

## Article

# Analysis of the Spatial and Temporal Characteristics and Dynamic Effects of Urban-Rural Integration Development in the Yangtze River Delta Region

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**Abstract:** Urban-rural integration has been found to be an inevitable trend in the development of urban-rural relations and a vital measure to tackle the unbalanced and uncoordinated development between urban and rural areas. Most existing studies on the development of urban-rural integration have only estimated its level and factors and compared the heterogeneity of cities in sample regions. Few studies have focused on the interactions between different categories of urban-rural integration levels. Accordingly, to fill the above research gap, an evaluation index system of the development of urban-rural integration is built in this study from four economic-social-spatial-ecological dimensions, the spatial and temporal evolution characteristics of the development of urban-rural integration in 27 central cities in the Yangtze River Delta region between 2003 and 2020 are analyzed, and the intrinsic dynamic shock effects are empirically investigated using a panel vector autoregression (PVAR) model. This study suggests the following points: (1) the development of urban-rural integration in the Yangtze River Delta region tends to increase while fluctuating and experiences an evolutionary process of “severe dysfunction–moderate dysfunction–mild dysfunction”, with an overall positive development trend. (2) In the study period, the agglomeration effect of the level of the development of urban-rural integration in the Yangtze River Delta has been strengthened continuously, and the overall spatial distribution pattern has changed from “low level, low gap” to “high level, high gap”, showing the characteristics of decreasing class distribution step by step, with Shanghai and Anqing as the markers from east to west. (3) All the endogenous variables of the development of urban-rural integration show a continuous positive response to their own shocks, thus suggesting that the respective variable has a certain path dependence on itself. Shocks of urban-rural ecological integration are capable of boosting the improvement of urban-rural economic integration and urban-rural social integration development, and shocks of urban-rural social integration contribute to the improvement of urban-rural ecological integration. The important policy implication of this study is that an intra-regional linkage and coordination mechanism should be built in the future, while the focus should be placed on the heterogeneity of regional development, and policies and measures regarding development of urban-rural integration in a disaggregated manner should be developed, so as to facilitate the improvement of the level of regional development of urban-rural integration.

**Keywords:** Yangtze River Delta region; urban-rural integration; spatio-temporal evolution; dynamic shocks



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## 1. Background of the Study

In the course of urbanization and modernization, developed and developing nations are facing the decline in the countryside, and the gap between rural and urban areas is becoming increasingly prominent in numerous parts of the world [1]. Thus, the correlation between urban and rural development should be stressed in all periods of economic development, which is the most fundamental economic and social relationship in a country, and

as an integral part of the urban and rural territorial system, the two have always been an inseparable organic fusion [2]. With the continuous promotion of urbanization, the interaction between urban and rural areas is becoming increasingly closer, thus promoting the continuous transformation of urban and rural development. However, unlike developed nations, urbanization in developing nations is often at the expense of the development of rural areas, which causes inequality in the flow of a considerable number of factors and the decline in rural areas [3]. Accordingly, the question of how to achieve integrated rural-urban development and rural rejuvenation has become a common challenge for all nations worldwide, and it takes on great significance in achieving the goal of global sustainable development.

China is the world's largest developing country. Its long-standing dualistic system of urban-rural division and urban-oriented view of development has exacerbated the "three divisions" of urban-rural division, land division, and separation of people and land. This system has been found as the root cause of the increasingly serious "rural disease", which has significantly restricted the integration of urban and rural areas and the healthy development of the countryside in China [4]. Scholars have generally suggested that the evolution of urban-rural relations in China has experienced a process of separation, confrontation, coordination, and then integration [5]. Since the beginning of the 21st century, the Chinese government has begun to address the contradictions between urban and rural development and has implemented a series of policies and measures conducive to rural development, successively proposing integrated urban-rural development, coordinated urban-rural development (*cheng xiang tong chou*), urban-rural unity (*cheng xiang yi ti hua*), as well as integrated urban-rural development (*cheng xiang rong he*). To be specific, urban-rural coordinated development emphasizes the means by which the government can enhance the correlation between urban and rural areas by allocating resources. Urban-rural unity aims to weaken the individuality of urban and rural areas, which ignores the uniqueness of rural development itself. Urban-rural integrated development stresses the equality of status between urban and rural areas, in which urban and rural areas achieve joint development via the two-way flow of factors and the effective allocation of resources.

