting effect of the establishment of NHTZs on green technology progress.

(2) Robustness Check Based on Altering the Sample

We divided the cities within the sample into two sub-samples: resource-based cities and non-resource-based cities, and performed regressions on each. The results are shown in Table 4.

Table 4 shows that establishment of NHTZs significantly promotes green technology progress (GTC) in cities within both sub-samples. However, the promotion effect of national HTZs on GTC is better and the coefficient is more significant in resource-based cities.

Table 4. Regression results based on altering the sample

	Resource-based cities	Non-resource-based cities
	GTC	GTC
DID	0.0476***	0.0227**
	(3.7476)	(2.5250)
L.GTC	0.4924***	0.5767***
	(12.0404)	(14.4015)
URBAN	0.0067	0.0083**
	(1.2753)	(2.0278)
HUMAN	-0.0035	-0.0084
	(-0.3561)	(-1.1543)
FIX	-0.0001	0.0003**
	(-0.5120)	(2.0734)
FIN	-0.0009	0.0020
	(-0.0890)	(0.1498)
FDI	-0.0000	-0.0026
	(-0.0139)	(-1.0970)
Constant	0.3936***	0.3259***
	(7.7962)	(6.0443)
Year	YES	YES
City	YES	YES
N	1302	1680
R-squared	0.5185	0.5741

5 Conclusions and Recommendations

This paper constructs an econometric model to conduct empirical tests, arriving at the conclusion that the establishment of NHTZs can significantly promote urban green technology progress. Based on these findings, this paper proposes that local governments should construct high-standard NHTZs to promote the green transformation and upgrading of urban industries. First, NHTZs should be supported in vigorously developing environmentally friendly future industries. Support should be provided for innovation and entrepreneurship through public services and key personnel, developing future industries that contribute to green economic development. Second, NHTZs should be supported in promoting the transformation and upgrading of existing industries towards environmental friendliness. NHTZs should be encouraged to build technology achievement transformation bases based on their own characteristics and advantages, focusing on local key industries such as agriculture, manufacturing, and producer services. Furthermore, they should promote the application of innovative achievements and create a number of environmentally friendly industrial clusters.

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