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Restructure or Misallocation? Enterprises' Carbon Emission Intensity under Market Integration

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Abstract: Incorporating urbanization with carbon efficiency into one analytical framework could be a new method for formulating the regional carbon emission reduction path. Based on the panel data from 2001 to 2014, the two-way fixed effects (TWFE) and continuous differences-in-differences (DID) methods are adopted to examine how the county-to-district upgrading policy (CDUP) affects the efficiency of an enterprise's carbon emissions. The results show that the CDUP will significantly decrease the efficiency of an enterprise's carbon emissions. The average carbon emissions of enterprises increased by 0.886 per unit of output by the CDUP, which remains significant after controlling for endogeneity. Heterogeneity analysis shows that the impact of the CDUP is significant for enterprises in low-level cities, but not in high-level cities, which is closely connected with regional governance and enterprise productivity. Moreover, market integration, regional carbon carrying capacity and industrial agglomeration is introduced to explain the phenomenon. The results suggest that the urbanization policy should coordinate the characteristics of industries and areas. Furthermore, the results can provide suggestions for enterprise production and local governance toward sustainable development.

Keywords: urbanization; county-to-district upgrading policy; market integration; industrial agglomeration

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1. Introduction

China has attached great importance to the development of clean and low-carbon energy, but faces the dilemma of transitioning from high carbon emission to low carbon emission [1]. Therefore, it is increasingly important to balance environmental protection and economic development [2–4]. As the 2021 government report points out, "China will expedite the transition of China's growth model to one of green development, and promote both high-quality economic growth and high-standard environmental protection". Furthermore, during the period of China's 14th Five-Year Plan (2021–2025), energy consumption per unit of GDP and carbon dioxide emissions per unit of GDP will be significantly reduced, which places the efficiency of carbon emissions in an important position. Meanwhile, China is undergoing the rapid promotion of industrialization and urbanization [5]. The industry and population continue to gather in the city, and administrative boundary adjustment has become the inevitable way for realizing sustainable economic and social development.

Administrative boundary adjustment, varying from country to country, is an effective tool for the central government to promote urbanization. To expand the space for urban development, optimize the allocation of resources and promote sustainable regional development, China has adopted the county-to-district upgrading policy (CDUP). The CDUP establishes municipal districts of the prefecture-level cities or municipalities. Located in the administrative area of the original counties, the municipal districts are directly under the central government. In other words, it is an administrative division adjustment of county-level administrative units to district-level administrative units under their jurisdiction [6]. After the approval of prefecture-level city governments, provincial governments and the State Council, the process of boundary adjustment, administrative level and subordination will change.

From 2009 to 2019, China's municipal districts increased by 110, counties decreased by 141, and the urbanization rate of the resident population increased by 25.36 percent. However, some studies showed that there are some places making the CDUP rigidly uniform and allowing for no flexibility. The counties that were upgraded to cities do not develop better than their counterparts that remained county status, in terms of both economic growth and environmental protection [7]. The change in the region's administrative level may cause enterprises to lose their original political connections, thereby reducing productivity [8,9]. Regardless of the result, to a large extent, the CDUP provides local officials with incentives for promotions, as well as promoting industrial transformation and upgrading [10,11]. As the basic unit of urbanization, enterprises are quite sensitive to administrative division adjustment policies [12]. Enterprises can directly reflect the impacts of the CDUP on market demand and regional development, such as changes in productivity and policy environment. Thus, the environmental externality of micro-enterprises is an important factor when measuring the effect of the CDUP. Nevertheless, the adjustment of administrative divisions is the core proposition of the reconstruction of inter-government relations in the form of a national structure. Studying the influence mechanism of the external adjustment of administrative regions is helpful to further improve the governance efficiency, as well as the enterprise's sustainable development.

Our research complements existing studies on administrative division reform policies, incorporating classical ideas on the theory of a unified large market. The main novelty of this study is that many specific suggestions have been obtained for the decomposition of policy impact mechanisms through refined research methods. The results can provide suggestions for different enterprises, industries and regional sustainable developments. This paper makes several contributions to three aspects: First, the existing literature in the studies of relationships between administrative boundary adjustment and carbon emission efficiency is limited, while this paper investigate the relevance between them from a distinctive perspective. It also contributes to establishing a more scientific environmental performance evaluation of the CDUP. Second, in terms of research data, this paper uses the panel data from micro pollution data to improve the reliability of the accounting of enterprises' carbon emissions efficiency. These micro data are more difficult to obtain in comparison to the macro data available at the regional and industrial level. Third, it reveals the mechanism of administrative division adjustment on the enterprises' carbon emissions efficiency, and provide sempirical support for the formulation of urbanization policies.

2. Literature Review

2.1. Theory of Large Markets

Studies on the relationship between administrative division adjustment and environmental pollution have attached emphasis to the macro level economy and trade liberation. Scholars represented by Scitovsky [13] and Deniau [14] have created the theory of large markets, which holds that regional development should break market segmentation, stimulate competition, and promote trade freedom. For environmental protection, trade liberalization can lower energy intensity [15]. The competition for resources and markets has gradually expanded from country-level and region-level to group-level, even to economic integration organizations [16].

However, some scholars suggest that government should limit migration between urban and rural areas, because free trade makes no contribution to improving the energy efficiency in China [17]. Most of them pay little attention to the efficiency of carbon emission from the micro-enterprise perspective. In this paper, the idea of establishing a large market was introduced to explore the impact of the CDUP, which provides a theoretical basis for this paper to explore from the perspective of enterprise.