The development of urban-rural integration is now highly valued by the Chinese government, and it has been proposed at several important meetings to develop a novel urban-rural relationship of co-prosperity and interaction by establishing institutional mechanisms for the development of urban-rural integration. Moreover, the strategy of rural revitalization has been proposed to emphasize the intrinsic motivation of rural development through the priority allocation of rural resources, so as to achieve prosperity and wealth in rural areas. It has been generally considered that from the urban-rural development of nations worldwide, integrated urban-rural development is critical to solve the imbalance between urban and rural development, and it is also the inevitable trend of the urban-rural development relationship in the new era. Promoting integrated urban-rural development has been found to be inevitable to boost the development of China's rural revitalization in the new era, an inevitable demand for China's high-quality economic development in the new era [5], as well as a major strategy to achieve China's modernization and sustainable development. Accordingly, as China's macro-strategic policies are being implemented, the study of promoting integrated urban-rural development takes on critical significance in reshaping the correlation between urban and rural development, exploring the laws of urban-rural development evolution and investigating the path of urban-rural integrated development. Furthermore, the measurement and analysis of the state of regional development of urban-rural integration lay a basis for the transformation from qualitative to quantitative development of urban-rural integration, which is of high significance in narrowing the regional development gap and promoting coordinated regional development.

The urban-rural relationship is a vital issue in human social development and has aroused wide attention from scholars worldwide. Urban-rural integration is an advanced stage in the development of urban-rural relations and reflects the evolution of urban-rural

relations, which can be traced back to the urban-rural development concept of the ideal socialists [6]. Existing research on the development of urban-rural integration primarily focuses on the theory of urban-rural relations, connotation elaboration and level measurement, and attempts to measure the level of regional development of urban-rural integration and explore its intrinsic factors by constructing a comprehensive index system [7–14]. However, first, only a small proportion of the existing research has investigated the inner mechanism of the development of urban-rural integration. Second, Most of the studies have built the evaluation index system from a static perspective, which cannot indicate the dynamic and comprehensive nature of the development of urban-rural integration in a scientific and comprehensive manner. Third, studies on the development of urban-rural integration have been largely at the national or provincial level, and there is a lack of spatial and temporal studies at the city scale.

The Yangtze River Delta region, the critical economic growth pole in China, shows a significant strategic position in China's all-round construction and opening-up pattern, and the integration of the Yangtze River Delta is a vital engine of China's economic development [15]. Regional economic development has been highly valued by the Chinese government. The Yangtze River Delta is a region with Shanghai, which comprises nine prefecture-level cities in the Jiangsu Province, nine prefecture-level cities in the Zhejiang Province, and eight prefecture-level cities in the Anhui Province as the central cities. This region has been driving the integrated development of the whole region by radiation. Under the development of the new era, urban-rural integration serves as an essential means to tackle the contradictions between urban and rural development in the Yangtze River Delta region. Moreover, urban-rural integration takes on great significance in boosting the high-quality economic and integrated regional development of the region. In the context of coordinated regional economic development, this raises the questions of what is the trend of urban-rural integration development in the Yangtze River Delta region, what are the spatial characteristics and effects of regional urban-rural integration, as well as what dynamic effects exist between regional urban-rural integration development systems. Accordingly, 27 central cities in the Yangtze River Delta region are selected as the research objects to develop a multi-dimensional urban-rural integration evaluation index system to measure the level of the development of urban-rural integration, and its spatial and temporal evolution characteristics are analyzed. Subsequently, a panel vector autoregression (PVAR) model is built to measure the dynamic impact effects between different dimensions of the development of urban-rural integration. Next, an empirical study is conducted to examine the dynamic impact effects between the dimensions of the development of urban-rural integration by building a panel vector autoregression (PVAR) model, so as to explore the interactive effects between the intrinsic dimensions and to provide scientific reference and suggestions for facilitating the development of urban-rural integration in the Yangtze River Delta region.

