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Spatiotemporal Evolution, Spatial Agglomeration and Convergence of Environmental Governance in China—A Comparative Analysis Based on a Basin Perspective

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Abstract: Scientifically measuring the level of environmental governance (EGL) and understanding its spatial convergence has important reference value for ecological governance. In this paper, the global entropy method is applied to measure the EGL of 284 prefecture-level cities in China from 2007 to 2019, which are divided into three major river basins, including the Yellow River, Yangtze River, and Pearl River, to observe the spatial–temporal evolutionary characterization through a standard deviation ellipse model. The coefficient of variation and the spatial econometric model are the tools used to conduct the spatial convergence test. The results are as follows: (1) China's EGL is low overall, though it is fluctuating upward at low magnitude, and the three major river basins follow the ranking: The Pearl River Basin > The Yangtze River Basin > The Yellow River Basin. (2) Spatially, the distribution pattern of China's EGL changes from "scattered and sporadic" to "multipolar core". (3) The center of China's environmental governance was concentrated in the east from 2007 to 2019, and the EGL in the midstream and downstream regions of the three major river basins increased rapidly. (4) Environmental governance in China has significant absolute and conditional β-convergence characteristics, as do the three major basins, while the ranking of convergence speed remains "Yangtze River Basin > Yellow River Basin > Pearl River Basin". Of these, economic development accelerated the convergence rate of environmental governance in China and its three major river basins; financial pressure significantly inhibited the convergence of the EGL of the Yellow River Basin. The improvement of the EGL in the Pearl River Basin was also negatively influenced by the industrial structure.

Keywords: environmental governance; spatial convergence; river basins; spatial agglomeration; China

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1. Introduction

Along with the rapid economic growth, the air, water, soil, biological and mineral resources in the natural environment have gradually surpassed the boundaries of nature and species, affecting people's production and livelihood. According to Making Peace With Nature 2021, global greenhouse gas emissions have doubled over the past 50 years, more than 20% of the world's land will be degraded by mid-century, and the global temperature will rise 1.5 °C by around 2040, if not sooner [1]. Continued environmental degradation further threatens human well-being. Currently, more than 90% of the world's population lives in places that do not meet the WHO Global Air Quality Guidelines, 3.2 billion people (about 40% of the global population) are adversely affected by land degradation, and pollution is responsible for the premature deaths of approximately 9 million people each year [1]. China is also continuously facing enormous pressure on environmental governance.

In the 1990s, the forest, grassland and wetland ecosystems in China decreased by 0.05%, 0.12% and 0.07% per year, respectively, while the desert ecosystems increased by 0.02% per year; the state-controlled sections have reached 10.2% in the ten major river basins of the Yangtze River, the Yellow River and the Pearl River, with water quality below Class V; 25% of the 60 lakes (reservoirs) under surveillance are in a state of eutrophication; the marine nutrient index has continued to decline and has been lower than the global average during the same period, and the seawater pollution in nearshore waters remains severe [2]. According to the "Cost of pollution in China: economic estimates of physical damages" jointly issued by the World Bank and the State Environmental Protection Administration, in 2007, China became the world's largest emitter of carbon dioxide and sulfur dioxide, with 58% of cities having an annual average PM10 concentration of more than 100 ug/m^3, and 54% of the water in the seven major water systems being unusable; the economic cost of the growing environmental problems accounts for at least 8% to 15% of the average annual GDP, and also results in significant health issues, with more than 700,000 people losing their lives each year [3].

To alleviate the enormous pressure brought by environmental issues, environmental protection has been established as a fundamental national policy of China [4]. A large number of top-down multi-dimensional environmental governance policies have been introduced at the central level. In 2001, China incorporated environmental governance into its national strategy for the first time, including a reduction in the total amount of pollutants in the 10th Five-Year Plan for National Economic and Social Development [5]. In 2006, the "one-vote veto system" directly linked pollutant reduction to local government performance [6]. In 2015, the so-called "most stringent" Environmental Protection Law was promulgated, and for the first time it included the ecological conservation redline in the law [7]. The law increased penalties for polluting enterprises through the implementation of the credibility archives, administrative detention, continuous daily fines, and uncapped fines in order to raise the cost of environmental pollution; added institutional provisions, such as the planning of environmental impact assessment (EIA), cross-administrative area joint control and prevention mechanisms; and pollutant discharge permit would also be needed [7]. In 2016, the Central Environmental Protection Inspectorate, one of China's highest level and most powerful monitoring measures, was launched for the first time to "supervise" local governments' environmental governance [8]. In 2021, carbon peaking and carbon neutrality were adopted as important targets for China's 14th Five-Year Plan, incorporated into the overall layout of the ecological civilization construction [9].

With such a high intensity of central concern, environmental governance has achieved some success over the long cycle, but remains unsatisfactory. Taking air pollution as an example, China's annual average fine particulate matter PM2.5 concentration was 70.542 μg/m^3 in 2011; in 2017, it fell to 52.665 μg/m^3 and further to 33 μg/m^3 in 2020 [10], but this number is still 6.5 times the safety value (10 μg/m^3) established by the World Health Organization [11]. In 2021, 34.7% of China's urban air quality still could not reach the standard, 3.8% of the country's land could be categorized into acid rain areas and I~III water quality sections accounted for 84.9%. Higher plants, vertebrates and macro-fungi that require priority attention and protection accounted for 29.3%, 56.7% and 70.3% of assessed species, respectively [12]. In terms of international comparison, according to the Global Environmental Performance Index (EPI) jointly published by Yale University and other research institutes, in the four rankings of 2006, 2008, 2010 and 2012, China continued to decline, ranking 94th (out of 133 countries), 105th (out of 149 countries), 121st (out of 163 countries) and 116th (out of 132 countries), respectively. China even ranked 160th (out of 180 countries) in 2022 with a score of 28.4, with a drop of 28.64% over the past decade [13]. An objective perception of the level of environmental governance is the basis for the effective provision of environmental public goods. However, the following questions have yet to be answered: what is the spatial and temporal distribution of environmental governance in China? Does spatial convergence exist, and if so, what are the characteristics of its spatial convergence?

2. Literature Review

Around the evaluation of environmental governance level (EGL), with the improvement of data availability and the change in research focus, the measurement of environmental governance presents the following characteristics: (1) The geographical scale of the study shows the evolution process as follows: "region [14]–country [15]–province [16]–urban agglomeration [17]–city [18]". The smaller the scale of the study, the relatively fewer indicators are covered by government statistics, whereas the geographic information data are more supportive of covering the basic components of the biosphere, such as soils, lakes, wetlands and forests. (2) The evaluation indicator system is constructed around the research objectives, focusing strongly on environmental pollution; the indicator design shifts from a single indicator (e.g., CO_2 [19], PM10 [20]) to a comprehensive multi-indicator evaluation, whose framing methods include comprehensive evaluation, pressure–state–response (PSR)-based evaluation, input–output framework and social–ecological system (SES) framework. (3) The measurement methods include the entropy method, principal component analysis (PCA), fuzzy comprehensive evaluation (FCE), data envelopment analysis (DEA), and data analysis (DA). Analysis (DEA) and questionnaire (scale analysis) are also included. (4) A positive trend of China's EGL can be seen over the past 30 years in the measurement results [21]; the number of the inland area is lower than the coastal area when it comes to spatial differentiation characteristics, and the spatial clustering effect is significant [22].

Most of the existing research discussing the factors that influence environmental governance can be incorporated into two categories: economic–social systems and government behavior. Economic–social systems and government behavior interact dynamically to influence environmental governance. From the aspect of economic–social systems, academia has widely discussed the level of economic development [23,24], industrial structure [25], urbanization level [26], technological development [27], population density [28], public concern [29]) and social capital [30] with regard to their influence on environmental governance. Providing environmental public goods is an important function of the government, and government behavior is considered an important factor influencing environmental governance. Government behaviors that affect environmental governance can be roughly separated into two categories: formal and informal systems. Among them, the formal system contains the division of authority and expenditure responsibilities [31], fiscal decentralization [32,33], political promotion [34], inter-governmental cooperation [35], governmental attention [36], collaborative governance [37], performance appraisal [38], environmental regulation [39], and auditing [40], etc. Informal systems, on the other hand, start from officials' characteristics and examine their influence on environmental governance based on officials' motivations, such as officials' place of origin [41], officials' tenure [42], officials' age and educational experience [43], and officials' turnover [44] and work experience [45].

Existing studies have provided important literature support and methodological references for this paper, but there is also room for further expansion as follows: (1) In terms of research data, when constructing the indicator evaluation system of EGL from the governmental perspective, due to the limitation of data accessibility, most of the studies focus on environmental pollution [46,47] without paying attention to ecosystem services. China's air, water, soil, and biodiversity all face serious environmental problems. When measuring the EGL, a comprehensive look at environmental quality from the biosphere level is indispensable. (2) Environmental public goods in basins are obviously non-exclusive, non-competitive and indivisible, and spatial spillovers have led to the problem of the "tragedy of the commons". However, from the perspective of the content of the research, the existing studies lack comprehensive examination of the characteristics of the dynamic spatial change of the EGL. Considering that the environment is a public good that has substantial spatial spillover, it is necessary to deepen the description of its spatial dynamics while observing its temporal evolution characteristics. (3) From the perspective of research scale, studies have been conducted to examine differences in EGL at the provincial level [48], which makes it difficult to distinguish subtle differences among cities within a basin. Most of the categorized discussions are based on the 1984 Seventh Five-Year Plan, which divided

China into three major economic zones: East, Middle and West, or four major sectors: East, Central, West and Northeast [49], which cuts off the horizontal linkages of basins, and do not contribute much to the progress of environmental governance [50]. Discussions based on the basin perspective have either only comparatively analyzed the Yangtze River and the Yellow River [51,52] or compared the EGL of the three major basins at the provincial level [53]. There is a lack of comparative studies of the three major basins at the municipal level.