2.2. Market Integration

In the context of increasingly serious environmental problems and public concern about the environment, some scholars have begun to include market integration as an important factor affecting the environment. As the opposite of market integration, market segmentation has been an important factor affecting enterprises' enjoyment of policy benefits. Under the Chinese-style decentralized system, there was a serious market segmentation between different administrative regions because of China's unique "administrative region economy" [18]. Studies on the country level have been discussed in detail and two opposing views have been extended. On the one hand, trade freedom is affected by market segmentation. Kennedy [1] argued that the governments of the two monopoly exporting countries would use environmental policies to subsidize their manufacturers and constantly lower environmental standards. Dua and Esty [19] and Wang Wei [12] also pointed out that global trade liberalization will push countries to reduce their environmental standards to strengthen the competitiveness of their products, resulting in the so-called "race to the bottom line". Chilchilnisky [20] argues that free trade in the absence of a clear definition of private property rights will accelerate the destruction of environmental resources in developing countries, thus posing a further threat to the global environment. All the above points conclude that free trade facilitated by market integration will promote the "bottom-line competition" phenomenon. However, these studies are based on the country level, which is different from the district-level study. Drawing on the ideas of existing research, this paper explores the impact of the CDUP on enterprises' carbon emissions efficiency. It not only complements existing theories based on microscopic perspectives, but also broadens the scope of theoretical application.

2.3. Carbon Carrying Capacity

It is argued that urbanization and ecological environment is interaction coupling [21]. The carbon carrying capacity reflects the capacity of an area to carry carbon emissions. Scholars have studied the response of different regional environments to environmental pollution. Improving carbon sequestration is a possible way to slow or stop the increase of atmospheric CO_2 concentrations [22]. Additionally, the endowments of the regional ecological environment would impose restrictions on urban development. To reduce their carbon emissions and improve the environment, often some districts move industries with high energy consumption and high emissions to other neighboring districts [23]. If the environment is damaged, enterprises and former central city residents who pursue high-quality life will be "expelled" from the city center. This phenomenon confirms that environmental pollution may be a discrete force that hinders the spatial agglomeration of economic activities [24]. Nevertheless, the energy consumption levels of different industries carried by different land-use types are quite different, so there are also significant differences in carbon emissions [25,26]. All in all, the regions with a good ecological environment have stronger ability to cope with the environmental challenges. And the carbon-carrying capacity will play an important role in the less-developed regions within the merged regions. Thus regions with high carbon-carrying capacity are more likely realize reasonable carbon displacement under the relative advantages.

2.4. Industrial Agglomeration

Some scholars emphasize that the diversification of urban industries is conducive to enterprises' innovative activities, thereby promotingcities' long-term growth [27]. There are also views denying the positive externalities of industrial agglomeration to the environment. Some scholars argue that the inter-regional transfer of polluting industries can not only reshape the industrial geographical pattern, but also promote the spread and transfer of environmental pollution, especially affecting the sustainable development of the transferred areas [28]. Their agglomeration can damage the environmentfor specific types of industries and market conditions. For example, Virkanen [29] pointed out that industrial agglomeration in some parts of Finland pollutes water quality and the atmospheric environment. The negative impact on the environment is consistent with Verhoef [30] and Nijkamp's conclusion that corporate agglomeration exacerbates environmental pollution [31]. Moreover, the CDUP has a Chinese-style local decentralization system, so the market under policy-led urbanization is not well established. Thus, the economy of scale cannot work well, because the agglomeration formed by favorable policies and the intervention of the government will affect the response of markets to prices and the improvement of carbon emissions efficiency [32]. Moreover, due to the lock-in effect, pollution-intensive enterprises will not move in a short time. The CDUP will then promote calling the area with higher pollution the "polluting garbage plant" in the adjacent area, so that carbon emissions will migrate to areas with heavier pollution emissions [33]. Other studies have pointed out that areas where industries are concentrated, due to their heavy dependence on external investment, are based on the theory of "environmental shelters" and "race to the bottom line of environmental standards" [34].

3. Methodology

3.1. Research Design

First, as a major tool in policy effect evaluation methods, the DID method is increasingly favored by more and more scholars because it can avoid the trouble of endogeneity to a large extent. Specifically, the traditional DID method requires that the policy be implemented in one go. However, the CDUP policy is implemented gradually. In that case, the continuous DID method is adopted to estimate the model, referring to Moser and Voena [29]. Crucially, the premise of the DID holds that there should be no systematic difference in the impact of CDUP policies at different implementation times. Even if there is a difference, the difference is fixed and consistent.

Second, the use of fixed effect estimation also alleviates the problem of missing variable bias to some extent. This paper uses the continuous difference-in-differences (DID) method with twice fixed effects (TWFE) to examine the significance of the CDUP's effect on enterprises' carbon emission efficiency.

Third, we test the robustness by replacing the dependent variable and carrying out the placebo test.

Finally, we explain how the CDUP affects the enterprise's carbon emission efficiency from three perspectives, including market integration, carbon carrying capacity and industrial agglomeration.

3.2. Data Description

The micro-financial and carbon emission data were selected from 2,463,252 industrial enterprises, truncated from 2000 to 2014. The data are formed by merging three databases: the firm-level pollution database, the national tax survey, and the Chinese industrial enterprise database.

(1) The firm-level pollution database counts industrial enterprises that account for 85% of the pollution load. It counts the energy consumption indicators of enterprises including coal, fuel oil, gas, etc. [35]. The data available are from 2001 to 2010.
(2) The national tax survey counts the enterprises' energy tax paid by the energy-consuming enterprise [36,37]. The data available are from 2008 to 2015.
(3) The database of Chinese industrial enterprises is collected by the National Bureau of Statistics of China, with large samples and adequate indicators [38–40]. It is authoritative and irreplaceable in the field of research on Chinese enterprises, which covers all enterprises with annual sales of more than CNY 5 million.
(4) The procedure for handling abnormal data is taken. The personnel end of the year is used to approximately replace the samples lacking the annual average personnel data. Additionally, observations that violate accounting standards are deleted. After

removing the outliers, a total of 2,307,219 observations from 2,463,252 companies remained for the DID model.

