sustainability

MDPI

Article

Coupling Coordination Relationship and Dynamic Response between Urbanization and Urban Resilience: Case of Yangtze River Delta

Kunjie Peng, Xiaorong He * and Chunxiao Xu *

College of Tourism, Hunan Normal University, Changsha 410081, China
* Correspondence: hxr@hunnu.edu.cn (X.H.); 10939@hunnu.edu.cn (C.X.)

Abstract: In the context of rapid urbanization, urban resilience, as a new way of thinking to seek solutions to urban risk crises, has become an important direction and a new development trend in the continued acceleration of urbanization. This study takes the Yangtze River Delta (YRD) as the study object, establishes a comprehensive evaluation index system of urbanization and urban resilience from a multi-dimensional perspective based on the improved entropy value method, and uses the coupling coordination degree (CCD) model, the kernel density estimation method, and the exploratory spatial data analysis (ESDA) method to investigate the spatio-temporal evolution trends of the CCD level of urbanization and urban resilience. Further, the dynamic response relationship of the coupling between the two systems is revealed by the PVAR model. The study results are shown as follows: (1) The urbanization level and the urban resilience level show a box-shaped clustering of overall urbanization values and urban resilience values, with a widening absolute gap between extreme value cities. (2) The kernel density estimates of CCD values for urbanization and urban resilience show an upward trend in the overall level of CCD, with regional integration replacing multi-level differentiation. (3) The level of CCD shows a continuous upward trend in terms of the spatial distribution characteristics of CCD, and the high-class area shows regional integration. (4) The spatial agglomeration trend of CCD continues to develop, reaching a region-wide hot spot agglomeration. (5) The PVAR model indicates that there is a dynamic response relationship between the urbanization system and the urban resilience system. Finally, based on the above research results, this study gives policy recommendations for the coordination and sustainable development of the urbanization system and the urban resilience system, providing some academic references for the relevant departments in the YRD to accelerate urbanization, enhance the urban resilience level, and promote regional integration.

Keywords: urbanization; urban resilience; coupling coordination; spatio-temporal evolution; dynamic response; the Yangtze River Delta

Citation: Peng, K.; He, X.; Xu, C. Coupling Coordination Relationship and Dynamic Response between Urbanization and Urban Resilience: Case of Yangtze River Delta. *Sustainability* **2023**, *15*, 2702. https://doi.org/10.3390/su15032702

Academic Editor: Agnieszka Bieda

Received: 21 November 2022
Revised: 17 January 2023
Accepted: 29 January 2023
Published: 2 February 2023

1. Introduction

With the acceleration of urbanization and globalization, cities have become a place where people gather. More than half of the population lives in cities, and human beings are ushering in a veritable "urban era". As the world's largest developing country, China's urbanization rate has increased rapidly since its reform and opening in 1978. By 2019, 60.60% of the national population lived in cities [1]. The impact of urbanization is multi-faceted, especially in China, where the accelerated urbanization process has brought many benefits to cities and residents, but it has triggered a series of negative issues. For example, urbanization has resulted in the concentration of heavy industries in cities, with many large chemical bases and oil refineries, seriously threatening the ecological safety of China's major cities; meanwhile, urbanization has led to the overcrowding of urban population, forced the overdevelopment of land, and pushed the intensity to the limit, causing a serious security risk for social security, food security, and sustainable development in Chinese cities. In addition, urbanization has also brought about various urban diseases, resulting in a series of problems, such as shrinking resources, ecological degradation, environmental pollution, population expansion, and traffic congestion in Chinese cities [2–4]. These problems are difficult to solve and make large economic downward pressure and ecological security pressure on Chinese cities to continue to grow, which will seriously challenge the sustainable development of cities in the long run. Urban resilience, as a new way to seek solutions to urban risk crises, can effectively compensate for the limitations of the traditional risk management model based on defensive means and better promote sustainable urban development [5].

Building resilient cities has become an important direction and a new trend for further healthy urbanization in China, and it is also a research hot topic in the field of urban planning and risk management at present [6]. The Yangtze River Delta (YRD) is one of the regions with the best urbanization foundation, the most complete industrial system, and the strongest comprehensive strength in China, and it plays an important role in China's regional integration and economic growth. Led by Shanghai, the leading cities in the YRD, i.e., a group of dynamic, economically developed, open and inclusive, and innovative cities, have developed in concert and driven the YRD to become a crucial growth pole that promotes China's rapid economic growth [7]. The starting hypothesis of this study is that by introducing urban resilience, exploration of the coupling and coordination relationship between urbanization and urban resilience in the YRD and promotion of the coordination and sustainable development of both is conducive to discovering the differences in urbanization levels in the region and effectively identifying the weak links in urban risk prevention and control. The objective of this study is to quantify the spatial and temporal evolutionary trends and the interactive response relationship of coupling and coordination between the urbanization system and urban resilience system in the YRD using a rational and scientific research method, thus, forming a new model of sustainable urban development that can be replicated and scaled up. This will open the research results to scholars in the fields of urbanization, urban resilience, sustainable development, coupled coordination, and urban agglomerations and provide important theoretical references for in-depth explorations of related fields. Further, it is of great practical significance for other rising regions in China and even urban agglomerations in the world to build high-quality resilient cities.

Urbanization is a process of socio-economic transformation and acceleration, which includes a decrease in the agricultural population and an increase in the urban population, the expansion of urban land to the suburbs, as well as the transformation of urban society, economy, and technology to the suburbs and rural areas [8]. The term "resilience" originated from the field of mechanical engineering, and it was introduced into the study of ecology by the Canadian scholar Holling, and gradually spread to other disciplines [9]. Urban resilience refers to the risk-proof, shock-resistant, and sustainable ability of cities to deal with the perturbations of various factors in the urban and external environments by adjusting the internal elements and structures of the system, thus, transforming the system from low to high levels [10]. It can be seen that both urbanization and urban resilience should be explored from multiple dimensions, perspectives, and factors to investigate their integrated development levels. The term "coupling" originated from physics and refers to a phenomenon in which two or more mutually independent substances and systems are interconnected, interact, and influence each other [11]. Commonly used research methods for coupling include the coupling coordination degree (CCD) model, impulse response function, system dynamics model, and spatial Durbin model [12].

The dynamic coupling between urbanization and urban resilience is reflected by the fact that both are composed of economic, social, ecological, and other urban subsystems [13]. The two systems complement each other with a strong coupling relationship. When the two systems are coupled and coordinated, improvements in the urbanization level help to improve the urban resilience level, while the high resilience level can effectively improve the urbanization level, and the two systems jointly promote improvements in comprehensive urban level; however, when the coupling of the two systems is dysfunctional, the rapid social transformation caused by the rapid urbanization process has many negative impacts on urban resilience building, thus, restricting further improvements in the urbanization level. Thus, the two systems together hinder comprehensive urbanization level improvement. To reduce the disadvantages of urban development caused by coupling dysfunction, better integrate the concept of urban resilience into the accelerated urbanization progress, and make regional development more coordinated, high quality, and sustainable, this study combines the urbanization system and the urban resilience system into one by considering them as two subsystems of urban CCD level. Then, this study selects many indicators, calculates the values of the urbanization level and urban resilience level, and uses the CCD model to calculate the CCD level of urbanization and urban resilience. Thus, this study is more scientific and comprehensive.

After years of development, urbanization research has formed the following mainstream research directions in recent years: research on urbanization-level measurement [14,15], construction of urbanization evaluation index systems [16,17], analysis of urbanization influence factors [18,19], exploration of urbanization efficiency [20,21], research on urban development paths [22,23], and research on integration and development of urbanization and other systems [24,25]. These research works are rich in content and show the development trend of outreach to other disciplinary research fields. Specifically, the study of urban resilience has explored the definition of urban resilience [26,27], theoretical framework [28,29], index system construction [30,31], resilience-level detection [32,33], evaluation method exploration [34,35], improvement strategy research [36,37], etc. The field has been expanded and refined with the exploration of numerous studies and has gradually become a new research hot spot. As an inevitable product of urban development, there is a strong interrelationship between urbanization and urban resilience. Therefore, it is necessary and urgent to investigate the relationship between urbanization and urban resilience to fully understand the current urbanization level and urban resilience level. Zhang et al. [38] proposed a socio-ecological resilience evaluation method to explicitly examine the impact of urbanization on resilience and explore how socio-ecological governance of urban ecosystem resilience can be strengthened. Dixson et al. [39] illustrated that the resilience of urban communities is weakening in the context of rapid urbanization and climate change. Rogerson et al. [40] took Newcastle as an example to explore the relationship regarding urbanization, transformation, and resilience. Botezat et al. [41] investigated the impact of administrative reforms of urbanization on the resilience of urban communities. Gao et al. [42] explored the coupling relationship between urban resilience and urbanization quality by taking Liaoning Province as an example. Rybak-Niedziolka et al. [43] improved urbanization by establishing an integrated model that considers the resilience of spatial development of urban riverfront areas. Li et al. [44] pointed out that population urbanization exacerbates the deterioration of natural ecosystems and the decline in ecosystem vitality, and urban resilience limits the sustainability of urbanization. Wang et al. [45] developed a "scale-density-morphology" urban ecological resilience evaluation system and used the CCD model to measure the CCD level between urbanization and ecological resilience in the Pearl River Delta from 2000 to 2015; also, they discussed the spatial and temporal evolution characteristics in depth.

Though the research on urbanization and urban resilience is relatively mature in their respective fields, the exploration of the relationship between the two is still limited and has the following problems: (1) In terms of research perspective, there are fewer studies exploring the spatial and temporal evolution characteristics of urbanization and urban resilience from a two-dimensional perspective of geographic time and space, by taking a typical research area (e.g., an urban agglomeration, integration area) as the research object. (2) In terms of research content, there are fewer studies investigating the relationship between urbanization and urban resilience, there is a lack of research to empirically prove the relationship between the two from the perspective of coupling coordination, and the scientificity of the index system needs to be further verified. (3) In terms of research methods, existing studies usually detect the urbanization level and urban resilience through qualitative description and spatial measurement, whereas the spatial distribution, spatial differences, and spatial agglomeration of the CCD index of urbanization and urban resilience are less explored by using the spatial visualization method of geography. Our study aims to explore the relationship between urbanization and urban resilience, and it attempts to answer the following four questions: First, from which dimensions is it more scientific and reasonable to construct the urbanization and urban resilience index system in the YRD? Second, what is the level of urbanization and urban resilience? Third, what is the spatial and temporal evolution trend of the CCD of urbanization and urban resilience? Fourth, what type of interaction relationship exists between urbanization and urban resilience? To answer these questions, this study constructs a comprehensive evaluation index system of urbanization and urban resilience from perspectives of population, economy, ecology, society, land, infrastructure, etc. Taking the YRD, a typical region, as a case study, and using interdisciplinary research methods, such as the geography spatial analysis method, the economics spatial measurement method, and the physics CCD model, this study explores the level of urbanization and urban resilience, detects the spatial and temporal evolution trend of the CCD level of urbanization and urban resilience, and reveals the dynamic response relationship of the coupling between the two systems by combining qualitative and quantitative research methods. Finally, based on the research results, policy recommendations are given for the coordination and sustainable development of the urbanization system and the urban resilience system. This study provides certain academic references for the relevant departments in the YRD to improve urbanization, enhance the level of urban resilience, and promote regional integration.

The rest of this paper is organized as follows: Section 2 introduces the study area and constructs a comprehensive evaluation index system for urbanization and urban resilience, including the research methods and data sources. Section 3 explores the spatial–temporal evolution trend and dynamic response relationship of the CCD of urbanization and urban resilience in the YRD by using various disciplinary research methods. Section 4 discusses and analyzes the possible reasons for the above results and proposes corresponding policy recommendations to improve the coordinated sustainable development of urbanization and urban resilience in the YRD. Finally, this paper is concluded, and the contributions and limitations are described.