There are three possible marginal contributions of this paper: (1) Regarding research content, this paper investigates the spatial and temporal evolution of EGL, taking care of the spatial spillover of environmental governance as a public good in basins. Existing studies have focused on the development of EGL centered on administrative divisions [35,43], which is a response to regional governance, and they lack the spatial spillovers of environmental governance in terms of basin divisions. This paper explores the spatial spillover impacts through the spatial convergence test of EGL in three major basins. (2) This paper adopts a large amount of geographic raster data in constructing the indicator system of China's EGL, covering natural elements such as species, vegetation, water networks and lakes to the greatest extent possible to show the EGL in an objective and comprehensive way. The availability of research data limits the objectivity and comprehensiveness of research conclusions to a certain extent. The majority of existing studies focus on environmental pollution when examining the level of environmental governance, which is inextricably linked to the availability of data. In addition, government statistics have also been questioned to some extent. The new geographic raster data used in this paper include PM2.5, PM10, ecological quality, lake transparency, vegetation normalization index and terrestrial ecosystem productivity. All the above data are remote sensing data with strong objectivity, and the data source is the National Earth System Science Data Center of China, which is of reliable quality. (3) The study scale covers the municipal level and compares the differences in environmental management levels among the three major river basins of the Yangtze, Yellow and Pearl Rivers. Under China's national spatial strategy of shifting from administrative to basin zoning [54], this paper not only responds to China's national spatial strategy adjustment by comparing the EGL of the three major river basins from a municipal scale, but also helps to differentiate the nuances of the EGL among cities.

3. Research Design

In this paper, 284 prefecture-level cities in China from 2007 to 2019 are taken as objects to portray the basic facts of China's environmental governance. The cities are divided into three major basins, namely, the Yellow River, the Yangtze River, and the Pearl River. They are analyzed comparatively, with the following specific steps: Firstly, an evaluation system is constructed for the indicators for EGL, which is measured by the global entropy value method (Stata SE 15). Secondly, the spatial–temporal evolution of China's environmental governance is characterized, based on three aspects: (1) depicting the temporal evolution of China's EGL; (2) portraying the spatial distribution of China's EGL while observing the spatial agglomeration trajectory of China's environmental governance through standard deviation ellipse model (ArcGIS 10.8); (3) using the spatial measurement model to examine the attributes of the spatial convergence of EGL (Matlab2022).

The observation period of this chapter is 2007–2019. In 2007, China's Ministry of Finance (MOF) first set up "211 Environmental Protection", which was renamed "211 Energy Conservation and Environmental Protection" in 2011, to reflect the financial expenditure incurred by local governments in environmental governance. To be compatible with the statistical period of this core indicator (expenditures on energy conservation and environmental protection), the observation period in this chapter begins in 2007. At the same time, because some core statistics for 2020 and beyond are not yet fully publicized (e.g., CO_2 emissions, ecological quality, lake transparency, etc.), this chapter sets the observation period up to 2019. For the sample, only cities of prefecture level and above are used. According to the China Urban Statistical Yearbook (2020), there are 297 cities that are above

prefecture level in China (excluding Hong Kong, Macao, and Taiwan). Among them, there are 278 prefecture-level cities, 4 directly controlled municipalities, and 15 sub-provincial cities. Considering the differences between city establishment and statistical data, this paper excludes samples based on data consistency and completeness: (1) seven cities that lack data consistency are excluded. Some prefecture-level cities were established after 2007 and lack data consistency, such as Sansha in Hainan Province, which was established in 2012; (2) six cities with missing data during the sample period were excluded. After a comprehensive examination, this paper finally obtained 284 cities of prefecture level and above as the sample.

To compare and examine EGL from a basin perspective, this paper further divides China into three major basins: the Yellow River Basin, the Yangtze River Basin, and the Pearl River Basin (Supplementary Materials S1). It should be noted that (1) The basis for the division of the Yellow River Basin is based on the Outline of Ecological Protection and High-Quality Development Plan for the Yellow River Basin in 2021, "The planning scope is the relevant county-level administrative districts of Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shanxi, Shaanxi, Henan, Shandong and nine other provinces where the main tributaries of the Yellow River flow" [55]. It has been taken into consideration that the core of economic and social development of Sichuan Province is concentrated in the Yangtze River Basin, and the Yellow River only flows through Aba, the Tibetan and Qiang Autonomous Prefecture and the Ganzi Autonomous Prefecture in Sichuan Province. The population and economy of these two provinces only account for 0.7% and 0.3% of the total population of the Yellow River basin, which has a relatively weak impact on the pattern of economic and social development of the Yellow River basin. Therefore, this paper only examines the other eight provinces and combines the Yellow River Water Resources Bulletin to delineate the prefecture-level cities covered by them. (2) The prefecture-level cities covered by the Yangtze River Basin are delineated according to the Guiding Opinions on Relying on the Golden Waterway to Promote the Development of the Yangtze River Economic Belt [56]. (3) The prefecture-level cities covered by the Pearl River Basin are delineated according to the Comprehensive Plan for the Pearl River Basin (2012–2030) [57].

3.1. Methodology

3.1.1. Measuring the Level of Environmental Governance: Global Entropy Method

Environmental governance is an assessment of the government's comprehensive performance in the process of environmental governance [58], which emphasizes the government's management of environmental pollution, and it reflects the government's ability to manage natural resources as well [59]. This paper combines the connotation of environmental governance and builds up an evaluation system for the indicators of China's EGL based on the PSR framework, which refers to the Pressure, State and Response model, a framework system used by the Organization for Economic Cooperation and Development (OECD) and the United Nations Environment Programme (UNEP) in research on environmental-related issues. Pressure characterizes the influence of human activities on the environment. It mainly considers the pressure generated by pollution. State characterizes the status of natural resources and ecosystem services, which is measured by environmental elements and ecological functions in this paper. Ecological functions include species, vegetation, water networks and lakes to the greatest extent possible. Response characterizes the local government's measures for facing environmental problems, including the inputs of governance elements and the results of governance. The governance inputs include human resources, finance, material and technology. Taking into consideration the accessibility and the comparability of existing data, this paper refers to existing studies [21,60] to further divides the three dimensions of pressure, state and response into 6 element indicators and 16 basic indicators (Table 1).

Table 1. Evaluation system for the indicators of China's EGL Based on the PSR Framework.

Dimension Indicators	Element Indicators	Basic Indicators	Unit	Attribute
Pressure (0.0062)	Air Pollution (0.0047)	Sulfur dioxide emissions from industries per CNY 10,000 of GDP (0.0014)	Tons/CNY 10k	-
		Carbon dioxide emissions per CNY 100 million of GDP (0.0003)	Million tons/CNY 100 million	-
		Annual average PM2.5 concentration per CNY 100 million of GDP (0.0015)	$\mu g/m^3$/CNY 100 million	-
		Annual average PM10 concentration per CNY 100 million of GDP (0.0014)	$\mu g/m^3$/CNY 100 million	-
	Other Pollution (0.0015)	Industrial wastewater discharge per CNY 100 million of GDP (0.0002)	10 k Tons/CNY 100 million	-
		Industrial smoke (dust) emissions per CNY 10,000 of GDP (0.0013)	Ton/CNY 10k	-
State (0.4665)	Environmental Elements (0.3677)	Ecological quality (0.0095)		+
		Lake transparency (0.3582)	cm	+
	Ecological Functions (0.0987)	Normalized difference vegetation Index (NDVI) (0.0137)		+
		Terrestrial ecosystem productivity per unit area (0.0850)	gc m^{-2} yr^{-1}/km^2	+
Response (0.5274)	Governance inputs (0.3969)	Number of employees to manage public facilities related to water and environment per unit area (0.0593)	Persons/km^2	+
		Energy conservation and environmental protection expenditures as a percentage of fiscal expenditures (0.0347)	%	+
		Ratio of fixed asset investment to GDP (0.0255)	%	+
		Number of green patent applications per capita (0.2773)	Items per 10,000 persons	+
	Governance Result (0.1305)	Comprehensive utilization rate of general industrial solid waste (0.1247)	%	+
		Greening coverage in built-up areas (0.0058)	%	+

Based on the evaluation system for the indicators of China's EGL, this paper adopts the global entropy method for measurement, which is a comprehensive evaluation method that objectively assigns weights to various indicators, which effectively circumvents the drawbacks of subjective assignment methods such as expert scoring, hierarchical analysis and fuzzy mathematics, and it has been widely used to evaluate multiple indicators [61]. But the traditionally used entropy value method is limited to cross-sectional data or time series data. Thus, this paper tries to use the global entropy method to obtain more scientific indicator weights, which overcomes the shortcomings of the traditional entropy method, i.e., to determine the weights of indicators by dealing with panel data of various indicators, different regions and multiple years [62]. The seven specific steps are shown below:

① Construct the global evaluation matrix. To evaluate the EGL of β indicators in α city in N years, the global matrix $\alpha N \times \beta$ is derived by arranging the N cross-sectional data tables $x^N = (x_{ij})_{\alpha \times \beta}$ in chronological order, which is denoted as:

$$x = \left(x^1, x^2, x^3, \ldots, x^N\right) = (x_{ij})_{\alpha N \times \beta} \quad (1)$$

② Standardize the indicators. The indicators of the global matrix for evaluation use distinct units; thus, they cannot be calculated directly without standardizing the indicators. Set x_{ij} as the evaluation unit $j(j = 1, 2, 3, \ldots, n)$ from the indicator value $i(i = 1, 2, 3, \ldots, m)$, specifically:

$$\begin{aligned} &\text{Positive indicator}: && Z_{ij} = \frac{x_{ij} - \min x_j}{\max x_j - \min x_j} \\ &\text{Negative indicator}: && Z_{ij} = \frac{\max x_j - x_{ij}}{\max x_j - \min x_j} \end{aligned} \quad (2)$$

In Equation (2), Z_{ij} represents the standardized indicator value, x_{ij} signifies the original value of the j indicator for city i; maxx_j refers to the maximum and minx_j represents the minimum of the j indicator, respectively.