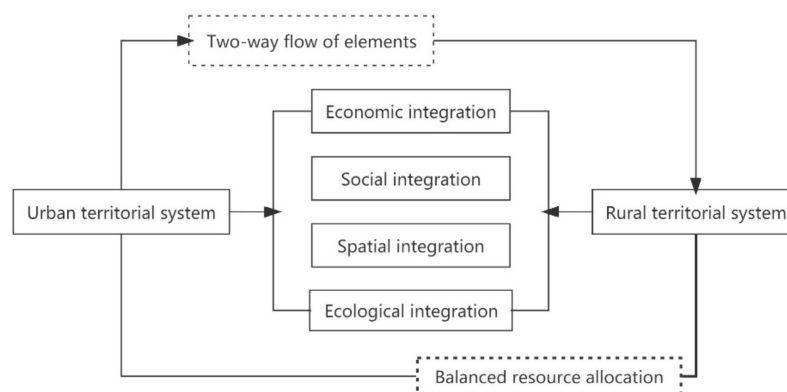
## 2. Definition and Mechanistic Description

### 2.1. Definition of Connotation

With the continuous promotion of urban-rural integration strategies, the factors between urban and rural areas have changed rapidly, thus gradually breaking down the boundaries, structures and even mechanisms of action between urban and rural areas [16], and the long-existing "dualistic order" has triggered the endogenous demand for "common (integrated) development". Driven by urbanization and industrialization, urban-rural territorial systems tend to be more coordinated, and their functions and structures are becoming multi-dimensional. Scholars in ecology have concluded that urban-rural integration should achieve the elimination of the imbalance of ecological development between urban and rural areas, while scholars in geography have suggested that urban-rural integration should be a rational spatial connection between urban and rural systems. Other scholars have clarified the connotation of urban-rural integration in accordance with "flow space" and urban-rural equivalence theory and have argued that in the era of rapid development of

information technology, conventional factors (e.g., land and population) break through the limitations of the field and exhibit dynamic and networked characteristics, thus affecting the mechanism of urban-rural factor flow [17,18]. In addition, the connotation of the development of urban-rural integration in accordance with the theory of urban-rural equivalence highlights the “different but equal” nature of urban-rural development. In brief, the integrated development of urban and rural areas should be achieved through the two-way flow of factors and the effective allocation of resources to achieve the interaction and integration of the economic, social and ecological fields of the urban and rural regional systems, and ultimately the development of urban and rural equivalence. The above process also refers to the transformation of the heterogeneous dual structure into a homogeneous monolithic structure, which is essential to the development of urban-rural integration [6].

As revealed by the above theoretical analysis, integrated urban-rural development is a complex, multi-level and multi-element composite structural system with profound connotations. The core meaning of urban-rural integrated development lies in the premise of ensuring the effective allocation of urban and rural factors and resources in both directions, realizing the co-prosperity and co-existence of urban and rural areas through the benign interaction between urban and rural areas, realizing the multi-dimensional integrated development of urban and rural areas in economic, social, ecological and spatial aspects, and ultimately realizing the equivalence of urban and rural regional systems [9]. The specific connotation is presented below. Urban-rural economic integration means that the marginal rewards of urban and rural areas tend to be equal through the two-way flow and optimal allocation of resources and factors under equal economic policies; urban-rural social integration means ensuring that public services (for example., employment, education, medical care and infrastructure) are of equal significance in urban and rural residents; urban-rural ecological integration is achieved through comprehensive and collaborative management of urban and rural regional systems to achieve a state of high integration and complementarity of urban and rural areas. Urban-rural spatial integration refers to the interaction and integration of urban and rural systems in terms of human, logistic and information flows, which is the carrier and basic condition for urban-rural integrated development (Figure 1).



**Figure 1.** Conceptual framework for integrated urban-rural development.

## 2.2. Mechanistic Elaboration

Under the goal of regional development, integrated urban-rural development should also achieve a unified process of achieving economic-social-ecological benefits of the urban-rural territorial system and a process of spatially balanced development of the urban-rural territorial system [19]. Accordingly, the theory of regional spatial equilibrium model can be borrowed to construct a spatial equilibrium model of urban-rural integrated development to reveal the inner mechanism of urban-rural integrated development [20].

