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Study on the Effectiveness of Environmental Regulations and Its Spatial Spillover in China's High-Quality Human Habitat Cities

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Abstract: High-quality human habitat cities in developing countries are facing new urban environmental problems as a result of the significant resource footprints of wealthy urban populations in the process of rapid urbanization. These areas are desperate for solutions to the coexistence of old and new pollutants, as well as inorganic and organic compounds. The authors of this study propose a comprehensive framework and methods for evaluating the effectiveness of environmental regulation in high-quality human habitat cities for a state-of-the-art path of improving environmental governance and optimizing environmental policies in these regions. This paper aims to analyze the effectiveness of environmental regulation and its spatial spillover in cities with high-quality human habitats. The results reveal that environmental regulation has a marginal effect on such cities, and local governments in the area have a race to the bottom in environmental governance. This study not only contributes to the promotion of an evaluation framework for examining the effectiveness of existing environmental regulations but also makes policy recommendations for adapting to the changing ecological environment in high-quality human habitat cities in developing countries.

Keywords: environmental regulation; human habitat; sustainable cities; difference-in-differences; spatial effect

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1. Introduction

1.1. Problems Faced by High-Quality Human Habitat Cities

Following rapid urbanization in the developing world, the growth of innovative behavior has greatly improved the quality of human habitats in urban areas over the past three decades, which is evident in the case of China [1–3]. According to the baseline data provided by the central government of China, by 2020, all 832 counties with national-level poverty were lifted out of poverty; 59.9% of all cities met urban ambient air quality standards; the proportion of excellent surface water quality sections nationwide increased to 83.4%; and the safe contaminated arable land use rate reached 90% [4]. Although the overall quality of human habitat is improving, environmental issues in urban areas remain an obstacle to achieving a better quality of life in an urbanizing world. Rapid urbanization has led to fast-growing consumerism, including expanding vehicle use and significant resource footprints of wealthy urban populations. Such "development" has resulted in new environmental problems, including new pollutants, the coexistence of old and new pollutants, as well as inorganic and organic compounds. Consequently, cities adjusted environmental policies to address new environmental problems. In China, the Ministry of Environmental Protection has adjusted the pollutant items and limit values in the Ambient

Air Quality Standards according to China's existing atmospheric environment, adding two pollutant control standards for ozone (O_3) and fine particulate matter ($PM_{2.5}$) [5].

However, the role of existing environmental governance tools in the face of new environmental standards and pollutants is still limited. This is supported by the case of a few areas with high-quality human habitats in China. The Ministry of Housing and Urban–Rural Development established the China Habitat Award in 2000 to recognize cities that have made outstanding achievements in creating a good human habitat environment, which combines a comprehensive assessment of the economic development and ecological performance of cities in the process of urbanization. Hence, in a way, the award is considered to reflect the effectiveness of existing environmental regulations, which is a tool to solve environmental problems in urbanization. Jiangsu, one of the top three high-quality human habitat cities in China, has seven cities (Nanjing, Wuxi, Changzhou, Suzhou, Xuzhou, Yangzhou, and Zhenjiang) that have won the China Habitat Award 15 times during 2000–2017, accounting for 34.88% of the award-winning cities in China. This award is used to recognize cities that have made outstanding achievements and achieved remarkable results in improving the quality of urban–rural environments and creating a good human habitat environment; it is the highest honorary award in the field of national human habitat construction. The selection of the award can promote more active and effective measures to increase urban infrastructure construction and environmental improvement. However, only 2 of the 13 provincial cities in Jiangsu, Nantong, and Yancheng met the revised Ambient Air Quality Standards in the year 2020, while others failed from 2012 to 2020. The main reason for the failure of these 13 cities was that they did not meet the standards for ozone (O_3) pollutant control. The comprehensive index for 2013–2018 shows that the O_3 concentration in Jiangsu increased from 139 $\mu g/m^3$ to 177 $\mu g/m^3$ [6].

In addition, state strategies, including the urban–rural continuum and the shared prosperity of cities and regions, have become key domains in improving human habitat, whereas the economic boom brought by such strategies has aggravated new urban environmental problems in cities, such as the regional spillovers of environmental pollution. In 2018, the results of an air pollution survey of cities in the southern and northern areas of Jiangsu showed that the range of $PM_{2.5}$ concentrations was 42–50 $\mu g/m^3$ for cities in the south, while such a figure was higher for cities in northern Jiangsu regions, accounting for 41–62 $\mu g/m^3$ [6]. The densely distributed industrial bases in the north of Jiangsu could be critical sources of pollution. The flat terrain facilitates the diffusion of air pollutants from the north to the south along the east coast or across lakes in the middle [7,8], which consequently leads to a significant regional aggregation and spatial spillover of air pollution in Jiangsu [9,10].

With regard to the limited effect of environmental governance on solving the new urban environmental problems in high-quality human habitat cities, these regions urgently need to examine the effectiveness of existing environmental policies and their implementation tools in dealing with new pollutants in complex circumstances. Environmental regulations have been most widely adopted as the main policy in developing countries, by which government agencies restrict the activities of social and economic agents to promote sustainable economic development [8,11]. Examining the effectiveness of such policies could also help us in optimizing the range and complexity of such policies and tools.

1.2. Concepts and Theory

The term "environmental regulation" refers to the policy tool for polluted emission control that broadly includes three types. The first type is command and control. Governments restrict the production and operational activities of discharge subjects via punitive regulations to reduce pollution emissions [12]. The second type is market incentives. In contrast to punishments, governments encourage environmentally friendly behavior through market incentives such as lower taxes, thus influencing emitters to voluntarily change to environmentally friendly productions and operations [13]. The last type is public participation. Governments raise public awareness of environmental protection through publicity, training, education, and information dissemination to create an environmentally friendly society and mobilize the public to participate in environmental protection behaviors on their own [14,15]. Research on the effectiveness of environmental regulations involving the above three types includes assessing the intensity of environmental regulation and examining the impact of such regulations on the ecological environment. Mostly based on the first financial penalty type of regulation, earlier studies used a range of single indicators, such as the amount of emission, a fine, and the cost of treatment, to evaluate the effect of environmental regulations [16,17]. In the context of the comprehensive policy set conducted, researchers tend to select composite criteria to examine the impact of the formulation and implementation of policies on the urban–rural ecological environment [18,19], which encompass indicators in other related domains, such as economic and public services [20–22].

The economic system of green and low-carbon circular development in a transformation from quantity to quality requires rethinking the existing environmental regulations that have been formulated in the conventional economic system. Therefore, we need to clarify two things. First, the goal of environmental regulations is generally defined as meeting the needs of the community for better quality human habitats [23,24]. In essence, studies on the effectiveness of environmental regulations focus on the degree to which the overall quality of human habitats specified by distinct modules, including but not limited to ecological environmental quality, has been improved under certain environmental regulations. Second, despite environmental quality being the direct indicator for evaluating environmental regulations, it has been conclusively shown that environmental quality is affected by other domains in human habitats [25–28]. Criteria for assessing other domains could have an impact on the rationality of indicators adopted by examining the effectiveness of environmental regulations.

As previously stated, it is necessary to discuss the definition and attributes of human habitat. Doxiadis [29] defines the human habitat as the territorial arrangement formed by human beings to meet the needs of human survival; it encompasses both the geographical dimension and the material manifestation of social and economic activity undertaken throughout the course of human habitat. From the perspective of sustainable development and complex ecosystems, human habitat is the coordinated complex ecosystem between human habitats and the working environment, development of material production, and social and cultural circumstances [30,31]. In this system, economic, social, and natural subsystems are interconnected and interactive. In this way, the improvement of human habitat is not only the unilateral governance of the natural environment but also the balance and coordination of nature and society (see Figure 1a). As a tool of governance of the natural environment could be considered as an interference to the human habitat system, environmental regulation has a direct impact on the economy and society subsystems, through the interaction among the subsystems, and ultimately on the natural subsystem. Moreover, due to the interaction of the three subsystems within the dynamic development of the human habitat system, changes in the economy and society subsystems inevitably result in changes in people's demands of the natural environment. Thereby, the effectiveness of changeless interference measures is questionable in the face of changing needs and systems. A two-way feedback principle in a complex system could be critical in the study of the effectiveness of environmental regulations (see Figure 1b).