③ Calculate the share of the indicator. The share y_{ij} of the city i for that indicator is calculated here:

$$y_{ij} = \frac{Z_{ij}}{\sum_{i=1}^{\alpha N} Z_{ij}}, 1 \le i \le \alpha N, 1 \le j \le \beta \tag{3}$$

④ Calculate the information entropy value. The information entropy value e_j of the indicator j is calculated here:

$$e_j = -k\sum_{i=1}^{\alpha N} y_{ij} \ln y_{ij}, 1 \le i \le \alpha N, 1 \le j \le \beta \qquad k = \frac{1}{\ln \alpha N} \tag{4}$$

⑤ Calculate the information utility value. The coefficient of variation d_j for the indicator j is calculated here:

$$d_j = 1 - e_j \tag{5}$$

⑥ Calculate indicator weights W_j:

$$W_j = \frac{d_j}{\sum_{i=1}^{m} d_j} \tag{6}$$

⑦ Calculate the EGL score:

$$U = \sum_{i=1}^{m} y_{ij} W_j \tag{7}$$

3.1.2. The Evolution of Spatial Agglomeration Patterns: SDE Model

Standard deviational ellipse (SDE) quantitatively depicts the evolution trend of the spatial agglomeration pattern by describing the spatial center, aggregation range and distribution direction of the EGL, in which the ellipse area quantitatively describes the range of core aggregation area of the spatial development when it comes to the EGL; the long half of the axis characterizes the distribution direction; the short half of the axis characterizes the discrete situation; the center of gravity portrays the centrality; and the azimuth angle portrays the trend [63]. In this paper, we analyze the evolution of the spatial agglomeration pattern of the environmental governance in China by calculating the area and center of gravity of the SDE [63]. If the environmental governance develops as centralized agglomeration, its distribution ellipse will experience spatial contraction; if it shows discrete agglomeration, the distribution ellipse will further expand spatially; and if it grows steadily, the distribution ellipse will basically remain unchanged. The specific steps are shown below:

① Calculate the position of the center of gravity of environmental governance and its movement trajectory. The calculation formula is:

$$\overline{E_i} = \frac{\sum_{j=1}^{n} y_{ij} E_{ij}}{\sum_{j=1}^{n} y_{ij}}, \ \overline{N_i} = \frac{\sum_{j=1}^{n} y_{ij} N_{ij}}{\sum_{j=1}^{n} y_{ij}} \tag{8}$$

In Equation (8), $\overline{N_i}$ and $\overline{E_i}$ are the horizontal and vertical coordinates of the center of environmental governance in year i, respectively, and the EGL of the city j in year i. E_{ij} and N_{ij} are the horizontal and vertical coordinates of the city j in year i, respectively.

② Calculate the direction of the ellipse, i.e., the azimuth α when rotated clockwise to the long axis of the ellipse with due north at 0°.

$$\tan\alpha = \frac{\left(\sum_{j=1}^{n}\widetilde{E}_j^{\,2} - \sum_{j=1}^{n}\widetilde{N}_j^{\,2}\right) + \sqrt{\left(\sum_{j=1}^{n}\widetilde{E}_j^{\,2} - \sum_{j=1}^{n}\widetilde{N}_j^{\,2}\right)^2 + 4\sum_{j=1}^{n}\widetilde{E}_j^{\,2}\widetilde{N}_j^{\,2}}}{2\sum_{j=1}^{n}\widetilde{E}_j\widetilde{N}_j} \tag{9}$$

In Equation (9), $\widetilde{E}_j$ and $\widetilde{N}_j$ are the horizontal and vertical coordinate deviations from the city j to the weighted average center $\overline{N_i}$ and $\overline{E_i}$, respectively.

③ Calculate the standard deviation δ_E and δ_N of the horizontal and vertical coordinates.

$$\begin{aligned}\delta_E &= \sqrt{\frac{\sum_{j=1}^{n}\left(\widetilde{E}_j\cos\alpha - \widetilde{N}_j\sin\alpha\right)^2}{n}}\\ \delta_N &= \sqrt{\frac{\sum_{j=1}^{n}\left(\widetilde{E}_j\sin\alpha - \widetilde{N}_j\cos\alpha\right)^2}{n}}\end{aligned} \tag{10}$$

④ Finalize the standard deviation elliptic model.

$$f = \left(\frac{E}{\delta_E}\right)^2 + \left(\frac{N}{\delta_N}\right)^2 \tag{11}$$

3.1.3. Spatial Convergence: σ Convergence and β Convergence

Convergence stems from the discussion of economic growth. Neoclassical growth models suggest that economic development will converge to a steady state as the marginal benefits of capital diminish. Similarly, for the EGL, it is possible that it will converge to a steady state as the marginal benefits of continuously invested factors of production diminish. During the long process, a convergence model is necessary to test whether a tendency exists for the spatial gap between the EGL of China and the cities in the three major river basins to narrow over time. In this paper, σ convergence and β convergence are used to test this from both stock and incremental perspectives, respectively.

σ Convergence indicates the trend of changes in the dispersion of EGL of cities over time. If the value of σ becomes smaller, that is, the dispersion of the EGL of the cities in the basin decreases over time, this means that the differences in the EGL between different cities are decreasing, and there is a σ convergence phenomenon. In this paper, convergence is measured by the coefficient of variation [64], calculated as:

$$\sigma = \frac{\sqrt{\sum_{i=1}^{N_j}\left(y_{ij} - \overline{y_{ij}}\right)^2 / N_j}}{\overline{y_{ij}}} \tag{12}$$

In Equation (12), y_{ij} is the EGL of city j in basin i; $\overline{y_{ij}}$ is the average value of environmental management water in city j in basin i, and N_j represents how many cities there are in basin j.

β convergence refers to a state of convergence in which cities that are at a lower level of environmental governance gradually catch up with cities in which the EGL is higher through higher growth rates over time, and eventually the gap between the two is gradually narrowed to the point where they are developing at the same or similar growth rates.

β convergence can be divided into two categories: absolute β convergence and conditional β convergence [65]. Absolute β convergence refers to the condition that, without considering other factors, the EGL of each city gradually converges to the same level over time, at which time the city with lower EGL has a faster growth rate than the city with higher EGL, and the growth rate of EGL is negatively correlated with its initial level. Con-

sidering the interaction between cities, the increasing mobility of some resource factors and the spatial spillover effect of the EGL itself, the spatial effect needs to be included when examining the convergence of EGL in China.

First, the global spatial auto-correlation test is applied here to determine whether a spatial correlation exists in China's EGL. To test whether the property value of a phenomenon and its neighboring units in geospatial space are significantly correlated or show a certain spatial distribution pattern, which is achieved by Moran's index (Moran's I) [66], global spatial auto-correlation is used, with the following formula:

$$I = \frac{\sum_{i=1}^{n}\sum_{j\neq i}^{n} W_{ij}(y_i - \overline{y})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij} y_i y_j / \sum_{i=1}^{n}\sum_{j=1}^{n} y_i y_j} \tag{13}$$

In Equation (13), n stands for the number of spatial units; y_i and y_j indicate the values of the spatial elements for spatial units i and j respectively. $\overline{y}$ signifies the mean value of the EGL and the queen-based adjacency weight matrix. Moran's I $\in [-1, 1]$, when Moran's I > 0, the environmental governance of each city in the sample shows an agglomeration effect. When Moran's I = 0 or close to 0, the EGL of each city in the sample is randomly distributed in space, and no spatial correlation can be found; when Moran's I < 0, the agglomeration of the environmental governance of each city in the sample is spatially diminishing or even disappearing. If the global auto-correlation is not significant, the local Moran's index is used to examine whether China's EGL is characterized by a local spatial auto-correlation, and the calculation method is the same as above.

Second, the spatial convergence test is conducted using absolute β convergence. Based on Elhorst's steps of the spatial econometric model selection [67], this paper adopts the LM test to find out whether a spatial auto-correlation effect can be seen in the convergence of the level of regional environmental governance. The model screening for the optimal spatial econometric model is conducted on the basis of the LR statistic and the Wald statistic (SAR, SEM, and SDM), as well as the specific forms of fixed effects (spatial fixed effects, time fixed effects and two-way fixed effects) were confirmed by Hausman test. The absolute β convergence formula is as follows:

$$OLS: \ln\left(\frac{y_{i,t+1}}{y_{it}}\right) = \alpha + \beta \ln(y_{it}) + \mu_i + \eta_t + \varepsilon_{it} \tag{14}$$

$$SAR: \ln\left(\frac{y_{i,t+1}}{y_{it}}\right) = \alpha + \beta \ln(y_{it}) + \rho \sum_{j=1}^{n} w_{ij} \ln\left(\frac{y_{i,t+1}}{y_{it}}\right) + \mu_i + \eta_t + \varepsilon_{it} \tag{15}$$

$$SEM: \ln\left(\frac{y_{i,t+1}}{y_{it}}\right) = \alpha + \beta \ln(y_{it}) + \mu_i + \eta_t + \varepsilon_{it} \quad u_{it} = \lambda \sum_{j=1}^{n} w_{ij} \ln\left(\frac{y_{i,i+1}}{y_{it}}\right) \tag{16}$$

$$SDE: \ln\left(\frac{y_{i,t+1}}{y_{it}}\right) = \alpha + \beta \ln(y_{it}) + \rho W_{ij} \ln\left(\frac{y_{i,t+1}}{y_{it}}\right) + \gamma W_{i,j} \ln(y_{it}) + \mu_i + \eta_t + \varepsilon_{it} \tag{17}$$

In Equations (14)–(17), $y_{i,t+1}$ and y_{it} are the logarithm of the EGL of the city i in period t and $t + 1$, respectively. $\ln\left(\frac{y_{i,t+1}}{y_{it}}\right)$ stands for the growth rate of the EGL of the city i in period $t + 1$, the spatial auto-regressive coefficient, and the spatial spillover coefficient. W_{ij} is the queen-based neighbor weight matrix, and the spatial weight matrix based on the distance relationship is used for the robustness test, containing the inverse distance spatial weight matrix and the economic distance spatial weight matrix. μ_i, η_t and ε_{it} indicate spatial individual fixed effects, time effects and random perturbation terms, respectively. β is the convergence coefficient, if $\beta < 0$ and it passes the significance test, it indicates that there is a trend of convergence in the level of environmental management in the basin, and

vice versa indicates a trend of divergence. Convergence speed $v = -\ln(1-|\beta|)/T$. δ is the parameter vector.