3.3. Variables Description

3.3.1. Dependent Variable

The carbon emissions per unit of output at the enterprise level (DCO_2) are selected as the dependent variable. The annual total carbon emission (CO_2) measurement method is proposed according to the United Nations Intergovernmental Panel on Climate Change (IPCC) and the "IPCC Guidelines for National Greenhouse Gas Inventories" of 2006. The calculation formula is as follows:

$$CO_2 = \sum_{i=1}^{n} E_i \cdot NCV_i \cdot CEF_i \cdot COF_i \cdot \frac{44}{12} \tag{1}$$

where E represents the final energy consumption; NCV represents the net calorific value of energy; CEF is the carbon emission factor per unit calorific value equivalent; COF is the carbon oxidation factor (99–100% of carbon in fossil fuels are oxidized, so according to IPCC, the default value of COF is set to 1), and the missing value is set to 1; 44 is the molecular weight of carbon dioxide; 12 is the molecular weight of carbon; i represents different types of energy. The carbon emissions efficiency of enterprises (DCO_2) is measured by the following formula:

$$DCO_2 = CO_2/output \tag{2}$$

where *output* represents the total annual output of the enterprise. To exclude outliers from interfering with the regression results, this paper performs a one percent bilateral abbreviated treatment on the logarithm of carbon emissions per unit of output value. That is, extreme value processing is carried out in the 1% and 99% quantiles. The value at 1% is used for numbers less than 1% and the value at 99% for numbers greater than 99%.

The total carbon emission trend and the carbon emissions per unit of output trend are shown in Figure 1. The average growth rate of corporate carbon emission efficiency and total carbon emissions is negative. Since 2001, the average annual change in the total carbon emissions of enterprises has been relatively stable, and the overall carbon emission efficiency of enterprises has shown a downward trend. From 2001 to 2006, the two declined steadily, followed by a phased rise, and in 2009, the two reached a peak at the same time, and a downward trend followed, showing the synergy between the total carbon emission trend and the carbon emissions per unit of output trend.

The sub-regional analysis is shown in Figure 2. In terms of average annual total carbon emissions, the central region has the lowest total carbon emissions, while the western region has the highest carbon emissions. In terms of carbon emissions per unit of output value, the central region has the lowest carbon emissions per unit of output value. The main reason is that the western part of the Chinese mainland is mostly energy-intensive, while the central region is dominated by a large number of industries with high energy consumption levels. In other words, the area where energy structure enterprises gather has, on the whole, higher carbon efficiency and lower carbon emission efficiency.

In terms of the variation trend of carbon emission efficiency, the carbon emission per unit output of enterprises showed a relatively stable fluctuation trend, and the central region and Northeast China showed a slight increase on the whole. The possible reason is that the energy structure of enterprises is relatively more rigid, and it is difficult to upgrade in the process of urbanization. That is, the goal of protecting the environment may be achieved at the expense of efficiency.

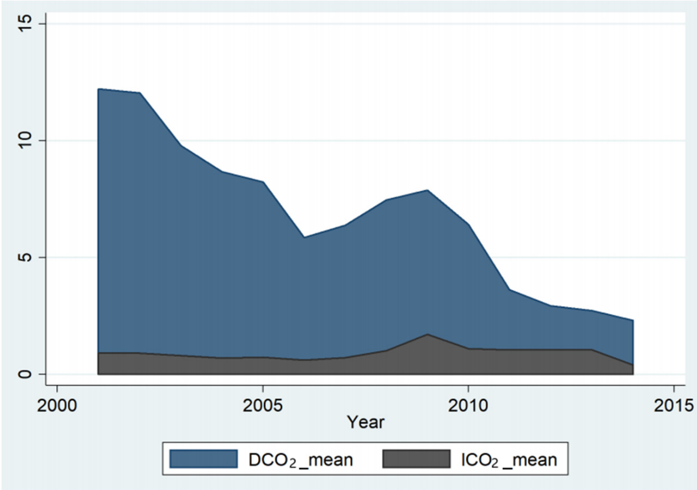

Figure 1. The average annual total carbon emission trend and the average annual carbon emissions per unit of output trend. DCO_2_mean is represented by the blue area, which refers to the annual average of carbon emissions per unit of output value. lCO_2_mean is represented by the black area, which refers to the logarithmic value of the annual average CO_2 emissions.

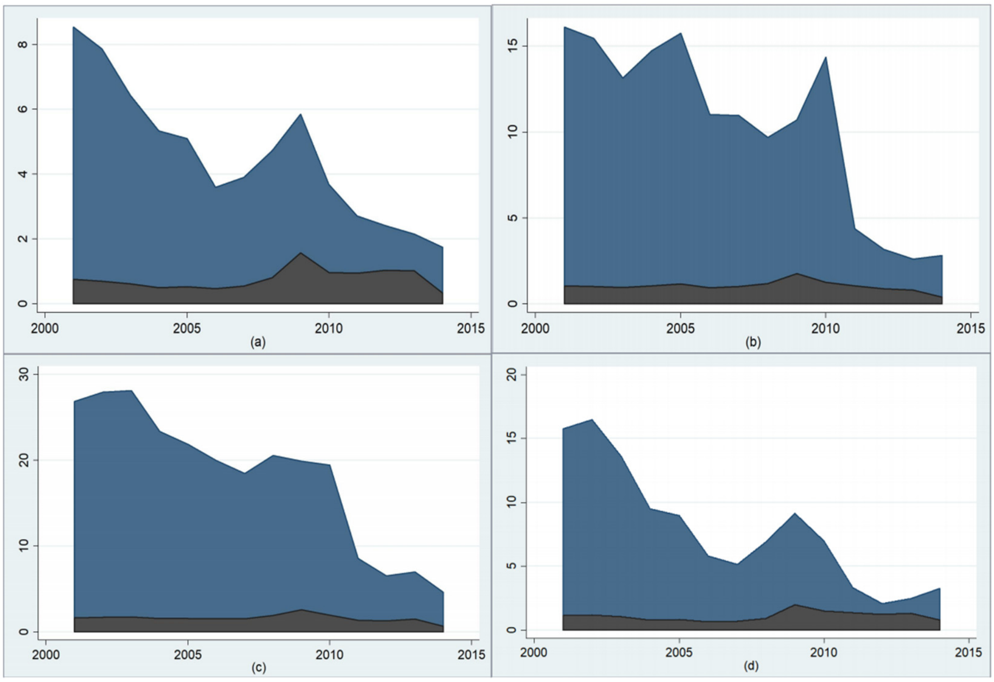

Figure 2. Sub-regional trends of the average annual total carbon emissions and the average annual carbon emissions per unit of output trend. The blue area refers to the annual average of carbon emissions per unit of output value, and the black area refers to the logarithmic value of the annual average CO_2 emissions. The upper left image (**a**) represents the eastern region (including Beijing, Shandong Province, Jiangsu Province, Zhejiang Province, Fujian Province); The upper right image (**b**) represents the central region (including Shanxi Province, Henan Province, Hubei Province, Anhui Province, Hunan Province, and Jiangxi Province); The bottom left image (**c**) represents the western region (including Inner Mongolia Autonomous Region, Xinjiang Uygur Autonomous Region, Ningxia Hui Autonomous Region, Shaanxi Province, Gansu Province, Qinghai Province, Chongqing Municipality, Sichuan Province, Tibet Autonomous Region, Guangxi Zhuang Autonomous Region, Guizhou Province, Yunnan Province). The bottom right image (**d**) represents the northeast region (including Heilongjiang Province, Jilin Province, and Liaoning Province).