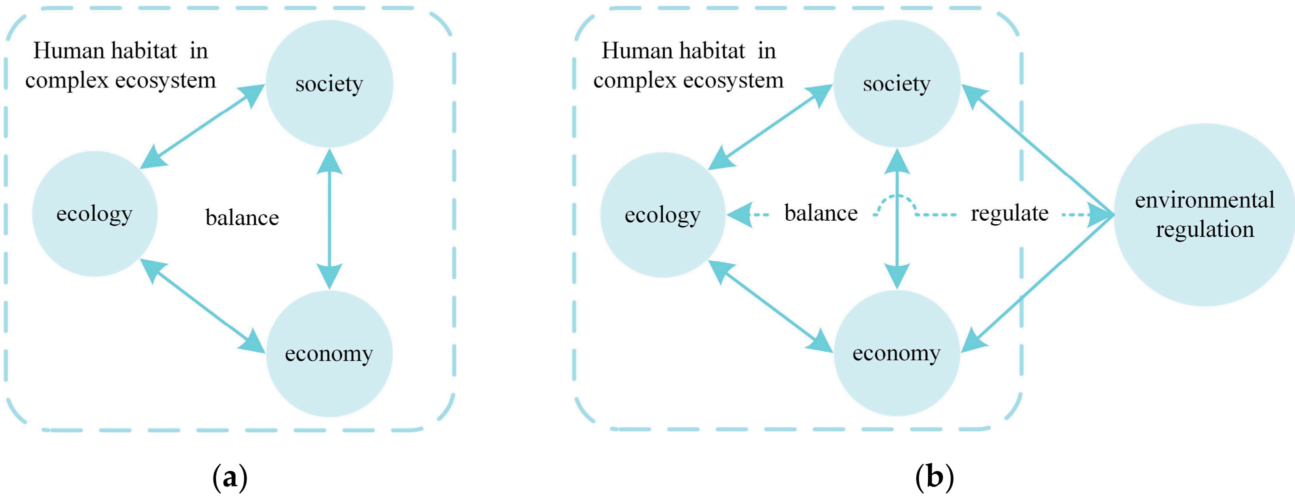

Figure 1. (**a**) Human habitat in a complex ecosystem; (**b**) the relationship between environmental regulation and human habitat.

In addition, built on the external effect of the complex system and the context of regional control by the central government in most developing countries, the geographical area of the region with explicit administration boundary has been taken as the scope of validity of environmental regulations. The area within the geographic boundary is set as the independent complex ecosystem, while the other adjacent areas and surroundings are the external circumstances. These systems, or the human habitat of regions, influence each other in a variety of aspects, including the strategies and policies of environmental regulations. Furthermore, the central government's specific performance rating method has sparked political rivalry among local governments in these regions, resulting in the formation of a political championship. Such multiregional interactions have led to the spatial spillover of environmental regulations among geographically connected regions, which might have both positive and negative impacts on each complex ecosystem [32–34]. Therefore, the following discussion of this paper is based on three hypotheses: first, the quality of human habitat is measured by dual criteria that encompass the comprehensive quality of economic, social, and natural subsystems, and the degree of balance and coordination of the three; second, the effectiveness of existing environmental regulation means and tools needs to match the quality of human habitats.; and third, there is spatial interaction in environmental governance between cities, and the spatial spillover effect is another factor affecting the effectiveness of environmental regulation.

1.3. Research Framework

The natural environment quality has become an essential aspect of gauging the quality of human habitats during the transition from high-speed to high-quality development. Residents' expectations of the natural environment are increasing in tandem with the rapid expansion of high-quality human habitats. Also, new environmental issues like new pollution have emerged under large-scale urbanization. However, the efficacy of existing environmental regulations in high-quality regions for satisfying greater requirements and managing new challenges is limited. There is still a certain gap between the quality of the ecological environment and the rising needs of the people.

This paper conducts quantitative analysis to investigate the effectiveness and spillover of environmental restrictions in the high-quality human habitat and proposes policy recommendations, guided by the preceding three research hypotheses, and offers three research questions: (1) Is there a balance and coordination in the expansion of high development human habi-tat's natural, economic, and social subsystems? If not, what are the underlying reasons for the imbalance? (2) Are the existing environmental regulations governing the ecological environment in high-quality human habitats effective? (3) How do spillovers affect the effectiveness of environmental regulations? This paper is arranged as follows (see Figure 2): First, according to the strategies of sustainable development and urban–rural integration, combined with the theory of complex ecosystems, this paper develops four criteria to evaluate the quality of human habitat, including economic development, urban–rural livelihood balance, public basic service guarantee, and ecological environment protection [35,36]. Secondly, Jiangsu Province is selected as the research area. According to the evaluation results of the human habitat quality, the cities in Jiangsu Province are divided into an experimental group and a control group. The effectiveness of environmental regulation is evaluated by comparing the environmental governance level of the experimental group and the control group during the period of environmental regulation. The control variable set is formed based on the human habitat evaluation index, and the econometric model is constructed by using the control variable set to investigate and quantify its geographical correlation and spillover impact. Based on this analysis, the paper proposes a systematic human habitat evaluation criterion for high-quality human habitat regions, which could also be a new reference for cities in the developing world transforming to high-quality habitats.

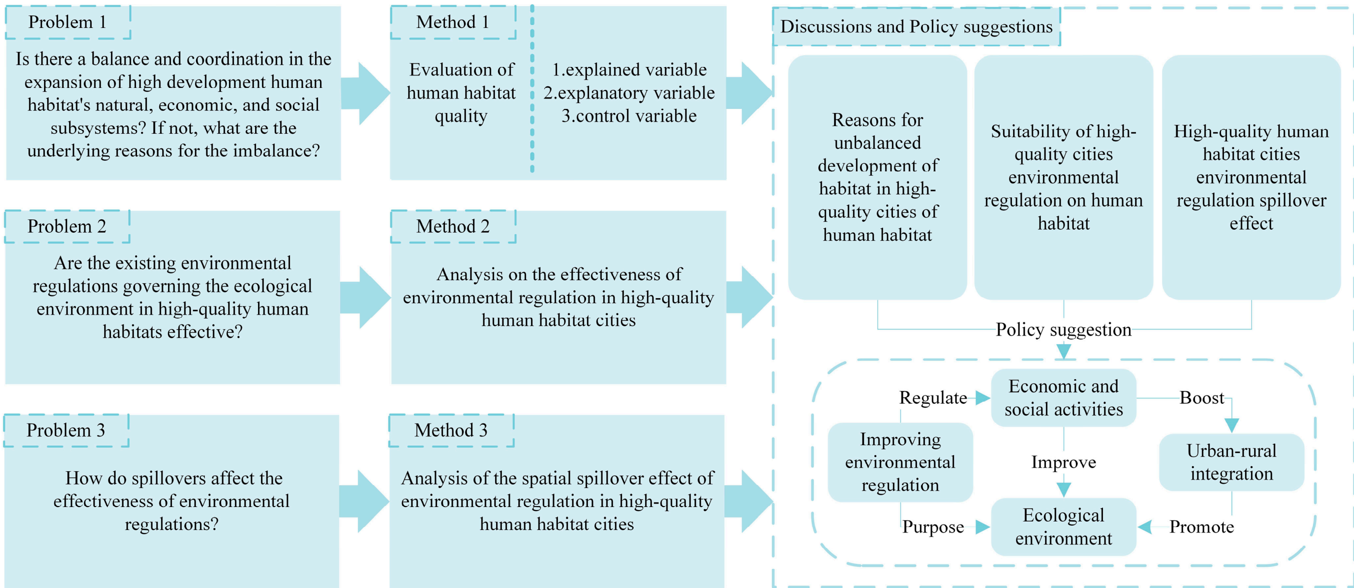

Figure 2. Research framework.

2. Materials and Methods

2.1. Study Area

Jiangsu Province is located in the Yangtze River Delta, China's eastern coast, and covers an area of 10.72 × 10^4 km^2. The study area includes 13 prefecture-level cities in Jiangsu Province (see Figure 3). Jiangsu's per capita GDP and development and life index (DLI) have ranked first in the whole country; this province has the highest comprehensive development level in China [37]. From 2000 to 2017, Nanjing, Wuxi, Changzhou, Suzhou, Xuzhou, and Zhenjiang in Jiangsu Province won the China Human Habitat Award 15 times, accounting for 34.88% of the cities that won the award.

