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Heterogeneous Environmental Regulation, Foreign Direct Investment, and Regional Carbon Dioxide Emissions: Evidence from China

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Abstract: As an important means to reduce carbon dioxide (CO_2) emissions, environmental regulation (ER) and foreign direct investment (FDI) have become popular research topics in recent years. Most studies have examined the single impact of ER or FDI on CO_2 emissions, while few investigated the regional heterogeneity and the spillover effect of different environmental regulations (ERs) on CO_2 emissions and neglected the impact of the interaction mechanism between ER and FDI on CO_2 emissions. This paper applies the spatial Durbin model (SDM) to explore the impact of different ERs and FDIs on regional CO_2 emissions in China's 30 provinces from 2003 to 2019. The results indicate that there are significant differences and regional heterogeneity in the effects of different environmental regulations on CO_2 emissions at the national level. FDI has a significant promoting effect on CO_2 emissions in the early years (2003–2009), especially in the eastern and western regions, but its effect is not significant in the late period (2010–2019). At the regional level, the abatement effects of the interaction term between FDIs and ERs are generally significant, indicating that ERs can influence the reduction effect of FDIs. Regulatory environmental regulation (RER) in the eastern region, command environmental regulation (CER), and economic environmental regulation (EER) in the central region can significantly affect the emission reduction effect of local FDI.

Keywords: carbon dioxide emission; environmental regulation; FDI; spatial Durbin model

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1. Introduction

Since China first put forward the quantitative target of controlling greenhouse gas emissions at the United Nations Climate Change Conference in 2009, CO_2 emission reduction has gradually become a major strategic decision of the Chinese government [1]. According to the International Energy Agency (IEA), China's total carbon emissions have continued to grow in recent years and will reach 11.90 billion tons in 2021, accounting for 32.78% of the world's total carbon emissions [2]. Meanwhile, China's coal-dominated energy structure brings huge challenges to carbon emission reduction. Therefore, Chinese President Xi Jinping clearly stated at the 75th General Assembly of the United Nations the ambitious goal of achieving carbon peaking and reducing carbon intensity by 60–65% compared to 2005 by 2030 and achieving carbon neutrality by 2060. Moreover, the National People's Congress (NPC) released the "Outline of the 14th Five-Year Plan for national economic and social development (2021–2025) and the long-range goals for 2035"(the Outline) in March 2021, proposing to achieve two goals of reducing carbon intensity by 18% during the 14th Five-Year Plan period and implementing carbon peaking by 2030, and pointed out that the Chinese government should further improve its modern environmental governance system and achieve binding targets such as environmental protection, energy conservation, and emission reduction [3]. However, due to the different levels of economic development, resource endowment conditions, and environmental bearing capacity among Chinese provinces, there are significant regional differences in the effects of various environmental regulations on carbon emissions [4], and how to formulate locally appropriate environmental regulation policies accordingly has become an urgent problem to be solved [5].

Meanwhile, the scale and structure of foreign investment in China have been changing in the face of the worldwide economic downturn. How to maintain the bottom line of China's economic development and make full use of the technological spillover effect of FDIs to boost regional carbon dioxide emission reduction has become an unprecedented challenge for the Chinese government [6]. The Outline mentions that building a higher level of the open economy requires upgrading the functions of the opening platform, accelerating system-based opening, optimizing the layout of opening in various regions, further reducing the negative list of foreign investment access, implementing post-entry national treatment, and promoting fair competition between domestic and foreign enterprises. While emphasizing the importance of foreign direct investment (FDI), how to use FDIs to promote CO_2 reduction has become a question worthy of deeper consideration. Scholars have started studying from the single-variable carbon reduction effects of ER and FDI [7,8], ignoring the dependency relationship between ER and FDI as well as the heterogeneity of the interaction effects between different ERs and FDIs [9,10]. For example, Gu et al. regarded the carbon finance market as an environmental regulatory tool and investigated its effect on carbon emission reduction in Chinese cities [11]. Chen et al. discussed the impact of environmental regulation on the carbon emissions of China's tourism industry [12]. In addition, some scholars have discussed the impact of FDI on carbon emissions and believed that FDIs played a positive role in China's carbon emissions [13]. Considering the changes in local governments' competitive willingness to attract investment, whether FDI can reduce carbon emissions needs to be retested, especially whether environmental regulations can affect regional carbon emissions by influencing the location choice of FDI, which is still a great controversy.

Therefore, this paper intends to analyze the impact of different ERs and FDIs on CO_2 emissions at the national and regional levels, respectively, and focuses on the effects arising from the interaction effects between ER and FDI. We aim to provide strong evidence for the government to design CO_2 reduction regulatory tools. Based on this, the possible marginal contributions of this paper compared to existing studies are the following three points: (a) this paper explores the impact of different types of ERs on CO_2 emissions, to analyze the CO_2 reduction effects of different regulatory instruments and provide support for the government to design some combination tools. (b) this paper examines the regional heterogeneity of the effects of ER and FDI on carbon emissions, which can provide a basis for the formulation of regionally differentiated emission reduction policies. (c) this paper examines the impact of the dependence between ER and FDI on CO_2 emissions and reveals the temporal and spatial variation of the interaction between ER and FDI on carbon emissions.

2. Literature Review and Theoretical Analysis

2.1. The Impact of ER on CO_2 Emissions

Regarding the effect of ER on CO_2 emissions, scholars generally hold the green paradox and forced emission reduction as two types of views. The green paradox was first proposed by Sinn. He analyzes the impact of the Kyoto Agreement on the behavior of resource extractors from a supply-side perspective, arguing that strict environmental regulations will promote accelerated stockpile extraction in response to the greening of Kyoto's national economic policies, which will cause a rapid increase in CO_2 emissions [14]. Employing the panel smooth transition regression technique, Wang et al. find that strict enforcement of environmental regulations in emerging economies leads to severe green paradox effects, hinders their economic development, and does not stimulate firms to engage in technological innovation and promote the internalization of abatement costs [15].

Scholars who hold the opposite view believe that environmental regulation can effectively urge enterprises to reduce CO_2 emissions by internalizing the cost of emission reduction. Wang et al. investigate the mechanism of the impact of environmental policy stringency on green productivity growth in the industrial sector of OECD countries and find that the "Porter hypothesis" was tested, which states that environmental policies have a beneficial impact on green productivity growth up to a certain degree of stringency [16].