2. Materials and Methods

2.1. Study Area

Covering an area of 358,000 km^2 and accounting for about a quarter of China's total economic output, the YRD is a region with the most active economic development, the highest degree of openness, and the strongest innovation capacity in China. It has a pivotal strategic position in the overall national modernization and all-round opening pattern. However, the CCD of urbanization and urban resilience in the region is at different levels, thus, expanding the absolute gap between the two systems of cities in the YRD. Meanwhile, the integration level needs to be improved, and it is urgent to assess the resilience of cities to risks. Therefore, under the new development concept of "integrated development" and "high-quality development" in the YRD, the focus is to improve the level of CCD between the urbanization system and urban resilience system and improve regional integration and high-quality development capacity (Figure 1).

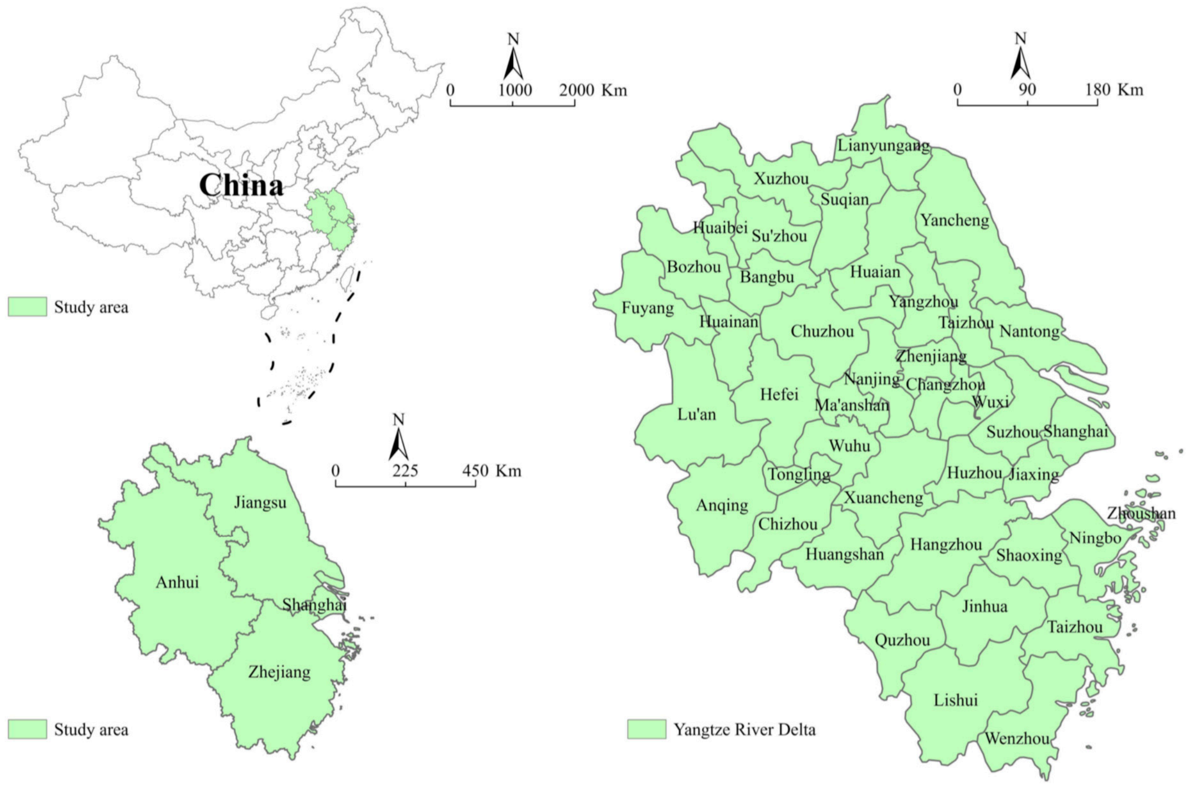

Figure 1. Location map of the YRD.

2.2. Research Methods

2.2.1. Improved Entropy Method

There are inconsistencies in the units and magnitudes of the indicators of each dimension of urbanization and urban resilience. To eliminate such inconsistencies, the indicators need to be dimensionless and normalized to facilitate comprehensive calculations and comparative analysis. In this study, the original data are dimensionless by using the extreme value standardization method [45]. After dimensionless processing, the data are standardized values, and the weights of the indicators can be obtained by the improved entropy method. The entropy method is an objective weighting method to find the weights, and the weighting values of different indicators can be determined by the correlation between the raw data of each indicator. By objectively reflecting the weights of each indicator, this method has a higher degree of credibility than the artificial subjective weighting method, so it is widely used in the calculation of indicator weights [13,46]. In contrast, the improved entropy method determines the unique weights of each indicator based on the entropy of each indicator and adds the time variable, which has higher credibility than the traditional entropy method [47]. After using the improved entropy method to obtain the weights of each indicator, the standardized values of each indicator of urbanization and urban resilience are multiplied with their corresponding weights and weighted to obtain the required level values of urbanization and urban resilience.

2.2.2. CCD Model

The computational measurement of the CCD model contains two main components: the coupling degree model and the CCD model. The coupling degree model mainly measures the existence of interactions between systems, and it is adopted in this study as a reference to measure the intensity of interactions between the urbanization system (U_1) and the urban resilience system (U_2). The calculation formula of coupling degree is as follows [48].

$$C = \left[U_1 \times U_2 / ((U_1 + U_2)/2)^2 \right]^{1/2} \tag{1}$$

where U_1 is the integrated evaluation value of the urbanization system, U_2 is the integrated evaluation value of the urban resilience system, and C is the coupling degree. The value of the coupling degree is taken between 0 and 1.

The coupling degree model can only indicate the existence of interactions between systems, but it cannot objectively reflect the level of CCD between systems [49]. To address this issue, this paper establishes a CCD model to measure the state and level of coordination development between the two systems with reference to previous literature. The calculation formula of the CCD is as follows [50].

$$D = \sqrt{C \times T} \quad T = \partial U_1 + \beta U_2 \tag{2}$$

where D is the CCD of the urbanization system and urban resilience system, which takes a value between 0 and 1; T is the comprehensive evaluation value the of urbanization system and urban resilience system; α and β are undetermined coefficients, where $\alpha + \beta = 1$. Since the acceleration ability of the urbanization system is as important as the protection ability of the urban resilience system, the value is selected as $\alpha = \beta = 0.5$. According to the previous literature [1], this study classifies the CCD level into five classes: serious disorder (0.0–0.2), moderate disorder (0.2–0.4), bare coordination (0.4–0.6), moderate coordination (0.6–0.8), and excellent coordination (0.8–1.0).

2.2.3. Kernel Density Estimation Method

The Kernel density estimation method is a nonparametric test for estimating a smooth empirical probability density function, and it is a common spatial analysis technique to describe the spatially distributed intensity of geographic events [51]. In this study, the three-dimensional kernel density estimation method is adopted to compare and analyze the distribution characteristics of the CCD values of the urbanization system and urban resilience system for multiple consecutive years to explore the absolute differences and change characteristics of the development of CCD of the urbanization system and urban resilience system in the YRD.

The calculation principle is to estimate the random variable density function $f(x) = f(x_1, x_2, x_3)$, where x_1, x_2, and x_n are independently distributed samples. The formula for estimating the probability density of the random variable at point x is as follows [52].

$$f(x) = \frac{1}{Nh}\sum_{i=1}^{n} K\left(\frac{X_i - x}{h}\right) \tag{3}$$

where N is the total number of samples, and there are 41 geographical units in the YRD; K is the random kernel function; h is the bandwidth of density estimation, and the larger the bandwidth, the smoother the density estimation and the larger the bias.

2.2.4. ESDA Method

The exploratory spatial data analysis (ESDA) method can be employed to explore the spatial distribution, aggregation, and association of research objects. In this study, the ESDA method is used to analyze the overall spatial correlation and spatial agglomeration of the CCD of urbanization and urban resilience.

The ESDA method includes global spatial autocorrelation analysis and local spatial autocorrelation analysis. In this study, global spatial autocorrelation is exploited to describe the spatial characteristics of CCD across the study area, and Moran's I value is taken as a computational metric to measure the global spatial autocorrelation. The calculation formula is shown below [53].

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\sum_{i=1}^{n}(x_i - \overline{x})^2} \tag{4}$$

where n is the geographical unit number in the study area, x_i (x_j) is the value of x of geographical unit i(j); $\overline{x}$ is the average value of the attribute values; W_{ij} is the binary adjacency matrix, and according to the common boundary rule, if region i is adjacent to region j then W_{ij} = 1, otherwise W_{ij} = 0. The calculated Moran's I value has three possibilities: (1) positive correlation for Moran's $I > 0$, and the larger the value, the more significant the spatial correlation; (2) negative correlation for Moran's $I < 0$, and the smaller the value, the greater the spatial variability; (3) random distribution for Moran's $I = 0$.

Local spatial autocorrelation is used to characterize the spatial agglomeration of the CCD in the study area, and Getis–Ord G^* is taken as a computational measure of local spatial autocorrelation. The calculation formulas are presented below [54].

$$G^* = \frac{\sum_{j=1}^{n} W_{ij} x_j - \overline{x}_j \sum_{j=1}^{n} W_{ij}}{S\sqrt{\frac{\sum_{j=1}^{n} {W_{ij}}^2 - \left(\sum_{j=1}^{n} W_{ij}\right)^2}{n-1}}} \tag{5}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} {x_j}^2}{n} - \overline{x}^2} \tag{6}$$

where x_j is the observed indicator D; S is the stand value of j. Getis–Ord G^* reflects the spatial agglomeration characteristics of the observations by hot spots and cold spots on the map, and if there are more hot spots, the spatial agglomeration of the region is significantly increased.

2.2.5. PVAR Model

The PVAR model is a panel vector autoregressive model whose modeling ability is usually not limited by economic theory, and it can exclude the constraints of endogeneity and homogeneity of variables. In the PVAR model, the interaction effects between systems, the degree of shocks, and the degree of contribution are explained mainly through impulse response functions and variance decomposition [55]. The model is used in this study to explain the dynamic response relationship between the urbanization system and the urban resilience system. The PVAR model developed in this study is expressed as follows [56].

$$y_{it} = a_0 + \sum_{j=1}^{p} a_j y_{i,t-p} + \eta_i + \mu_t + \varepsilon_{it} \tag{7}$$

where i and t represent region and time, a_0 denotes the intercept term, a_j is the parameter matrix, p is the number of lags; $y_{i,t-p}$ is the p-order lag term of y_{it}, η_i denotes the individual effect vector, μ_t denotes the time effect vector, and ε_{it} is the random perturbation term.

2.3. Construction of Evaluation Indicator System

Through the previous conceptual analysis and the literature review of urbanization and urban resilience, it is clear that the dynamic coupling between urbanization and urban resilience is reflected by the fact that both systems are composed of economic, social, ecological, and other urban subsystems and the number of indicator dimensions of both systems should be approximately equal. According to the index systems constructed in the existing literature, the urbanization system index is constructed mainly from the population, economic, social, and land (spatial) dimensions [6,52,57–60], and the urban resilience system index is constructed mainly from the economic, social, ecological, and infrastructure (engineering) dimensions [1,6,42,46,58,59,61,62]. Therefore, to collect and screen indicators, this study follows the principles of scientificity, comparability, and accessibility of indicator collection and combined them with previous work on the dimensions of urbanization and urban resilience indicator system construction. Finally, 12 urbanization indicators and

16 urban resilience indicators are selected, which constitute a comprehensive evaluation indicator system of urbanization and urban resilience (Table 1).

Table 1. The comprehensive evaluation index system of urbanization and urban resilience.