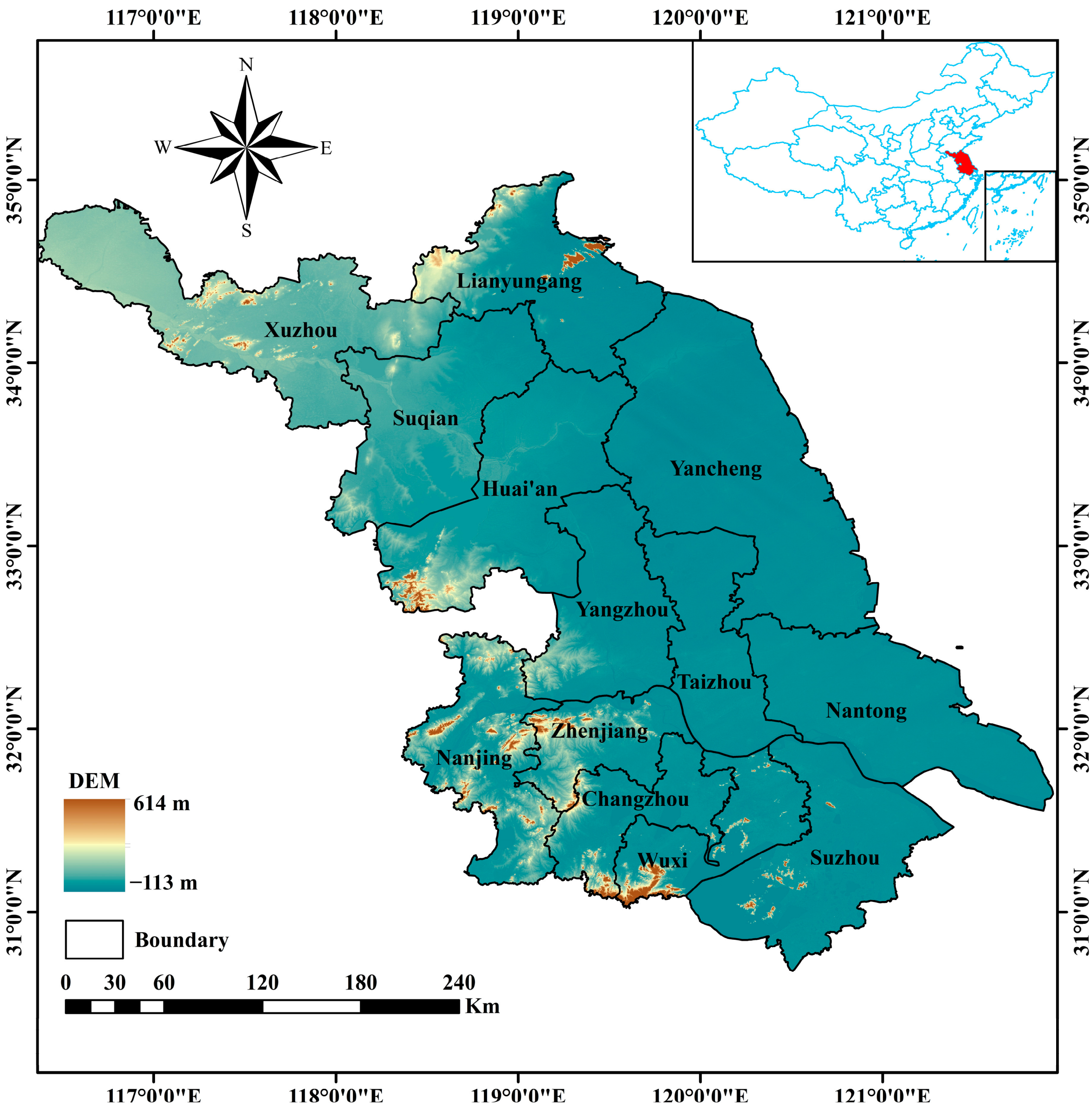

Figure 3. Location map of the study area.

2.2. Data Sources

The original data of the indicators were obtained from the Jiangsu Statistical Yearbook and the annual socio-economic statistical bulletin of each city from 2002 to 2019 of the Jiangsu Provincial Bureau of Statistics [38]. Some indicators average the original data of indicators according to the population of the study area, and the missing data are supplemented by multiple interpolation methods or with surrounding cities as a reference. The interpolation method is used to insert the function value of several points in a certain interval, make the appropriate specific function, take the known value at these points, and use the value of this specific function as the approximate value of the function at other points in the interval.

2.3. The Calculation Process of Human Habitat Quality

This comprehensive evaluation adopts the coupling coordination degree model [39] and the relative development model, and selects indicators via the literature method and expert scoring method. Using the coupling coordination degree model can better analyze the coordinated development level of the system, but in addition to the coordinated development level of the system, it is necessary to examine the relative development between the systems, so the relative development degree model needs to be introduced. Then, the indicator data are collected from the database, and the entropy weight method [40] is used to determine the indicator weight. The entropy weight method can deeply reflect the distinguishing ability of the index and determine a better weight. Finally, the coupling coordination degree of the human habitat evaluation system is calculated using the coupling coordination degree model, and the relative development of the human habitat is evaluated by using the relative development model to measure the human habitat quality.

2.3.1. Indicator Selection

According to the concept that the construction of human habitat proposed by China's urban–rural integration strategies needs the joint creation of urban–rural, this paper adds urban–rural subsystems to the complex ecosystem and constructs a human habitat evaluation system based on the four subsystems of economic, ecological, social, and urban–rural. In the human habitat evaluation system, according to the needs of each category layer, this paper refers to and selects 112 primary indicators from relevant literature over the years [41–50] and selects 35 indicators according to the selection principles of indicators and referring to the relevant research results [36,51]. Then, two indicators are eliminated according to the scores of the three experts in the field of ecological environment. Finally, the human habitat evaluation system selected 33 indicators and placed them into 4 categories (Table 1).

Table 1. Human habitat evaluation system.

Category	Primary Indicators	Secondary Indicators	Property
(ECD) Economic development degree	(AM) Agricultural modernization	Agricultural labor productivity	+
		Land productivity	+
		Proportion of effective irrigation area	+
		Agricultural mechanization level	+
		Rural per capita electricity consumption	+
	(IM) Industrial modernization	Labor productivity of the second and third industries	+
		The proportion of GDP in the second and third industries	+
		The proportion of employees in the second and third industries	+
	(DCC) Dual contrast coefficient	Dual contrast coefficient	
(URB) Urban–rural livelihood balance degree	(URE) Urban–rural employment environment	Urban–rural employment ratio	
		Non-agricultural share of rural workers	
		Urbanization rate	+
	(URL) Urban–rural livelihood	Urban–rural per capita income ratio	+
		Urban–rural per capita income consumption expenditure ratio	+
		Engel coefficient ratio of urban–rural residents	+
		Housing area ratio of urban–rural residents	+
(PBSG) Public basic service guarantee degree	(EC) Educational and cultural	Teacher–student ratio of ordinary middle schools	−
		Books per capita in public libraries	+
	(TC) Transportation–communication	Total per capita postal and telecommunications business	+
		Per capita civilian car ownership	+
		Public transport coverage rate	+
	(HS) Health security	Number of hospital beds per capita	+
	(IS) Infrastructure security	Popularization rate of residential gas consumption	+
		Popularization rate of tap water	+
(EEP) Ecological environment protection degree	(EB) Ecological basis	Forest coverage	+
		Per capita public toilets	+
		Daily water consumption per capita	+
	(ES) Ecological stress	Daily sewage discharge per capita	−
		Per capita air pollutant emissions	−
		Industrial wastewater discharge per capita	−
	(ER) Ecological response	Sewage treatment rate	+
		Daily processing capacity of per capita harmless treatment plant	+
		Annual disposal amount of waste feces	+

Note: In the table, + is expressed as the positive indicator, − is expressed as the negative indicator, and others are expressed as moderate indicators. The optimal value of the moderate indicators is generally set to 1.

2.3.2. Calculation of Coupling Degree and Coupling Coordination Degree of the Human Habitat Evaluation System

The calculation steps of the coupling coordination degree of the human habitat evaluation system are as follows: (1) According to the level indicators of the category, the coupling degree of the human habitat evaluation system is calculated by the coupling degree model. (2) The weight of the category layer is calculated by the entropy weight method, and the comprehensive index of the human habitat evaluation system is calculated by combining the level indicators of the category. (3) According to the coupling degree and comprehensive index of the human habitat evaluation system, the coupling coordination degree of the human habitat evaluation system is calculated by the coupling coordination degree model, which is used as the human habitat development index, and the specific equations are shown as (1), (2), and (3):

$$C = \left\{ \frac{ECD \times URB \times PBSG \times EEP}{[(ECD + URB + PBSG + EEP)/\ 4]^4} \right\}^{\frac{1}{4}} \quad (1)$$

$$T = \alpha ECD + \beta URB + \gamma PBSG + \delta EEP \quad (2)$$

$$D = \sqrt{C \times T} \quad (3)$$

where C is the coupling degree of the human habitat evaluation system; T is the comprehensive index of the human habitat evaluation system; and α, β, γ, and δ represent the proportion of each category layer of the human habitat evaluation system. This is the sum of the weights of the secondary indicators corresponding to each category layer. The weight of the secondary indicators is calculated using the entropy weight method, which regards all the secondary indicators as indicators under the system. D is the human habitat development index.

2.3.3. Calculation of Relative Development Degree

In order to evaluate human habitat development more reasonably, this paper introduces a relative development model to evaluate the relative development degree of 13 prefecture-level cities in Jiangsu Province.

$$R = \frac{EEP}{ECD \times URB \times PBSG/\ 3} \quad (4)$$

In Equation (4), R represents the relative development degree. If $R < 0.8$, ecological construction lags behind economic and social development; and if $0.8 <= R <= 1.2$, ecological construction and economic and social development simultaneously; and if $1.2 < R$, economic and social development lags behind ecological construction [52,53].

