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Impact of Carbon Emission Trading Market on Regional Urbanization: an Empirical Study Based on a Difference-In-Differences Model

Haoyuan Cheng [a], Xiaoqian Liu [b,*], Zhenlong Xu [c]

[a] *Institute of Western China Economic Research, Southwestern University of Finance and Economics, Chengdu, China*

[b] *Research Institute of Economics and Management, Southwestern University of Finance and Economics, Chengdu, China*

[c] *Kogod Business School, American University, Washington, USA*

ABSTRACT

China's carbon emission trading market has been formally established, but few studies have been conducted to analyze the impact of this policy on the regional urbanization level. Therefore, this paper evaluates whether the carbon trading pilot policy can enhance the regional urbanization level in China through the difference-in-differences method and analyzes the mediating role of industrial structure upgrading in this process. The results prove that the carbon trading market policy can accelerate the transformation and upgrading of industrial structure in the region so that it promotes the development of regional urbanization. Moreover, the effects of the policy are concentratedly manifested in the eastern region of China.

KEYWORDS

Carbon emissions trading market; Difference-in-differences method; Industrial structure; Urbanization level

*Corresponding author: Xiaoqian Liu
E-mail address: xqliu1368@163.com

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1. Introduction

In September 2020, in the 75th session of the United Nations General Assembly, China formally proposed the goal of achieving carbon peak by 2030 and carbon neutrality by 2060. Since then, various departments of the Chinese government have launched various policies and systems one after another to achieve the vigorous development of the "dual carbon" economy. This policy will inevitably affect the process of China's industrial structure upgrading; and the economic benefits it brings and the level of urbanization will have an impact on people's quality of life. In this macroeconomic context, it is particularly important to study the effectiveness of the carbon trading pilot policies.

The carbon trading market has been widely used as an environmental protection type of economic policy in the international arena. The pilot project of carbon emissions trading in China was launched in 2013; according to the data of China's carbon trading network, the total transaction amount of the pilot market is about 5.866 billion yuan. The issue of the carbon trading market has become a widespread concern. This paper compiles data from the statistical yearbooks of provinces and municipalities directly under the central government of National Bureau of Statistics of China, and empirically analyzes the impact of the carbon trading market on the development process of regional urbanization based on existing studies. Further, this paper fills the gap in academic discussions on the relationship between the carbon trading market and urbanization, verifies the intermediary role of industrial structure upgrading in this process, and proposes policies for the improvement of the national carbon trading market from the perspective of promoting urbanization. Some policy recommendations for the improvement of the national carbon trading market from the perspective of promoting urbanization are suggested.

2. Literature review

There is a large body of literature on the emission reduction effects of carbon trading markets. Wu et al. (2021) analyzed the theoretical mechanism and practical effects of carbon trading markets in the context of China's economic system and demonstrated that the policy can reduce carbon emission levels without affecting the growth rate of economic development; Zhang (2019) used provincial-level data to measure CO_2 emissions and other environmental indicators fluctuating under the carbon trading market policy, proving the contribution of the policy to the low-carbon economy; Hu et al. (2020) measured through the DID model that the carbon trading market policy can reduce the pilot emissions by 15.5 percentage points in the pilot region. A large number of scholars have analyzed the economic benefits of carbon market trading policy from different entry points. Shao et al. (2020) studied the impact of the carbon trading market on high-quality economic development from total factor productivity; Chen et al. (2020) demonstrated that the carbon trading market promoted enterprises to accelerate the innovation of low-carbon technology; Yu et al. (2020) used a two-way fixed effects model to study the green and economic growth effects of this policy, demonstrating that the policy can improve environmental quality and accelerate economic growth. The current study fully affirms the economic and environmental effects brought by the policy. However, existing studies do not focus on whether the carbon trading market pilot policy can enhance the level of regional urbanization development. To fill the research gap, this empirical study focuses on the issue and analyzes the internal mechanism of the carbon trading market in promoting the level of regional urbanization development so as to assess the impact of the policy.

3. Method

3.1. Entropy value method to construct evaluation index system

In this paper, data from 31 provinces, municipalities directly under the central government, and autonomous

regions in China from 2003 to 2020 are selected for empirical evidence, and the data are referred to the statistical yearbooks of provinces and municipalities directly under the central government in the calendar year from 2003 to 2020 of the National Bureau of Statistics of China and EPS database, and the data are processed into panel data for empirical analysis.

The explanatory variable of the paper is the urbanization development level score (*UL_Score*), and the index system of urbanization development level is constructed by the entropy method with reference to the existing study (Han, 2022), and the measured results reflect the quality of urbanization development in each province and municipality in China. In this paper, the measurement system is constructed from three dimensions of population urbanization, economic model urbanization and living space urbanization, and the specific indicators are listed in Table 1.

Table 1. Evaluation index system of urbanization development level.