Thus, we first assume that under integrated regional urban-rural development, various factors of production (including population) in the region are free to move. The

comprehensive development benefits of regional development ( $\Sigma F_M$ ) consists of social benefit  $F_1$ , economic benefit  $F_2$  and ecological benefit  $F_3$ ; and if it is assumed that a certain type of development benefit  $A_M$  is composed of land  $B_M$ , labor  $C_M$ , technology  $D_M$ , and capital  $E_M$  and other factors of production, then the expression of the function is as follows:

$$\Sigma F_M = F_1 + F_2 + F_3 \quad (1)$$

$$A_M = f(B_M, C_M, D_M, E_M) \quad (M = 1, 2, 3) \quad (2)$$

Under integrated urban-rural development, through the flow and optimal allocation of factors, urban and rural territorial systems can eventually achieve equal development benefits per capita in urban and rural territorial systems, i.e., eventually realize the equivalence of urban and rural development, and the expression of the model of balanced urban-rural development [21].

$$OF_1 = \frac{\Sigma D_{1M}}{O_1} = \frac{\Sigma D_{2M}}{O_2} = OF_2 \quad (3)$$

In this equation,  $\Sigma D_{1M}$  and  $\Sigma D_{2M}$  denote the combined development benefits of rural and urban areas, respectively.  $O_1$  and  $O_2$  represent the total rural and urban populations, respectively.  $OF_1$  and  $OF_2$  express the combined development benefits per capita in rural and urban areas, respectively. Equation (3) is derived based on the assumption that the goods (services) generating social development benefits in rural and urban areas are private goods, whereas social and environmental development benefits are mostly public or quasi-public goods in reality, thus making it difficult to avoid the existence of non-exclusive, non-competitive and indivisible characteristics. Accordingly, to obtain per capita development benefits in the above cases, the spatial equilibrium model should be modified using a correction factor.

$$OF_1 = \frac{\Sigma D_{1M}}{\alpha_1 O_1} = \frac{\Sigma D_{2M}}{\alpha_2 O_2} = OF_2 \left( \alpha_1 \in \left( \frac{1}{O_1}, 1 \right), \alpha_2 \in \left( \frac{1}{O_2}, 1 \right) \right) \quad (4)$$

This model is an extension of the idea of balanced regional development theory and can more effectively explain the inner mechanism of integrated urban-rural development [22]. In line with the above connotation explanation, the two-way flow of factors between urban and rural areas and the optimal allocation of resources are vital prerequisites for achieving integrated urban-rural development. First, relevant studies have found that China's urbanization level is still lower than the average of comparable nations in the world [23]. Second, as the level of integrated development between urban and rural areas is being improved, increasing modernization factors in cities are allocated to rural systems, which are manifested as the net inflow of capital, technology and other factors. Third, with the implementation of the rural revitalization strategy, the proportion of basic public services in rural areas is increasing, which is manifested as an increasing proportion of public goods. Through the flow and optimal allocation of factors between urban and rural areas, the population of rural areas ( $O_1$ ) tends to decrease within a certain range, along with the continuous promotion of urbanization. Through the input of various factors from cities and the implementation of the rural revitalization strategy, the comprehensive development efficiency of the rural territorial system tends to increase, which means that the per capita development efficiency of the rural territorial system is increasing, and the spatial, economic and social distribution of the urban and rural territorial system is optimized. As a result, the per capita development efficiency of the urban and rural territorial system eventually tends to be equalized, and the integrated development of urban and rural areas is achieved.

### 3. Selection of Indicators and Research Methodology

#### 3.1. Selection of Indicators

As mentioned earlier, the key to the development of urban-rural integration lies in the process of transformation from a heterogeneous dual structure to a homogeneous mono-