3.3.2. Independent Variable

The independent variable is a dummy variable (*policy*), indicating the changes in the administrative division of the county where the enterprise is located (i.e., it equals 0 for years before the county upgraded, and it equals 1 for years after the county upgraded; for jurisdictions that remain counties, it equals 0 in all years). The source of the data is the manual compilation of data from 2001 to 2014 in China.

3.3.3. Moderating Variables

(1) Market integration (*mrk-integ*). The main measurement methods of the market integration in existing research include production method, price method, trade law, economic cycle method, etc. Among them, the price index method is regarded as the most direct and comprehensive method to measure the market trading information [40].
(2) Carbon-carrying capacity (*capacity*). The carbon carrying capacity reflects the capacity of an area to carry carbon emissions [21].
(3) Location entropy (*Entropy*). Location entropy is chosen to measure the level of industrial agglomeration [41,42].

3.3.4. Control Variables

The enterprise-level control variables are selected as follows [43,44]:

(1) Total revenue of the enterprise (*reve*). Enterprises with different incomes react differently to polluting carbon emissions due to their different profitability. After upgrading, different enterprises react differently. Enterprises with more revenue may ignore the "carbon tax" and other fee penalties, thus being insensitive to policy constraints to pollute the environment, while enterprises with less annual income are more sensitive. To control the influence of this factor, the annual income of the enterprise is selected as the control variable, which is treated logarithmically.
(2) Operating profit of the enterprise (*prof*). The operating income reflects the operating efficiency and profitability of the enterprise, which needs to be controlled.
(3) Total output of the enterprise (*outp*). The size of the enterprise is crucial in the production and environmental impact of the enterprise, and the total output value of the enterprise is used as the control variable to control the scale of the enterprise, which is treated logarithmically.
(4) Regional GDP (*lgdp*). Regional GDP is an important indicator to measure the regional economic level; enterprises in different economic development levels have heterogeneity, and the impact of this factor needs to be controlled.
(5) Financial leverage of the enterprise (*leve*). Financial leverage is an important indicator to measure the financial risk of enterprises, reflecting the enterprise's ability to create value, thus the impact of this factor needs to be controlled.
(6) Population density of the region (*pden*). The higher the population density of the region is, the larger the carbon emissions are likely to be. The population density of prefecture-level cities was selected as the control variable.
(7) Descriptive statistics of the variables are shown in Table 1.

Table 1. Descriptive statistics of variables.

Variables	Unit	Observations	Mean	Std. Dev	Min	Max
DCO_2	Total carbon emission/total of output	2,461,694	6.57	36.57	0	303.10
policy	Dummy variable	2,463,252	0.09	0.28	0	1.00
reve	ln(1 + total revenue of the enterprise)	2,448,198	10.53	1.42	0	20.69
prof	ln(1 + operating profit of the enterprise)	2,449,731	7.22	2.21	0	18.84
outp	ln(1 + total output of the enterprise)	2,463,252	10.58	1.43	0	19.85
leve	Total liabilities/total assets of the enterprise	2,463,189	0.57	0.47	−371.13	120.59
lgdp	ln(1 + gross product of the region)	2,463,252	7.32	1.01	3.46	9.72
pden	ln(1 + population/region's area)	2,463,211	597.15	324.20	4.72	11,564.00

3.4. Econometric Model

The carbon dioxide emissions of enterprises can be calculated when the energy consumption of enterprises is known. However, due to the difficulty in obtaining the power consumption data of enterprises, and great spatial and temporal differences in the carbon emissions generated by power production and consumption, this paper only focuses on the efficiency of carbon emissions directly generated by the fossil energy consumption of enterprises. The econometric model is showed in formula (3), which concludes the TWFE model and clustering into enterprises.

$$DCO_{2\,affect} = \alpha_0 + \alpha_1 policy + \alpha_2 Explained + \mu_i + \eta_t + \varepsilon_{it} \tag{3}$$

where *policy* is a dummy variable indicating the CDUP, which equals 1 if the enterprise is located in the county where the CDUP was implemented and the time is after the policy happened, and equals 0 otherwise. i and t represent the enterprise and the year. *Explained* represents controlled variables at the enterprise and city level, including the total output of enterprises, annual revenue of the enterprises, the population density of prefecture-level cities, corporate financial leverage, and regional GDP; λ_t represents the year fixed effect; γ_i represents the enterprise fixed effect;ε_{it} is error disturbance term; α_0, α_1, α_2 are the parameters to be estimated by the DID method with twice-fixed effects (TWFE).

Furthermore, we put the interaction terms of CDUP and market integration, CDUP and carbon carrying capacity, and CDUP and location entropy into the above model, to test how the CDUP affects the enterprise's carbon emission efficiency. The specific models are as follows:

$$DCO_{2\,affect} = \beta_0 + \beta_1 policy + \beta_2 mrk\_integ + \beta_3 policy * mrk\_integ + \beta_4 Explained + \mu_i + \eta_t + \varepsilon_{it} \tag{4}$$

$$DCO_{2\,affect} = \delta_0 + \delta_1 policy + \delta_2 capacity + \delta_3 policy * capacity + \delta_4 Explained + \mu_i + \eta_t + \varepsilon_{it} \tag{5}$$

$$Entropy_{affect} = \phi_0 + \phi_1 policy + \phi_2 Explained + \mu_i + \eta_t + \varepsilon_{it} \tag{6}$$

where *mrk_integ* represents market integration, β_1 is the estimated coefficient of market integration, and β_3 is the estimated coefficient of the interaction between the CDUP and market integration. Similarly, δ_1 is the estimated coefficient of carbon carrying capacity, and β_3 is the estimated coefficient of the interaction between the CDUP and market integration. ϕ_1 is the estimated coefficient of the CDUP on location entropy. Other descriptions of variables are the same as the Model (3).