There are variations in the way different types of ERs act on CO_2 emissions, and such variations require governments to be able to make reasonable use of different regulatory tools [17,18]. Early studies often equated environmental regulation with government regulation, arguing that relying on government administrative directives to limit uncontrolled corporate emissions was the most effective way to do so [19]. With the increasing marketization, various economic instruments have been applied to the field of environmental governance. Many scholars believe that economic regulation is more flexible than government regulation and can flexibly control enterprises according to their different emission levels [20,21]. Jiang and Ma examine the technology spillover effects of environmental regulation on CO_2 emissions networks from a global level and argue that the spatial association of CO_2 emissions among Organization for Economic Co-operation and Development (OECD) countries is related to trade activities [22]. Using carbon trading pilot policies as a quasi-natural experiment, Dong and Wang find that market-based environmental policies are effective and have cross-border emission reduction effects, i.e., carbon trading policies can reduce local CO_2 emissions and promote carbon reduction in neighboring regions [23]. Jiang and Lyu quantitatively and empirically test the impact of environmental regulations on China's pollution-intensive industry shifts by dividing them into three categories from the legal, economic, and informal regulation domains, respectively [24]. Shen et al. classify environmental regulations into command-based, market-based, and voluntary, analyze their impact on industrial GTIE, and then judge their contribution to the dual carbon target [25].

Inspired by the above studies, there are significant differences in the impacts of different types of environmental regulations, so it is necessary to explore whether each type of environmental regulation is effective in curbing CO_2 emissions. Based on the design of Qu [26], this paper divides environmental regulations into command-based environmental regulation (CER), economic environmental regulation (EER), and regulatory environmental regulation (RER). While analyzing the impact of different types of environmental regulations on CO_2 emissions, we will also consider the regional heterogeneity of this impact, and put forward the following hypotheses about the effects of the three types of environmental regulations on CO_2 emissions:

Hypothesis 1a (H1a). *CER can achieve regional mandatory CO_2 emission reduction through legislative means.*

Hypothesis 1b (H1b). *EER can reduce regional CO_2 emissions by increasing the economic investment in pollution control.*

Hypothesis 1c (H1c). *RER can achieve forced CO_2 emission reductions utilizing negative penalties for excessive emissions.*

2.2. The Impact of FDI on CO_2 Emissions

Under the reality of economic globalization, the importance of foreign direct investment to China's economic development is overwhelming. However, along with the entry of foreign enterprises, pollution has become an inevitable by-product [6]. The impact of FDI on environmental quality is gradually becoming one of the hot spots of research, and the research viewpoints can be roughly divided into two categories: pollution paradise and pollution halo [8]. The pollution paradise hypothesis assumes that high-emitting foreign enterprises, constrained by high levels of environmental regulation in economically developed countries or regions, tend to choose to move their industries to less developed countries to avoid higher taxes [27], which will lead to a gradual increase in CO_2 emissions levels in the host country [28]. The pollution halo hypothesis, on the other hand, believes that the introduced FDI has certain technological advantages for the host country, which not only avoids increasing the environmental burden of the host country but also has a technological spillover effect to a certain extent, thus accelerating the development of environmental governance in the host country and reducing CO_2 emissions [29]. Zhang et al. empirically analyze the impact of FDI on energy efficiency in China's manufacturing industry, and the results show a positive significant relationship between the effect of FDI competitiveness and energy efficiency [30]. By analyzing the factors influencing manufacturing CO_2 emissions in OECD 1989–2016, Pazienza concludes that the negative impact of FDI on CO_2 emissions declines as the size of its influx increases [31]. Domestic research on the mechanism of FDI on CO_2 emissions is gradually increasing. Ren et al. calculate CO_2 emissions reflected in China's international trade by an input-output analysis. The study finds that the influx of large amounts of FDI further aggravates China's CO_2 emissions and suggests that China should make efforts to change its trade growth pattern and adjust the structure of foreign investment [32].

However, with the development of China's economy and the emphasis on environmental quality, we need to consider whether the impact of FDI on CO_2 emissions in China has changed [33]. In this paper, we will analyze the CO_2 emissions' impact of FDI from 2003–2009 and 2010–2019 (two time periods), and propose the following hypothesis:

Hypothesis 2 (H2). *The entry of foreign enterprises will cause environmental burdens, produce a pollution paradise effect, and promote regional CO_2 emissions in China.*

2.3. The Interaction Effect of ER and FDI

The interaction term reflects the interdependence between variables, and the coefficient of the interaction term reflects the impact of this dependence between variables on the explanatory variables [34]. The interaction between ER and FDI exists objectively, as the attractiveness of ER to FDI varies with different levels of stringency, and local governments will adjust the level of local regulations due to this attractiveness [35]. Neglecting the strong linkage between them will lead to errors. Wang and Zhang investigate the urban heterogeneity of the role of ER in carbon reduction for 282 cities in China. The results show that the current ERs have a dampening effect on CO_2 emissions in China, but FDI exhibits a pollution paradise effect under the stringency of environmental regulations [36]. Neves et al. use environmental tax revenues to measure the environmental regulation and believe that environmental regulation could effectively reduce CO_2 emissions by promoting FDI re-structuring to attract high-quality investment; that is, the pollution halo hypothesis was tested in EU countries [37].

Therefore, we believe that a reasonable regulatory combination and level of regulation are conducive to attracting high-quality FDIs to the region, which is a benign dependency relationship that facilitates the development of regional CO_2 emissions reduction, manifested as a "top-by-top competition" among local governments. This paper will focus on the impact of the interaction between environmental regulation and FDI on CO_2 emissions. The hypothesis is as follows:

Hypothesis 3a (H3a). *The interaction between FDI and CER can curb CO_2 emissions.*

Hypothesis 3b (H3b). *The interaction between FDI and EER can curb CO_2 emissions.*

Hypothesis 3c (H3c). *The interaction between FDI and RER can curb CO_2 emissions.*

3. Materials and Methods

3.1. Research Area Overview

Based on the characteristics of regional economic development, geographical conditions, and population distribution, this paper refers to the division method of the Chinese National Bureau of Statistics (NBS) and divides the 31 provinces in mainland China into the eastern region (11 provinces/cities), central region (8 provinces/cities), and western region (12 provinces/cities). Considering the data missing in Tibet, this paper removes it and adjusts the western region to 11 provinces and cities. Accordingly, we divide the 30 provinces into three regions and use them as research areas (as shown in Table 1).

Table 1. Division of study area.

Areas	Provinces and Cities
Eastern region	Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan.
Central region	Shanxi (山西), Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan.
Western region	Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi (陕西), Gansu, Qinghai, Ningxia, Xinjiang.

Note: This regional classification is based on the practice of the Chinese National Bureau of Statistics. (https://data.stats.gov.cn/easyquery.htm?cn=E0103, accessed on 12 March 2022).

3.2. Variable Description

3.2.1. Explained Variable

The explained variable is CO_2 emission (CO_2). According to the method proposed by the IPCC [38] and Wang et al. [39], CO_2 emissions from each province can be regarded as the product of CO_2 emission factors from various energy combustion sources and the amount of energy combusted in each province [30]. Based on regional fossil energy consumption data, we calculated the CO_2 emissions of each province in China. The calculation formula is shown below.

$$CO_2 = \sum_1^8 E_i \cdot \xi_i \cdot \psi_i \quad (1)$$

where i represents the type of energy, and E_i represents the physical consumption of the i-th energy. The conversion coefficients (ξ_i) are sourced from the China Energy Statistical Yearbook; and CO_2 emission coefficients (ψ_i) of each fossil energy are sourced from IPCC [38] as shown in Table 2.