	Criterion Layer	Index Layer	Units	Indicator Meaning	Literature Sources	Weight
Urbanization	Economic urbanization	GDP growth rate	(%)	Urban economic development level	Wan et al. [57]	0.0144
		Fiscal revenue per capita	(yuan/person)	Urban government economic strength	Zeng, Wei and Duan. [52]	0.1771
		Social fixed asset investment per capita	(yuan/person)	Urban infrastructure capacity building	Wan et al. [57]	0.0921
	Population urbanization	Urbanization rate	(%)	Degree of urbanization	Xiong et al. [6]	0.0384
		Percentage of employment in the secondary and tertiary sector	(%)	Healthy level of urban employment structure	Chan and Lee. [58]	0.0112
		Population density of a built-up area	(people/km^2)	Urban population pressure	Zeng, Wei and Duan. [52]	0.0145
	Social urbanization	Total retail sales of consumer goods per capita	(yuan/person)	Urban spending power	Wang et al. [59]	0.1396
		Per capita disposable income of urban residents	(yuan/person)	Income level of urban residents	Wang et al. [59]	0.0778
		Average salary level of on-post employees	(yuan/person)	Urban employee income levels	Wan et al. [57]	0.0770
	Land urbanization	The proportion of built-up area in a total urban area	(%)	Land area available for use in the city	Zhou et al. [60]	0.1698
		Urban housing area per capita	(m^2/people)	Risk of urban land conflicts	Xiong et al. [6]	0.1326
		Urban road area per capita	(m^2/people)	Urban traffic convenience	Zhou et al. [60]	0.0555
Urban resilience	Economic resilience	GDP per capita	(yuan)	Urban total economic level	Hong, Wang and Li. [61]	0.0672
		The share of second and third industries in GDP	(%)	Urban advanced level of industrial structure	Wang et al. [59]	0.0310
		Year-end balance of urban resident savings per capita	(yuan/person)	Urban residents' saving capacity	Ma et al. [46]	0.0982
		The proportion of science and technology expenditure in financial expenditure	(%)	Urban scientific research investment level	Luo et al. [1]	0.0772
	Ecological resilience	Green coverage rate in built-up areas	(%)	Degree of urban greening construction	Ma et al. [46]	0.0067
		Park green area per capita	(m^2/people)	Urban capacity to maintain the ecological environment	Chan and Lee. [58]	0.0346
		The comprehensive utilization rate of industrial solid waste	(%)	Urban solid waste disposal capacity	Luo et al. [1]	0.0052
		Urban sewage treatment rate	(%)	Urban wastewater treatment capacity	Luo et al. [1]	0.0129
	Social resilience	The number of doctors per 10,000 people in the municipal area	(person/10,000 people)	Urban medical treatment capacity	Gao and Chen. [42]	0.0488
		Urban registered unemployment rate	(%)	Urban social security risks	Chan and Lee. [58]	0.0010
		The number of college students per 10,000 people in the municipal area	(person/10,000 people)	Urban innovation capacity	Gao and Chen. [42]	0.1483
		Post and telecommunications business volume per capita	(yuan/person)	Urban postal and telecommunications communication capacity	Xiong et al. [6]	0.1342
	Infrastructure resilience	Drainage pipeline density in the municipal district	(km/km^2)	Urban capacity to cope with flooding	Li et al. [62]	0.0355
		Bus number per 10,000 people	(vehicle/10,000 people)	Intra-city traffic operation capacity	Hong, Wang and Li. [61]	0.0468
		The number of hospital beds per 10,000 people	(beds/10,000 people)	Level of urban medical infrastructure	Ma et al. [46]	0.1202
		The number of mobile phone users per 10,000 people	(households/10,000 people)	Urban instant messaging level	Li et al. [62]	0.1320

2.4. Data Sources and Processing

This study selects panel data on a total of 28 indicators of the urbanization system and urban resilience system for 41 cities in the YRD during 2010–2019. Specifically, the data of GDP growth rate, urbanization rate, total retail sales of consumer goods per capita, the share of second and third industries in GDP, the comprehensive utilization rate of industrial solid waste, urban sewage treatment rate, the number of doctors per 10,000 people in the municipal area, bus number per 10,000 people, and many other indicators are obtained from the China City Statistical Yearbook (2011–2020) and the statistical yearbooks and statistical bulletins of provinces and cities in the YRD. Meanwhile, the data of the proportion of built-up area in a total urban area, urban housing area per capita, urban road area per capita, green coverage rate in built-up areas, park green area per capita and drainage pipeline density in the municipal district are obtained from the China City Construction Statistical Yearbook (2011–2020). The treatment of missing data in this study is as follows: for some indicators with data from 2010–2017 and missing data for 2018 and 2019, the average annual growth rate is used to interpolate the missing data; for some indicators with data for 2017 and 2019 and missing data for 2018, the weighted average of the data in 2017 and 2019 is used to fill in the missing data for 2018.

3. Results Analysis

3.1. The Level of Urbanization and Urban Resilience

This study calculates the level of urbanization and urban resilience via the improved entropy method and draws box plots to analyze the time-series evolution of the combined level of urbanization and urban resilience in 41 cities in the YRD (Figure 2). It can be seen from the box plot that urbanization level and urban resilience level of 41 cities are generally clustered in a box shape, with low dispersion and few outliers, and the urbanization level and urban resilience level of most cities are close, while those of only some cities are dispersed. These cities with both high urbanization levels and urban resilience levels, such as Shanghai, Nanjing, Suzhou, Hangzhou, Hefei, etc., and cities with low urbanization levels and urban resilience levels, such as Suqian, Fuyang, Suzhou, Lu'an, Bozhou, etc., indicate that the regional integration phenomenon in the YRD is increasingly obvious, and the urbanization level and urban resilience level of provincial capitals and economically developed cities are higher and enhance faster, which is consistent with the result obtained in the study of Zeng et al. [52] on urban agglomerations in China. Meanwhile, the box position shifts upward over time, which indicates that the level of urbanization and urban resilience is increasing. Then, the maximum and minimum values of each year are selected for comparison, and it is found that the absolute gap expands, indicating that the overall level of urbanization and urban resilience in the YRD is increasing, but the differences within the region also show an expansion trend. Since the degree of integration in the YRD is increasing over time, the "Matthew effect" becomes more and more obvious, and cities with a high urbanization level and high urban resilience level gradually increase their oppressiveness to those with a low urbanization level and low urban resilience level, thus, gradually enlarging the development gap between the extreme value cities in the region.

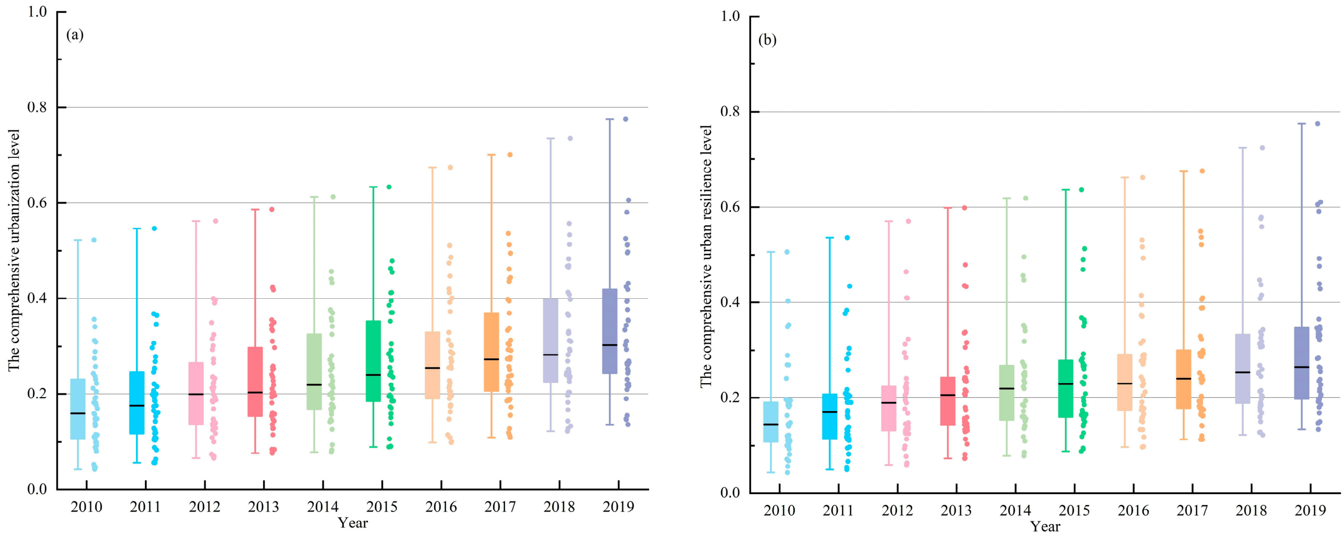

Figure 2. Changes in the comprehensive urbanization level and urban resilience level of all cities in the YRD. (**a**) Box plot of urbanization level of all cities in the YRD; (**b**) Box plot of urban resilience level of all cities in the YRD.

3.2. The CCD of Two Systems

3.2.1. The Dynamic Evolutionary Characteristics

After exploring the time-series evolution characteristics of urbanization and urban resilience levels, this study employs the kernel density estimation method to further explore the absolute differences and change characteristics of the CCD of urbanization and urban resilience in the YRD, as illustrated in Figure 3.

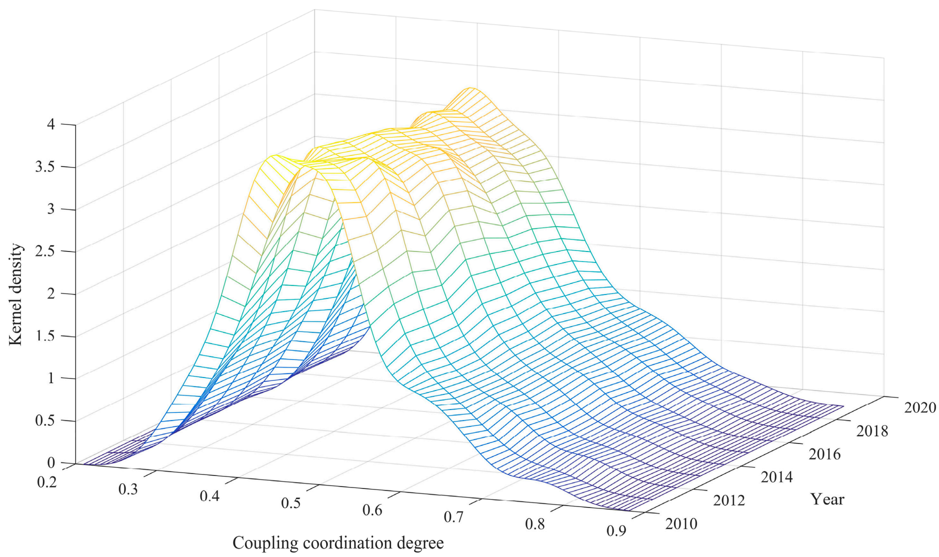

Figure 3. The kernel density estimation results of CCD for all cities in the YRD.

First, it can be seen from Figure 3 that the kernel density curve of the CCD values in the YRD in each year shows an obvious right-shifting trend, which indicates that the overall level of CCD of urbanization and urban resilience in the YRD during the study period shows a continuous climbing trend toward good development.

Meanwhile, the kernel density curve of the CCD values in the YRD in each year shows a distribution trend that the width becomes larger year by year, indicating that the absolute gap between the CCD level of urbanization and urban resilience in the YRD expands significantly, and the difference between the extreme value cities is increasingly significant.

In addition, the distribution extension of the kernel density curve tends to be weakened, indicating that the low and medium CCD values tend to be closer to the average level of the overall CCD values in the region. This proves that the overall level of CCD between urbanization and urban resilience in the YRD is more consistent and gradually progresses in the direction of dynamic equilibrium.