Finally, a spatial econometric model of conditional β convergence is constructed by selecting a number of control variables and adding them into the absolute β convergence formula in order to discuss whether the level of environmental governance eventually converges to the steady level under the condition of controlling other influencing factors. Referring to the existing studies and considering the reality of China, the control variables $X_{i,t+1}$ are economic development (pgdp), evaluated by the logarithm of the deflated real GDP per capita; government preference (gdpgoal), measured by the GDP growth target; industrial structure (tis), evaluated by the ratio of tertiary industry value-added in the value-added of the GDP; foreign direct investment (fdi), measured by the ratio of FDI per unit of GDP; environmental attention (ea), evaluated by the sum of the number of keyword phrases about environment in the government's work report; and fiscal expenditure decentralization (fd), calculated as

$$\text{fd} = \text{per capita municipal fiscal expenditure}/(\text{per capita municipal fiscal expenditure} + \text{per capita provincial fiscal expenditure} + \text{per capita central fiscal expenditure}) \quad (18)$$

3.2. Data Sources and Pre-Processing

The variable data in the observation period mainly come from the National Earth System Science Data Center, China Urban Statistical Yearbook from 2008 to 2020, the statistical yearbooks of each city and the information that was publicized upon request. The statistical caliber is the entire administrative area of the city. The data of monetary indicators are based on 1978 as the base period, and the GDP index (1978 = 100) is utilized for the constant price treatment. Table 2 has revealed the statistical description of the variables. The relevant data have the following points to be clarified:

Table 2. Descriptive statistics of variables.

Variables	Codes	Samples	Average	Standard Deviation	Minimum	Maximum
Environmental Governance level	egl	3692	0.0795	0.0358	0.0259	0.4279
Economic Development	pgdp	3692	34,240.42	22,499.06	3354.5760	160,899.8
Financial Pressure	gdpgoal	3692	0.1071	0.0316	0.01	0.31
Industrial Structure	tis	3692	0.3942	0.0985	0.0858	0.8352
foreign direct investment	fdi	3692	0.0181	0.02	0	0.3323
Fiscal Decentralization	fd	3692	0.3991	0.0984	0.1639	0.8923
Environmental Attention	ea	3692	97.4247	30.8842	17	259

(1) The transformation of geographic raster data. The geographic raster data used in this paper include PM2.5, PM10, ecological quality, lake transparency, vegetation normalization index and terrestrial ecosystem productivity. These six data types have been processed via spatial raster analysis, and the municipal average was taken to transform the annual raster data into the municipal annual panel data. The processing of the vegetation normalization index was divided into three steps: first, the month-by-month raster data were combined into annual data; second, the range was processed to exclude negative values (i.e., values filled with −3000 or negative values caused by noise), multiplied by 0.0001, and transformed into the value of [−1, 1]; lastly, the data were transformed into the municipal annual panel data. Terrestrial ecosystem productivity was transformed into annual municipal panel data by raster statistics by region after excluding negative values filled with −9999.

(2) Industrial fumes (dust) emissions. The "*China City Statistical Yearbook*" of the year 2011 and before only has the statistics of industrial fumes emissions; since 2011, the

statistical caliber for industrial fumes and dust have been combined. This paper finds the 2007–2010 industrial smoke and dust emission from the statistical yearbook of various provinces and prefecture-level cities, respectively, and adds them up to calculate the industrial fumes (dust) emissions of each city to maintain the consistency of statistical caliber.

(3) The staff numbers of the water conservancy industry, environment industry and public facilities management industry. These data were mainly obtained from the *China Urban Statistical Yearbook*. The missing values are filled in according to the number of urban non-private employees in the relevant industry in the local statistical yearbooks, or by using the linear function method (TREND function).

(4) Gross regional product. These data were mainly collected from the *China City Statistical Yearbook*. The 2017 GDP of various cities in Fujian province was supplemented based on the *Quanzhou Statistical Yearbook 2018*, the 2017 GDP of Jiangxi was supplemented based on the *Shangrao Statistical Yearbook 2018*, and the 2018 GDP of Zunyi was supplemented based on the *Zunyi Statistical Yearbook 2020*. The fourth national economic census was carried out in 2018, and the GDP of the region in 2018, along with previous years, was systematically revised; therefore, the GDP data published by localities in 2019 are also revised data. Since it is not possible to obtain the revised data for 2018 and previous years for each prefecture-level city, the unrevised data were used, and the 2019 GDP data were obtained by multiplying the 2018 data by the 2019 economic growth rate.

(5) Annual GDP growth target. These data can be found in the annual Government Work Report of each city, which is available through the web portals of the governments of each city, statistical yearbooks, "special features" columns of yearbooks, and government information disclosure platforms upon request. It should be noted that not all GDP growth targets are reported in the annual Government Work Report, and specific treatments vary. For the economic growth target with modifiers such as "around", "not less than", "about", etc., the targets are directly modified based on the economic growth target using specific values. For an economic target expressed in the form of a growth range, the interval average is used instead. For the total GDP announced in the form of figures, the (total expected GDP minus total annual GDP)/total expected GDP) formula is used to calculate the expected GDP growth target [68].

(6) Environmental attention. Environmental attention is decomposed into three categories: development concept, pollution control and ecological governance, and the word sum of related keywords is calculated as a measure of environmental attention resource allocation at this level of government.

4. Spatial and Temporal Evolution of EGL in China

In this paper, the indicator system in Table 1 is meant to examine the EGL of China and the three major basins from 2007 to 2019 by applying the global entropy method. The outcome can be seen in Supplementary Materials S2.

4.1. Temporal Evolution

From 2007 to 2019, China's EGL was low overall, but still showed a rising trend of low amplitude fluctuations. From 0.0772 in 2007 to 0.0904 in 2019, the average annual growth rate of the national EGL was only 1.44%. The national EGL peaked in 2013 and 2018 (Figure 1), during which the first peak in 2013 may have come from the policy signals released by the central government. These signals serve as the guide for lower-level governments to invest relevant human, financial and material resources in environmental governance to promote the improvement of EGL in a top-down way, such as the five-year plan and the National Congress of the Communist Party of China. In 2012, the State Council issued the 12th Five-Year Plan for National Environmental Protection, which, based on the two targets of the 11th Five-Year Plan for National Environmental Protection, expanded the total emission control targets of major pollutants to include chemical oxygen

demand, sulfur dioxide, ammonia nitrogen, and nitrogen oxides [69]. In the same year, the 18th National Congress of the Communist Party of China (CPC) put forward the idea of "placing the construction of ecological civilization in a prominent position" [70], and the construction of ecological civilization has become a key component of the overall layout of the Five-sphere Integrated Plan of the socialist cause with Chinese characteristics. Vertical authoritative pressure from the central government led to the second peak in 2018, as a result of the high "political potential" offered by environmental protection inspections to exert pressure from the top down, urging local governments to enhance the level of environmental governance. The year 2016 saw the first launch of the central inspections of environmental protection, and 2018 saw the realization of the first round of inspections in four rounds, providing full coverage of 31 provinces and cities across the country [8]. The central inspections of environmental protection are the highest-level and the most powerful environmental protection inspection measures in China, motivating local governments to promote environmental protection by prioritizing all administrative resources, mainly through four mechanisms: spiritual propaganda, meeting mobilization, environmental protection interviews, and accountability with punishment.

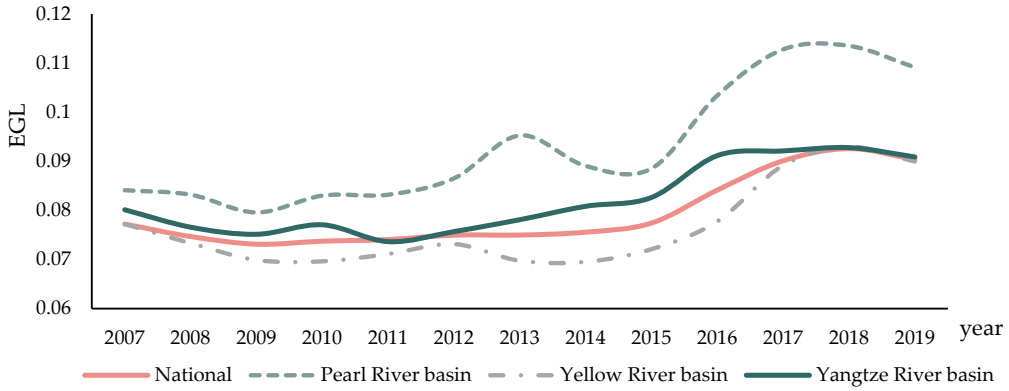


Figure 1. Temporal changes in the EGL in China and the 3 major river basins, 2007–2019.

Specifically for each river basin, the difference in the EGL is relatively small, and the absolute value of EGL shows the overall pattern of "Pearl River > Yangtze River > Yellow River" (Figure 1). The average value of EGL over the years also shows a decreasing trend of "Pearl River (0.0932)–Yangtze River (0.0821)–Yellow River (0.0766)", and average value of the Yellow River Basin in the past few years has been slightly lower than the national average (0.0795). Further analysis reveals that the annual average growth rate of the basins with high EGL is significantly higher than that of the basins with low EGL, and the difference in EGL between these basins is constantly widening, showing certain dispersion characteristics. Specifically, the average annual growth rate of EGL in the Pearl River Basin is 2.40%, significantly higher than the national average (1.44%), which is 1.71 times and 2.09 times higher than that of the Yangtze river Basin (1.40%) and the Yellow River Basin (1.15%), respectively.

4.2. Spatial Distribution

This paper combines the natural breaks method of ArcGIS and the principle of equal intervals to classify the EGL into three grades to further investigate the spatial distribution of the EGL in China and the three major river basins, as well as to visualize its spatial–temporal distribution pattern, namely low (egl < 0.07), medium (0.07 ≤ egl < 0.14) and high (0.14 ≤ egl). The years 2007 and 2019 are selected for the visualization analysis (Figure 2). Generally speaking, from 2007 to 2019, the national EGL gradually showed a change in the distribution pattern from "scattered and sporadic" to "multipolar core" (Figure 2a). Among them, the spatial distribution pattern of the EGL in the Yellow River Basin has changed significantly, with the low-level areas decreasing significantly, while the high and medium-level areas increased while shifting to the southeast (Figure 2b); the EGL in the Yangtze River Basin has

increased, and gradually formed a contiguous distribution pattern along the river (Figure 2c). The EGL of the Pearl River Basin declined slightly, but the overall pattern did not change fundamentally, and the spatial viscosity was strong (Figure 2d).