2.4. Analysis of the Effectiveness of Environmental Regulation in High-Quality Human Habitat Cities

According to Hypothesis 2, the effectiveness of environmental regulation for the composite ecosystem of human habitat is directly reflected in the governance effect of the natural subsystem. Therefore, this study uses the difference-in-differences (DID) to measure the effectiveness of high-quality human habitat cities in Jiangsu Province during the period of environmental regulation.

DID is a commonly used policy effect evaluation method [54,55]. Its principle is to construct DID statistics reflecting the policy effect by comparing the differences between the control group and the treatment group before and after the implementation of the policies. This method can deal with the common trend problem that cannot be observed before and after the environmental regulation period. We need this method to identify the difference in the effectiveness of environmental regulation between high-quality human habitats and other regions during the environmental regulation period, which is as follows:

$$EEP_{it} = \alpha + \beta Treat_{it} \times Post_{it} + \gamma control_{it} + \varphi_i + \delta_t + \varepsilon_{it} \quad (5)$$

Among them, EEP_{it} represents the ecological environment protection degree of i city in t year; $Treat_{it}$ is the dummy variable indicating whether the city i belongs to the first-class of area (A1); $Post_{it}$ is the dummy variable that represents the environmental regulation period; $Treat_{it} \times Post_{it}$ is the dummy variable that denotes A1 in the environmental regulation period. Because this study examines the impact of environmental regulation on the degree of ecological environment protection in A1, the regression coefficient β of the cross term $Treat_{it} \times Post_{it}$ is the main focus. If β is positive, it means that compared with the second-class of area (A2), A1 is more effective under environmental regulations.

In Equation (5), $control_{it}$ is a series of control variables that affect the degree of ecological environment protection, including each primary indicator in the three categories of economic development degree, urban–rural livelihood balance degree, and public basic service guarantee degree. The data of the primary indicators are calculated using the entropy weight method. φ_i denotes city-fixed effect, δ_t denotes time-fixed effect, and ε_{it} denotes error term.

2.5. Analysis of the Spatial Spillover Effect of Environmental Regulation in High-Quality Human Habitat Cities

Due to the developed traffic and high degree of regional coordination, the positive and negative effects of the environment in high-quality human habitat cities with high urbanization rates show obvious regional linkage. Under the background of regional regulation, the construction of human habitat has been greatly affected by policy linkage, regional governance, local climate, and other factors. The effect of environmental regulation in high-quality human habitat cities should not only be measured by the administrative boundary delimitation unit of the city but should also consider the spatial spillover effect of the area. According to hypothesis 3, this study uses spatial difference-in-differences (SDID) to analyze the spatial spillover effect of environmental regulation in high-quality human habitat cities. SDID considers the spatial interaction and spatial structure analysis of DID [56,57].

2.5.1. Spatial Weights Matrices

The spatial weights matrix is a key part of the spatial econometric model that measures the proximity between two cities by distance or economic difference. The spatial weight matrix used in this paper includes W_A, W_E, and W_{GE}.

Spatial adjacency weight matrix (W_A): When the city i and the city j have a common border, $W_{ij} = 1$; otherwise, $W_{ij} = 0$. With W_A, we assume that the city only interacts with its neighbors who share the same boundaries.

$$W_{A,ij} = \begin{cases} 1, & i \neq j \\ 0, & i = j \end{cases} \quad (6)$$

Spatial economic weight matrix (W_E): W_E assumes that there is an interaction between all cities, but unequally. It is measured by the economic development gap between two cities [58]. W_{ij} is equal to the reciprocal of the economic gap between city i and city j, and cities with similar levels of economic development are more likely to influence each other. The elements are defined as follows:

$$W_{E,ij} = \begin{cases} \frac{1}{\left|\bar{Y}_i - \bar{Y}_j\right|}, & i \neq j \\ 0, & i = j \end{cases} \quad (7)$$

In Equation (7), $\overline{Y}_i$ is the per capita real GDP at 2000 prices of the city i from 2002 to 2019. The unit of per capita real GDP is yuan/year.

Spatial geographical economic weight matrix (W_{GE}): W_{GE} examines both the geographical and economic distances between the two cities. When the geographical distance and economic development gap between the two cities is smaller, the interaction between the two cities is more likely to occur [59]. W_G is the spatial geographical weight matrix. This study focuses on the spatial correlation of cities with geographical and economic influences.

$$W_{G,ij} = \begin{cases} \frac{1}{\sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \times \pi/180 \times 6378.2}, & i \neq j \\ 0, & i = j \end{cases} \tag{8}$$

$$W_{GE,ij} = \begin{cases} W_{G,ij} \times W_{E,ij}, & i \neq j \\ 0, & i = j \end{cases} \tag{9}$$

In Equation (8), x and y represent the longitude and dimension of the city, respectively. The numerical unit in the matrix is kilometers.

In this study, we standardized all spatial weight matrices. The standardization method is as follows:

$$W\prime = \begin{bmatrix} {W_1}^{-\frac{1}{2}} & & \cdots & 0 \\ & {W_2}^{-\frac{1}{2}} & & \\ \vdots & & \ddots & \vdots \\ & & {W_{i-1}}^{-\frac{1}{2}} & \\ 0 & & \cdots & {W_i}^{-\frac{1}{2}} \end{bmatrix} \times W \times \begin{bmatrix} {W_1}^{-\frac{1}{2}} & & \cdots & 0 \\ & {W_2}^{-\frac{1}{2}} & & \\ \vdots & & \ddots & \vdots \\ & & {W_{i-1}}^{-\frac{1}{2}} & \\ 0 & & \cdots & {W_i}^{-\frac{1}{2}} \end{bmatrix} \tag{10}$$

In Equation (10), W' represents the standardized spatial weight matrix; W represents the unprocessed spatial weight matrix; and W_i represents the sum of the data in line i of W.

2.5.2. Spatial Difference-in-Differences Model

The current spatial econometric models used in SDID mainly include the spatial lag model (SLM), spatial error model (SEM), and spatial Durbin model (SDM) [60]. SLM is used to analyze whether the variables in certain regions have spillover effects. SEM is used to examine the direction and extent of the influence of the observed values of the explained variables in adjacent regions on the observed values of the local region. SDM uses the complementarity of SLM and SEM to examine the spatial correlation between the explanatory variables and the explained variables. Before the calculation, the model should be selected by the Lagrange multiplier test (LM), likelihood-ratio test (LR), and Hausman test.

This paper used the spatial econometric model of SDID is the SDM-DID model, and the SDM-DID model is as follows:

$$EEP_{it} = \alpha + \rho\sum_j W_{ij}EEP_{jt} + \beta Treat_{it} \times Post_{it} + \theta\sum_j W_{ij}Treat_{jt} \times Post_{jt} + \gamma control_{it} + \psi\sum_j W_{ij}control_{jt} + \varphi_i + \delta_t + \varepsilon_{it} \tag{11}$$

In Equation (11), EEP_{it} represents the explained variable; $Treat_{it} \times Post_{it}$ is the core explanatory variable; $control_{it}$ denotes other control variables; φ_i, δ_t, and ε_{it} indicate individual-fixed effect, time-fixed effect, and random interference term, respectively.

3. Results and Discussion

3.1. Quality of Human Habitat in Jiangsu

Figure 4 shows the human habitat development index of prefecture-level cities in Jiangsu Province over the years. The index for the cities in Jiangsu Province from 2002 to 2019 was 0.31 to 0.88. From 2002 to 2019, the index of Nanjing, Wuxi, Changzhou, and Suzhou fluctuated between 0.69 and 0.88. The index of Xuzhou, Nantong, Lianyungang, Huai'an, Yancheng, Yangzhou, Zhenjiang, Taizhou, and Suqian fluctuated from 0.31 to 0.65.