Moreover, the kernel density curve of the CCD values in the YRD in the early years shows a gentle mountain range class distribution, and as the height of the wave crest increases over time, the kernel density curve shows a steeper pyramid class distribution. This indicates that the CCD level of urbanization and urban resilience in the YRD shows a trend of gradual concentration in the study period, and the sustainable development capacity is further improved. Additionally, the kernel density curve in the right tail transforms from multiple side peaks to a converging and smoothing flat curve distribution, indicating that the trend of multi-level differentiation of the CCD values gradually disappears, the overall CCD level of urbanization and urban resilience improves significantly, and the phenomenon of regional integration replaces multi-level differentiation.

3.2.2. Spatial Distribution Characteristics

By using ArcGIS 10.3 software, this study selects data with the same interval of years, 2010, 2013, 2016, and 2019. Then, the calculated values of the CCD of urbanization and urban resilience for 41 cities in the YRD are spatially visualized to analyze the spatial distribution pattern of the development of the CCD level in the region, as shown in Figure 4.

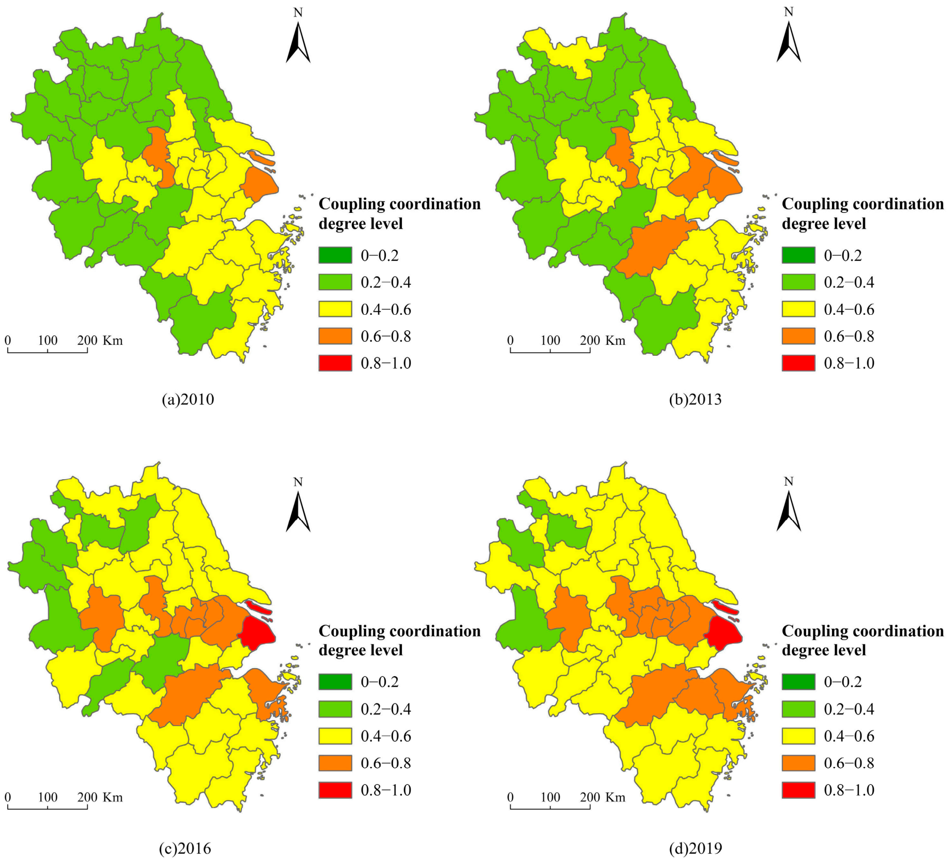

Figure 4. The spatial pattern of CCD level for all cities in the YRD.

From the temporal perspective, the CCD level of each city in the YRD shows an upward trend: in 2010, the number of cities in the excellent coordination class is 0, which in the moderate coordination class is 2, in the bare coordination class is 18, and in the moderate disorder class is 21. In 2013, the number of cities in the moderate coordination class was 4, with an increase of 2; the number of cities in the bare coordination class was 19, with an increase of 1; and the number of cities in the moderate disorder class was 18, with a decrease of 3. In 2016, the number of cities in the excellent coordination class was 1, with an increase of 1; the number of cities in the moderate coordination class was 7, with an increase of 3; the number of cities in the bare coordination class was 26, with an increase of 7; and the number of cities in the moderate disorder class was 7, with a decrease of 11. In 2019, the number of cities in the excellent coordination class was 1; the number of cities in the moderate coordination class was 9, with an increase of 2; the number of cities in the bare coordination class was 28, with an increase of 2; the number of cities in the moderate disorder class was 3, with a decrease of 4. From the above results, it can be seen that the cities in the bare coordination class and above gradually increase from less than 50% at the beginning to more than 90%, indicating that the vast majority of cities in the YRD have reached the preliminary coordination level after development during the study period. Meanwhile, the CCD levels of urbanization and urban resilience in the overall region and individual cities have increased, while medium and low CCD values are getting closer to the average value of the overall regional CCD.

From the spatial perspective, in 2010, only two cities, Shanghai and Nanjing, were of the CCD class in moderate coordination, and with these two cities as the core, the CCD level decreased toward the surrounding areas, showing an obvious "island effect". This is closely related to the fact that Shanghai opened up to the outside world earlier and Nanjing, and the establishment of the metropolitan area, improved the CCD level of the two cities rapidly; in 2013, Suzhou and Hangzhou also joined in the moderate coordination class, indicating that Shanghai and Nanjing with high CCD levels gradually produce a "trickle-down effect", promoting the rapid development of the CCD level of Suzhou and Hangzhou, attributed to a closer geographic location, better economic strength and more policy inclination; in 2016, Shanghai was promoted to the excellent coordination class, and Hefei, Ningbo, Wuxi, and Changzhou stepped into the moderate coordination class, and the spatial distribution of the CCD class has gradually changed from an isolated core to multiple decentralized cores. This phenomenon indicates that, led by Shanghai, Zhejiang Province, Jiangsu Province, and Anhui Province have formed their core cities, and they take the core cities as the central area to develop the surrounding areas, which better drives improvements in the overall regional CCD level; in 2019, the promotion of the CCD class of 41 cities in the YRD began to slow down, and the phenomenon of regional integration replaced the phenomenon of multi-level differentiation and gradually developed toward dynamic equilibrium. However, the absolute disparity between cities with extreme values in the region becomes increasingly significant, and the CCD level of three cities in Anhui Province, namely, Su'zhou, Bozhou, and Lu'an still fails to be promoted to the preliminary CCD class. The above results indicate that because the urbanization and urban resilience CCD class of core cities have reached a very high level, the role of regional assimilation is close to the limit, so the development rate of the CCD class of neighboring cities slows down and becomes stable; also, due to the "Matthew effect", cities with high urbanization level and high urban resilience level gradually increase their oppressiveness to those with a low urbanization level and low urban resilience level, thus, gradual widening the development gap between cities with extreme values in the region.

3.2.3. Spatial Agglomeration Characteristics

By adopting ArcGIS 10.3 software, this study selects data with the same interval of years, 2010, 2013, 2016, and 2019. Then, the global autocorrelation analysis module is established, and the results are presented in Table 2.

As shown in Table 2, the Z-variance is greater than 1.96 and the p-value is less than 0.01, indicating that the results of each year can pass the significance level test of more than 99%. Thus, it can be determined that there is a significant positive spatial autocorrelation and spatial agglomeration effect for the CCD of each year in the YRD. The value of Moran's I is less volatile, greater than 0, and falls between 0.4207 and 0.4433, and the data show a spatially positive correlation distribution. This indicates that the coupling coordination development level of urbanization and urban resilience in the YRD has continued to improve and is stable. Meanwhile, the development rate of the later period is faster than that of the earlier period, which proves that the spatial agglomeration effect of the region shows a trend of continuous and accelerated diffusion.

Table 2. Global autocorrelation analysis of the CCD for all cities in the YRD.

Index \ Year	2010	2013	2016	2019
Moran's *I*	0.4207	0.4261	0.4346	0.4433
Z-Variance	3.7271	3.7637	3.8204	3.8983
p-Value	0.0002	0.0002	0.0001	0.0001

After proving the existence of significant positive spatial autocorrelation between the CCD of each city in the YRD, this study uses the Getis–Ord G^* index in the local autocorrelation analysis to further explore the evolution characteristics of spatial agglomeration of hot spots and cold spots in each city. Referring to Jenks's natural break method, this study divides the region into five categories: hot spot area, secondary hot spot area, transition area, secondary cold spot area, and cold spot area, and the spatial agglomeration evolution characteristics are illustrated in Figure 5.

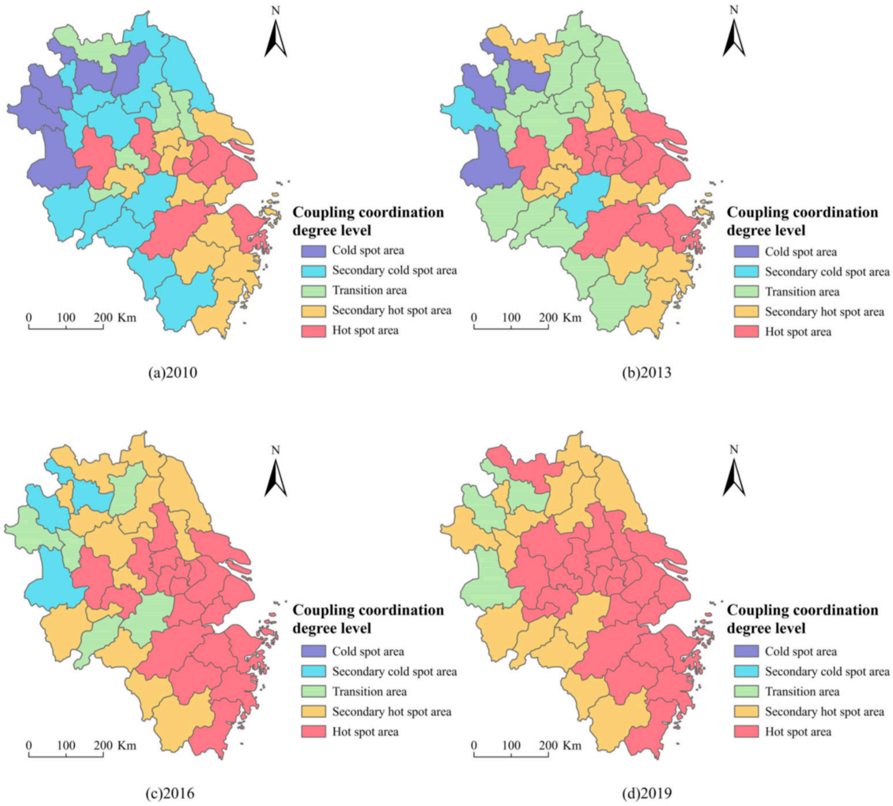

Figure 5. The spatial pattern evolution of CCD for all cities in YRD.

It can be seen from Figure 5 that the overall CCD level shows a spatial agglomeration trend of high in the east and low in the west, high on the coast and low in the interior, and the distribution of hot spots in the study area gradually expands, from point to surface and from east to west. Until 2019, the cold spot area converged and only existed in northern Anhui.