3.5. Hypothesis Development

According to Section 3.3, to verify that the DID method is valid, Hypothesis 1 is developed as follows:

Hypothesis 1 (H1). *The trends of the treatment group and control group are parallel.*

According to Section 2.1, we introduce the large market theory for analysis. The integration of the market is conducive to promoting market competition, improving the degree of specialization of enterprises and improving the efficiency of enterprises' carbon emissions. However, personnel flow caused by market integration and regional resources will affect the CDUP's effect. Thus, Hypothesis 2 and Hypothesis 3are developed as follows:

Hypothesis 2 (H2). *The CDUP will decrease the efficiency of enterprises' carbon emission.*

Hypothesis 3 (H3). *The CDUP will increase the efficiency of enterprises' carbon emission.*

Moreover, the degree of market integration is introduced to explore the implementation mechanism of the policy. So Hypothesis 4 and Hypothesis 5are developed as follows:

Hypothesis 4 (H4). *Market integration will exacerbate the pollution effect of the CDUP.*

Hypothesis 5 (H5). *Market integration will inhibit the pollution effect of the CDUP.*

More importantly, existing studies show that carbon-carrying capacity is an important factor affecting regional carbon emissions. We propose the following hypotheses:

Hypothesis 6 (H6). *The region's carbon-carrying capacity will mitigate the pollution effect of the CDUP.*

Hypothesis 7 (H7). *The region's carbon-carrying capacity will exacerbate the pollution effect of the CDUP.*

Further, the CDUP may lead to the agglomeration of some industries. Industries with different carbon emission intensities have different industrial structures, so their responses to the CDUP may vary according to Section 2.4. Based on the above analysis, Hypothesis 8 and Hypothesis 9 are developed.

Hypothesis 8 (H8). *The CDUP will promote industrial agglomeration.*

Hypothesis 9 (H9). *The CDUP will weaken industrial agglomeration.*

4. Analysis of Empirical Results

4.1. Benchmark Regression

The parallel trend test is used to verify that the DID method is valid [45]. The test result is reported in Figure 3. Before the CDUP occurs, the 0-axis is contained in the 95% confidence interval of the estimated coefficients of DCO_2 in the treatment and control group, which shows that there is no obvious difference in the groups before the CDUP occurred. Hence, the following regression analyses are based on a valid foundation, so we fail to reject H1.

Table 2 reports the regression results of the Model (3). The estimated coefficient of β_1 is 0.886, and is positive at the significance level of 5%. That is, the average carbon emissions per unit of enterprise output may increase by 88.6% due to the CDUP's pollution effect. It indicates that the CDUP will decrease the enterprise's carbon emissions efficiency. Hence, we fail to reject H2.

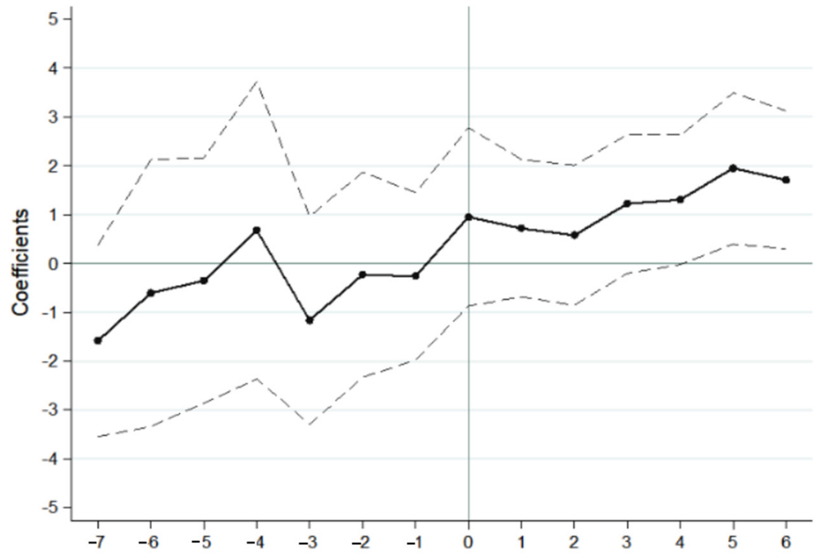

Figure 3. Result of the parallel trend test. Note: The horizontal axis represents time (7 years before the policy and 6 years after the policy). The vertical axis represents the percentage change in the observed variable (the dependent variable) of the treatment group and the control groups. The solid line indicates the estimated points of the difference between the treatment and control group's change. The grey dashed line represents the 95% confidence intervals of the estimated points.

Table 2. Regression results of upgrading policy on carbon efficiency of enterprises.

	Fixed Effects of Panel Data					
	(1)	(2)	(3)	(4)	(5)	(6)
	DCO_2	DCO_2	DCO_2	DCO_2	DCO_2	DCO_2
policy	0.684 * (1.92)	0.647 * (1.88)	0.659 * (1.92)	0.738 ** (2.13)	0.892 ** (2.51)	0.886 ** (2.49)
reve		−0.732 *** (−9.86)	−0.729 *** (−9.85)	2.275 *** (13.40)	2.342 *** (13.58)	2.340 *** (13.57)
prof			−0.031 (−1.30)	−0.026 (−1.15)	−0.023 (−1.05)	−0.023 (−1.06)
outp				−3.279 *** (−19.36)	−3.281 *** (−19.23)	−3.276 *** (−19.07)
leve				−0.116 (−0.86)	−0.127 (−0.93)	−0.127 (−0.93)
lgdp					−4.254 *** (−5.58)	−4.293 *** (−5.67)
pden						0.001 (1.59)
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,307,219	2,301,153	2,300,049	2,300,012	2,300,012	2,299,972
Adj. R-squared	0.528	0.530	0.530	0.531	0.531	0.531

Note: ***, ** and * represent significance levels of 0.01, 0.05 and 0.1, respectively. Values in brackets are T-values. The standard error is treated robustly. *reve*: Annual revenue of the enterprise; *prof*: Operating profit; *outp*: Total output of enterprises; *lgdp*: Regional GDP; *pden*: Population density of the city.