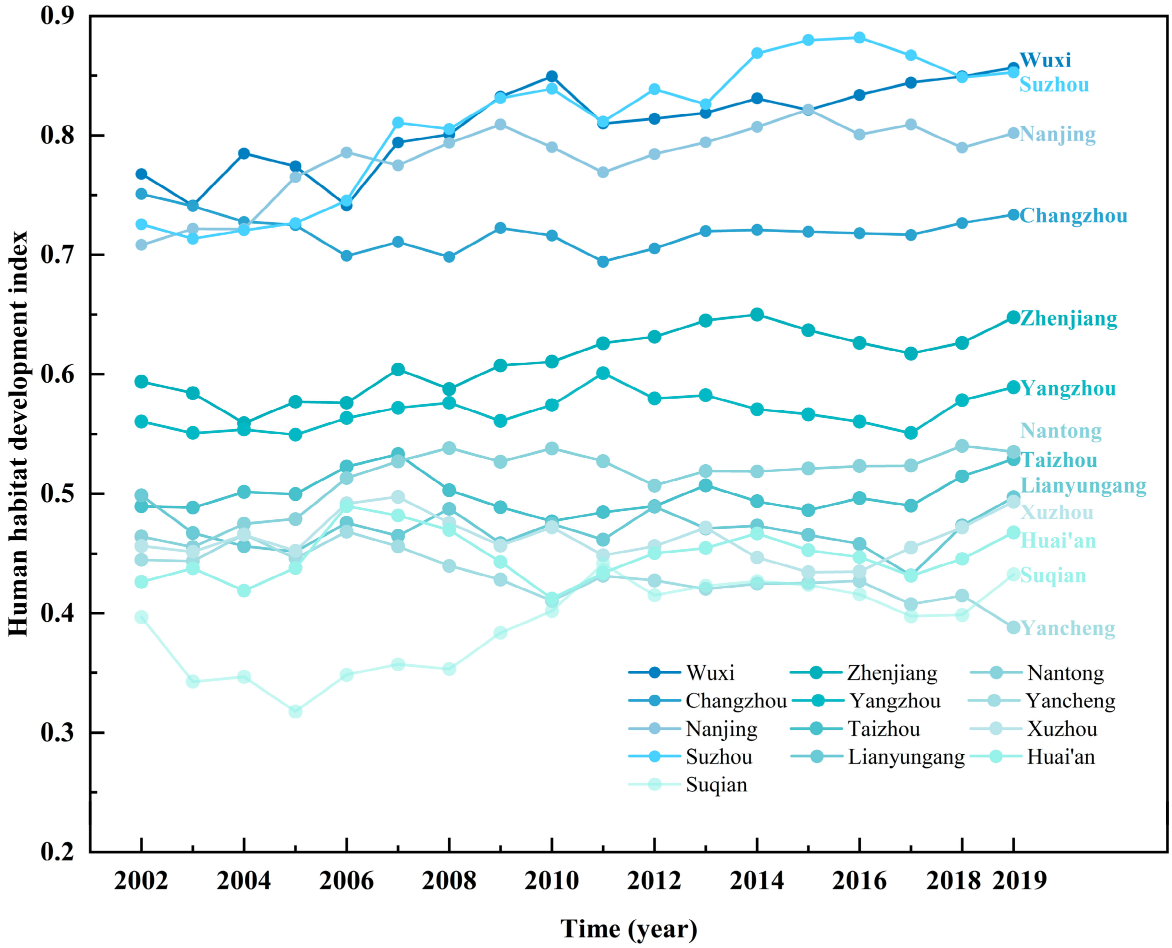

Figure 4. The broken line diagram of the human habitat development index in provincial-level cities in Jiangsu Province.

Figure 5 shows the spatial distribution map of the human habitat development index in provincial-level cities in Jiangsu Province in 2002, 2005, 2010, 2015, and 2019. From a spatial perspective, the spatial distribution of the index of cities in Jiangsu Province includes two areas. The indexes of Nanjing, Wuxi, Changzhou, and Suzhou are relatively good. The indexes of other areas, such as Nantong, Lianyungang, Huai'an, Yancheng, Suqian, Xuzhou, Yangzhou, Zhenjiang, and Taizhou are relatively poor.

Figure 6 displays the relative development degree and the average relative development degree of each prefecture-level city in Jiangsu Province over the years. Based on the evaluation of the relative development degree of 13 prefecture-level cities in Jiangsu Province, it is found that the development of human habitats in Jiangsu Province is unbalanced. In the evaluation results in 2019, the relative development degree of 13 prefecture-level cities in Jiangsu Province was between 0.48 and 1.37. In order to reasonably evaluate the cities, this study calculated the average relative development degree of 13 prefecture-level cities from 2002 to 2019. The results show that it is between 0.62 and 1.39. The cities with economic and social lag are Nanjing and Suqian, and the cities with ecological lag are Suzhou, Nantong, and Taizhou.

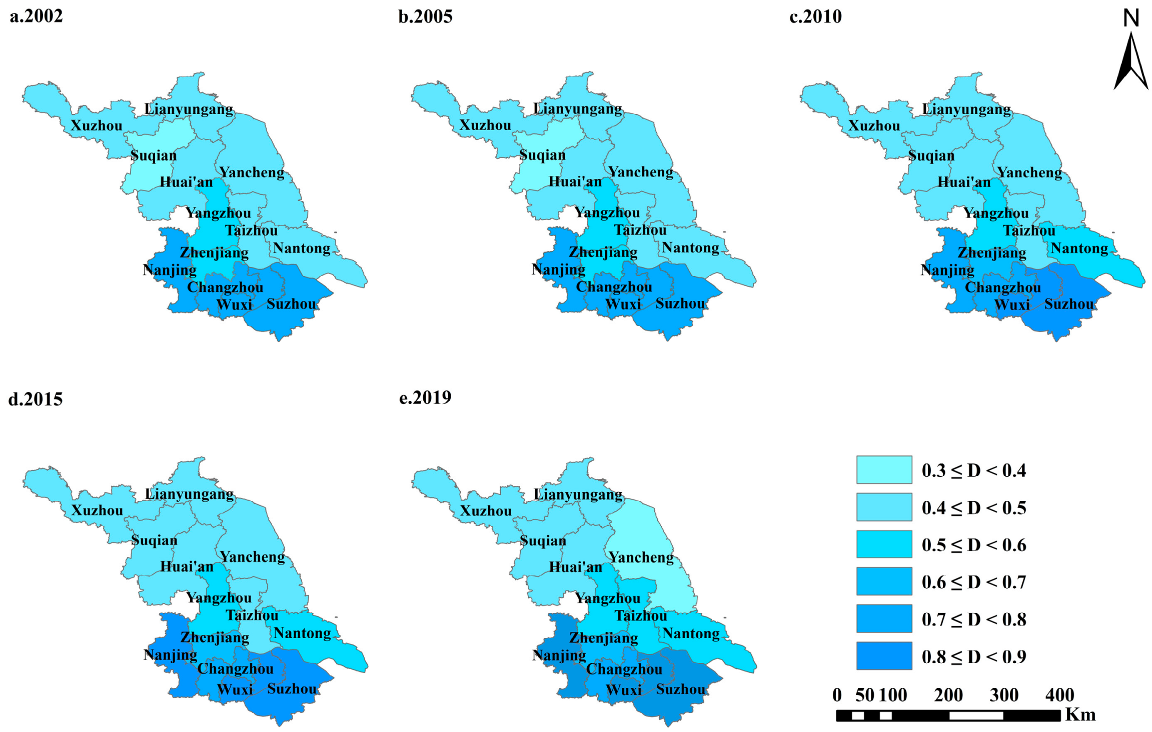

Figure 5. Spatial distribution map of human habitat development index in provincial-level cities in Jiangsu Province in 2002, 2005, 2010, 2015, 2019.

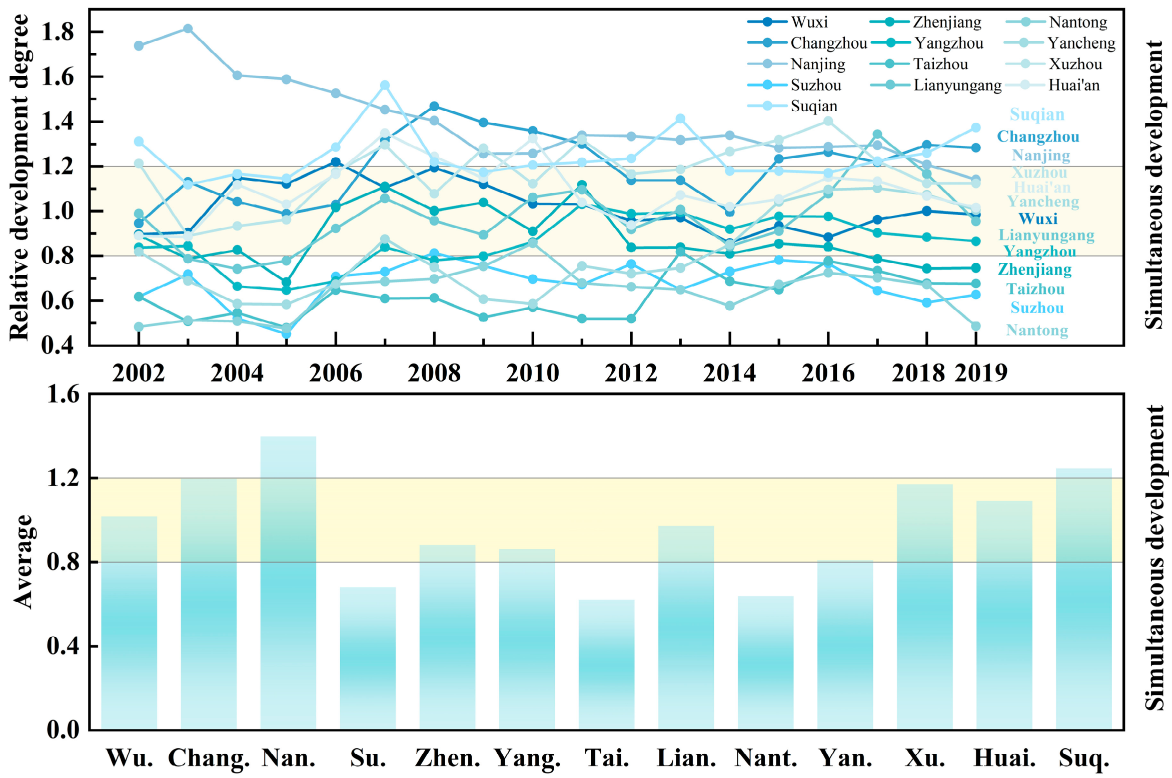

Figure 6. The relative development degree in provincial-level cities in Jiangsu Province over the years.