Specifically, in 2010, northern Anhui was in the center of the cold spot of CCD, and the secondary cold spot area spreads and agglomerates outward around this area; Shanghai, Suzhou, Wuxi, Hangzhou, Ningbo, Nanjing, and Hefei are the hot spot areas of CCD, and the secondary hot spot areas agglomerate outward around this area in a semi-encircling manner, as the cold spot and hot spot areas are distinct and do not intersect with each other. This shows that the "trickle-down effect" of the cities in the hot spot areas is not very obvious, which causes the CCD of the two systems of urbanization and urban resilience in the overall region to increase slowly. In 2013, the cold spot area began to converge; only Su'zhou, Bozhou, and Lu'an are still cold spot areas, while northern Jiangsu, southern Anhui, and southern Zhejiang have been transformed from the cold spot and secondary cold spot areas into transition areas, and the hot spot areas around Shanghai, i.e., southern Jiangsu and northern Zhejiang regions, show a clear trend of outward diffusion. The secondary cold spot area is gradually transformed into a transition area, which shows that the spatial agglomeration of cold spots and hot spots is broken, demonstrating a new spatial agglomeration characteristic of mutual penetration and intermingling. The reason for this phenomenon is that Shanghai, southern Jiangsu, and northern Zhejiang are geopolitically close to each other and have become the first experimental areas of regional integrated development. Through the unified development of the link in several years, the regional economic level has been improved, the infrastructure construction has been accelerated, and the urbanization level has been enhanced; also, special treatment actions for the urban habitat environment have been conducted in depth, problems have been strengthened and rectified, and the level of urban resilience has been improved. Due to this, the CCD level of urbanization and urban resilience in the region has been greatly improved; in 2016, the cold spot area completely disappeared, and only Su'zhou, Bozhou, and Lu'an are still secondary cold spot areas in the whole region. In this year, Shanghai, southern Jiangsu, and northern Zhejiang regions show the spatial trend of hot spot agglomeration in the whole region, and northern Jiangsu, southern Anhui, and southern Zhejiang regions have transformed into secondary hot spot areas. After this period, the overall cold spot area in the YRD further converged, and the spatial agglomeration feature of the whole region for good development has become increasingly obvious. The reason is mainly because some cities in Anhui province join the YRD Urban Agglomeration, and Anhui takes Hefei as the axis city to radiate and drive the surrounding areas to develop coordinately, which improves the coupling coordination level of the whole Anhui region, so the southern Anhui region also gradually eliminates the cold spot area under the drive of Hefei; meanwhile, through the orderly implementation of the action plan "North-South Counterpart Support", the mutual placement of resources and sharing of advantages between cities have been promoted, further improving the "blood-making" ability and endogenous power of northern Jiangsu and southern Zhejiang regions. Thus, these two regions have gradually become secondary hot spot cities under the lead of the core cities; in 2019, in addition to Su'zhou, Bozhou, and Lu'an, the overall region shows the spatial agglomeration characteristics of hot spots and secondary hot spots. After the "Outline of the Integrated Regional Development of Yangtze River Delta " was officially introduced, all four provinces and cities of Jiangsu, Zhejiang, Anhui, and Shanghai were included in the YRD, regional integration gradually became a reality from the slogan, and the YRD became the region with the best urbanization foundation, the most complete industrial system, and the strongest urban resilience capacity in China. With an obvious development trend of system integration and symbiosis, the overall CCD between the urbanization system and urban resilience system has reached a preliminary coordination level and demonstrated strong sustainable development capability.

3.3. Analysis of Dynamic Response Relationship among Two Systems

3.3.1. Unit Root Test

The above theoretical mechanism investigates the dynamic response relationship between the urbanization system and the urban resilience system from the perspective of qualitative analysis. To make this study more scientific, the PVAR model of Formula (5) is applied, and the values of urbanization level and urban resilience level from 2010 to 2019 are substituted into the model to explore the dynamic response relationship between the urbanization system and urban resilience system in the YRD.

To eliminate the effects caused by heteroskedasticity, the values of urbanization level and urban resilience level are first taken as logarithms; also, data non-stationarity can lead to pseudo-regression phenomena, so after taking the logarithm, a unit root test is performed on the panel time-series data to ensure the stationarity of the data [63]. In this study, the LLC test is chosen for data stationarity testing. Specifically, urbanization is taken as the logarithm and called $\ln x$, and urban resilience is taken as the logarithm and called $\ln y$. From Table 3, it can be observed that both unit root test values corresponding to p-values are smaller than 0.01, which pass the test at a 1% significance level and reject the original hypothesis of the existence of a unit root, indicating that the variables are stable and can proceed with the analysis.

Table 3. The unit root test results of the panel data.

Detection Method	Variables	Detection Value	*p*-Value
LLC	$\ln x$	−11.448	0.0000
	$\ln y$	−7.9994	0.0000

3.3.2. Optimal Lag Order and Cointegration Test

By determining the optimal lag order, it can be ensured that the accuracy of the results will not be reduced because the lag order is too small, and the sample size of the study will not be missing because it is too large. Thus, determining the optimal lag order is the key to constructing the PVAR model. In this study, AIC, BIC, and HQIC are adopted to determine the optimal lag order of the model, and all three information criteria are used to select the order corresponding to the minimum information value as the optimal lag order. Table 4 shows that all three information criteria choose lag order 1 as the optimal lag order. Then, the cointegration test is performed to determine whether there is a cointegration relationship between the two variables, and this study adopts the Pedroni test for cointegration test analysis. Table 5 below shows the results of the cointegration test, all the statistics of the test terms correspond to a p-value of less than 0.01, and they pass the test at a significance level of 1%. Thus, the original hypothesis that there is no cointegration relationship is rejected, indicating that there is a long-term equilibrium relationship between the two systems of urbanization and urban resilience. Meanwhile, since the optimal lag order is 1, a long-term equilibrium relationship exists between the two systems and is unique.

Table 4. The selection of optimal lag order of the PVAR model.

Lag	AIC	BIC	HQIC
1	−12.3404 *	−11.3038 *	−11.9016 *
2	−12.2984	−11.1928	−11.8804
3	−11.9935	−10.6541	−11.4542
4	−11.7225	−10.1339	−11.0799

Note: * indicate significant at 10% level.

Table 5. The results of the cointegration test.

Test Items	Detection Value	*p*-Value
Modified Philips-Perron t	4.6097	0.0000
Phillips-Perron t	−5.7722	0.0000
Augmented Dickey-Fuller t	−8.2366	0.0000

3.3.3. Granger Causality Test

The Granger causality test is further performed to determine whether there is a causal relationship between the two systems of urbanization and urban resilience and the direction of causality. By constructing a panel error correction model for the Granger causality test, the test results in Table 6 indicate that when the original hypothesis is that ln$x$ is not the Granger cause of ln$y$, the Chi^2 statistic is 3.0626, and the corresponding p-value is 0.000. Since the p-value is less than 0.05, the original hypothesis is rejected, and it means that, at a significance level of 5%, ln$x$ is the Granger cause of ln$y$; similarly, it can be inferred that at a significance level of 5%, ln$y$ is the Granger cause of ln$x$. Therefore, ln$x$ and ln$y$ are mutually causal, indicating that urbanization plays a pulling and "trickle-down effect" on urban resilience; also, urban resilience can protect and enhance the urbanization level, and they are mutually Granger causal.

Table 6. The results of the granger causality test.

Original Assumptions	Chi^2 Statistic	p-Value	Conclusions
Lnx cannot Granger cause Lny	3.0626	0.0000	Reject
Lny cannot Granger cause Lnx	0.0918	0.0290	Reject

3.3.4. Impulse Response Analysis

The impulse response function reflects the effect of a shock with one standard deviation applied to the perturbation term on the current and future values of the endogenous variables [64]. This study explores the dynamic shock effects between the two systems by performing impulse response simulations of urbanization and urban resilience. The impulse response results are presented in Figure 6.

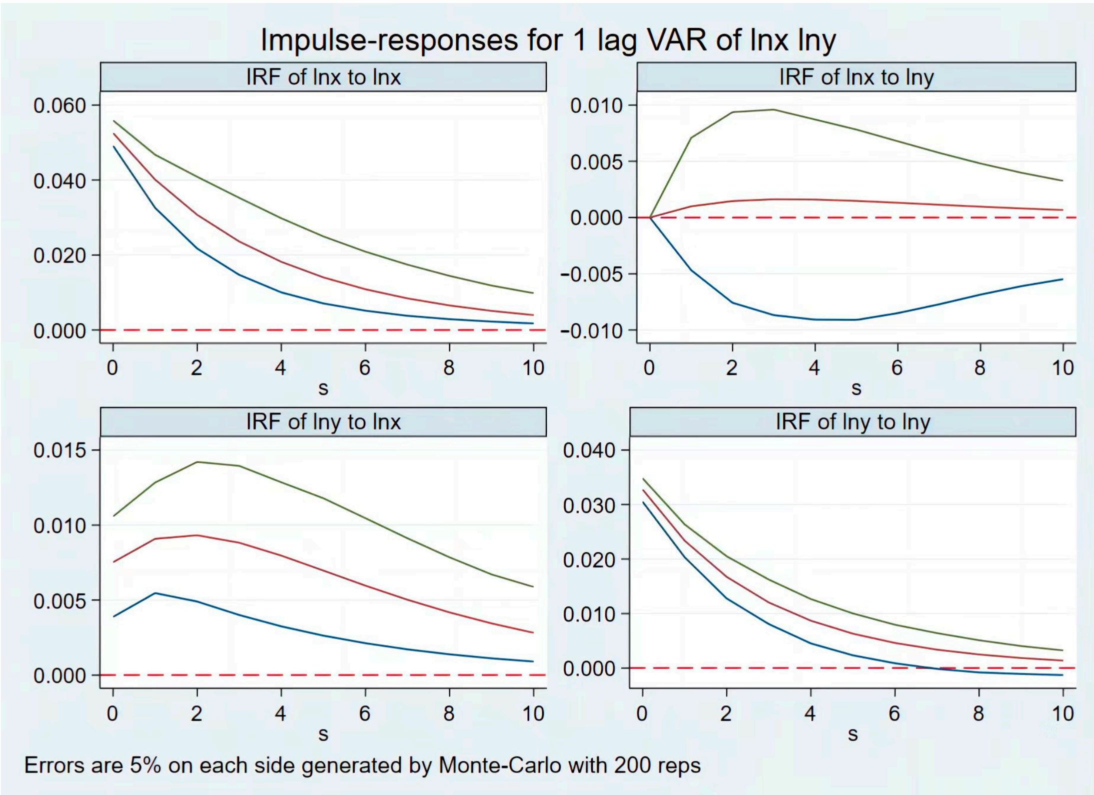

Figure 6. The impulse response diagram of urbanization and urban resilience in the YRD. The red line is the impulse response estimates for a horizon of 10-period time, and the green and blue lines are the one-standard error confidence bands.

As shown in Figure 6, the shock of urbanization is weakening, and each period is in the positive response phase. In the long run, the impact effect is more obvious at the beginning and gradually stabilizes in the middle and later periods. The shock of urbanization on urban resilience shows a weak development trend, where the first to the third periods is a slow increase phase, and from the fourth period onwards, the response effect decreases steadily and reaches the minimum in the tenth period. Thus, the stability of the urbanization system mainly depends on its influence, and it is less affected by urban resilience.

The overall shock of urban resilience on urbanization shows an upward and then downward trend, with each period in the positive response phase; the response effect reaches the maximum in the second period and gradually declines in the third period, with a more obvious impact effect in the earlier and middle periods, and it gradually stabilizes in the middle and later periods. The shock of urban resilience on itself is weakening, and each period is in the positive response phase. From the beginning, the shock has been in a downward trend, and the downward trend is significant in the earlier and middle periods and gradually becomes stable in the later period. Thus, the stability of the urban resilience system is highly dependent on the influence of both itself and urbanization, and the influence of urbanization on urban resilience continues.

3.3.5. Variance Decomposition Analysis

To explain the contribution of shocks between variables to the results, the mean squared deviation of urbanization and urban resilience over the next 10 periods is analyzed through variance decomposition. The results are presented in Table 7.

Table 7. The decomposition table of variance between urbanization and urban resilience.