Table 2. Standard conversion coefficient and CO_2 emission coefficient of each energy.

Items	Coal	Coke	Crude Oil	Fuel Oil	Gasoline	Kerosene	Diesel	Natural Gas
ξ_i	0.71	0.97	1.43	1.43	1.47	1.47	1.46	1.33
ψ_i	0.76	0.86	0.55	0.59	0.59	0.57	0.62	0.45

3.2.2. Core Explanatory Variables

Environmental regulation (ER): different types of environmental regulation tools have heterogeneous impacts on CO_2 emissions [26]. This paper classifies environmental regulations into three types: (a) command-based environmental regulation (CER) is expressed by the sum of the cumulative number of environment-related laws and regulations enacted by each provincial government. (b) Economical environmental regulation (EER), which is measured by the ratio of industrial pollution control completion to industrial added value, is used to investigate whether the pollution control capital investment can play an effective role in governance. (c) Regulatory environmental regulation (RER) is expressed by the number of pollution-related administrative penalty cases in each province to measure the government's supervision of enterprise pollution emissions.

Foreign direct investment (FDI): to assess the impact of foreign capital on China's CO_2 reduction, we selected the amount of direct investment of foreign-invested enterprises in each province to represent.

3.2.3. Control Variables

To strengthen the reliability of this study, we have considered several factors that can affect CO_2 emissions from different aspects by referring to the previous study designs and identifying the following five control variables.

Economic development (GDP). The environmental policies implemented and the degree of attractiveness of FDI vary greatly between regions with different levels of economic development, so economic development is an influential factor that cannot be ignored in this study. We choose GDP per capita as the indicator of economic development level for each province.

Population agglomeration (POD). Population agglomeration often leads to changes in production and lifestyle, thus affecting regional CO_2 emissions. To control the influence of the population factor, this paper selects the population density of each province as the control variable.

Industrial structure (STR). From the perspective of China's CO_2 emission status, the secondary industry is the largest CO_2 emitting sector. The higher the secondary industry structure, the higher the CO_2 dioxide emissions in the region. Therefore, we use the ratio of value-added in the secondary sector to the regional GDP as an indicator of industrial structure.

Energy structure (ENS). The pollution emissions generated by different types of energy consumption vary greatly, among which coal, as a traditional fossil energy source, produces much more CO_2 from its combustion than other clean energy sources [40,41]. Therefore, this paper selects the proportion of coal consumption to total energy consumption to assess the impact of energy structure on CO_2 emissions.

Level of urbanization (UR). The scale effect, agglomeration effect, and people's lifestyle in the development of regional urbanization have complex effects on CO_2 emissions [42,43]. We choose the percentage of urban dwellers to the total population in each province to measure the level of urbanization.

All data in this paper are obtained from the China Statistical Yearbook, China Environment Yearbook, and China Energy Statistical Yearbook. Some missing data were supplemented by provincial statistical yearbooks and related websites or complemented by the linear interpolation method. In this paper, the economic variables, such as GDP and FDI, are deflated with 2015 as the base period at a constant price, and all the data are logarithmically processed to eliminate the effect of heteroscedasticity. Table 3 shows the results of the descriptive statistics of the main variables.

Table 3. Variable descriptive statistics.

Variables	Num	Mean	Sd	Min	Max
$lnCO_2$	510	10.01	0.809	7.036	11.750
lnCER	510	2.503	1.076	0.000	4.585
lnEER	510	−5.565	1.217	−8.667	−0.193
lnRER	510	7.556	1.322	2.079	10.720
lnFDI	510	10.81	1.426	6.936	14.380
lnGDP	510	10.41	0.595	8.709	11.910
lnPOD	510	7.696	0.626	5.226	8.749
lnSTR	510	−0.817	0.218	−1.833	−0.527
lnENS	510	−0.375	0.351	−3.419	−0.024
lnUR	510	−0.702	0.308	−1.698	−0.110

3.3. Econometric Strategy

The methodological process consists of three stages. First, we use the Moran index to test the spatial correlation to determine the applicability of the spatial econometric model; second, we use the LM test to identify the spatial econometric model, and use the Hausman test to determine whether the fixed-effects model or the random-effects model is adopted; finally, according to the above judgment, we decided to construct the two-way fixed-effects spatial Doberman model (SDM) for empirical testing.

3.3.1. Spatial Correlation Analysis

The linkage between adjacent regions cannot be ignored; therefore, to test whether there is a spatial correlation of CO_2 emissions in China, this paper calculates the Moran index of total national CO_2 emissions from 2003 to 2019. The spatial Moran index reflects the degree of correlation of a factor in a region, and a positive index indicates a positive correlation, and vice versa, a negative correlation. Moreover, the larger the absolute value, the stronger the correlation. Table 4 shows the calculation results of all global Moran indexes across China from 2003 to 2019.

Table 4. Global Moran index of CO_2 emissions in 30 Chinese provinces.

Variable	I	E(I)	Sd (I)	Z-Value	*p*-Value *
$CO_2$2003	0.060	−0.034	0.035	2.664	0.004
$CO_2$2004	0.053	−0.034	0.035	2.478	0.007
$CO_2$2005	0.054	−0.034	0.035	2.532	0.006
$CO_2$2006	0.050	−0.034	0.035	2.381	0.009
$CO_2$2007	0.048	−0.034	0.036	2.293	0.011
$CO_2$2008	0.051	−0.034	0.036	2.371	0.009
$CO_2$2009	0.044	−0.034	0.036	2.184	0.014
$CO_2$2010	0.043	−0.034	0.036	2.174	0.015
$CO_2$2011	0.036	−0.034	0.036	1.968	0.025
$CO_2$2012	0.030	−0.034	0.036	1.809	0.035
$CO_2$2013	0.030	−0.034	0.036	1.806	0.035
$CO_2$2014	0.030	−0.034	0.036	1.786	0.037
$CO_2$2015	0.032	−0.034	0.036	1.851	0.032
$CO_2$2016	0.027	−0.034	0.036	1.709	0.044
$CO_2$2017	0.027	−0.034	0.036	1.697	0.045
$CO_2$2018	0.023	−0.034	0.036	1.585	0.057
$CO_2$2019	0.019	−0.034	0.036	1.492	0.068

Note: * *p*-Value is the adjoint probability, which is obtained by Monte Carlo simulation 1000 times.

As shown in Table 4, the global Moran index of China's total inter-provincial CO_2 emissions in the period 2003–2019 is significantly positive at the 5% level, which indicates that China's CO_2 emissions are not randomly distributed in space, but rather show a certain positive correlation and remain stable over time. Ignoring the spatial correlation to study the impact of ER and FDI on China's CO_2 emissions will lead to unstable results, so this paper proposes to use a spatial econometric model for the analysis.