Analyzing the control variables, the estimated coefficient of *reve* is significantly positive at 1%, which means that the higher the annual revenue is, the more carbon emissions enterprises would emit. The reason is that enterprises in a better profit situation may emit carbon by purchasing "polluting rights", or may not regulate pollutant emissions because of the high cost of environmental protection. Similarly, local governments prefer to allow polluting companies to spend limited money on profitable activities rather than environmental investments, in order to generate more tax contributions [11]. The estimated coefficient of *lgdp* is significantly negative at 1%. That is probably because the level of regional economic development represents people's ability to earn and the public's preference for environmental quality. The better the regional economic development, the greater the power of lobbying the government or polluting companies [5]. The estimated coefficient of *outp* is significantly negative at 1%. That is probably because enterprises with scale advantages have relative advantages in production technology and efficiency, which emits relatively few pollution emissions. With low capacity, companies that are unable to cope with pollution penalties tend to choose provinces with lower environmental regulations, resulting in "pollution shelters".

4.2. Robustness Test

4.2.1. Placebo Test

To ensure that the impact of CDUP on carbon efficiency is not affected by other factors, we randomize the experimental group and control group of the policy, according to the method of Lu et al. [42]. The experimental and control groups were randomly selected, with the model (1) repeatedly estimated to obtain 500 estimated coefficients of the core independent variable (policy). As can be seen from Figure 4, the coefficient estimates obtained in the placebo test differ greatly from the coefficient estimates obtained by benchmark regression, indicating that the conclusions are robust.

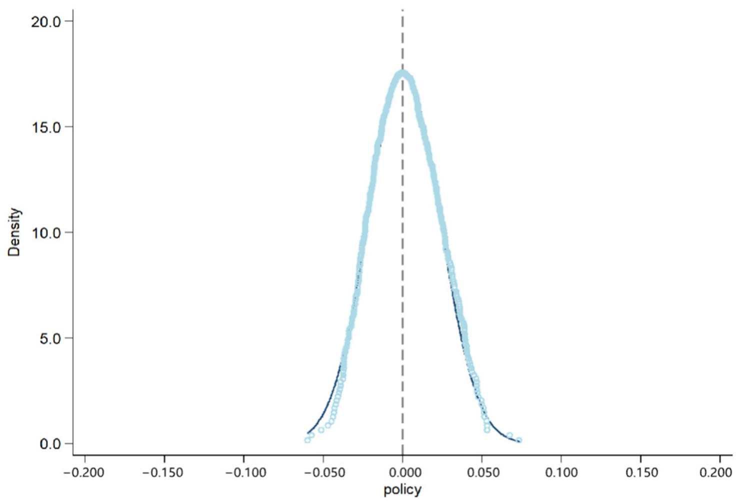

Figure 4. Result of the placebo test. The blue hollow circles represent the estimated coefficients of random sampling results. The estimated coefficients are located near zero, and only a few random sampling results have estimated coefficients greater than the baseline regression results (i.e., 0.886).

4.2.2. Replace Variables and the Time Window

The enterprise's total carbon emissions are used to replace the formerly dependent variable to test the robustness of the conclusions. As shown in Figure 1, the enterprise's total annual carbon emissions and the enterprise's carbon emission efficiency show similar changes, and both can reflect the impact of the CDUP on the enterprises. Regression results are reported in columns (1) and (2) in Table 3. The estimated coefficient of the enterprise's total carbon emission is 0.061 and significantly positive. Although the estimated coefficient is different from the baseline regression result (0.886), it also indicates that the CDUP will aggravate the enterprises' carbon emissions.

Table 3. Regression results of the robustness test.

	Replace Dependent Variable		Replace the Time Window	
	(1)	**(2)**	**(3)**	**(4)**
policy	0.033 (1.12)	0.061 * (1.81)	1.361 * (1.88)	1.230 * (1.70)
Control	No	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Observations	2,308,660	2,301,313	809,763	806,808
Adj. R-squared	0.506	0.509	0.356	0.362

Note: * represents significance levels of 0.1. Values in brackets are T-values. The standard error is treated robustly.

Moreover, considering the uneven distribution of data and the shock of the financial crisis, samples after 2007 are deleted. The regression results based on the sample from 2001–2007 are shown in columns (3) and (4) in Table 3. The estimated coefficient of the DCO_2 is 1.123 and positive, which fails to reject H2. Additionally, the coefficient here is significantly higher than that of the baseline regression (0.886), indicating that the financial crisis may lead to an underestimation of the CDUP's pollution effects.

4.3. Heterogeneity Analysis

Table 4 represents the heterogeneity analysis of the enterprise's carbon emission efficiency. Studies have confirmed that the size of cities affects the exertion of urban agglomeration effects [46], and the development and administrative level of the city also plays an important role. The cities with higher administrative levels, including four municipalities directly under the central government, twenty-six provincial capitals, and the other five cities with separate planning, were retained as a high-level group and the rest as a low-level group. The sub-samples were estimated separately, with the same model as the benchmark regression.

Table 4. Regression results of the heterogeneity analysis.

	$\mathbf{DCO_2}$			
	Low-Level Cities		**High-Level Cities**	
	(1)	**(2)**	**(3)**	**(4)**
policy	0.856 ** (2.05)	1.127 *** (2.72)	0.172 (0.30)	0.244 (0.41)
Control	No	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Observations	1927461	1921930	379605	377892
Adj. R-squared	0.531	0.533	0.509	0.512

Note: *** and ** represent significance levels of 0.01 and 0.05 respectively. Values in brackets are T-values. The standard error is treated robustly.