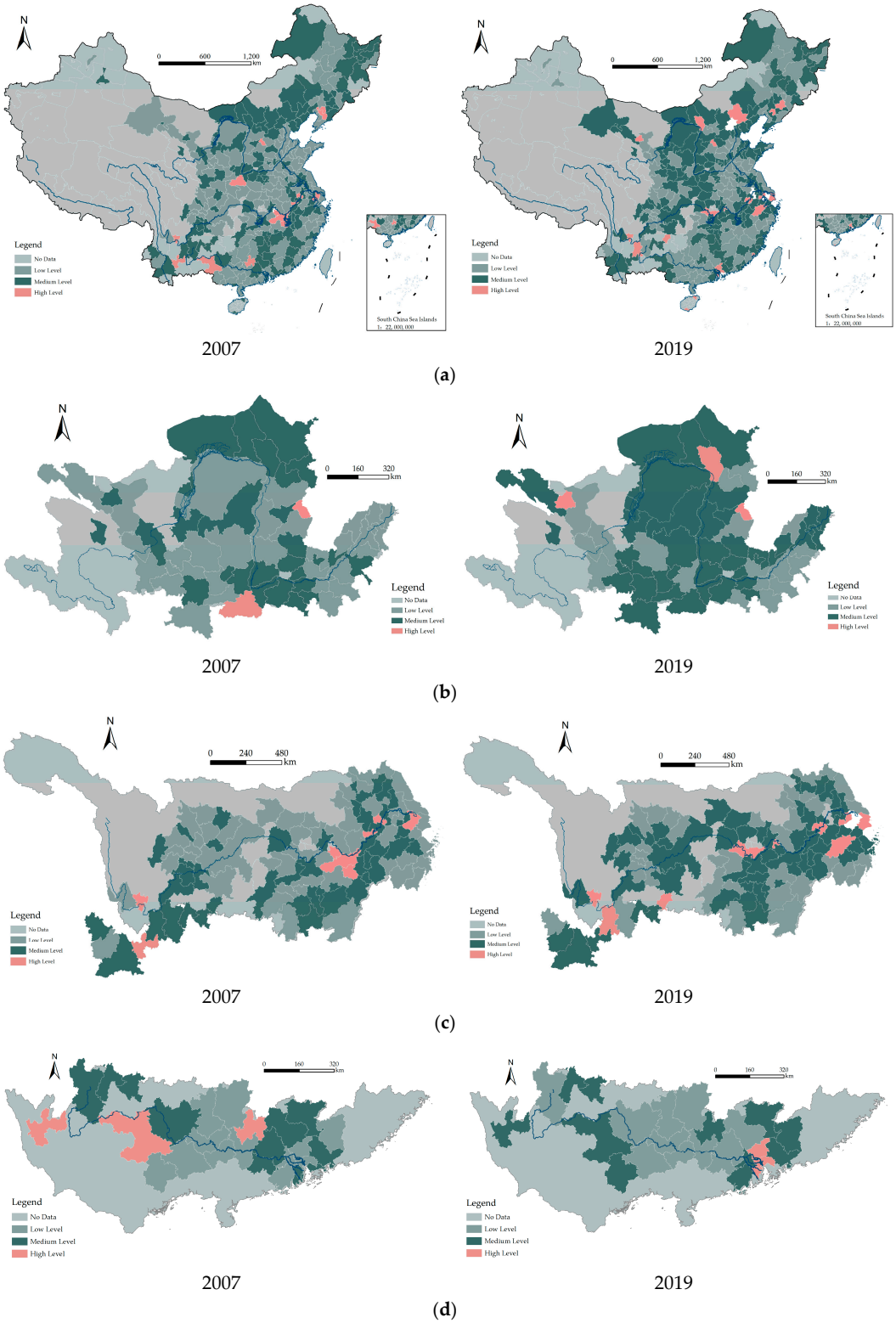


Figure 2. Spatial distribution characteristics of EGL in China and 3 major river basins. (**a**) China, (**b**) Yellow River basin, (**c**) Yangtze River basin, (**d**) Pearl River basin. Note: Based on the standard base map of the standard map service system of the national surveying, mapping and geographic information administration of China (Review No. GS (2020) 4630), with no modifications to the base map.

4.3. Evolution of Spatial Agglomeration Patterns

To further investigate the spatial distribution of the agglomeration of China's EGL, this paper plots the three major river basins' EGL in 2007 and 2019 based on the SDE model (Figure 3) and examines the features of the trend of spatial agglomeration. The results show that the center of China's environmental governance from 2007 to 2019 is concentrated in the east, and the EGL in the midstream and downstream regions of the three major river basins is rapidly increasing. Nationally, the center of environmental governance has always shifted back and forth in Henan Province and has been moving southeastward; the standard deviation ellipse covers a more stable area and migrates slightly to the southeast. As for basins, the EGL of the lower reaches of the three major basins improved faster in 2007–2019, gradually showing a catching-up trend. Among them, the center of the EGL of the Yellow River Basin has moved slowly to the northwest; the distribution of its standard deviation ellipse shows a northwestern–southeastern direction and expands east–west, showing that the levels of environmental governance in the upstream and downstream regions have been continuously improving. The center of environmental governance in the Yangtze River Basin is slowly moving northward, its standard ellipse area is stable and moves slowly toward the northeast, indicating that the EGL of the downstream region is improving faster. The spatial agglomeration pattern of environmental governance in the Pearl River Basin has changed most obviously, with its center moving rapidly to the east; its standard ellipse distribution also shows a rapid trend of movement to the southeast, indicating that the catching-up effect of environmental governance in the downstream region of the Pearl River has been obvious during this period.

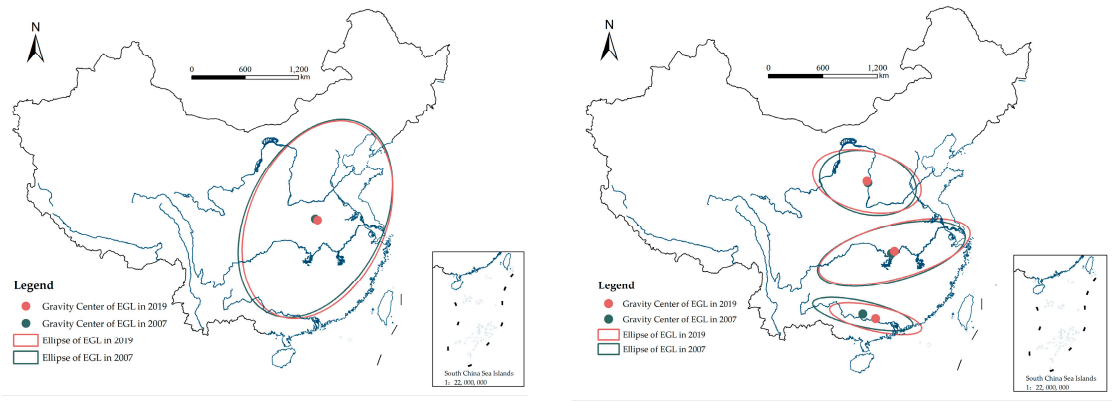


Figure 3. Standard deviation ellipse and center of gravity shift of EGL in China and 3 major river basins. Note: Based on the standard base map of the Standard Map Service System of the National Surveying, Mapping and Geographic Information Administration of China (Review No. GS (2020) 4630), with no modifications to the base map. (**a**) China. (**b**) Three Main Basins.

5. Spatial Convergence of EGL in China

5.1. σ Convergence Test

China's level of environmental governance varies significantly across cities and river basins. Is this variation convergent? Can it converge to equilibrium? In this paper, we use the coefficient of variation to portray its σ convergence and analyze the spatial convergence characteristics of EGL from the perspective of stock. As shown in Figure 4, the ending value (2019) of the EGL of the whole country and the Pearl River Basin in the sample period is larger than the beginning value (2007), and there is a σ dispersion phenomenon, i.e., the regional disparity of the horizontal EGL is gradually expanding, while the Yellow River Basin and the Yangtze River Basin show a σ convergence characteristic, i.e., the regional disparity of the horizontal EGL is gradually narrowing. Specifically, the trend of the whole country and the Yangtze River Basin is similar, and the coefficients of variation of EGL fluctuate slightly around 0.44, indicating that their internal differences are relatively stable.

The coefficient of variation of the EGL of the Yellow River Basin fluctuates and decreases during the sample period, indicating that its internal differences have been narrowing over time. The coefficient of variation of the EGL in the Pearl River Basin has experienced a large fluctuation process of "slow decline–relatively stable–sharp rise" in 2015–2019, with a rapid rise from 0.393 to 0.684, an increase of 74.05%. The overall difference is rapidly expanding.

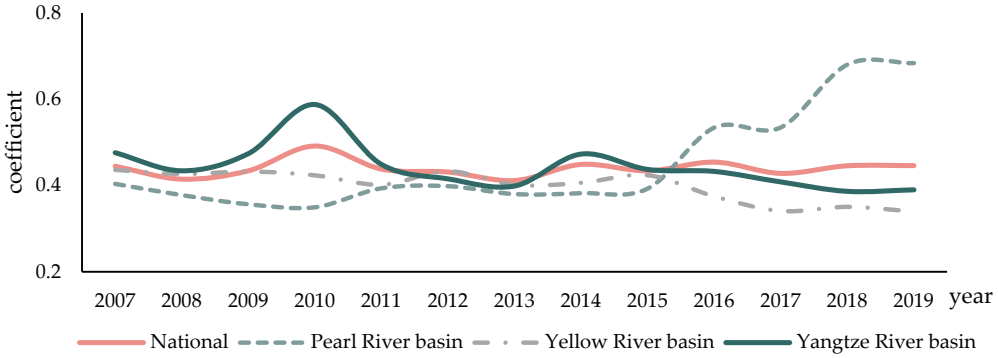


Figure 4. The σ coefficient of EGL in China and 3 major river basins.