3.3.2. Model Selection

According to Table 4, it should be known that the spatial correlation of CO_2 emissions between provinces in China exists objectively [44,45]. Therefore, this paper focuses on spatiality and adopts a spatial econometric model for the empirical study, and it passes the LM test. The general spatial model includes the spatial error model, spatial Durbin model, and spatial lag model. After conducting the Lagrange multiplier test (LR test), it is found that the LR chi2 values are 42.67 and 42.98 with *p*-values of 0.0000, so the hypothesis that the model would degenerate is rejected. Then, we choose the spatial Durbin model for empirical study in this paper. Finally, after the Hausman test, the value of chi2 is 491.12 and the *p*-value is 0.0000, which rejects the use of the random effects model at a 1% significance level and chooses the two-way fixed model. Therefore, we construct a two-way fixed SDM, whose basic panel data form is shown below:

$$Y_{it} = \sigma\sum_{j=1}^{N} W_{ij}Y_{jt} + X'_{it}\beta + \sum_{j=1}^{N} W_{ij}X''_{jt}\theta + \mu_i + \varepsilon_{it} \quad (2)$$

where $Y_{it} = (y_{1t}, y_{2t}, \cdots, y_{nt})'$; X'_{it} is the explanatory variable matrix; X''_{jt} is the Durbin term, which describes the spatial effects between the explanatory variables; W_{ij} is the given spatial weight matrix; μ_i is the individual effect; ε_{it} is the random disturbance term that satisfies the assumption of independent and identical distribution.

3.3.3. Model Design

To test the role of each influencing factor on CO_2 emissions reduction in China, we use the above SDM to construct the basic empirical model (3), and analyze the direct effect as well as the spatial spillover effect.

$$CO_{it} = \sigma\sum_{j=1}^{N} W_{ij}CO_{jt} + X'_{it}\beta + \sum_{j=1}^{N} W_{ij}X''_{jt}\theta + \mu_i + \varepsilon_{it} \quad (3)$$

where CO_{it} is the total annual CO_2 emissions of each province; X'_{it} includes the core explanatory variables CER, EER, RER, and FDI, and other control variables; X'_{jt} reflects the spatial spillover effects of each explanatory variable; other settings are the same as above.

Given the close relationship between inter-regional ER and FDI, whether the interaction between the two can be used to promote regional CO_2 emissions reduction is one of the objectives of this paper. Therefore, we add the interaction term of three types of ERs and FDIs to the explanatory variables of the model (4) as follows.

$$CO_{it} = \sigma\sum_{j=1}^{N} W_{ij}CO_{jt} + X'_{it}\beta + \beta_1\text{CER\_FDI} + \beta_2\text{EER\_FDI} + \beta_3\text{RER\_FDI} + \sum_{j=1}^{N} W_{ij}X''_{jt}\theta + \mu_i + \varepsilon_{it} \quad (4)$$

The positive and negative magnitudes of the coefficients β_1, β_2, and β_3 reflect the impact of the interaction between the three kinds of environmental regulations and FDIs on CO_2 emissions. The presence of this influence is often understood as a moderating effect of FDI in the process of environmental regulation for CO_2 emissions governance. However, this paper argues that the interaction term represents the interdependence between the two explanatory variables, and the coefficient of the interaction term represents the impact of this dependence on the explanatory variables. We conducted regressions for the above two models at the national level and the regional level to test the existence of regional heterogeneity in CO_2 emissions by comparing the results.

4. Results and Discussion

4.1. Model Testing and Results Analysis

To confirm whether the core explanatory variables selected in this paper can significantly affect the explanatory variables, we first include three types of environmental regulations and FDI in the model (3), then the selected control variables are added, and the results obtained are shown in columns (1) (4) of Table 5. However, the results show that both CER and EER have promoted CO_2 emissions, which is inconsistent with China's CO_2 reduction achievement in recent years. To verify the reasonableness of this result, we take the 2009 United Nations Climate Change conference as the boundary when China first put forward the quantitative target of CO_2 reduction, and divide the sample period of 2003–2019 into two time periods, 2003–2009 and 2010–2019, which constructs panel data to conduct regressions separately. In this paper, empirical tests are conducted for two sample intervals to reveal the temporal changes in the impact of ER and FDI on carbon emissions, and the results are shown in Table 5. In order to obtain more informative conclusions, we focus on the regression results for the sample period from 2010 to 2019.

Table 5. The impact of ER and FDI on CO_2 emissions at the national level.

Variable	Direct				Indirect			
	(1) 2003–2019		(2) 2003–2009	(3) 2010–2019	(4) 2003–2019		(5) 2003–2009	(6) 2010–2019
CER	0.059 ***	0.082 ***	0.021	0.024	0.286 ***	0.121 *	−0.017	0.221 ***
	(2.677)	(3.993)	(1.091)	(0.761)	(3.689)	(1.925)	(−0.431)	(2.640)
EER	0.069 ***	0.044 ***	0.006	−0.019 *	0.093 **	0.055	−0.013	0.025
	(4.894)	(3.393)	(0.400)	(−1.656)	(2.156)	(1.601)	(−0.328)	(0.973)
RER	−0.014	−0.008	0.015	−0.039 ***	0.053 *	0.075 ***	−0.007	0.038 *
	(−1.341)	(−0.792)	(1.412)	(−3.899)	(1.741)	(2.906)	(−0.238)	(1.821)
FDI	0.084 ***	0.062 **	0.171 ***	0.038	0.132	−0.078	−0.078	−0.027
	(3.258)	(2.455)	(6.636)	(1.383)	(1.627)	(−0.954)	(−1.072)	(−0.349)
GDP		0.164	0.817 ***	−0.214		−1.132 ***	0.101	−0.079
		(1.628)	(5.704)	(−1.437)		(−3.748)	(0.233)	(−0.292)
POD		−0.015	−0.012	−0.016		−0.081	0.015	0.327 ***
		(−0.812)	(−0.939)	(−0.430)		(−1.373)	(0.427)	(3.373)
STR		0.563 ***	0.149	0.423 ***		1.160 ***	0.429	−0.122
		(4.542)	(0.977)	(3.333)		(2.958)	(1.239)	(−0.388)
ENS		0.280 ***	−0.210 ***	0.278 ***		−0.116	−0.267	−0.026
		(7.567)	(−2.906)	(7.207)		(−1.381)	(−1.340)	(−0.362)
UR		0.052	0.023	−0.495 ***		0.820 ***	−0.159	1.306 ***
		(0.767)	(0.502)	(−4.180)		(3.071)	(−0.974)	(2.625)
Observation	510	510	210	300	510	510	210	300
R-squared	0.223	0.037	0.104	0.153	0.223	0.037	0.104	0.153

Note: Z-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

As shown in column (3) of Table 5, both EER and RER are effective in reducing CO_2 emissions at the national level. Comparing the results in column (2), we can see that all three types of environmental regulations have insignificant effects on CO_2 emissions from 2003 to 2009, which shows that with the emphasis on CO_2 reduction and sustainable development in China, ERs can gradually exert their desired effects, and this result is also consistent with the actual situation [46]. However, the effect of CER regulation on CO_2 emissions is not significant, indicating that the relevant environmental laws and regulations promulgated by local governments do not play a desirable role. This has two possible causes: from the government's perspective, strict control of CO_2 emissions means slowing down economic development, which often makes the relevant laws and regulations lose their effectiveness; while for enterprises, overly stringent ERs will bring additional costs of emission reduction and related taxes. To maintain stable operating profits, enterprises will often choose to expand production, which coincides with the green paradox hypothesis [47]. Therefore, we reject Hypothesis H1a and accept Hypotheses H1b and H1c at the national level. Compared with the results of column (2) in Table 5, the coefficient of FDI is no longer significantly positive, implying that CO_2 emissions do not increase with foreign investment. This is because, with the development of China's economy and the concern for environmental management, the quality of foreign investment introduced has gradually improved. This finding verifies that Hypothesis H2 is not valid, and China is not a pollution paradise for foreign enterprises at present.