The variant score of each city in the evaluation system supports hypothesis 1, which proposed that cities with high scores in the human habitat development index do not necessarily have a good performance in the relative development of the human habitat. Lag phenomena in the relative development of such cities have led to an imbalanced status of the human habitat, even though they scored highly on the human habitat development index. Ultimately, this causes a decrease in the integrated quality of the human habitat. Suzhou is one of the most representative cities; its ecological environment construction lags behind its economic and social development under the high score of the human habitat development index, the likely cause of which is Suzhou's economic development structure. Suzhou, the largest industrial city in Jiangsu Province, accounted for 24 percent of all industrial firms and 28 percent of the total industrial assets in 2019. Furthermore, Suzhou has a relatively developed ship transportation sector as the city with the highest industrial and economic development in Jiangsu Province. Suzhou's reliance on international commerce is as high as 114.3 percent, according to the economic advantages of China's four major ports. Suzhou's secondary sector contributes 47.5 percent of the regional GDP as the region with the highest regional GDP in Jiangsu Province. While a highly developed economy has provided a relatively higher living standard for local residents, such an economic structure, which consumes natural resources, has a significant impact on the local ecological environment. Furthermore, the authors find that Jiangsu Province's industrial output value accounted for 38% of the province's GDP in 2019, whereas in terms of industrial structure, heavy industry accounted for 77% of all industrial assets. Such an economic structure with a large concentration of industry explains why Jiangsu Province, although being a high-quality human habitat city, has comparatively serious environmental pollution in the southeast coastal area.

3.2. Effectiveness of Environmental Regulation in High-Quality Human Habitat Cities

3.2.1. Areas Division of Human Habitat Quality

Figure 7 shows the prefecture-level cities in Jiangsu Province divided into two types of areas based on the quality of human habitat. Nanjing, Wuxi, Changzhou, and Suzhou are categorized under A1 using a clustering method based on the human habitat development index, and Xuzhou, Nantong, Lianyungang, Huai'an, Yancheng, Yangzhou, Zhenjiang, Taizhou, and Suqian are categorized under A2. The human habitat quality in A1 is higher than that in A2. However, Nanjing and Suzhou are lagging behind in the evaluation of relative development. Taking into account the positive trend of Nanjing in the evaluation of relative development, this paper only divides Suzhou into A2 from A1.

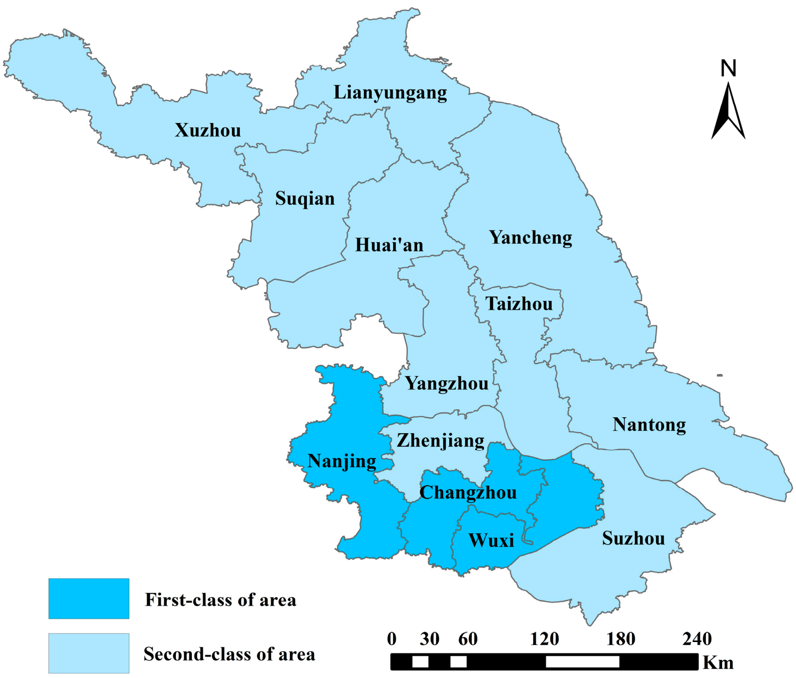

Figure 7. Area chart of the quality of human habitat in provincial-level cities in Jiangsu Province.

3.2.2. Period Division of Environmental Regulation

This paper collected data on 608 local government pollution prevention policies in Jiangsu Province from 2002 to 2019. The statistics of local government documents show that the means of urban environmental governance are basically command–control type. Taking Nanjing as an example, there were 75 pollution control policies between 2002 and 2019, of which 72 were command–control type, accounting for 96%.

Figure 8 shows the number of pollution control policies in Jiangsu Province over the years. By comparing the numbers, we find that the number of pollution control policies has greatly improved since 2011. In the 12th Five-Year Plan of 2011, it began to increase significantly, and the ecological environmental protection degree also showed a steady upward trend. This indicates that in the process of energy conservation and emission reduction in the 11th Five-Year Plan, environmental regulations and high-pollution enterprises adapted to each other, and ecological environment governance achieved initial success. Therefore, this paper defines the year after 2011 as the period of environmental regulation.

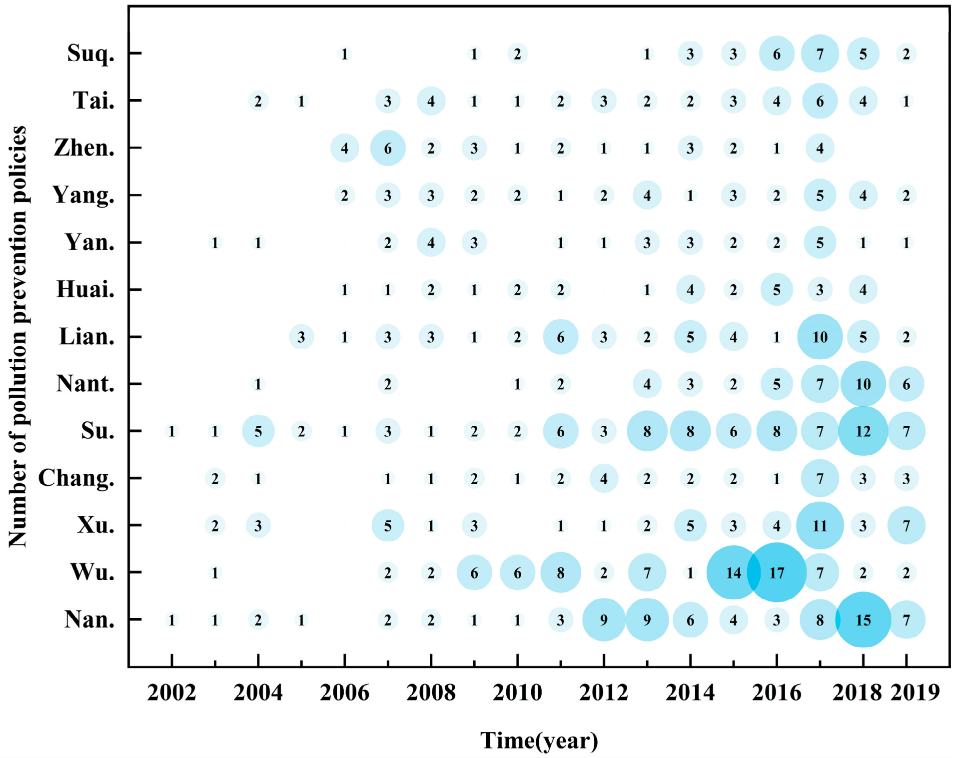

Figure 8. The number of pollution control policies in provincial-level cities in Jiangsu Province over the years.

3.2.3. Effectiveness Analysis of Environmental Regulation in High-Quality Human Habitat Cities

This paper selects the data based on each primary indicator of the human habitat quality evaluation system, and the data are derived from the entropy weight method. In Table 2, we present the descriptive statistics.

Table 2. Descriptive statistics of major variables.