First grade indexes	Second grade indexes
Economic urbanization	Regional GDP growth rate Proportion of output value of secondary industry Proportion of output of tertiary industry Per capita investment in fixed assets
Population urbanization	Urbanization rate
Spatial urbanization	Proportion of urban built-up area Green coverage rate

3.2. Benchmark DID model

The study constructs a policy impact model using the difference-in-differences (DID) method to compare the difference in measurement results of development level between the treatment group and control group to assess the impact of policies on urbanization development, and the specific model is as follows:

$$UL\_Score = \beta_0 + \beta_1 did_{it} + \beta_2 X_{it} + \gamma_i + \mu_t + \varepsilon_{it}$$
$$did_{it} = treat_i \times post_t \quad (1)$$

where subscript i denotes provinces and municipalities directly under the central government and t denotes time. The explanatory variable (UL_Score) is the urbanization development level of each province and municipality. The parameter $treat_i$ represents the dummy variable of carbon trading pilot: $treat_i = 1$ for pilot provinces and municipalities directly under the central government, $treat_i = 0$ for non-pilot provinces and municipalities directly under the central government. The parameter $post_t$ represents the dummy variable of time of carbon trading pilot policy implementation. This paper takes 2013 as the time node of policy implementation, $post_t = 0$ represents the policy implementation; $post_t = 0$ means before the implementation of the policy ($t <$ 2013); and $post_t = 1$ means after the implementation of the policy ($t \geq 2013$). The paper investigates the effect of carbon trading pilot policy on regional urbanization development level as the explanatory variable. did_{it} coefficient denotes province fixed effects; μ_t denotes time fixed effects, and γ_i represents the random error term. X_{it} denotes the control variables, as shown in the following table.

Table 2. Descriptive statistics.

Variables	Variable abbreviation	Description	Mean	P50	S.D.	Min	Max
Economic level	*lnPGDP*	Regional per GDP	10.349	10.472	0.75	8.162	12.01
Assets scale	*lnK*	Logarithm of the total	9.466	9.656	1.249	4.388	11.92

		assets of industrial enterprises					
Labor scale	*lnL*	Logarithm of the number of industrial employees	6.038	6.051	1.137	2.514	7.874
Industrialization level	*IL*	Ratio of industrial output to regional GDP	0.372	0.387	0.103	0.068	0.562
Energy intensity	*EI*	Ratio of total energy consumption to regional GDP	0.116	0.093	0.078	0.032	0.55
Infrastructure development level	*INFRA*	Road mileage per unit area	0.127	0.047	0.231	0	2.306

4. Empirical results

4.1. Baseline regression results

This paper verifies the effectiveness of carbon trading market policies on the improvement of regional urbanization development level based on the benchmark DID model, and the regression results are shown in Table 3. Columns (2) and (3) in Table 3 gradually add province fixed effects and time fixed effects on the basis of Column (1), respectively, while Column (4) is regressed by removing control variables on the basis of Column (3). The regression results show that the coefficients of the difference-in-differences coefficients of the DID benchmark model are significantly positive when province and time fixed effects and control variables are taken into account, indicating that China's carbon trading market pilot policy has a positive impact on the urbanization level of the experimental area.

Table 3. Baseline regression results.

	(1) *UL_Score*	(2) *UL_Score*	(3) *UL_Score*	(4) *UL_Score*
did	0.050***	0.043***	0.034***	0.033***
	(0.007)	(0.005)	(0.005)	(0.005)
lnPGDP	0.071***	0.122***	0.076***	
	(0.006)	(0.010)	(0.011)	
lnK	0.041***	-0.009	-0.021*	
	(0.005)	(0.008)	(0.009)	
lnL	-0.022***	-0.006	-0.000	
	(0.004)	(0.004)	(0.004)	
IL	-0.378***	-0.496***	-0.232***	
	(0.024)	(0.022)	(0.032)	
EI	0.074*	0.228***	0.100*	
	(0.031)	(0.048)	(0.045)	
INFRA	0.097***	0.013	-0.006	
	(0.009)	(0.011)	(0.010)	
Province fixed effects	No	Yes	Yes	Yes
Year fixed effects	No	No	Yes	Yes
_cons	-0.530***	-0.652***	-0.224*	0.226***
	(0.043)	(0.044)	(0.091)	(0.004)
N	556	556	556	558

*Notes: *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively; Standard errors in parentheses*
** p < 0.05. ** p < 0.01. *** p < 0.001.*

5. Mechanism analysis

This paper assumes that there is an intermediary effect of industrial structure upgrading on the process of carbon trading market policy to enhance the level of regional urbanization, and the transformation and upgrading of regional industrial structure promotes the flow of rural population to cities and the transfer of labor force to secondary and tertiary industries, while driving the improvement of infrastructure construction within the region, thus achieving a comprehensive enhancement of urbanization level. Two indicators, the proportional relationship of each industry and the average labor productivity of the industry, are added to assess the level of regional industrial structure (Han, 2021), and the intermediary variable advanced index of industrial structure (AIS_{it}) is measured and calculated as follows.

$$AIS_{it} = \sum_{i=1}^{3} v_{it} \times LP_{it} \tag{2}$$

where v_{it} represents the proportion of gross value of industry i to GNP in time period t, LP_{it} is the labor productivity of industry i in time period t. The validation results of the mediated utility model are as follows.