As shown in column (6) of Table 5, CER and RER can indirectly promote CO_2 emissions, implying that the more environment-related laws and regulations and the more severe administrative penalties in neighboring regions, the higher the CO_2 emissions in the region. This may be because stringent local regulations and administrative penalties in neighboring regions will induce high-emitting firms to move, which in turn will promote local CO_2 emissions. However, the indirect effects of EER are not obvious, which may be because EER is limited to the governance of the region and has a negligible impact on neighboring areas. Compared to the direct impact of FDI, its indirect impact is also insignificant, which shows that foreign capital has not played a positive role in reaching China's CO_2 emissions targets at the national level.

In column (3) of Table 5, STR and ENS have a facilitating influence on CO_2 emissions, which means that the higher the proportion of secondary industry in the region, the more CO_2 emissions are generated. Similarly, the higher the proportion of coal in energy consumption, the higher the CO_2 emissions. China's industry-led economic structure and coal-dominated energy structure have led to a dramatic increase in fossil energy consumption and CO_2 emissions in the industrial sector [48]. In addition, the UR has a dampening effect on CO_2 emissions, implying that the higher the level of urbanization, the lower the CO_2 emissions in the region. This is because in recent years, as the central government has attached great importance to CO_2 emissions, regions with higher levels of economic development have become the "front-runners" in emission reduction, so the level of urbanization is inversely correlated with total CO_2 emissions.

4.2. Regional Heterogeneity Analysis and Discussion

4.2.1. Direct Effect Analysis and Discussion

According to the central government, "regions with the ability to reach the peak first, developed regions to reach the peak earlier", and the differentiated emission reduction targets require different regions to build a reasonable emission reduction system according to local conditions [49]. In this paper, the spatial and temporal differences in CO_2 emissions effects of various factors are comprehensively considered. According to the characteristics of regional economic development, geographical conditions, and population distribution [50], this paper divides the 30 provinces in mainland China (except Tibet) into three regional blocks: east (11 provinces/cities), central (8 provinces/cities), and west (11 provinces/cities). Similarly, to avoid unreliable regression results due to long sample periods, we also conduct region-level regressions for two sample periods, 2003–2009 and 2010–2019, respectively, and obtain the direct effect results as shown in Table 6. In order to obtain more informative conclusions, we will focus our analysis on the regression results from 2010 to 2019.

Table 6. The results of direct effect at the regional level.

Variable	2003–2009			2010–2019		
	(1) East	**(2) Central**	**(3) West**	**(4) East**	**(5) Central**	**(6) West**
CER	0.005	0.117 **	−0.009	−0.102 ***	0.230 ***	0.019
	(−0.157)	(−2.345)	(−0.458)	(−2.578)	(−3.275)	(−0.583)
EER	0.039	0.083 ***	−0.002	−0.020 **	0.036 **	−0.035 **
	(−1.427)	(−2.688)	(−0.131)	(−2.253)	(−2.073)	(−2.049)
RER	−0.020	−0.047 ***	−0.003	0.020 **	−0.047 ***	−0.018
	(−0.799)	(−2.656)	(−0.249)	(−2.110)	(−3.824)	(−1.088)
FDI	0.332 ***	0.062	0.105 ***	−0.015	0.018	−0.001
	(−4.308)	(−0.783)	(−3.963)	(−0.480)	(−0.459)	(−0.034)
GDP	1.876 ***	0.592	0.842 ***	0.674 ***	−0.492 **	0.181
	(−6.185)	(−1.136)	(−5.042)	(−4.439)	(−1.987)	(−0.880)
POD	−0.092 **	−0.029	−0.004	0.287 ***	−0.173 **	0.031
	(−2.127)	(−0.813)	(−0.169)	(−3.958)	(−2.177)	(−0.719)
STR	−0.037	0.661	0.367	0.428 **	0.324 **	0.671 ***
	(−0.142)	(−1.199)	(−1.584)	(−2.540)	(−2.030)	(−3.848)
ENS	−0.475 ***	0.675	1.039 ***	0.001	1.448 ***	0.911 ***
	(−4.017)	(−1.006)	(−4.856)	(−0.024)	(−4.515)	(−6.769)
UR	0.486 ***	−0.135	0.022	0.211	−2.210 ***	0.430 ***
	(−4.444)	(−0.693)	(−0.437)	(−1.010)	(−5.206)	(−3.635)
Observation	77	56	77	110	80	110
R-squared	0.321	0.212	0.088	0.448	0.049	0.096

Note: Z-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$.

Eastern region results analysis: comparing the two columns of (1) (4) in Table 6, the CO_2 reduction effect of environmental regulation in the east has been greatly enhanced. CER and EER can significantly suppress CO_2 emissions in the eastern provinces. It may be because with the introduction of China's quantified CO_2 reduction targets, the positive response from the eastern region has achieved some remarkable results, which provide some experience for the design of ERs in the eastern and western regions. However, RER will boost CO_2 emissions, implying that the stricter the RER in the eastern region, the higher the CO_2 emissions. This may be because the strict regulatory effort in the eastern region drives the local governments to form regional barriers and competitive mechanisms [51,52]. Therefore, we accept H1a and H1b and reject H1c in the eastern region.

Central region results analysis: comparing columns (2) (5) in Table 6, the impact of the three ERs on CO_2 emissions is essentially unchanged in the central region. CER promotes CO_2 emissions in the central region, which is the opposite of the results in the eastern region. This may be because companies in the central region are higher emitters compared to the eastern region. The effect of EER on CO_2 emissions is not significant, indicating that the current investment in pollution control in the central region is still insufficient, and further investment is needed to reach the level of effective CO_2 reduction. RER can significantly curb CO_2 emissions. This is because administrative penalties not only confiscate a certain amount of money from enterprises but also hurt their reputation, so the emission reduction effect of RER is most significant in the central region. Therefore, we reject H1a and H1b and accept H1c in the central region.

Western region results analysis: comparing the two columns of (3) (6) in Table 6, it can be seen that only EER can curb CO_2 emissions. This is because the western region, as a slower-developing region of China, has always needed to avoid economic development being affected by environmental management, and the upper-level government has not exerted heavy pressure to reduce CO_2 emissions; therefore, both command-based environmental regulation and regulatory environmental regulation are lax. Therefore, we reject H1a and H1c and accept H1b in the western region.