Variable	Definition	Obs	Min	Max	Mean	SD
Treat × Post	The dummy variable that represents A1 in the environmental regulation period	234	0	1	0.12	0.32
EEP	Ecological environment protection degree	234	0.13	0.89	0.37	0.19
AM	Agricultural modernization	234	0.04	1.00	0.32	0.27
IM	Industrial modernization	234	0.01	1.00	0.49	0.33
DCC	Dual contrast coefficient	234	0.01	1.00	0.43	0.29
URE	Urban–rural employment environment	234	0.11	0.77	0.48	0.14
URL	Urban–rural livelihood	234	0.12	0.82	0.44	0.15
EC	Educational and cultural	234	0.01	1.00	0.34	0.24
TC	Transportation–communication	234	0.01	1.00	0.29	0.28
HS	Health security	234	0.01	1.00	0.38	0.33
IS	Infrastructure security	234	0.01	1.00	0.81	0.26
Policies	The number of pollution control policies	234	0	17	2.598	2.829

The model in (Table 3) corresponds to the estimation results of the difference-in-differences of the ecological environmental protection degree of prefecture-level cities in Jiangsu Province, and the estimation results of the total area, A1 and A2, under the double-fixed effect. It can be seen from the estimation results of the second column in Table 3 that the estimation results of difference-in-differences and double-fixed effects are basically consistent in terms of positive and negative values. The third and fourth columns in Table 3 display the differences in the estimation results for A1 and A2.

Table 3. Results of suitability analysis of environmental regulation in high-quality human habitat cities.

Variable	DID-EEP	EEP	A1-EEP	A2-EEP
Treat × Post	−0.0314 ***			
AM	−0.107	−0.0835	−0.280	0.00888
IM	0.325 **	0.254 *	1.401 **	0.214 **
DCC	0.0329	0.0311	−0.0573	0.0461 *
URE	−0.137 **	−0.177 **	−0.126	−0.126 **
URL	−0.00211	0.00817	−0.0877	0.00657
EC	0.0608 *	0.0867 ***	0.0261	0.0689
TC	0.0763 ***	0.0744 ***	0.114 **	0.157 **
HS	0.0636 **	0.0597 **	0.135	0.0149
IS	0.0128	0.0114	0.0765 ***	0.0155
Policies	−0.00166	−0.00213	−0.000817	−0.000576
Constant	0.181 **	0.208 **	−0.470	0.112 *
Observations	234	234	54	180
R^2	0.549	0.535	0.684	0.636

Note: *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively. The note remains the same for all tables below.

For the ecological environment protection degree, the coefficient of Treat × Post is −0.0314, and it passes the test at the 1% significance level, indicating that during the period of environmental regulation, the growth rate of the ecological environment protection degree in A1 is lower than that in A2. Area division was carried out using the human habitat development index and relative development degree. Therefore, from the area division conditions and area results, it can be seen that the effectiveness of traditional environmental regulation has a marginal effect on the synchronization and improvement of the development of human habitat. The reason for this could be China's early extensive economic development model, which made most cities have problems such as high industrial proportion, unbalanced urban–rural development, and serious environmental pollution [61,62]. The simultaneous development of high-quality human habitat cities supports the choice of more efficient solutions to these problems. This is reflected in the estimation results of the control variable set.

First, the estimated coefficients of the IM of A1 and A2 for EEP are positive at the 5% significance level, and the estimated coefficient of A1 is much higher than that of A2. The results indicate that the positive effect of the industrial modernization of A1 on the ecological environment protection degree is stronger than that of A2. This means that the traditional high-pollution and high-energy-consumption industries in high-quality human habitat cities are forced to transform or relocate under the influence of environmental regulation [63,64]. The green transformation of industrial technology has a highly positive effect on ecological environment governance, which is particularly obvious in areas with high economic development in China [65]. In this case, the industrial development degree in high-quality human habitat cities makes the transformation of industrial green technology start earlier, and the treatment level of pollutants is more advanced [66]. Industries that strictly comply with environmental regulations and have green innovative technologies have a positive effect on ecological environment governance [67–69].

Second, the estimated coefficient of URE of A2 for EEP is negative at the 5% significance level, which shows that the urban–rural employment environment of A2 has a negative effect on the ecological environment protection degree. This means that the urban–rural balance will cause changes in the quality of the ecological environment, but there are area-wise differences in this impact [70]. In areas where development lags behind, shrinking the proportion of the rural population and expanding the scale of cities and towns will reduce the carrying capacity of the ecological environment [71–73].

Third, the estimated coefficients of TC of A1 and A2 for EEP are positive at the 5% significance level, and the estimated coefficient of IS of A1 for EEP is positive at the 1% significance level. The results show the significant positive effect of urban basic services on ecological environment protection in areas. This indicates that the urban development of high-quality human habitats is mutually beneficial to the construction of an ecological civilization [74,75].

In this case, high-quality human habitat cities are more vulnerable to economic incentives and public participation in environmental regulation [76,77]. In China, local governments mostly adopt the form of command–control and economic incentives in their environmental regulations. These two forms of environmental regulations have obvious effects on areas under the traditional economic development model. In the case of the early start of industrial green technology in these areas, environmental regulations for high-pollution and high-energy-consuming industries to limit pollutant emissions have a marginal effect, and the growth rate of the effectiveness of environmental regulation is declining. Therefore, current environmental regulations should increase the proportion of market incentives and public participation, and improve the quality of the ecological environment by encouraging environmentally friendly behaviors of enterprises and environmental governance models of public supervision.

3.2.4. Parallel Trend Test

Figure 9 displays the estimated parameters, with ecological environmental protection degree as the explained variable. The broken line in the figure reflects the difference in the growth trend of ecological environmental protection degree between A1 and A2. When the broken line is positive, it indicates that the growth trend of A1 is higher than that of A2. It can be seen that after the environmental regulation period, the broken line changed from positive to negative, which shows that the growth trend of A1 began to be lower than that of A2, which shows that the environmental regulation effect on A1 during the environmental regulation period is lower than A2.

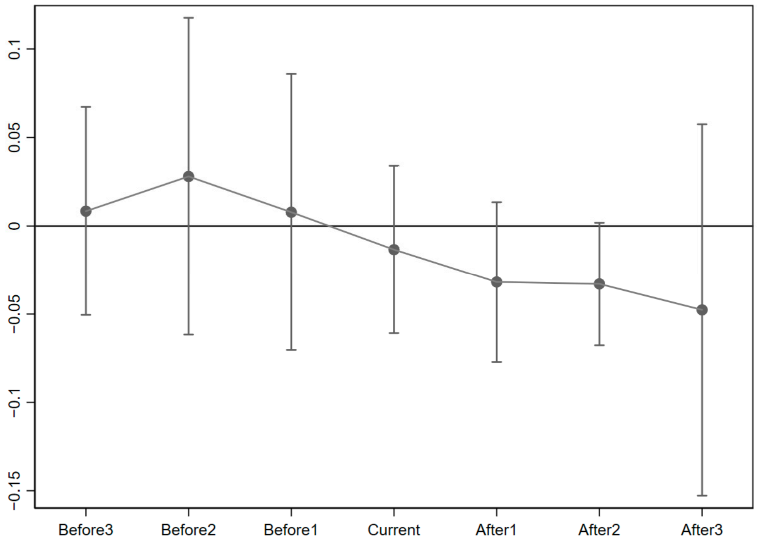

Figure 9. Results of parallel trend test.

3.3. Exploratory Spatial Data Analysis and Spatial Spillover Effect Analysis

3.3.1. Global Spatial Autocorrelation Analysis

Table 4 gives the global Moran index of the ecological environment protection degree of 13 provincial cities in Jiangsu Province from 2002 to 2019. The data in the table correspond to the spatial adjacency weight matrix, spatial economic weight matrix, and spatial geographical economic weight matrix.

Table 4. Global Moran's index of ecological environmental protection degree.

Year	W_A	W_E	W_{GE}
2002	0.273 ***	0.387 ***	0.371 ***
2003	0.256 **	0.417 ***	0.395 ***
2004	0.223 **	0.298 ***	0.269 ***
2005	0.198 **	0.276 ***	0.241 ***
2006	0.156 **	0.289 ***	0.280 ***
2007	0.255 **	0.433 ***	0.438 ***
2008	0.241 **	0.460 ***	0.480 ***
2009	0.294 **	0.500 ***	0.534 ***
2010	0.271 **	0.479 ***	0.511 ***
2011	0.288 **	0.457 ***	0.482 ***
2012	0.228 **	0.477 ***	0.519 ***
2013	0.277 **	0.416 ***	0.426 ***
2014	0.219 **	0.434 ***	0.465 ***
2015	0.236 **	0.494 ***	0.529 ***
2016	0.238 **	0.502 ***	0.535 ***
2017	0.222 **	0.449 ***	0.467 ***
2018	0.256 **	0.434 ***	0.445 ***
2019	0.299 ***	0.472 ***	0.498 ***

Note: ** and *** denote significance at the 5 and 1 percent levels, respectively. The note remains the same for all tables below.