5.2. Spatial Correlation

Before investigating if China's EGL is characterized by β convergence, it is necessary to conduct a preliminary exploration of its spatial correlation using the global auto-correlation method. Therefore, this study conducts a preliminary test of the correlation between different EGLs of 284 cities in China, making use of the Moran index, and the results are shown in Table 3. The Moran index of China's EGL from 2007 to 2019 is significantly positive. Thus, there exists a significant positive correlation between China's EGL, i.e., Spatially, China's EGL does not show up randomly, but has the characteristic of "high–high" or "low–low" spatial clustering. Meanwhile, the Moran index of China's EGL increased from 0.2891 in 2007 to 0.3332 in 2019, and the fluctuating increase in the Moran index indicates that the spatial correlation has been strengthened over time during the period of the sample, and that geographic position is already one of the most significant factors affecting China's EGL. Thus, the spatial effect needs to be considered when examining the convergence trend of environmental governance.

Table 3. Moran index of China's EGL, 2007–2019.

Years	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Moran index	0.2891	0.2811	0.2719	0.2704	0.2950	0.3116	0.2998	0.3227	0.3300	0.3247	0.3218	0.3108	0.3332
Z-value	8.1739	7.4767	7.1079	7.1696	7.7166	8.4049	7.4610	7.8807	8.6292	8.6493	8.5679	8.0061	8.8603
p-value	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

5.3. β Convergence Test

5.3.1. Absolute β Convergence Test

From the incremental perspective, will there be a trend of convergence over time when it comes to the national and three major basins' environmental management levels? The results of the absolute β convergence test are revealed in Table 4. First, there exists β absolute convergence in the EGL of the whole country and the three basins. The β coefficients are significantly negative at the 1% confidence level, showing that the EGL of the whole country and the three basins will eventually converge to the same steady state over time under similar influencing factors, including the economy, society, and institutions in each place. Second, the speed of convergence of the EGL in the three major basins is lower than the national level (0.0539%), although there are differences. Third, the national and the Yellow River Basin show different spatial effects. Specifically, there is a spatial lag of the explanatory variables for the nation as whole, and ρ or λ is at the 1% level, which is significantly positive. That means that changes in the EGL in various

cities are simultaneously influenced by positive spatial spillovers from the EGL in other cities and their rates of change. The ρ coefficient or the λ coefficient for the EGL in the Yellow River Basin is strongly negative at the 5% confidence level, which signifies that the rate of change in the EGL in the Yangtze River Basin decreases while the rate of change increases in other regions. However, the absolute β convergence characteristics of the EGL of the country and the three major river basins that is shown above are established under strong assumptions of economic and social similarity of each region, which is not compatible with the reality. In reality, every region has distinct resource endowment as well as economic/social development. As a result, the further effective management of this kind of elements should be indispensable to examine the conditional β convergence for further investigation.

Table 4. Absolute β convergence of EGL in China and 3 major river basins.

Regions	China	Yellow River Basin	Yangtze River Basin	Pearl River Basin
Model Types	Dual-fixed SEM	Dual-fixed SAR	Dual-fixed SAR	Dual-fixed SAR
$^{\beta}$(ln egl)	−0.4764 ***	−0.4425 ***	−0.4746 ***	−0.3628 ***
	(−31.9523)	(−14.6106)	(−19.1785)	(−8.2335)
ρ *or* λ	0.3091 ***	−0.3785 **	−0.2012	−0.2798
	(3.7376)	(−1.6981)	(−1.1419)	(−1.1662)
R^2	0.29	0.3267	0.2907	0.3115
Log-likelihood	1222.8405	251.9505	574.4381	116.4083
Spatial Fixed Effect	815.3514 ***	162.4708 ***	302.5625 ***	73.416 ***
Time Fixed Effect	815.3514 ***	162.4708 ***	302.5625 ***	73.416 ***
Hausman Test	700.8762 ***	101.3944 ***	273.216 ***	26.262 ***
LM Spatial Lag	117.0144 ***	4.4195 ***	5.7118 ***	4.7095 **
Robust LM Spatial Lag	11.4424 ***	0.0624	2.3533	0.1581
LM Spatial Error	162.7102 ***	4.3933 **	3.9178 **	4.9201 **
Robust LM Spatial Error	57.1382 ***	0.0362	0.5593	0.3686
Wald Test Spatial Lag	0.2005	0.5986	0.1813	0.6261
LR Test Spatial Lag	0.214	0.4223	0.1738	0.6397
Wald Test Spatial Error	0.1833	0.0487	2.5121	0.1244
LR Test Spatial Error	0.1747	−0.1471	2.5445	0.1837
Convergence Velocity v (%)	0.0539	0.0486	0.0536	0.0375
Observed Values	284	62	108	27

Notes: T-statistics in parentheses, *** and ** denote statistical significance at the 1% and 5% level, respectively.

5.3.2. Conditional β Convergence Test

Considering that the conditional β convergence only incorporates the initial values into the test estimation, it is inconsistent with the reality or will influence the precision of the estimation results. In this paper, a bunch of heterogeneity factors that are influential are further included as control variables to re-test the estimation, and the outcome of the conditional β convergence test for the EGL of the whole China and the three major basins are reported in Table 5. First, the convergence coefficients of the EGL of the whole country and the three basins are all strongly negative at the 1% confidence level, indicating that there are conditional β convergence characteristics of the EGL of the whole of China and the three basins, i.e., the EGL of the whole country and the three basins are still moving towards the steady-state level after taking into account regional heterogeneity such as the economic development, the financial pressure, the industrial structure, the opening-up policy, the financial decentralization, and the attention to the environment. Second, compared with the absolute β convergence, the convergence speed of EGL is accelerated in the whole country and the three major basins. Under the conditional β convergence, the convergence speed of the national EGL increases to 0.0578%, and the order of the convergence speed of the three major basins remains "Yangtze River Basin > Yellow River Basin > Pearl River Basin". Third, the whole country and the three major basins show different spatial effects; the coefficients, as well as the types of spatial effects, are different from the absolute β convergence. Specifically, the coefficient ρ or λ of the national environmental governance is

still hugely positive at the 1% confidence level, so the growth of the environmental level in some provinces within the country promotes the increase in the convergence rate; however, the coefficients of the EGL of the Yellow River Basin and the Yangtze River Basin are hugely negative at 1%, which means that the environmental governance within the basins has a negative spatial spillover effect, which may be related to the existence of cross-region pollution between the upstream region, the midstream region and the downstream region of the river.

Table 5. Conditional β convergence of EGL in China and 3 major river basins.

Regions	China	Yellow River Basin	Yangtze River Basin	Pearl River Basin
Model Types	Dual-fixed SDM	Dual-fixed SDM	Dual-fixed SDM	Dual-fixed SAR
β (ln egl)	−0.5001 ***	−0.5065 ***	−0.5234 ***	−0.4582 ***
	(−34.9486)	(−16.1429)	(−21.4758)	(−9.6955)
pgdp	0.000005 ***	0.000004 ***	0.000005 ***	0.000011 ***
	(7.621)	(2.6794)	(4.7018)	(4.2316)
gdpgoal	−0.0763	−1.0937 ***	0.0121	0.2608
	(−0.4)	(−3.0612)	(0.0268)	(0.395)
tis	−0.0378	−0.1053	0.0015	−0.8527 **
	(−0.3594)	(−0.4435)	(0.0082)	(−2.0561)
fdi	0.1502	0.162	−0.1165	−0.2975
	(0.6453)	(0.2581)	(−0.2207)	(−0.2688)
fd	−0.0447	−0.1324	−0.0625	−0.7545
	(−0.3428)	(−0.3748)	(−0.3512)	(−1.2358)
ea	0.000025	−0.0005	0.0002	0.0003
	(0.1942)	(−1.5997)	(1.2503)	(0.8035)
θ (w × ln egl)	−0.0177	−1.3059 ***	−0.8975 **	
	(−0.1632)	(−2.7142)	(−2.4982)	
pgdp	−0.000009 ***	−0.000013	0.000001	
	(−3.3865)	(−0.6752)	(0.1438)	
gdpgoal	1.237 **	−1.359	3.8105	
	(2.0215)	(−0.4273)	(1.3365)	
tis	1.8585 ***	0.9852	0.2984	
	(3.4023)	(0.3886)	(0.203)	
fdi	−0.3497	11.8495	−26.0251 ***	
	(−0.2916)	(1.1644)	(−3.5844)	
fd	2.8898 ***	18.5046 ***	−5.6166 ***	
	(2.9194)	(3.0806)	(−1.7553)	
ea	0.0026 ***	−0.0043	−0.0035	
	(3.0333)	(−1.4729)	(−1.4133)	
ρ *or* λ	0.062	−0.999 ***	−0.582 ***	−0.3029
	(0.6662)	(−3.5411)	(−2.5818)	(−1.252)
R^2	0.3117	0.3774	0.3161	0.3882
Log-likelihood	1273.7599	275.6057	594.3638	137.0225
Spatial Fixed Effect	738.5868 ***	163.2853 ***	266.6216 ***	61.4742 ***
Time Fixed Effect	59.2623 ***	33.4558 ***	27.9712 ***	25.4899 ***
Hausman Test	726.6825 ***	153.6312 ***	259.0004 ***	62.1601 ***
LM Spatial Lag	60.0289 ***	3.7802 **	25.7741 ***	7.253 ***
Robust LM Spatial Lag	3.2122 *	4.1017 **	8.7828 ***	0.9459
LM Spatial Error	59.8691 ***	5.9443 **	18.1553 ***	6.3562 **
Robust LM Spatial Error	3.0523 *	6.2657 **	1.164	0.0491
Wald Test Spatial Lag	53.2602 ***	23.5832 ***	20.9815 ***	11.156
LR Test Spatial Lag	50.461 ***	23.7148 ***	18.8216 ***	10.9891
Wald Test Spatial Error	50.3736 ***	18.4051 **	19.5951 ***	13.1224 *
LR Test Spatial Error	47.2994 ***	17.8715 **	18.1135 **	12.8802 *
Convergence Velocity v (%)	0.0578	0.0589	0.0618	0.0511
Observed Values	284	62	108	27

Notes: T-statistics in parentheses, ***, **, and * denote statistical significance at the 1%, 5% and 10% level, respectively.