Overall, FDI in all three regions will no longer contribute to CO_2 emissions during the period 2010–2019, indicating that in recent years, with the continuous improvement of the quality of foreign investment introduced, China has avoided becoming a pollution haven for foreign companies. Regretfully, foreign direct investment has not contributed to CO_2 reduction either, indicating that its quality needs further improvement [53]. Therefore, we reject H2 in all three regions.

4.2.2. Spatial Spillover Effects Analysis and Discussion

To test whether there is regional heterogeneity in the spatial spillover effects of various environmental regulations on CO_2 emissions, we follow the previous design and run regressions at the regional level from two sample periods, 2003–2009 and 2010–2019, respectively, and the results are shown in Table 7.

Eastern region results analysis: compared with column (1) in Table 7, CER and EER both have significant indirect effects in the period of 2010–2019, implying that the higher the number of environmental regulations and the higher the level of pollution control investment in neighboring regions, the lower the local CO_2 emissions. That is to say, as the eastern region of China pays more attention to CO_2 reduction, the eastern provinces and cities will compete to improve their environmental regulations, leading to the gradual intensification of inter-provincial "top-to-top competition", and this benign competition brings a great impetus to regional CO_2 emission reduction.

Central region results analysis: the results of column (5) in Table 7 show that only the EER can curb CO_2 emissions, which is consistent with the results for the eastern region. It is possible that with the emphasis on CO_2 reduction, some benign competition has been formed in the central region too. The coefficient of XER changes from significantly negative to insignificant, probably because the central region gradually relaxes the relevant environmental policies to accept the industrial transfer from the eastern region, resulting in the spatial spillover effect of the CER on CO_2 emissions no longer being significant.

Table 7. The results of the indirect effect at the regional level.

Variable	2003–2009			2010–2019		
	(1) East	(2) Central	(3) West	(4) East	(5) Central	(6) West
CER	0.060	−0.102 *	−0.107 ***	−0.088 **	0.126	0.179 ***
	(−1.182)	(−1.664)	(−2.785)	(−2.067)	(−1.125)	(−2.733)
EER	−0.004	0.050	0.004	−0.019 *	−0.051 **	−0.007
	(−0.071)	(−1.084)	(−0.137)	(−1.657)	(−2.190)	(−0.261)
RER	0.048	−0.007	−0.010	−0.007	−0.011	−0.003
	(−1.040)	(−0.308)	(−0.414)	(−0.450)	(−0.973)	(−0.082)
FDI	−0.390 **	−0.145 *	−0.226 ***	−0.011	−0.108 *	0.006
	(−2.248)	(−1.774)	(−4.466)	(−0.223)	(−1.688)	(−0.106)
GDP	1.421	1.675 **	−0.276	−0.128	1.942 ***	0.371
	(−1.291)	(−2.252)	(−0.939)	(−1.287)	(−5.962)	(−0.904)
POD	−0.068	0.043	−0.035	0.374 ***	0.160 **	0.052
	(−0.637)	(−1.130)	(−1.028)	(−3.804)	(−2.079)	(−0.626)
STR	0.169	−1.791 **	−0.201	0.108	−0.604 ***	−0.828 **
	(−0.307)	(−2.343)	(−0.620)	(−0.723)	(−3.189)	(−2.346)
ENS	0.080	0.273	−0.431	0.175 ***	0.389	1.761 ***
	(−0.196)	(−0.338)	(−1.122)	(−3.645)	(−0.937)	(−4.312)
UR	0.470	0.473 *	0.175 *	1.152 ***	1.627 ***	0.385 *
	(−1.586)	(−1.840)	(−1.800)	(−3.742)	(−3.313)	(−1.668)
Observation	77	56	77	110	80	110
R-squared	0.321	0.212	0.088	0.448	0.049	0.096

Note: Z-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Western region results analysis: as column (6) in Table 7 shows, only the CER can curb CO_2 emissions, indicating that in the western region, the stricter the neighboring CER, the higher the CO_2 emissions in the region. This may be because there is also some transfer of high-emitting firms between provinces in the western region. Unlike the east and central regions, EER does not generate significant indirect effects. Compared with column (6) of Table 6, EER can only locally inhibit CO_2 reduction, which suggests that the benign competition among local governments has not been formed in the western region.

Overall, regulatory environmental regulation (RER) fails to produce significant indirect effects in all three regions. The possible reason is that administrative penalties, such as government regulation of local enterprises, do not have a large impact on neighboring regions [35], so the spatial spillover effect of RER on CO_2 emissions can be neglected. Meanwhile, FDI can promote CO_2 reduction in all three major regions from 2003 to 2009, indicating that FDIs in China had a spatial spillover effect on CO_2 emissions in the early period [54]. However, with China's industrial upgrading and rapid economic development, the technological differences between domestic enterprises and foreign-funded enterprises have gradually narrowed [55], and the spatial spillover effect of FDIs on China's CO_2 emissions has also decreased, i.e., the level of foreign investment between neighboring regions would not affect local CO_2 emissions.

4.3. Interaction Effects Analysis and Discussion

In general, environmental regulations influence the introduction of FDI, and local governments are influenced by FDI when formulating regulatory policies [45]. The impact of this interaction between ER and FDI on CO_2 emissions is often overlooked. In this paper, we design model (4) and follow the treatment in the previous section to test at the national level and regional level, respectively.

4.3.1. National-Level Results Analysis and Discussion

Firstly, we regress model (4) to obtain the CO_2 emissions effect of the interaction between three environmental regulations and FDI at the national level, and the results are shown in Table 8.

Table 8. The results of the interaction effect at the national level.

Variable	Direct		Indirect	
	(1) 2003–2009	(2) 2010–2019	(3) 2003–2009	(4) 2010–2019
CER	0.140 ***	0.665 ***	−0.099	0.215
	(−3.243)	(−4.964)	(−0.649)	(−0.722)
EER	0.170	−0.143 **	−0.450 *	0.215
	(−1.599)	(−2.348)	(−1.862)	(−1.282)
RER	0.086	−0.024	0.000	0.021
	(−1.251)	(−0.326)	(−0.001)	(0.132)
FDI	0.118	0.318 ***	0.218	−0.158
	(−1.611)	(−5.352)	(−1.219)	(−1.111)
CER_FDI	0.022 ***	0.063 ***	−0.015	0.000
	(−3.028)	(−5.073)	(−0.586)	(−0.009)
EER_FDI	−0.019 *	0.012 **	0.045 *	−0.016
	(−1.849)	(−2.130)	(−1.898)	(−1.100)
RER_FDI	−0.007	−0.002	−0.001	0.000
	(−0.996)	(−0.292)	(−0.047)	(−0.026)
GDP	0.632 ***	0.450 ***	0.062	0.455 *
	(−4.030)	(−3.059)	(−0.127)	(−1.734)
POD	−0.015	0.014	0.022	0.298 ***
	(−1.118)	(−0.400)	(−0.653)	(−3.140)
STR	0.229	0.689 ***	0.502	0.185
	(−1.457)	(−5.705)	(−1.155)	(−0.622)
ENS	−0.153 *	0.170 ***	−0.326 *	0.001
	(−1.732)	(−4.075)	(−1.695)	(−0.007)
UR	0.024	0.536 ***	−0.128	0.609
	(−0.493)	(−4.565)	(−0.862)	(−1.310)
Observation	210	300	210	300
R-squared	0.138	0.064	0.138	0.064

Note: Z-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The results of the direct effects show that the interaction effect between CER and FDI promotes CO_2 emissions in China all along. The coefficient of EER_FDI changes from negative to positive, indicating that the interaction effect between EER and FDI promotes CO_2 emission reduction in China as the economy develops. The coefficient of the direct effect of RER_FDI is negative, but not significant, probably because the local administrative penalties are not strict for foreign enterprises, resulting in minimal emission reduction. Therefore, we reject H3a, H3b, and H3c at the national level.