According to columns (1) and (2) in Table 4, the regression coefficients of *policy* are significantly positive in the low-level cities group. It shows that the *CDUP* significantly increases DCO_2 with an estimated coefficient of 0.856. After controlling the control variables, the estimated coefficients of DCO_2 become more significant with the estimated coefficient of 1.127. In columns (3) and (4), the coefficients of *policy* are not statistically significant. The results indicate that the impact of the CDUP is significant for enterprises in low-level cities, but not in high-level cities.

The possible reasons are as follows. First, high-level urban environmental governance has a stronger restrictive effect on population migration, while environmental governance in low-level cities has a promoting effect on population migration [47]. Second, the environmental governance system of high-grade cities is much better, which means more attention would be paid to environmental protection. High-level cities usually have more complete transportation facilities and business environments, and their barriers to the flow of talent and resources are relatively small. Therefore, in high-level cities, they are more able to attract foreign investment and labor employment and retain high-quality talent. For low-level cities, inefficient enterprises will crowd out other enterprises, making urban pollution levels rise and prompting talented employees to quit a local job for a better one. Third, from the perspective of carbon transfer, the implementation of the policy may lead to low-level cities undertaking carbon emissions from the adjacent areas. It indicates that the current inter-regional carbon emission accounting system still needs to be further improved and clarification is needed as to who is the main body responsible for carbon emissions.

4.4. Reanalysis Based on Moderating Effects

4.4.1. Market Integration

Considering the difference in commodity prices between regions, we used the price index method using relative price information to measure the degree of the region's market integration, and explore the impact of the county and district on the degree of market integration. The interaction term (*policy * mrk_integ*) between upgrading policy and market integration was introduced based on the static panel in the baseline regression, as shown in Table 5. Columns (1)–(3) of Table 5 represent the regression results after gradually adding the control variables.

Table 5. Results of market integration on the CDUP's pollution effect.

	DCO_2		
	(1)	**(2)**	**(3)**
policy	−1.160 (−1.06)	−1.166 (−1.06)	−1.171 (−1.06)
mrk_integ	0.013 (1.61)	0.013 (1.58)	0.012 (1.53)
policy * mrk_integ	0.020 * (1.72)	0.020 * (1.73)	0.022 * (1.83)
Enterprise control	No	Yes	Yes
Region control	No	No	Yes
Year fixed effect	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes
Observations	2,011,359	2,011,327	2,011,327
Adj. R-squared	0.505	0.505	0.505

Note: * represents significance levels of 0.1. Values in brackets are T-values. The standard error is treated robustly.

4.4.2. Carbon-Carrying Capacity

It is clearly shown that, after gradually adding the control variables at the enterprise level and the region level, the estimated coefficient is 0.022 and significant. With the improvement of the market integration level, the pollution effect of CDUP on the efficiency of enterprise increases, which fails to reject H4. This is probably because the policy has broken down the administrative barriers between urban centers and counties, and the integration of the market has enabled the optimal allocation of resources, which can improve the overall efficiency of the dismantling areas. Similarly, it has also provided a channel for carbon transfer, which paves the way for pollutant diffusing.

Carbon carrying capacity is derived from the theory of "ecological footprint"; it reflects the amount of fixed CO_2 for various photosynthesis preparations in the region [48]. In other words, it reflects the largest CO_2 emission of economic and social activities that can be carried by a certain region in a year. This paper further introduces the interaction term (*policy * capacity*) between upgrading policy and market integration based on the static panel in Table 4, as shown in Table 6. Columns (1)–(3) in Table 6 represent the regression results after gradually adding the firm level control variables and regional level control variables.

Table 6. Results of carbon carrying capacity on the CDUP's pollution effect.

	DCO$_2$		
	(1)	**(2)**	**(3)**
policy	1.304	1.749 **	2.375 ***
	(1.50)	(2.01)	(2.72)
capacity	−0.268 **	−0.279 **	−0.275 **
	(−2.24)	(−2.41)	(−2.32)
policy * capacity	−0.425	−0.599	−0.705 *
	(−1.00)	(−1.47)	(−1.65)
Firm control	No	Yes	Yes
Region control	No	No	Yes
Year fixed effect	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes
Observations	2,261,815	2,254,913	2,052,871
Adj. R-squared	0.528	0.531	0.522

Note: ***, ** and * represent significance levels of 0.01, 0.05 and 0.1, respectively. Values in brackets are T-values. The standard error is treated robustly.

The results show that, when control variables are not added, the estimated coefficient of *policy * sequestration* is not significant due to the influence of external factors. After the addition of control variables, the interaction term becomes significant with a coefficient of −0.705, while in the baseline regression, the estimated coefficient of CDUP on DCO_2 was 0.886; that is, regional carbon carrying-capacity weakened the pollution effect of CDUP. The result failed to reject H6.

Analyzing this result, the possible reasons are as follows: areas with high carbon carrying capacity may be equipped with clean technologies earlier, or have an industrial structure more appropriate for local development. The carbon-carrying capacity imposes less pressure on the ecological environment caused by spatial urbanization and economic urbanization, thereby reducing carbon emissions.

4.4.3. Industrial Agglomeration

Based on the description of Section 2.4, pollutants are the product of industrial development, and thus the agglomeration and development of industries have a significant impact on environmental pollution [48]. The carbon emission trading pilot industry was selected as the high-carbon industry group, and the rest as the low-carbon industry group. To verify that the CDUP will affect the industrial agglomeration of different industries, this paper further introduces the industrial agglomeration (*Entropy*) to study the influence on industry caused by the CDUP, as shown in Table 7.

Columns (1) and (2) in Table 7 represent the regression for enterprises in high-carbon industries, while columns (3) and (4) represent the regression enterprises in low-carbon industries. After controlling the influence of some exogenous variables, the estimated coefficient of the CDUP on location entropy is 0.411 in the high-carbon industries group, and it is significant at the level of 5%, which means that the CDUP increases the location entropy of enterprises in the high-carbon industries, while the estimated coefficient of CDUP on location entropy in the low-carbon industries group is not significant, indicating that the effect is not significant for enterprises in the low-carbon industries.