In addition, after adding a bunch of control variables to the conditional convergence analysis, the R^2 and Log-likelihood coefficients of the whole country and the three major basins increased compared to the absolute β convergence. The data further proved that the selection process of control variables is totally scientific. Strong statistical differences can be seen in terms of the factors influencing the level of environmental management in the country and the three major basins. Among them, economic development accelerates the convergence of environmental governance in the whole country and the three basins; financial pressure significantly inhibits the convergence of EGL in the Yellow River Basin; and the improvement of EGL in the Pearl River Basin is vastly influenced in a negative way.

6. Conclusions

Based on measuring the EGL of 284 cities, whose levels are above the prefecture in China from 2007 to 2019, using the global entropy method and further dividing them into three major basins, namely, the Yellow River Basin, the Yangtze River Basin and the Pearl River Basin, this paper depicts the evolution process of their spatial agglomeration patterns by using the spatial statistical SDE model. Finally, the coefficient of variation and spatial econometric model are applied to test the spatial convergence. The conclusions of the study are as follows.

From 2007 to 2019, China's EGL was low overall, but still showed an upward trend with low-amplitude fluctuation, and reached peak in 2013 and 2018. The EGL of the three major river basins had small differences, showing a decreasing trend in the order of "Pearl River–Yangtze River–Yellow River". In contrast to the "high in the east and low in the west" pattern from the existing studies [52], this paper finds that the national environmental governance performance gradually shows a spatial distribution pattern from "discrete and sporadic" to "multipolar core", and basically, the distribution of cores is consistent with the distribution of urban agglomerations in the basin. Among them, the high and medium level areas in the Yellow River Basin are increasing and shifting to the southeast; the Yangtze River Basin is gradually forming a continuous distribution along the river; and the Pearl River Basin is more spatially viscous. In addition, the center of gravity of China's environmental governance in 2007–2019 is clustered in the east, and the EGL in the midstream and downstream regions of the three major river basins is rapidly increasing.

The convergence test found that (1) the EGL of China and the Pearl River Basin in the sample period showed the phenomenon of σ dispersion, while the Basin of Yellow River and the Basin of Yangtze River showed the σ convergence characteristics. (2) There was a significant positive spatial correlation between China's EGL from 2007 to 2019, and the spatial correlation continuously strengthened over time. (3) Absolute β convergence and conditional β convergence was be found in the EGL of China and its three major river basins. (4) For the conditional convergence with the addition of control variables, the convergence speeds of the whole country and the three major basins increased, but the order remains "Yangtze River Basin > Yellow River Basin > Pearl River Basin", in which the economic development accelerated the convergence speed of the environmental governance of China and the three major basins; the convergence of the level of environmental governance of the Yellow River Basin was significantly inhibited by financial pressure; and the enhancement of the level of the Pearl River Basin was significantly inhibited by the industrial structure.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land13020231/s1, Table S1: Coverage of the 3 Major Basins in China and the Basis for their Delineation; Table S2: Environmental Governance Levels of 284 Cities in China, 2007–2019.

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References

1. United Nations Environment Programme. *Making Peace with Nature: A Scientific Blueprint to Tackle the Climate, Biodiversity and Pollution Emergencies*; UNEP: Nairobi, Kenya, 2021.
2. Xu, H.G.; Ding, H.; Ouyang, Z.Y.; Zhang, W.G.; Cui, P.; Xu, W.H.; Liu, L.; Wu, J.; Lu, X.Q.; Cao, M.C.; et al. Assessing China's Progress toward the 2020 Global Biodiversity Targets. *Acta Ecol. Sin.* **2016**, *36*, 3847–3858. (In Chinese)
3. The World Bank. *Cost of Pollution in China: Economic Estimates of Physical Damages*; World Bank: Washington, DC, USA, 2010.
4. Ministry of Ecology and Environment of the People's Republic of China. The Second National Environmental Protection Conference. Available online: https://www.mee.gov.cn/zjhb/lsj/lsj_zyhy/201807/t20180713_446638.shtml (accessed on 1 February 2024).
5. Central Government of the People's Republic of China Report on the Outline of the Tenth Five-Year Plan for National Economic and Social Development. 2001. Available online: https://www.gov.cn/gongbao/content/2001/content_60699.htm (accessed on 7 February 2024).
6. The State Environmental Protection Administration of the People's Republic of China Verification Measures for the Total Emission Reduction of Major Pollutants during the 11th Five-Year Plan Period (Trial). 2007. Available online: https://www.mee.gov.cn/gkml/zj/wj/200910/t20091022_172473.htm (accessed on 7 February 2024).
7. Central Government of the People's Republic of China. *Environmental Protection Law of the People's Republic of China*; The National People's Congress Standing Committee: Beijing, China, 2014.
8. The Academy of Contemporary China and World Studies. Central Inspection on Eco-Environmental Protection. Available online: http://www.china.org.cn/english/china_key_words/2023-01/12/content_85056440.html (accessed on 31 January 2024).
9. Central Government of the People's Republic of China. Outline of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China. 2021. Available online: https://www.gov.cn/xinwen/2021-03/13/content_5592681.htm (accessed on 7 February 2024).
10. IQAir. World's Most Polluted Countries in 2021—PM2.5 Ranking. Available online: https://www.iqair.com/world-most-polluted-countries (accessed on 2 February 2023).
11. WHO. WHO Global Air Quality Guidelines. Available online: https://www.who.int/news-room/questions-and-answers/item/who-global-air-quality-guidelines (accessed on 2 February 2023).
12. The State Environmental Protection Administration of the People's Republic of China. *2021 Bulletin on China's Ecological Environment*; The State Environmental Protection Administration of the People's Republic of China: Beijing, China, 2022.
13. EPI. China | Environmental Performance Index. Available online: https://epi.yale.edu/epi-results/2022/country/chn (accessed on 29 January 2023).
14. Bereznev, S.; Zonova, O.; Kulpina, E. Environmental Performance Index: Regional Aspect. *E3S Web Conf.* **2018**, *41*, 02003. [CrossRef]
15. Sheng, Q.Y.; Zhou, Q. Environmental Decentralization, Government Hierarchy and Environmental Performance: An Empirical Research Based on the 78 Countries Data. *NJ J. Soc. Sci.* **2017**, *04*, 20–26. (In Chinese) [CrossRef]
16. Chen, L.; Lin, Q.; Li, X.X.; Wen, C.H. Performance Evaluation and Influencing Factors Analysis of Rural "Sansheng" Environmental Governance in China. *Stat. Decis.* **2022**, *38*, 88–92. (In Chinese) [CrossRef]
17. Li, Y.L.; Li, Z.C. Intergovernmental Cooperation, Financial Autonomy, and Regional Environmental Governance Performance: Based on the Analysis of Beijing Tianjin Hebei and Yangtze River Delta Urban Agglomerations. *Urban Probl.* **2022**, *02*, 13–22. (In Chinese) [CrossRef]
18. Liu, W.; Fan, W.Y. Does Public Interest Litigation Promote the Performance of Urban Environmental Governance? An Empirical Study Based on Micro-data of 287 Prefecture-level Cities. *J. Sufe* **2021**, *23*, 48–62. (In Chinese) [CrossRef]
19. Zaim, O.; Taskin, F. Environmental Efficiency in Carbon Dioxide Emissions in the OECD: A Non-Parametric Approach. *J. Environ. Manag.* **2000**, *58*, 95–107. [CrossRef]
20. Pan, Y.; Chen, Q.P.; Dai, Y.Y. Environmental Assessment and Local Environmental Management: Evidence from the Replacements of the Municipal Party Secretaries. *J. XMU Arts Soc. Sci.* **2017**, *239*, 23–32. (In Chinese)
21. Ren, B.P.; Lv, C.H. Changing Trend and Spatial Distribution Pattern of Ecological Environment Quality in China. *Rev. Econ. Manag.* **2019**, *35*, 120–134. (In Chinese) [CrossRef]
22. Tang, H.; Tie, W.; Zhong, F. Research on Spatial Spillover Effects of China's Environmental Governance Level. *J. Stat. Inform.* **2022**, *37*, 75–89. (In Chinese)