In addition, the results of the indirect effects show that the interaction effect of all three types of environmental regulations and FDI fails to produce a significant indirect effect over the period 2010–2019, while indicating that the interaction effect formed by local ER and FDI at the national level can only have an impact on local areas, and cannot form a significant spatial spillover effect on neighboring areas. This is because the interaction effect between ERs and FDI is already an indirect CO_2 reduction effect to some extent, and it is difficult to form an additional indirect effect on neighboring regions.

4.3.2. Regional-Level Results Analysis and Discussion

In this paper, considering the regional heterogeneity in the impact of the interaction effects between different types of ERs and FDI on carbon emissions, regressions are conducted at the regional level for two sample periods, 2003–2009 and 2010–2019, and the results are shown in Table 9. We will focus on the results of 2010–2019 to obtain more informative conclusions.

Eastern region results analysis: from the results of columns (1) and (4) in Table 9, we can see the interaction effect between CER and FDI (CER_FDI) directly promotes CO_2 emissions in the eastern region all along. It may be because the economic development level in the eastern region is higher and foreign enterprises do not have absolute technological advantages. As the CER in the eastern region becomes stringent, foreign enterprises also need to expand their production to compensate for the taxes and fees, which will promote CO_2 emissions. The interaction effect between EER and FDI (EER_FDI) does not affect CO_2 emissions significantly, probably because pollution control investment mainly targets local enterprises, with minimal impact on foreign enterprises. The interaction effect between RER and FDI (RER_FDI) can significantly reduce CO_2 emissions in the eastern region. Compared with the direct effect at the national level, it can be inferred that it is the administrative penalties in the eastern region that deter foreign firms as well [56]. Therefore, we reject H3a and H3b and accept H3c in the eastern region. The results of column (4) in Table 9 show that only RER_FDI affects CO_2 emissions significantly, which is the opposite of the result in the direct effect, indicating that although the interaction effect between RER and FDI can directly promote CO_2 reduction in the region, it promotes CO_2 emissions in neighboring regions. This may be because strict administrative penalties cause a portion of high-emitting foreign firms to flee to neighboring regions.

Central region results analysis: as shown in columns (2) and (5) of Table 9, CER_FDI shifts from promoting CO_2 emissions to curbing them, which indicates that with the emphasis on CO_2 emissions, gradually stricter environmental regulations are beginning to effectively control the entry of high-emission foreign investment, while higher-quality FDI is also having an impact on emission reduction in the central region. EER_FDI can curb CO_2 emissions all along; this may be because FDI still has some technological advantages for the central region and can play a certain demonstration effect. However, RER_FDI does not have a significant effect on CO_2 emissions, and it may be that the government in the central region is not strict enough in regulating foreign enterprises. Therefore, we accept H3a and H3b and reject H3c in the central region. The results of column (11) in Table 9 show that only the CER_FDI has a significant indirect effect on CO_2 emissions, indicating that the interaction effect between CERs and FDI from neighboring places will promote local CO_2 emissions. Compared with the direct effect, it is easy to find that the interaction effect between command-based environmental regulation and FDI has a crowding-out effect on high-emission foreign enterprises [45].

Western region results analysis: the results in column (6) of Table 9 show that CER_FDI and EER_FDI have no significant effect, while RER_FDI promotes CO_2 emissions in the western region. These results are generally consistent with Table 6, which again demonstrates the inadequate impact of ERs on CO_2 emissions in the western region at present. This requires that the western region should try to seek a new route of low-carbon development, and not follow the old path of "polluting first and treating later" and should strengthen the supervision of foreign enterprises to avoid becoming a "pollution paradise" for foreign investors. Therefore, we reject H3a, H3b, and H3c in the western region. As shown in column (12) of Table 9, the coefficients of the interaction terms between all three types of ERs and FDI are insignificant, which is consistent with the results of direct effects. The interaction effect between ER and FDI is not significant in the local area, let alone for the surrounding areas, which reinforces the need for the western region to attach importance to environmental quality.

Table 9. The results of the interaction effect at the regional level.