Period	ln*x*		ln*y*	
	ln*x*	ln*y*	ln*x*	ln*y*
1	1.000	0.000	0.050	0.095
2	1.000	0.000	0.079	0.921
3	0.999	0.001	0.079	0.894
4	0.999	0.001	0.079	0.871
5	0.999	0.001	0.148	0.852
6	0.998	0.002	0.161	0.839
7	0.998	0.002	0.171	0.829
8	0.998	0.002	0.179	0.821
9	0.998	0.002	0.183	0.817
10	0.998	0.002	0.187	0.813

In terms of the variance decomposition of urbanization, the YRD is affected by its shock up to 100% in the first period, and the overall trend is continuously declining, but the decline is small; meanwhile, the shock of urbanization on itself still reaches 99.8% until the tenth period. The variance decomposition of urban resilience is different, and the impact of its shock declines from 95% to 81.3%. Although its shock is still the main influencing factor, the influence of urbanization on urban resilience cannot be ignored, which is consistent with the conclusion drawn from the impulse response function above and again validates the scientificity of the study. However, it can also be seen that by the fifth period, the influence of urbanization on urban resilience has reached 14.8%, while the influence of the increase in urbanization on urban resilience in the following five periods decreases to only 3.9%. This phenomenon has two implications: (1) the promotion of urbanization on urban resilience is greater than the promotion of urban resilience on urbanization; (2) the promotion of urbanization on urban resilience is decreasing. The reason lies in two aspects. On the one hand, with the rapid rise of the regional economy, the level of urbanization has increased, with core cities such as Shanghai as the central region spreading development to the surrounding areas, thus, improving the overall regional CCD level. The cities have sufficient funds and resource reserves to support the construction and operation of urban development planning, infrastructure construction, industrial innovation, and other related systems, which improves the quality of comprehensive disaster prevention and mitigation of the urban system and enhances the level of urban resilience. On the other hand, with the gradual formation of regional integration in the YRD, the improvement in urban CCD level gradually slows down, the urbanization level of each city has gradually reached the upper limit, and its influence on urban resilience continues, but the improvement has gradually slowed down, so the improvement in the urban CCD level needs to find a breakthrough point.

4. Discussion

Urbanization is an inevitable process of urban development, which is usually reflected by the increase or decrease in population, economic, social, and spatial levels [45]. In the urbanization process, urban problems are bound to arise, and how to solve these problems is a concern of many urban researchers. Previous studies indicate that urban resilience systems are closely related to other urban systems [1], and Gao's study [42] confirmed that the dynamic coupling between urban resilience and urbanization is reflected by the fact that both are composed of economic, social, ecological, and other urban subsystems. Therefore, investigating the relationship between urbanization and urban resilience can better promote sustainable urban development and solve or prevent some problems in urban development [61].

First, according to the time-series evolution characteristics of urbanization and urban resilience, the levels of the two systems in the YRD are clustered in a box shape, with only some cities having a large dispersion, indicating that the overall levels of the two systems have a positive development trend. Second, according to the dynamic evolution characteristics of the CCD of urbanization and urban resilience, the kernel density curve in the YRD shows a continuous rightward shift, the height of the main peak is decreasing, and the distribution extension is slowing down, indicating that the overall CCD level of urbanization and urban resilience has improved significantly, and regional integration has replaced multi-level differentiation. This is correlated with the implementation of a series of policies, including "the New Urbanization Strategy", "the Yangtze River Delta City Cluster Development Plan", and "the Outline of the Yangtze River Delta Regional Integrated Development Plan". After the implementation of these policies, regional integration has gradually become a reality from a slogan, and the YRD has become the region with the best urbanization foundation, the most complete industrial system, and the strongest comprehensive strength in China. Meanwhile, the system integration and symbiotic development is increasingly obvious, which promotes the coordinated sustainable development of urbanization and urban resilience system in the region and makes its comprehensive level show a continuous upward trend. This is consistent with the findings of Zhao et al. [56].

In addition, according to the spatial distribution and spatial agglomeration characteristics of the CCD of urbanization and urban resilience, after development during the study period, most of the cities in the YRD reached the initial coordination level and the core cities in the region, namely, Shanghai, Nanjing, Suzhou, Hangzhou, Hefei, Ningbo, Wuxi, and Changzhou, reached a high class in the CCD level, while Su'zhou, Bozhou, and Lu'an are still in a state of coupling disorder. At the same time, there are regional differences in the CCD, showing a spatial agglomeration trend of high in the east and low in the west, high on the coast and low in the interior; the distribution of hot spots in the study expands gradually, from point to surface and from east to west in a covering development characteristic, which is consistent with the spatial distribution; Su'zhou, Bozhou, and Lu'an are the only three cities in the area that have not yet jumped to the hot spots. On the one hand, the vast majority of cities in the region have been upgraded faster and have gradually reached the class of coupling coordination. These cities have strengthened regional cooperation and linkage, thus, promoting the integrated development of the YRD, accelerating the establishment of Shanghai, Nanjing, Hangzhou, Suzhou-Wuxi-Changzhou, Hefei, and Ningbo metropolitan areas, promoting the mutual placement of resources, scientific and technological flows, economic development, and information sharing, and initially forming a coordinated sustainable development trend of regional integration; on the other hand, by providing policy tilting subsidies to the developing regions, the Jiangsu, Zhejiang, and Shanghai regions realize "blood transfusion" to help Anhui cities to build high-tech industrial parks, thus, attracting high-level talents, optimizing economic and industrial structures, increasing financial investment in science and technology, promoting the integration of domestic and foreign trade, coordinating the spatial layout of commodity circulation, and forming multi-network integration of rail transportation and other measures. These measures contribute to a positive spatial agglomeration effect in the region so that almost the whole area of the YRD (except for Su'zhou, Bozhou, and Lu'an) has realized the hotspot spatial agglomeration posture. However, Su'zhou, Bozhou, and Lu'an are far behind other cities in economic development in the region, with a relatively underdeveloped level of urbanization and weak urban resilience building capacity, and the three cities are located in the peripheral zone of the YRD, with weak radiation trickle-down effects from major core cities and insufficient locational advantages, so they are still in the primary stage of coupling coordination development. This is consistent with the findings of Lu et al. [65].

Moreover, this study verified through the PVAR model that there is a causal relationship between urbanization and urban resilience, and they are mutually influential. This implies that it is scientific to measure the relationship between the two systems with a CCD model. To deepen the credibility of the study, why a coupling coordination relationship exists between the two systems is investigated from a qualitative perspective for the following reasons. On one hand, when the two are coupled and coordinated, the urbanization process can bring great economic benefits and development opportunities to cities and promote urban resilience development [66]. For example, cities have sufficient capital and resource reserves to support the construction and operation of urban development planning, infrastructure construction, industrial innovation, and other related systems, which helps to improve the quality of comprehensive disaster prevention and mitigation of the urban system and enhances the level of urban resilience; meanwhile, the high level of resilience can effectively promote improvements in urbanization. The superiority of urban resilience lies in its ability to create a safe and healthy operating environment, consolidate the ability of cities to resist risky disasters, provide hardware and software strength operating urban mega-systems, maintain a normal and orderly exchange of materials, energy, and information within the city and the external environment, and keep the city stable by not being disturbed by internal and external factors, thus, achieving orderly promotion of the urbanization process [61]. On the other hand, when the coupling between urbanization and urban resilience is dysfunctional, the rapid social transformation caused by the rapid advancement of the urbanization process also brings about many negative impacts on urban resilience construction [67]. Factors, such as large population concentration, a disorderly proliferation of building land, an increase in people's consumption level, an increase in resource consumption intensity, and other uncertainties, will lead to intensive, mobile, regional, and concurrent urban risks. Further, excessive population density and an excessive consumption level lead to increased urban demand for various resources, and unreasonable allocation of urban construction land and ecology will cause space urban ecological safety capacity to decline seriously, thus, damaging or reducing the protection capacity of urban resilience; similarly, a low resilience level restricts the improvement in urbanization level. Cities with low levels of resilience tend to have a high probability of risk occurrence, and there are many "pain points" and "shortcomings" in urban risk prevention and scientific control. For example, a decline in economic resilience leads to an imbalance in the ability of coordinated urban economic development, a decline in social resilience results in social disorder, a decline in ecological resilience leads to an increase in urban environmental pollution, and a decline in infrastructure resilience leads to an increase in urban public safety risks, which together seriously restrict the urbanization process [42]. Therefore, it is reasonable and scientific to explore the existence of a coupling relationship between the urbanization system and urban resilience system and explore its spatio-temporal evolution trend by the method of the CCD model. Meanwhile, insights can be obtained by looking at the impulse response and variance decomposition of the PVAR model: when the CCD level between urbanization and urban resilience is low, the acceleration of urbanization can drive the development of urban resilience more significantly, thus, promoting a rapid improvement in the urban CCD level; after the urbanization level reaches the bottleneck, only raising the priority level of urban resilience and the level of urban resilience can better promote the urban CCD level. This indicates that our development strategy needs to be adjusted according to the different CCD levels of each city: whether to give priority to promoting higher levels of urbanization or to vigorously develop urban resilience.

Therefore, by investigating the coupling coordination relationship between urbanization and urban resilience, this paper recognizes the spatial and temporal evolutionary trends and dynamic response relationships between urbanization and urban resilience. Further, this paper gives policy recommendations for the coordinated sustainable development of the two systems based on the research results to provide valuable academic references for healthy and sustainable urban development.

Based on the above findings, the following policy recommendations are given.

(1) Adhere to the regional integration strategy of the YRD and narrow the absolute gap between cities in terms of the CCD level between urbanization and urban resilience. On the one hand, strengthening inter-city twinning and supporting efforts will enable cities in the CCD high-class area to help cities in the CCD low-class area, stimulate the endogenous development momentum in the coupling dysfunctional areas of Su'zhou, Bozhou, and Lu'an, and raise the coupling coordination class to a coordinated state as soon as possible, thus, making the cites become secondary hot-spot regions and narrowing the absolute gap between cities; on the other hand, accelerating the construction of the core-edge multi-level spatial structure of cities in the YRD will enable Shanghai, as the leader of the metropolitan area, to give full play to its radiation trickle effect, and the five major metropolitan areas (including Hangzhou, Nanjing, Ningbo, Suzhou-Wuxi-Changzhou, and Hefei) should actively take a staggered competition and cooperation to achieve resource sharing, complementary advantages, and positive spillover, thus, comprehensively improving the urbanization and urban resilience CCD level.

(2) When the CCD level of the urbanization system and urban resilience system is low, the enhancement of the urbanization system can more significantly promote the rapid improvement in the urban CCD level. Cities with a low CCD level should actively undertake the industrial transfer from more developed regions, adjust the existing industrial structure, improve the resource utilization efficiency, disperse the population density in urban areas, improve the income level of urban residents, and ensure the reasonable distribution of land types, thus, accelerating the construction of new dynamics of economic, demographic, social, and land urbanization and improving the urbanization level well and fast. The improvement in urbanization level enables cities to have sufficient capital and resource reserves to support the construction and operation of urban resilience-related systems, such as economic restructuring, infrastructure construction, and social mobilization capacity, which helps to improve the comprehensive disaster prevention and mitigation quality of the urban system and enhances the urban resilience level, thus, promoting the coordination and sustainable development of the urbanization system and urban resilience system.

(3) After the urbanization level reaches the bottleneck, only raising the importance of urban resilience and vigorously developing the urban resilience system can better promote the comprehensive improvement in the urban CCD level. The next development stage of cities in high-value CCD areas focuses on the urban resilience system, which should fully integrate the urban resilience concept into urban construction, improve urban infrastructure construction, promote urban economic diversification, maintain social security and stability, increase ecological environmental protection, enhance urban risk prevention ability, and comprehensively promote the development of urban resilience ability. The improvement in urban resilience capacity helps to maintain a normal and orderly exchange of materials, energy, and information within the city and the external environment and keep the city

stable by not being disturbed by internal and external factors, thus, feeding and supporting the steady urbanization progress, making the two systems integrated, and jointly promoting the coordination and sustainable development of the urbanization system and urban resilience system.