23. Li, Z.; Dong, H.; Huang, Z.; Failler, P. Impact of Foreign Direct Investment on Environmental Performance. *Sustainability* **2019**, *11*, 3538. [CrossRef]
24. Behera, P.; Sethi, N. Nexus between Environment Regulation, FDI, and Green Technology Innovation in OECD Countries. *Environ. Sci. Pollut. Res.* **2022**, *29*, 52940–52953. [CrossRef]
25. Zhang, J.; Zhang, Z.; Ballesteros-Pérez, P.; Skitmore, M.; Yang, G.; Philbin, S.P.; Lu, Q. Factors Influencing Environmental Performance: A Bibliometric Review and Future Research Agenda. *Int. J. Urban Sci.* **2021**, *27*, 543–569. [CrossRef]
26. Wang, S.F.; Cheng, L.W. Industrial Structure, Open Trade and Haze Pollution Control: Based on Research on Spatial Panel Double Model of 27 Cities in the Central Area of Yangtze River Delta. *J. CQUT Soc. Sci.* **2021**, *35*, 68–78. (In Chinese) [CrossRef]
27. Ai, H.; Deng, Z.; Yang, X. The Effect Estimation and Channel Testing of the Technological Progress on China's Regional Environmental Performance. *Ecol. Indic.* **2015**, *51*, 67–78. [CrossRef]
28. Esquivias, M.A.; Sugiharti, L.; Rohmawati, H.; Rojas, O.; Sethi, N. Nexus between Technological Innovation, Renewable Energy, and Human Capital on the Environmental Sustainability in Emerging Asian Economies: A Panel Quantile Regression Approach. *Energies* **2022**, *15*, 2451. [CrossRef]
29. Wu, L.B.; Yan, M.M.; Sun, K.K. Impact of Public Environmental Attention on Environmental Governance of Enterprises and Local Governments. *China Popul. Resour. Environ.* **2022**, *32*, 1–14. (In Chinese)
30. Qi, Y.; Lu, H.Y.; Lv, C.Y. Social Capital, Institutional Environment and Environmental Governance Performance: Evidence from Chinese Cities. *China Popul. Resour. Environ.* **2015**, *25*, 45–52. (In Chinese)
31. Ma, P.C.; Zhu, Y.C. Did the Establishment of Village-level River Chief Improve the Performance of Rural Water Environment Governance? Based on the Counter-Factual Estimation of the Propensity Score Matching (PSM). *J. NJAU Soc. Sci.* **2022**, *22*, 149–159. (In Chinese) [CrossRef]
32. Xu, Y.Z.; Fan, X.M.; Tong, H.Y. Does Environmental Decentralization Affect Environmental Management Performance? *J. CUG Soc. Sci.* **2021**, *21*, 110–124. (In Chinese) [CrossRef]
33. John, L.; Gerking, S. Regulatory Federalism and Environmental Protection in the United States. *J. Reg. Sci.* **2002**, *40*, 453–471. [CrossRef]
34. Zhou, L.A. Governing China's Local Officials: An Analysis of Promotion Tournament Model. *Econ. Res. J.* **2007**, *7*, 36–50. (In Chinese)
35. Li, H.X.; Wang, X.W.; Liu, L.J. Will Intergovernmental Cooperation Help Improve Regional Environmental Governance Performance? Analysis Based on the Structural Difference Perspective. *Reform. Econ. Syst.* **2022**, *2*, 18–25. (In Chinese)
36. Xu, M.; Li, J.; Ping, Z.; Zhang, Q.; Liu, T.; Zhang, C.; Wang, H. Can Local Government's Attention Allocated to Green Innovation Improve the Green Innovation Efficiency?—Evidence from China. *Sustainability* **2022**, *14*, 12059. [CrossRef]
37. Li, Z.C.; Li, Y.L. Horizontal Cooperation and Vertical Intervention: How does Inter-governmental Cooperation Affect Environmental Governance? A Comparative Study Based on Three Urban Agglomerations. *Public Admin. Policy Rev.* **2022**, *11*, 36–48. (In Chinese)
38. Zhang, Z.B. From Race-to-the-bottom to Strategic Imitation: How does the Ecological Transformation of Government Performance Assessment Affect the Competing Strategy of Environmental Governance across Chinese Local Governments. *J. Public Admin.* **2020**, *13*, 114–131+211–212. (In Chinese)
39. Wu, J.; Yang, J.; Zhou, Z. How Does Environmental Regulation Affect Environmental Performance? A Case Study of China's Regional Energy Efficiency. *Expert Syst.* **2020**, *37*, e12326. [CrossRef]
40. Cao, H.; Zhang, L.; Qi, Y.; Yang, Z.; Li, X. Government Auditing and Environmental Governance: Evidence from China's Auditing System Reform. *Environ. Impact. Assess. Rev.* **2022**, *93*, 106705. [CrossRef]
41. Wang, H.; Yin, J.Y. Environmental Governance Effects of Local Complex: An Empirical Study Based on the Perspective of Official Heterogeneity. *J. YNUFE* **2019**, *35*, 80–92. (In Chinese) [CrossRef]
42. Zhang, C.; Zhou, G.S.; Deng, Z.P. Fiscal Decentralization, Characteristics of Official and Ecological Efficiency: Empirical Research Based on Provincial Data from 2003 to 2017. *Fisc. Sci.* **2021**, *07*, 51–66. (In Chinese) [CrossRef]
43. Fu, C.F. An Economic Analysis of Environment Governance Performance of Local Government: Empirical Evidence from 196 Prefecture-level Cities in China. *J. Technol. Econ.* **2020**, *39*, 193–199. (In Chinese)
44. Wu, P.C.; Wang, Z. The impact of official turnover on urban environmental pollution: Based on panel data of prefecture level cities. *Urban Probl.* **2016**, *05*, 74–81. (In Chinese) [CrossRef]
45. Zang, C.Q.; Chu, S. Local Officials' Characteristics, Exchange and Environmental Management: Empirical Evidence from 25 Provincial Units of China in 2003–2013. *Collect. Essays Financ. Econ.* **2016**, *11*, 105–112. (In Chinese) [CrossRef]
46. Lu, Z.F.; Deng, W.M.; Zhu, W.W. Dynamic Evaluation of Ecological Environment Governance Performance of Jiangsu Province: Based on PCA-SBM and TFP Index. *E China Econ. Manag.* **2019**, *33*, 32–38. (In Chinese) [CrossRef]
47. Lin, C.; Sun, Y.J. The Relationship between Fiscal Decentralization and China's Environmental Governance Performance: Empirical Test Based on Provincial Panel Data. *Reform. Econ. Syst.* **2019**, *2*, 150–155. (In Chinese)
48. Lu, Z.; Deng, W.; Zhu, W. Performance Evaluation of Provincial Environmental Governance in China. *Stat. Decis.* **2021**, *37*, 70–74. (In Chinese) [CrossRef]
49. Song, M.; Zhang, G.; Fang, K.; Zhang, J. Regional Operational and Environmental Performance Evaluation in China: Non-Radial DEA Methodology under Natural and Managerial Disposability. *Nat. Hazards* **2016**, *84*, 243–265. [CrossRef]

50. Yang, B. The Economic Zoning of China into the Eastern, Central, and Western Regions Unsuitable for the Requirements of Development. *J. GUFE* **2007**, *4*, 40–47. (In Chinese)
51. Liu, H.J.; Qiao, L.C.; Shi, Y. Comparative Study on Ecological Efficiency of Yangtze River Economic Belt and Yellow River Basin from the Perspective of Major National Strategic Regions. *China Soft. Sci.* **2021**, *10*, 73–81. (In Chinese)
52. Qiu, Z.L. An Analysis of Ecological Efficiency Differences and the Causes between the Yangtze River Economic Belt and the Yellow River Basin. *Contemp. Econ. Manag.* **2022**, *44*, 39–49. (In Chinese) [CrossRef]
53. Tian, Z.; Pan, J.J.; Ren, F.R.; Mao, C.M. Research on Ecological Efficiency Evaluation and Influencing Factors of China's Three Major River Basins under the Background of Great Protection. *Soft Sci.* **2022**, *36*, 91–97. (In Chinese) [CrossRef]
54. Guo, H.; Ren, B.P. Spatial Governance of High-quality Development in the Yellow River Basin: Mechanism Interpretation and Practical Strategies. *Reform* **2020**, *4*, 74–85. (In Chinese)
55. Central Government of the People's Republic of China. *Outline of Ecological Protection and High Quality Development Plan for the Yellow River Basin*; The Central Committee of the Communist Party of China, The State Council of the People' s Republic of China: Beijing, China, 2021.
56. Central Government of the People's Republic of China. *The Guiding Opinions on Relying on the Golden Waterway to Promote the Development of the Yangtze River Economic Belt*; The State Council of the People' s Republic of China: Beijing, China, 2014.
57. Ministry of Water Resources, China. *The Comprehensive Plan for the Pearl River Basin (2012–2030)*; Pearl River Water Conservancy Commission: Guangzhou, China, 2013.
58. *ISO/TC 207/SC 4*; Environmental Performance Evaluation; ANSI Environmental Management—Environmental Performance Evaluation—Guidelines. 2021. Available online: https://www.iso.org/standard/81453.html (accessed on 7 February 2024).
59. EPI. Environmental Performance Index. Available online: https://epi.yale.edu/ (accessed on 30 January 2023).
60. Du, X.R.; Liu, Y.H. Evaluation and Application of Lake Environmental Governance Performance Based on PSR Model. *Resour. Ind.* **2022**, *24*, 146–158. (In Chinese) [CrossRef]
61. Guo, X.G. Entropy Method and its Application in Comprehensive Evaluation. *Financ. Trade Res.* **1994**, *12*, 56–60. (In Chinese) [CrossRef]
62. He, Y.X.; Jiao, Z.; Yang, J. Comprehensive Evaluation of Global Clean Energy Development Index Based on the Improved Entropy Method. *Ecol. Indic.* **2018**, *88*, 305–321. [CrossRef]
63. Lefever, D.W. Measuring Geographic Concentration by Means of the Standard Deviational Ellipse. *Am. J. Sociol.* **1926**, *32*, 88–94. [CrossRef]
64. Zhang, Z.Q.; Zhang, T.; Feng, D.F. Study on Regional Differences, Dynamic Evolution and Convergence of Carbon Emission Intensity in China. *J. Quant. Technol. Econom.* **2022**, *39*, 67–87. (In Chinese) [CrossRef]
65. Barro, R.J. Convergence. *J. Political Econ.* **1992**, *100*, 223–251. [CrossRef]
66. Zhang, W.; Bai, Y.X. Research on Regional Differences, Distribution Dynamic Evolutionand and Spatial Correlation of China's Rural Revitalization Level. *J. Quant. Technol. Ecno.* **2022**, *39*, 84–102. (In Chinese) [CrossRef]
67. Elhorst, J.P. *Spatial Econometrics: From Cross-Sectional Data to Spatial Panels*; Briefs in Regional Science; Springer: Berlin/Heidelberg, Germany, 2014; ISBN 978-3-642-40339-2.
68. Zhang, C.; Liu, T.; Li, J.; Xu, M.; Li, X.; Wang, H. Economic Growth Target, Government Expenditure Behavior, and Cities' Ecological Efficiency—Evidence from 284 Cities in China. *Land* **2023**, *12*, 182. [CrossRef]
69. The State Council of the People's Republic of China. The 12th Five-Year Plan for National Environmental Protection. 2011. Available online: https://www.gov.cn/zwgk/2011-12/20/content_2024895.htm (accessed on 7 February 2024).
70. Central Government of the People's Republic of China. Chinese Leader Hu Jintao Delivered a Report on Thursday at the Opening of the 18th National Congress of the Communist Party of China. 2012. Available online: http://cpc.people.com.cn/n/2012/1118/c64094-19612151.html (accessed on 7 February 2024).

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