Variable	Direct						Indirect					
	2003–2009			2010–2019			2003–2009			2010–2019		
	(1) East	(2) Central	(3) West	(4) East	(5) Central	(6) West	(7) East	(8) Central	(9) West	(10) East	(11) Central	(12) West
CER	0.139 *	0.370 ***	0.007	−1.063 ***	2.986 ***	0.148	0.514 ***	0.885 ***	−0.185 ***	−0.150	−3.084 ***	−0.556
	(−1.918)	(−3.918)	−(0.209)	(−4.485)	(−4.582)	(−0.572)	(−4.507)	(−5.689)	(−2.597)	(−0.450)	(−4.061)	(−0.987)
EER	0.130	3.564 ***	−0.256 **	0.068	0.689 **	−0.027	0.275	−1.751 ***	0.364 *	−0.075	−0.273	0.269
	(−0.639)	(−8.224)	(−2.268)	(−0.861)	(−2.557)	(−0.217)	(−0.808)	(−2.819)	(−1.695)	(−0.504)	(−0.754)	(−0.841)
RER	0.504 **	1.280 ***	−0.141	0.241 **	0.106	−0.274 **	0.416	−0.415	−0.576 ***	−0.522 ***	0.085	0.001
	(−2.206)	(−5.268)	(−1.195)	(−2.133)	(−0.607)	(−2.536)	(−0.952)	(−1.329)	(−3.207)	(−2.724)	(−0.382)	(−0.007)
FDI	0.522 ***	−0.900 ***	0.106	−0.110	0.731 ***	−0.150	0.015	0.202	−0.858 ***	−0.398 **	−1.052 ***	−0.374
	(−4.451)	(−4.113)	(−0.850)	(−1.094)	(−3.826)	(−1.071)	(−0.035)	(−0.639)	(−3.882)	(−2.191)	(−4.101)	(−1.296)
CER_FDI	0.023 **	0.057 ***	0.005	0.074 ***	−0.265 ***	−0.011	0.075 ***	0.170 ***	−0.016	0.009	0.297 ***	0.079
	(−2.024)	(−3.036)	(−0.765)	(−4.101)	(−4.269)	(−0.441)	(−3.644)	(−6.200)	(−1.037)	(−0.359)	(−4.270)	(−1.407)
EER_FDI	−0.010	−0.356 ***	0.026 **	−0.007	−0.062 **	−0.002	−0.029	0.134 **	−0.036	0.004	0.021	−0.028
	(−0.574)	(−8.427)	(−2.086)	(−1.012)	(−2.483)	(−0.168)	(−0.975)	(−2.181)	(−1.501)	(−0.351)	(−0.621)	(−0.852)
RER_FDI	−0.046 **	−0.133 ***	0.014	−0.019 **	−0.014	0.025 **	−0.038	0.048	0.062 ***	0.044 ***	−0.008	−0.002
	(−2.395)	(−5.489)	(−1.085)	(−2.054)	(−0.815)	(−2.314)	(−1.055)	(−1.510)	(−3.087)	(−2.796)	(−0.373)	(−0.111)
GDP	1.955 ***	0.572 **	0.653 ***	0.472 ***	0.008	0.042	0.908 **	1.957 ***	−0.243	−0.431 ***	1.399 ***	0.397
	(−11.435)	(−2.056)	(−3.074)	(−2.595)	(−0.034)	(−0.164)	(−2.012)	(−4.847)	(−0.574)	(−3.237)	(−4.552)	(−0.767)
POD	−0.052	−0.060 ***	−0.001	0.354 ***	−0.084	0.014	−0.068	−0.019	−0.009	−0.290 ***	0.023	0.035
	(−1.622)	(−2.704)	(−0.049)	(−5.028)	(−1.279)	(0.282)	(−0.867)	(−0.772)	(−0.258)	(−3.018)	(−0.300)	(−0.323)
STR	0.018	0.875 *	1.114 ***	0.430 **	0.026	0.572 ***	0.354	−3.995 ***	0.189	0.172	−0.463 ***	−1.004 **
	(−0.087)	(−1.831)	(−4.242)	(−2.514)	(−0.178)	(−2.936)	(−0.222)	(−9.111)	(−0.641)	(−1.143)	(−2.589)	(−2.195)
ENS	−0.316 ***	1.306 ***	1.135 ***	−0.054	1.521 ***	0.982 ***	0.417	0.847 **	−0.652	0.124 **	0.044	2.158 ***
	(−2.604)	(−3.281)	(−4.595)	(−1.491)	(−5.163)	(−6.597)	(−1.624)	(−2.123)	(−1.523)	(−2.041)	(−0.114)	(4.561)
UR	0.515 ***	−0.181	0.057	0.268	−2.190 ***	−0.451 ***	0.585 ***	0.925 ***	0.231 ***	1.064 ***	1.723 ***	0.151
	(−8.089)	(−1.636)	(−1.211)	(−1.185)	(−5.345)	(−2.944)	(−3.935)	(−6.372)	(−2.892)	(−2.941)	(−3.423)	(−0.507)
Observation	77	56	77	110	80	110	77	56	77	110	80	110
R-squared	0.316	0.021	0.015	0.376	0.076	0.028	0.316	0.021	0.015	0.376	0.076	0.028

Note: Z-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Conclusions, Policy Implications, and Future Research

5.1. Main Conclusions

(1) At the national level, EER and RER can effectively curb CO_2 emissions, indicating that China's governance investment and administrative penalty system in carbon emission reduction have played an important role. In contrast, the direct impact of CER on local carbon emissions is not obvious, but there is a significant spatial spillover effect, indicating that strict environmental regulations in neighboring regions will promote local carbon emissions through the crowding-out effect on energy-intensive and high-polluting industries.

(2) There is significant regional heterogeneity in the CO_2 reduction effects of the three environmental regulations from 2010 to 2019. CER has a significant direct emission reduction effect and spatial spillover effect only in the eastern region; EER in the eastern and western regions has a direct effect on CO_2 emission reduction, while EER has a significant spatial spillover effect in the eastern and central regions; and RER has a significant impact on carbon reduction in the central region and its indirect impact is not significant in all three regions.

(3) The impact of FDI on CO_2 emissions gradually weakened with the development of China's economy, and its impact showed a positive mitigation effect in the early stage (2003–2009), especially in the eastern and western regions; however, in the late stage (2010–2019), its emission reduction effect was not significant. Moreover, the study found that the interaction effect between CER and FDI and the interaction effect between EER and FDI can suppress CO_2 emissions in the central region; the interaction effects between RER and FDI can promote CO_2 emissions reduction in the eastern region.

5.2. Policy Implications

Based on the above conclusions, this paper proposes the following suggestions:

(1) It is important to rationalize the differential impacts of different ERs on China's CO_2 emissions to efficiently achieve CO_2 emission reduction targets. Among the three types of ERs covered in this paper, the most effective is RER, but it does not mean that stricter supervision will curb CO_2 emissions, which requires the government to use its regulatory powers wisely. At the same time, government departments should flexibly enforce relevant environmental regulations and keep monitoring companies' responses to different levels of stringency of regulations to promote emission reductions in a step-by-step manner [39].

(2) It is necessary to design regional differentiated emission reduction policies and improve the orderly peaking governance system. The eastern region should focus on consolidating the current emission reduction achievements, effectively play the role of CER in reducing emissions, improve the investment scale and utilization efficiency of environmental governance, and strengthen environmental monitoring and penalties for illegal emissions [57]. The central region needs to further strengthen EER and promote treatment investments to reduce CO_2 emissions, while the western region should give play to regional energy characteristics and gain time to realize the gradual replacement of new energy and promote the energy low-carbon transition.

(3) Local governments should pay attention to the interaction between ER and FDI, and guide foreign investment in energy conservation and environmental protection. The local governments should gradually improve and strictly implement environmental regulation policies to promote the inflow of high-quality FDI [58], achieving a win-win situation between the introduction of FDI and the construction of ERs, and promoting the continuous adjustment and upgrading of industrial structure. In the central and western regions, where economic development is slow, it is necessary to avoid the excessive relaxation of regulations to attract foreign investment and ensure the sustainable and healthy development of the local economy.

5.3. Future Research

This paper mainly examines the impact of different types of ERs and FDI on China's carbon emissions. In the process of the study, we believe that there are some issues worthy of further investigation. Firstly, this paper chooses different indicators to indicate the level of ER but does not address specific regulatory instruments, such as environmental tax, carbon tax, and carbon trading mechanism, etc. The emission reduction effects of specific environmental regulation policies and their impact mechanisms can be explored in the future. Secondly, the explanatory variable in this paper is carbon emissions. From the perspective of China's coal-based energy consumption structure, air pollution and carbon emissions are homogeneous, and it is worthwhile to study the synergistic emission reduction effects of different types of ERs. Finally, the willingness of local governments affects the stringency of environmental regulations and the location choice of FDI. Therefore, it is very important to study the interaction mechanism of environmental regulation and investment attraction competition and its abatement effect from the perspective of inter-governmental competition.

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