The theoretical innovations and contributions of this study are as follows: First, the previous studies on urbanization mainly explored the relationships between the urbanization system and ecological environmental system, the urbanization system and regional economic system, and the internal relationships of urbanization systems. This study introduces urban resilience into urbanization research, and innovatively constructs a comprehensive evaluation index system for both the urbanization system and urban resilience system, which helps to fully investigate the coupling coordination relationship of urban multi-dimensional index systems. Secondly, previous studies seldom took typical research regions (e.g., urban agglomerations and integrated regions) as research objects and only conducted empirical studies from a geospatial–temporal perspective. This study takes the YRD, a typical region, as the research object, and explores, in detail, the temporal evolution and spatial characteristics of the CCD between urbanization and urban resilience in 41 geographical units of the YRD from 2010 to 2019 from the geospatial–temporal perspective. This will open up the research results to scholars in the fields of urbanization, urban resilience, sustainable development, and coupled coordination and urban agglomerations, and will provide important theoretical references for the in-depth exploration of related field cases. In addition, previous studies on coupling coordination relationships only focused on calculating and analyzing the time-series variation characteristics of the CCD in the subsystem but failed to show whether there is a significant coupling coordination relationship between the systems, which makes the scientificity of the study insufficient. This study explores the dynamic response relationship of the coupling between the two systems in depth using the PVAR model and, based on this, with reference to previous studies, the discussion provides an in-depth explanation of the existence of a strong coupling coordination relationship between the urbanization system and the urban resilience system, which provides a new scientific and reasonable approach for exploring the coupling coordination relationship between the systems in the future.

Of course, this study inevitably has some limitations and needs further research. First, due to the technical limitations of the research team, the data source of this study is the statistics data on the Internet, which is relatively singular. In the future, we will add multiple sources of data (such as atmospheric data, remote sensing data, and crawler data) to enrich the index data of the urbanization system and the urban resilience system. Second, due to the difficulty in data collection, this study fails to conduct research at the unit of the county in the YRD. When the relevant data and indicators are fully disclosed in the future, we will investigate the relationship between urbanization and urban resilience in the YRD from a more microscopic scale to provide further theoretical contributions and academic references for constructing high-quality resilient cities in other rising regions in China and even in urban agglomerations in the world. Third, based on this paper, scholars can further explore the influencing factors of urbanization and urban resilience, which will help to enrich and expand the research in this field.

5. Conclusions

Based on the improved entropy value method, this study uses the CCD model, the kernel density estimation method, and the ESDA method to explore the spatio-temporal evolution trends of the CCD of the urbanization and urban resilience systems in 41 geographical units of the YRD from 2010 to 2019, and the dynamic response relationship of the coupling between the two systems is revealed. The main findings are as follows.

(1) According to the box plot analysis of the urbanization level and urban resilience level, the urbanization values and urban resilience values of 41 cities are generally clustered in a box shape, but the absolute gap is enlarged to some extent. Comparing the box plots of urbanization and urban resilience, it can be found that the absolute difference between

urbanization values is smaller than that of urban resilience values, and the average value is higher.

(2) According to the analysis of the numerical kernel density estimation of the CCD between urbanization and urban resilience, the curve shows an obvious right-shifting development trend, the gap becomes wider year by year, and the distribution extension tends to slow down. In addition, the curve in the right tail transforms from multiple side peaks to a convergence-smoothing curve.

(3) The analysis based on the spatial distribution characteristics of the YRD indicates that the CCD class of each city in the YRD shows a continuous upward development trend; in 2010, the areas of northern Anhui, northern Jiangsu, and southern Zhejiang are in the low-class CCD area, while the high-class CCD areas around Shanghai and Nanjing show an obvious "island effect"; in 2013, the high-class CCD areas gradually spread to the southern Jiangsu and northern Zhejiang regions represented by Suzhou and Hangzhou, and the core-edge structure trend is obvious; in 2016, the spatial distribution of the CCD class gradually changes to the spatial pattern of multi-level decentralized distribution, with Hefei, Ningbo, Wuxi, and Changzhou becoming second high-class CCD areas; in 2019, the increase in the CCD class of 41 cities in the YRD slows down, regional integration replaces multi-level differentiation, and the CCD of the overall region shows a preliminary coordinated spatial distribution, but the CCD classes of Su'zhou, Bozhou, and Lu'an are still not promoted to the preliminary CCD class.

(4) According to the analysis of the spatial agglomeration characteristics of the YRD, the spatial agglomeration is high in the east and low in the west, high on the coast and low in the interior, and the distribution of hot spots in the study area gradually expands. In 2010, the cold spot and hot spot areas are distinct and do not intersect with each other; in 2013, the spatial agglomeration of cold spots and hot spots was broken, showing a new spatial agglomeration characteristic of mutual penetration and intermingling; in 2016, the overall cold spot area in the YRD further converged, and the spatial agglomeration of the whole region for good development became more and more obvious; in 2019, in addition to Su'zhou, Bozhou, and Lu'an, the overall region showed the spatial agglomeration characteristics of hot spots and secondary hot spots.

(5) According to the analysis based on the PVAR model, the Granger causality test shows that urbanization and urban resilience are causally related to each other. Meanwhile, the impulse response function plots show that the change in the stability of the urbanization system mainly depends on its influence; the change in the stability of the urban resilience system is highly dependent on both its influence and urbanization. In addition, the contribution of variables in the variance decomposition table shows that urbanization promotes urban resilience to a greater extent than urban resilience promoting urbanization.

Author Contributions: Conceptualization, K.P.; Data curation, K.P.; Formal analysis, K.P.; Funding acquisition, K.P., X.H., and C.X.; Methodology, K.P.; Writing—original draft preparation, K.P.; Writing—review and editing, X.H. and C.X. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Hunan Province Postgraduate Research Innovation Project, grant number CX20220479, the National Natural Science Foundation of China, grant number 41971187, and the Hunan Province Natural Science Foundation Project, grant number 2022JJ30387.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The datasets used during the current study are available from the first author on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Luo, X.; Cheng, C.; Pan, Y.; Yang, T. Coupling Coordination and Influencing Factors of Land Development Intensity and Urban Resilience of the Yangtze River Delta Urban Agglomeration. *Water* **2022**, *14*, 1083. [CrossRef]
2. Ren, Y.; Bai, Y.; Liu, Y.; Wang, J.; Zhang, F.; Wang, Z. Conflict or Coordination? Analysis of Spatio-Temporal Coupling Relationship between Urbanization and Eco-Efficiency: A Case Study of Urban Agglomerations in the Yellow River Basin, China. *Land* **2022**, *11*, 882. [CrossRef]
3. Liu, J.; Schlünzen, K.H.; Frisius, T.; Tian, Z. Effects of Urbanization on Precipitation in Beijing. *Phys. Chem. Earth Parts ABC* **2021**, *122*, 103005. [CrossRef]
4. Su, H.; Wang, W.; Jia, Y.; Han, S.-C.; Gao, H.; Niu, C.; Ni, G. Impact of Urbanization on Precipitation and Temperature over a Lake-Marsh Wetland: A Case Study in Xiong'an New Area, China. *Agric. Water Manag.* **2021**, *243*, 106503. [CrossRef]
5. El-Kholei, A.O. Are Arab Cities Prepared to Face Disaster Risks? Challenges and Opportunities. *Alex. Eng. J.* **2019**, *58*, 479–486. [CrossRef]
6. Xiong, Y.; Li, C.; Zou, M.; Xu, Q. Investigating into the Coupling and Coordination Relationship between Urban Resilience and Urbanization: A Case Study of Hunan Province, China. *Sustainability* **2022**, *14*, 5889. [CrossRef]
7. Fang, G.; Wang, Q.; Tian, L. Green Development of Yangtze River Delta in China under Population-Resources-Environment-Development-Satisfaction Perspective. *Sci. Total Environ.* **2020**, *727*, 138710. [CrossRef] [PubMed]
8. Guo, Y.; Wang, H.; Nijkamp, P.; Xu, J. Space–Time Indicators in Interdependent Urban–Environmental Systems: A Study on the Huai River Basin in China. *Habitat Int.* **2015**, *45*, 135–146. [CrossRef]
9. Holling, C.S. Resilience and Stability of Ecological Systems. *Annu. Rev. Ecol. Syst.* **1973**, *4*, 1–23. [CrossRef]
10. Meerow, S.; Newell, J.P.; Stults, M. Defining Urban Resilience: A Review. *Landsc. Urban Plan.* **2016**, *147*, 38–49. [CrossRef]
11. Li, Y.; Li, Y.; Zhou, Y.; Shi, Y.; Zhu, X. Investigation of a Coupling Model of Coordination between Urbanization and the Environment. *J. Environ. Manag.* **2012**, *98*, 127–133. [CrossRef] [PubMed]
12. Tang, Z. An Integrated Approach to Evaluating the Coupling Coordination between Tourism and the Environment. *Tour. Manag.* **2015**, *46*, 11–19. [CrossRef]
13. Liu, N.; Wang, S.; Su, F.; Ye, J. Research on Coupling Coordination of China's New-Type Urbanization and Urban Resilience—Taking Yangtze River Economic Belt as an Example. *Sustainability* **2023**, *15*, 456. [CrossRef]
14. Shi, Y.; Zhu, Q.; Xu, L.; Lu, Z.; Wu, Y.; Wang, X.; Fei, Y.; Deng, J. Independent or Influential? Spatial-Temporal Features of Coordination Level between Urbanization Quality and Urbanization Scale in China and Its Driving Mechanism. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1587. [CrossRef]
15. Zhang, B.; Zhang, J.; Miao, C. Urbanization Level in Chinese Counties: Imbalance Pattern and Driving Force. *Remote Sens.* **2022**, *14*, 2268. [CrossRef]
16. Niu, J.; Du, H. Coordinated Development Evaluation of Population–Land–Industry in Counties of Western China: A Case Study of Shaanxi Province. *Sustainability* **2021**, *13*, 1983. [CrossRef]
17. Xu, D.; Hou, G. The Spatiotemporal Coupling Characteristics of Regional Urbanization and Its Influencing Factors: Taking the Yangtze River Delta as an Example. *Sustainability* **2019**, *11*, 822. [CrossRef]
18. Guo, L. Coupling Coordination Degree between New Urbanization and Eco-Environment in Shaanxi, China, and Its Influencing Factors. *Discret. Dyn. Nat. Soc.* **2021**, *2021*, e1555362. [CrossRef]
19. Zhang, H.; Chen, M.; Liang, C. Urbanization of County in China: Spatial Patterns and Influencing Factors. *J. Geogr. Sci.* **2022**, *32*, 1241–1260. [CrossRef]
20. Liu, B.; Tian, C.; Li, Y.; Song, H.; Ma, Z. Research on the Effects of Urbanization on Carbon Emissions Efficiency of Urban Agglomerations in China. *J. Clean. Prod.* **2018**, *197*, 1374–1381. [CrossRef]
21. Yang, F.; Liu, G. Research on Spillover Effect of Urbanization on Rural Land Transfer Based on the SDM Model of Intelligent Computing. *Mob. Inf. Syst.* **2022**, *2022*, e9921309. [CrossRef]
22. Liu, Y.; Gao, H.; Cai, J.; Lu, Y.; Fan, Z. Urbanization Path, Housing Price and Land Finance: International Experience and China's Facts. *Land Use Policy* **2022**, *113*, 105866. [CrossRef]
23. Zhang, H.; Tian, J. Supporting Paths for the Development of New Urbanization in Shaanxi Province Based on Fast Fourier Transform. *Math. Probl. Eng.* **2022**, *2022*, e1091278. [CrossRef]
24. Addai, K.; Serener, B.; Kirikkaleli, D. Empirical Analysis of the Relationship among Urbanization, Economic Growth and Ecological Footprint: Evidence from Eastern Europe. *Environ. Sci. Pollut. Res.* **2022**, *29*, 27749–27760. [CrossRef] [PubMed]
25. Shen, W.; Huang, Z.; Yin, S.; Hsu, W.-L. Temporal and Spatial Coupling Characteristics of Tourism and Urbanization with Mechanism of High-Quality Development in the Yangtze River Delta Urban Agglomeration, China. *Appl. Sci.* **2022**, *12*, 3403. [CrossRef]
26. Bruneau, M.; Chang, S.E.; Eguchi, R.T.; Lee, G.C.; O'Rourke, T.D.; Reinhorn, A.M.; Shinozuka, M.; Tierney, K.; Wallace, W.A.; von Winterfeldt, D. A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. *Earthq. Spectra* **2003**, *19*, 733–752. [CrossRef]
27. Adger, W.N.; Hughes, T.P.; Folke, C.; Carpenter, S.R.; Rockström, J. Social-Ecological Resilience to Coastal Disasters. *Science* **2005**, *309*, 1036–1039. [CrossRef]
28. Cutter, S.L.; Barnes, L.; Berry, M.; Burton, C.; Evans, E.; Tate, E.; Webb, J. A Place-Based Model for Understanding Community Resilience to Natural Disasters. *Glob. Environ. Chang.* **2008**, *18*, 598–606. [CrossRef]