The data in the table show that in the three matrices, there is a spatial correlation between adjacent cities. The Moran index of W_E and W_{GE} is positive and significant at the 1% level, and that of W_A is positive and significant at the 5% level. The results indicate that the local governments in Jiangsu Province will be affected by the ecological environment protection degree of neighboring cities when formulating environmental regulations, so the effectiveness of environmental regulation has regional effects.

3.3.2. Spatial Spillover Effect Analysis

Table 5 shows the test results of the spatial econometric model. According to Moran's index test, the ecological environment protection degree has a spatial effect, so it is necessary to add a spatial lag. Spatial econometric models need to be selected before the results are analyzed. According to the LM test, the LM spatial error test and spatial lag test pass the test with 1% aboriginality. In the robust LM test, the robust LM spatial error test and spatial lag test pass the test with 1% aboriginality. On this basis, the LR test rejects the original hypothesis, that is, SDM cannot be conversely transformed into SLM or SEM. Therefore, SDM is the best choice. In addition, the Hausman test rejects the original hypothesis, so the model needs to adopt a fixed effect. Finally, the SDM with a double-fixed effect is selected for analysis.

Table 5. Test results of the spatial econometric model.

Statistic	W_A	W_E	W_{GE}
LM-spatial error	103.856 ***	106.155 ***	98.076 ***
LM-spatial lag	111.927 ***	108.684 ***	99.631 ***
Robust LM-spatial error	17.018 ***	20.95 ***	17.956 ***
Robust LM-spatial lag	25.09 ***	23.479 ***	19.511 ***
Hausman test	178.2 ***	178.2 ***	178.2 ***
LR-spatial error	69.51 ***	92.15 ***	129.53 ***
LR-spatial lag	74.46 ***	100.14 ***	130.42 ***

Note: *** denotes significance at the 1 percent level. The note remains the same for all tables below. The data in the table represent the statistics for each test result.

The results in (Table 6) display that, under the three spatial weight matrices, the estimated coefficient of EEP(ρ) is negative and significant at the 1% level. The results show that environmental regulation effectiveness has a strong negative spatial correlation, which means that the environmental governance of neighboring cities has a negative spatial spillover effect on local environmental governance. In addition, the estimated coefficient of W × Treat × Post is close to zero and not significant; we predict that the difference in the spatial spillover effects of environmental regulation effectiveness between A1 and A2 is not economically and statistically significant. The results indicate that there are race-to-the-bottom environmental regulations in A1 and A2. This phenomenon arises from the imitation behavior of environmental regulations among local governments. Due to the central government's overall control of the local government's environmental governance and the integration of environmental governance into political assessment performance, local governments have shown certain homogeneity in their formulation [78]. The development of high-quality human habitat cities makes it impossible for the area to form a competitive relationship with other areas, resulting in a race to the bottom in its formulation in the area and deteriorating regional interaction in environmental governance [79].

The spatial spillover effect of the control variables on EEP shows that the estimated coefficients of W × URL and W × HS are positive and significant at the 10% level under the three spatial weight matrices. This displays that the urban–rural livelihood and health security of neighboring cities have a positive spatial spillover effect on the local EEP. In addition, under W_E and W_{GE}, the estimated coefficients of W × TC and policies are positive and significant at the 10% level. This means that between cities with similar economic and geographical distances, the transportation–communication and number of pollution control policies in neighboring cities have a positive spatial spillover effect on the local EEP. The study found that reducing the income gap between urban and rural residents means the improvement of low-income residents' consumption level, and a higher consumption level increases the environmentally friendly consumption behavior of residents [80,81]. Moreover, a good medical level and transportation–communication have improved residents' requirements for the ecological environment. A better medical level is conducive to residents' health awareness, which makes them more sensitive to the surrounding ecological environment [82,83]. The improvement of transportation–communication means the expansion of the scope of information received by residents, which leads residents to compare the ecological environment in which they live, indirectly reducing the tolerance of residents to environmental pollution [84]. In this case, the concept of ecological environment protection is more easily accepted and disseminated by residents, and the improvement of the regional governance of the ecological environment is obvious. Current environmental regulations can improve the degree of public participation and enhance the awareness of environmental protection in various regions through the dissemination of Internet media, so as to achieve cross-regional governance of the ecological environment.

Table 6. Results of spatial spillover effect analysis.

Statistic	W_A	W_E	W_{GE}
EEP(ρ)	−0.433 ***	−0.577 ***	−0.453 ***
W × Treat × Post	−0.009	0.001	0.003
W × AM	0.019	0.043	0.009
W × IM	0.062	−0.026	0.076
W × DCC	0.061	0.002	0.018
W × URE	0.151	0.041	0.091
W × URL	0.221 ***	0.139 **	0.154 ***
W × EC	0.018	−0.020	−0.022
W × TC	−0.023	0.241 ***	0.205 ***
W × HS	0.098 **	0.087 *	0.097 **
W × IS	0.003	0.026	0.019
W × Policies	0.001	0.004 *	0.003 **
σ^2	0.001 ***	0.001 ***	0.001 ***
Observations	234	234	234
R^2	0.534	0.572	0.536

Note: *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively. The note remains the same for all tables below. This table reports the partial results of SDM-DID using the spatial adjacency weight matrix, spatial economic weight matrix, and spatial geographical economic weight matrix. EEP(ρ) is the spatial lag term, short for $\sum_j W_{ij}EEP_{jt}$. W × Treat × Post is the spatial spillover effect of core explanatory variables, short for $\sum_j W_{ij}Treat_{jt} \times Post_{jt}$. Other variables are the spatial spillover effects of control variables, short for $\sum_j W_{ij}control_{jt}$.

4. Conclusions and Policy Implications

The dual criteria to identify the quality of human habitat offered by this study encompassing the development index and balanced degree assessment constitute a broader systematic framework with multiple factors for analysis of the impact of environmental regulations on human habitat. In addition, this paper uses DID and SDID models to evaluate the effectiveness and spatial spillover effects of environmental regulation in high-quality human habitat cities in Jiangsu Province. In the evaluation of the quality of human habitats, some cities in the province are of high quality, but most cities have unbalanced development. For the evaluation of the effectiveness of environmental regulation in high-quality human habitat cities, the current environmental regulation methods cannot match the existing development of human habitat, and the growth rate of the ecological environment protection degree shows a more obvious decline. In the spatial interaction of environmental governance in a province, local governments have a race to the bottom in environmental governance. Furthermore, industrial modernization, reducing the income gap between urban and rural residents, and strengthening the public basic service guarantee have a positive effect on the protection of the ecological environment, but it should be noted that urbanization in areas with unbalanced development of human habitat has a negative effect. In view of this, we compared the means of human habitat quality and environmental regulation of neighboring provinces in Jiangsu Province. It is found that Zhejiang Province, as a neighbor of Jiangsu, has a similar economic development structure; its average ratio of days with good air quality in Zhejiang is 96.2%, whereas it was 81% in Jiangsu in 2020 [85]. This is because the content of environmental regulations in Zhejiang is more biased towards market incentives and public participation.

In an environment of green development, the economic and social development of high-quality human habitat cities has undergone new changes. The existing methods of environmental regulation do not match, and the new economic and social patterns should use new regulatory methods. We believe that the current environmental governance in Jiangsu Province needs more market incentives and public participation in environmental regulations, and we put forward the following three suggestions for the current environmental regulation with a theoretical basis and policy implications for the future transformation of environmental regulation. (1) Based on the positive effect of industrial modernization on the effectiveness of environmental regulation, it was determined that industrial development in environmental regulation has a positive effect on ecological environment protection. This shows that environmental regulations have created a good production environment for industries that comply with pollution emission limits and that traditional industries actively promote green technology innovation for benefits. Therefore, the government needs to increase economic incentives for green industries, create a green economic environment, and guide traditional industries to transform into clean, low-carbon enterprises. (2) This study found that there is a race to the bottom in environmental regulations in high-quality human habitat cities using the spatial double-difference method. Therefore, the relevant departments of the province should establish a communication and coordination mechanism with the relevant departments of the provinces, municipalities directly under the central government, and other neighboring provinces in the Yangtze River Delta region; share regional environmental information and strengthen scientific research cooperation on pollution prevention and control with the provinces, municipalities directly under the central government, and other neighboring provinces in the Yangtze River Delta region; and organize or participate in joint research on major issues, such as prevention and control policies, standards, and measures. (3) The protection of the ecological environment requires the active participation of people. The urban–rural integration and health security are conducive to the development of eco-friendly behaviors and to improve the public's demand for an ecological environment. The government needs to change the way of environmental governance, balance urban–rural development, cultivate residents' awareness of environmental protection, scientifically and effectively mobilize the public to carry out environmental governance, actively reward the reporting of illegal sewage discharge, disclose illegal sewage discharge units to the society according to law, and change the traditional mode of environmental protection that only relies on limiting pollution discharge.

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