That is to say, the CDUP can increase the local entropy for industries with high carbon emissions. However, this effect is not significant in low-carbon industries. According to the research of Krugman [49] and Duranton [50], there are significant differences in the motivation and effect of industrial agglomeration in different industries. Therefore, the impact of CDUP on high-carbon industries and low-carbon industries is different. Furthermore, in the dismantling area, high-polluting enterprises realize that they cannot cope with environmental regulatory pressures through technological innovation, and will move to areas with weaker environmental regulations [51]. More importantly, the impact of CDUP on enterprise carbon emissions is accumulating, and the factors affecting the environment of enterprises are also gradually accumulating. Under the vicious circle, the impact of the CDUP on enterprises' carbon emission efficiency has a cumulative effect. That is, the implementation of the CDUP reduces the efficiency of an enterprise's carbon emissions, and the increase in regional carbon emissions will further strengthen this effect through the cumulative effect. This further confirms the "pollution shelter effect", resulting in enterprises with low-carbon nature often having better self-restraint, while high-carbon emission enterprises choose to indulge themselves in a "race to the bottom line" [32,33].

Table 7. Test on the impact of industrial agglomeration on the CDUP's pollution effect.

	High-Carbon Industries		**Low-Carbon Industries**	
	(1)	**(2)**	**(3)**	**(4)**
	Entropy	**Entropy**	**Entropy**	**Entropy**
policy	0.264	0.411 **	−0.070	0.025
	(1.30)	(2.03)	(−0.47)	(0.17)
Control	No	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	104,654	93,681	246,783	219,581
Adj. R-squared	0.564	0.601	0.664	0.690

Note: ** represents significance levels of 0.05, respectively. Values in brackets are T-values. The standard error is treated robustly.

5. Conclusions and Limitations

5.1. Implications for Theory and Research

This paper uses the continuous DID and TWFE at the enterprise level to explore the relevance between the CDUP and an enterprise's carbon emission efficiency. Research shows that the CDUP will decrease the efficiency of enterprises' carbon emissions. The mechanism behind this phenomenon can be divided into market integration, carbon-carrying capacity, and industrial agglomeration.

We applied the theory of large markets, and believe that integration can promote the free flow of factors in the market. However, based on this theory, we find that the integration of the market will accelerate the regional carbon transfer, resulting in a decline in the overall carbon emission efficiency and accelerating enterprises' carbon efficiency to "race to the bottom". From the perspective of carbon efficiency, a unified national market should also be applied to the field of carbon emissions and environmental regulation. Moreover, the efficiency of factors and resource allocation should be the primary considerations for establishing this market, which are closely related to ecological maintenance, industrial structure, labor mobility, and other factors.

Firstly, our research points out that the CDUP will decrease the carbon emission efficiency of enterprises. On the one hand, the result is contrary to some conclusions of the large market theory [4,5]. On the other hand, it provides a strong supplement to this theory based on China's national conditions. Second, this paper reveals the mechanism of the "environmental shelters" theory [20,21] from the enterprise and regional perspective. That is, the adjustment of administrative divisions will cause the enterprises' carbon emissions to shift, which will be further amplified in the location with a higher degree of market integration. Third, the CDUP will promote the agglomeration of enterprises in high-carbon industries, which may not produce positive externalities, while leading to increased pollution.

For practicality, the research proposes new ideas for the advancement of urbanization. Environmental protection is particularly critical in this case, because areas with stronger carbon-carrying capacity will reduce the negative impact of policies on the environment. The research may help the government to tailor urbanization development plans to local conditions and raise the focus on environmental protection. Additionally, this study could raise the government's attention to the environmental performance of enterprises, especially enterprises with high carbon emissions, as they tend to congregate and cause "polluting paradises".

5.2. Marginal Contributions and Limitations

Meanwhile, this study has some potential limitations that may have influenced the results. First, the data are limited from 2000 to 2014, indicating that our results will not reflect the latest trends. Second, the data are merged from three databases, with the inconsistency of historical indicators, missing data, and serious recording errors. The deviations in the data processing process may affect the results. Third, this paper selects the carbon emissions directly generated by the fossil energy consumption of enterprises to measure the carbon emissions, and uses a simple calculation method to calculate carbon efficiency. This method of indicator selection may lead to some potential factors being missed. Fourth, the carbon emissions are indirectly measured based on the energy consumption of the enterprises. Due to the regional differences in the energy quality and combustion efficiency, the calculated results may differ from the actual results. Finally, the research may ignore other pollution effects caused by the CDUP, which should be further discussed. Thus, the research can be further discussed based on the limitations.

5.3. Recommendations

This study provides a new perspective for the policy evaluation of administrative division adjustment, and fills the theoretical gap in the field of corporate environmental performance. It reveals that, when exploring the role of urbanization, the degree of market integration, regional environmental conditions, and industrial layout changes will all affect the channels of policy transmission. This will greatly affect the judgment of policy effects, because policies may have positive effects in terms of governance efficiency alone, but the potential negative externalities of policies may be ignored in this way. Moreover, most studies believe that the failure of China's CDUP is due to the overall poor performance of the regional economy, which is not explained by the transmission mechanism.

Moreover, for policy, the government should take active measures to reduce carbon emissions. The policies should be tailored to carbon emission technical standards, carbon trading, enterprise entry thresholds for carbon emissions, energy conservation, and emission reduction, etc. In this way, the government should take more scientific and strict measures to further regulate the enterprises' carbon emissions, and supervise the location change of the enterprise. Further, enterprises with long-term excessive emissions, no production structure and no governance ability should be shut down, while enterprises with the carbon disclosure project should be able to access loans and guarantees from the government.

Certainly, enterprises should integrate into the urbanization process and adapt to the requirements of policies on enterprise management, technical levels, and process conditions. Accordingly, developers should supervise the indirect carbon emissions generated by upstream and downstream enterprises rather than enterprises to achieve healthy competition, improving carbon efficiency while reducing carbon emissions.

On the whole, we should follow the trend of the establishment of a unified large market, attach importance to regional development with differences, and optimize the distribution of regional industries as well as reducing carbon emissions.

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