29. Nyström, M.; Jouffray, J.-B.; Norström, A.V.; Crona, B.; Søgaard Jørgensen, P.; Carpenter, S.R.; Bodin, Ö.; Galaz, V.; Folke, C. Anatomy and Resilience of the Global Production Ecosystem. *Nature* **2019**, *575*, 98–108. [CrossRef]
30. Cutter, S.L.; Ash, K.D.; Emrich, C.T. The Geographies of Community Disaster Resilience. *Glob. Environ. Chang.* **2014**, *29*, 65–77. [CrossRef]
31. Lam, N.S.-N.; Qiang, Y.; Arenas, H.; Brito, P.; Liu, K. Mapping and Assessing Coastal Resilience in the Caribbean Region. *Cartogr. Geogr. Inf. Sci.* **2015**, *42*, 315–322. [CrossRef]
32. Wang, J.; Deng, Y.; Qalati, S.A.; Qureshi, N.A. Urban Resilience and Transportation Infrastructure Level in the Yangtze River Delta. *Front. Environ. Sci.* **2022**, *10*, 445. [CrossRef]
33. Li, Y.; Kappas, M.; Li, Y. Exploring the Coastal Urban Resilience and Transformation of Coupled Human-Environment Systems. *J. Clean. Prod.* **2018**, *195*, 1505–1511. [CrossRef]
34. Wang, Z.; Chen, Z.; Ma, C.; Wennersten, R.; Sun, Q. Nationwide Evaluation of Urban Energy System Resilience in China Using a Comprehensive Index Method. *Sustainability* **2022**, *14*, 2077. [CrossRef]
35. Xun, X.; Yuan, Y. Research on the Urban Resilience Evaluation with Hybrid Multiple Attribute TOPSIS Method: An Example in China. *Nat. Hazards* **2020**, *103*, 557–577. [CrossRef] [PubMed]
36. Silva, A.; Benites Lazaro, L.L.; Andrade, J.; Prado, A.F.; Ventura, A.; Campelo, A.; Tridello, V. Examining the Urban Resilience Strategy of Salvador, Bahia, Brazil: A Comparative Assessment of Predominant Sectors Within the Resilient Cities Network. *J. Urban Plan. Dev.* **2022**, *148*, 05022002. [CrossRef]
37. Heinzlef, C.; Robert, B.; Hémond, Y.; Serre, D. Operating Urban Resilience Strategies to Face Climate Change and Associated Risks: Some Advances from Theory to Application in Canada and France. *Cities* **2020**, *104*, 102762. [CrossRef]
38. Zhang, C.; Li, Y.; Zhu, X. A Social-Ecological Resilience Assessment and Governance Guide for Urbanization Processes in East China. *Sustainability* **2016**, *8*, 1101. [CrossRef]
39. Komugabe-Dixson, A.F.; de Ville, N.S.E.; Trundle, A.; McEvoy, D. Environmental Change, Urbanisation, and Socio-Ecological Resilience in the Pacific: Community Narratives from Port Vila, Vanuatu. *Ecosyst. Serv.* **2019**, *39*, 100973. [CrossRef]
40. Rogerson, R.J.; Giddings, B. The Future of the City Centre: Urbanisation, Transformation and Resilience—A Tale of Two Newcastle Cities. *Urban Stud.* **2021**, *58*, 1967–1982. [CrossRef]
41. Botezat, A.; David, M.; Incaltarau, C.; Nijkamp, P. The Illusion of Urbanization: Impact of Administrative Reform on Communities' Resilience. *Int. Reg. Sci. Rev.* **2021**, *44*, 33–84. [CrossRef]
42. Gao, Y.; Chen, W. Study on the Coupling Relationship between Urban Resilience and Urbanization Quality—A Case Study of 14 Cities of Liaoning Province in China. *PLoS ONE* **2021**, *16*, e0244024. [CrossRef]
43. Rybak-Niedziółka, K.; Grochulska-Salak, M.; Maciejewska, E. Resilience of Riverside Areas as an Element of the Green Deal Strategy-Evaluation of Waterfront Models in Relation to Re-Urbanization and the City Landscape of Warsaw. *Desalination Water Treat.* **2021**, *232*, 357–371. [CrossRef]
44. Li, W.; Wang, Y.; Xie, S.; Cheng, X. Coupling Coordination Analysis and Spatiotemporal Heterogeneity between Urbanization and Ecosystem Health in Chongqing Municipality, China. *Sci. Total Environ.* **2021**, *791*, 148311. [CrossRef] [PubMed]
45. Wang, S.; Cui, Z.; Lin, J.; Xie, J.; Su, K. The Coupling Relationship between Urbanization and Ecological Resilience in the Pearl River Delta. *J. Geogr. Sci.* **2022**, *32*, 44–64. [CrossRef]
46. Ma, F.; Wang, Z.; Sun, Q.; Yuen, K.F.; Zhang, Y.; Xue, H.; Zhao, S. Spatial–Temporal Evolution of Urban Resilience and Its Influencing Factors: Evidence from the Guanzhong Plain Urban Agglomeration. *Sustainability* **2020**, *12*, 2593. [CrossRef]
47. Jiao, S.; Wang, P.; Dai, Q.; Hu, S. Network Structure and Evolution Analysis of Urban Economic Connection in the Yunnan-Guizhou-Guangxi Provincial Border Region. *Hum. Geogr.* **2018**, *33*, 77–86. (In Chinese)
48. Cui, D.; Chen, X.; Xue, Y.; Li, R.; Zeng, W. An Integrated Approach to Investigate the Relationship of Coupling Coordination between Social Economy and Water Environment on Urban Scale—A Case Study of Kunming. *J. Environ. Manag.* **2019**, *234*, 189–199. [CrossRef]
49. Liu, L.; Chen, J. Strategic Coupling of Urban Tourism and Regional Development in Liaoning Province, China. *Asia Pac. J. Tour. Res.* **2020**, *25*, 1251–1268. [CrossRef]
50. Lv, T.; Wang, L.; Zhang, X.; Xie, H.; Lu, H.; Li, H.; Liu, W.; Zhang, Y. Coupling Coordinated Development and Exploring Its Influencing Factors in Nanchang, China: From the Perspectives of Land Urbanization and Population Urbanization. *Land* **2019**, *8*, 178. [CrossRef]
51. Peng, J.; Zhao, S.; Liu, Y.; Tian, L. Identifying the Urban-Rural Fringe Using Wavelet Transform and Kernel Density Estimation: A Case Study in Beijing City, China. *Environ. Model. Softw.* **2016**, *83*, 286–302. [CrossRef]
52. Zeng, P.; Wei, X.; Duan, Z. Coupling and Coordination Analysis in Urban Agglomerations of China: Urbanization and Ecological Security Perspectives. *J. Clean. Prod.* **2022**, *365*, 132730. [CrossRef]
53. Hou, Y.; Zhang, K.; Zhu, Y.; Liu, W. Spatial and Temporal Differentiation and Influencing Factors of Environmental Governance Performance in the Yangtze River Delta, China. *Sci. Total Environ.* **2021**, *801*, 149699. [CrossRef]
54. Fan, T.; Xue, D. Spatial Correlation of Cultural Industry and Tourism Industry in Shaanxi Province, China: LISA Analysis Based on Coordination Model. *Asia Pac. J. Tour. Res.* **2020**, *25*, 967–980. [CrossRef]
55. Erlando, A.; Riyanto, F.D.; Masakazu, S. Financial Inclusion, Economic Growth, and Poverty Alleviation: Evidence from Eastern Indonesia. *Heliyon* **2020**, *6*, e05235. [CrossRef]

56. Zhao, W.; Jiang, C. Analysis of the Spatial and Temporal Characteristics and Dynamic Effects of Urban-Rural Integration Development in the Yangtze River Delta Region. *Land* **2022**, *11*, 1054. [CrossRef]
57. Wan, J.; Zhang, L.; Yan, J.; Wang, X.; Wang, T. Spatial–Temporal Characteristics and Influencing Factors of Coupled Coordination between Urbanization and Eco-Environment: A Case Study of 13 Urban Agglomerations in China. *Sustainability* **2020**, *12*, 8821. [CrossRef]
58. Chan, P.; Lee, M.-H. Prioritizing Sustainable City Indicators for Cambodia. *Urban Sci.* **2019**, *3*, 104. [CrossRef]
59. Wang, Z.; Liang, L.; Sun, Z.; Wang, X. Spatiotemporal Differentiation and the Factors Influencing Urbanization and Ecological Environment Synergistic Effects within the Beijing-Tianjin-Hebei Urban Agglomeration. *J. Environ. Manag.* **2019**, *243*, 227–239. [CrossRef] [PubMed]
60. Zhou, J.; Fan, X.; Li, C.; Shang, G. Factors Influencing the Coupling of the Development of Rural Urbanization and Rural Finance: Evidence from Rural China. *Land* **2022**, *11*, 853. [CrossRef]
61. Hong, T.; Wang, B.; Li, L. The Coupling Relationship between Urban Resilience Level and Urbanization Level in Hefei. *Math. Probl. Eng.* **2022**, *2022*, e7339005. [CrossRef]
62. Li, G.; Kou, C.; Wang, Y.; Yang, H. System Dynamics Modelling for Improving Urban Resilience in Beijing, China. *Resour. Conserv. Recycl.* **2020**, *161*, 104954. [CrossRef]
63. Andrews, D.W.K.; Lu, B. Consistent Model and Moment Selection Procedures for GMM Estimation with Application to Dynamic Panel Data Models. *J. Econom.* **2001**, *101*, 123–164. [CrossRef]
64. Brana, S.; Djigbenou, M.-L.; Prat, S. Global Excess Liquidity and Asset Prices in Emerging Countries: A PVAR Approach. *Emerg. Mark. Rev.* **2012**, *13*, 256–267. [CrossRef]
65. Lu, H.; Lu, X.; Jiao, L.; Zhang, Y. Evaluating Urban Agglomeration Resilience to Disaster in the Yangtze Delta City Group in China. *Sustain. Cities Soc.* **2022**, *76*, 103464. [CrossRef]
66. Zhou, Q.; Liu, D. Study on the Coordinated Development of Urban Resilience and Urbanization Level in the Urban Agglomeration of Yangtze River Delta. *Res. Soil Water Conserv.* **2020**, *27*, 286–292. (In Chinese)
67. Zhang, Y.; Liu, Q.; Li, X. The Coupling Coordination of Urban Resilience and New Urbanization in the Yangtze River Delta Urban Agglomeration. *Urban Prob.* **2022**, 17–27. (In Chinese) [CrossRef]