Table 4. Impact mechanism test.

	(1) UL_Score	(2) AIS	(3) UL_Score
did	0.034***	4.505***	0.019***
	(0.005)	(0.427)	(0.005)
AIS			0.005***
			(0.000)
Control variables	Yes	Yes	-Yes
Province fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
_cons	-0.224***	-45.540***	-0.408***
	(0.091)	(3.656)	(0.045)
N	556	556	556

*Notes: *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively; Standard errors in parentheses*
** p < 0.05. ** p < 0.01. *** p < 0.001.*

According to the regression results in Column (2) of Table 4, the explanatory variables are significantly positive when the mediating variables are used as explanatory variables, indicating that the carbon trading pilot policy has a facilitating effect on the optimization of industrial structure upgrading in the pilot areas; AIS_{it} and *did* in Column (3) are both significantly positive, indicating that the optimization and upgrading of industrial structure under the influence of the carbon trading pilot policy has a mediating effect on the improvement of regional urbanization level, and it is a partially mediating effect.

6. Heterogeneity analysis

China's economic development differs between the eastern, central and western regions, and the effects of policy implementation in China tend to be heterogeneous. The carbon trading market policies in Beijing, Shanghai, Tianjin, and Guangdong (with Shenzhen) belong to the eastern region, Hubei Province belongs to the central region, and Chongqing belongs to the western region. The effects of the policy on the urbanization development level in the eastern, central and western regions are regressed separately. Table 5 shows the verification results of the intermediary utility of industrial structure upgrading by region. The regression results in columns (1) and (2) are significantly positive, indicating that the optimization and upgrading of industrial structure has a partially intermediary effect on the upgrading of urbanization level in the eastern region. From the regression results in

columns (3) and (4), it is clear that although the pilot policy has promoted the optimization and upgrading of industrial structure in the pilot provinces in the central region as a result, the policy effect on urbanization development level is not yet significant; the regression results in columns (5) and (6) of Table 5 for the western region are not significant, and the impact of the carbon pilot policy on the upgrading of industrial structure in the western region is not significant, nor can it affect the urbanization level in the western region through this path.

Table 5. Regression results of heterogeneity analysis.

	Eastern region		Central region		Western region	
	(1)	(2)	(3)	(4)	(5)	(6)
	AIS	*UL_Score*	*AIS*	*UL_Score*	*AIS*	*UL_Score*
did	3.390***	0.018**	2.986***	-0.024	1.751	0.006
	(0.643)	(0.006)	(0.448)	(0.021)	(1.273)	(0.010)
AIS		0.004***		0.004		0.003***
		(0.001)		(0.004)		(0.001)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
_cons	42.319*	-0.761***	-53.434***	-0.842	-110.844***	-0.335*
	(18.235)	(0.175)	(14.765)	(0.585)	(16.473)	(0.150)
N	233	233	108	108	215	215

*Notes: *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively; Standard errors in parentheses*
** p < 0.05. ** p < 0.01. *** p < 0.001.*

7. Conclusions and policy implications

This study adopts the difference-in-differences method to test the impact of the carbon trading market pilot policy on the development level of regional urbanization, and draws the following conclusions. First, carbon emission trading market policies can promote the development level of regional urbanization. Second, carbon emission trading market policies can accelerate low-carbon technology innovation and promote the transformation and upgrading of regional industrial structure; its effect is significantly reflected in the eastern region; the transformation and upgrading of industrial structure is also an intermediary factor for carbon trading pilot policies to promote the level of urbanization in the eastern region. Third, the role of carbon emissions trading market on the improvement of regional urbanization level is heterogeneous; the effect of this policy is better in the eastern region than that in the central and western regions. The policy has driven the optimization of industrial structure in the central region, but it has not yet raised the level of urbanization development, and the effect of the policy on the development of industrial structure and urbanization process in the western region is not yet obvious.

Based on the above findings, the study proposes the following policy recommendations.

(1) Optimize the way of carbon emission quota allocation. We should avoid the overly high benchmarks that lead to the failure to recognize the advantages of low energy consumption enterprises in terms of technology level; focus on the allocation of carbon emission rights in the central and western regions.

(2) Increase the vitality of the carbon trading market. In response to problems such as inactive trading markets in some pilot provinces, we should encourage financial institutions to participate in trading product innovation and market transactions, explore the development of carbon financial products, enhance market liquidity, and establish a perfect trading system.

(3) Strengthen the integrated management of the national carbon trading market. We should solve the problem of cross-regional trading barriers and strengthen the circulation of elements between regions in the carbon trading market.

(4) Focus on the sustainable development of the national carbon trading market. We should give full consideration to the differences in economic development levels and resource endowments of different regions; promote the synergistic development of the carbon trading market in the eastern, central and western regions, so as to ultimately promote the development level of urbanization in the central and western regions.

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Declaration of Competing Interest

All authors claim that the manuscript is completely original. The authors also declare no conflict of interests.

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