lithic structure, and the development of urban-rural development from dichotomy to full integration is bound to undergo a dynamic process of evolution from spatial imbalance to urban-rural equilibrium. From this perspective, urban-rural integration is a goal and a state, as well as a process. Thus, the selection of indicators of the development of urban-rural integration should break through the previous static scope, and include indicators of urban-rural comparison and difference (comparison category), as well as indicators reflecting “urban-rural interaction and integration” (driving category), and also indicators of urban-rural development status (comprehensive category). In brief, according to the connotation and mechanism analysis of the development of urban-rural integration, and using the frequency analysis method and the expert validation method to determine the indicators one by one, twenty indicators in four dimensions, including economic, social, ecological and spatial dimensions, are finally determined (Table 1), and twenty-seven central cities in the Yangtze River Delta region are selected for the study, including Shanghai, Nanjing, Suzhou, Wuxi, Changzhou, Yancheng, Taizhou, Yangzhou, and Yangzhou in Jiangsu Province, Yancheng, Taizhou, Yangzhou, Zhenjiang, and Nantong in Jiangsu Province, Hangzhou, Wenzhou, Ningbo, Huzhou, Jinhua, Jiaxing, Shaoxing, Tai'zhou, and Zhoushan in Zhejiang Province, as well as Hefei, Maanshan, Wuhu, Tongling, Chuzhou, Anqing, Chizhou, and Xuancheng in the Anhui Province. The world has witnessed a rapid urbanization trend over the past few years. Moreover, numerous urban agglomerations have emerged. Similar to the Yangtze River Delta urban agglomeration, the Northeast Atlantic coastal urban agglomeration and the five major urban agglomerations in North America have been formed in foreign countries [24]. The above urban agglomerations are characterized by superior location conditions, higher levels of comprehensive economic development, developed transportation, advanced industrial structure, as well as closer interactions between urban and rural areas. Accordingly, the urban-rural integration index system constructed in this study can also explain the development trend of urban-rural integration in the development of urban agglomerations in other regions. In addition, urbanization is an inevitable result of socio-economic development and a manifestation of social progress. The urban-rural integration development indicators established in this study can also lay a theoretical basis for urban-rural integration in developing countries and provide a reference for cities in developed countries to feed their villages.

**Table 1.** Urban-rural integration evaluation indicator system.

Objectives	Subsystems	Indicator Layer	Description or Calculation of the Indicator	Properties	Type of Indicator
Level of urban-rural integration	Economic integration	GDP per capita	Total regional GDP/total regional population/yuan	Positive	General
		Non-farm industry ratio	Primary industry output/secondary and tertiary industry output/%	Negative	Contrast category
		Ratio of urban to rural Engel's coefficient	Urban Engel's coefficient/rural Engel's coefficient/%	Negative	Contrast category
		Ratio of urban to rural household consumption per capita	Rural per capita consumption/urban per capita consumption/%	Negative	Contrast category

Table 1. Cont.

Objectives	Subsystems	Indicator Layer	Description or Calculation of the Indicator	Properties	Type of Indicator
		Ratio of urban to rural per capita income	Urban per capita income/rural per capita income/%	Negative	Contrast category
		Fixed asset investment per capita in urban and rural areas	Urban and rural fixed asset expenditure/total population/yuan/person	Positive	Drivers
		Ratio of urban to rural expenditure on culture, education and recreation	Urban residents' expenditure on culture, education and recreation/rural residents' expenditure on culture, education and recreation/%	Negative	Contrast category
		Ratio of health care expenditure per capita in urban and rural areas	Urban per capita health expenditure/rural per capita health expenditure/%	Negative	Contrast category
	Social integration	Comparative coefficient of urban and rural transport communications	Urban per capita expenditure on transport and communication/rural per capita expenditure on transport and communication/%	Negative	Contrast category
		Urban and rural pension insurance coverage	%	Positive	General
		Urban and rural unemployment insurance coverage	%	Positive	General
		Percentage of practicing physicians in urban and rural areas	Number of practicing doctors in urban and rural areas/total population/%	Positive	General
		Urban and rural domestic waste treatment	%	Positive	General
	Ecological integration	Sewage treatment factor	Urban and rural sewage treatment rate/%	Positive	General
		Industrial solid waste disposal	Urban and rural industrial solid waste disposal rate %	Positive	General
		Level of land urbanization	Area of built-up area/total land area/%	Positive	Drivers
		Level of population urbanization	Urban population/total population (%)	Positive	Drivers
	Spatial integration	Urban and rural mobility network	Road mileage in operation/total land area (km/km <sup>2</sup> )	Positive	Drivers
		Urban spatial expansion factor	Area of built-up area/area under crop cultivation/%	Negative	General
		Urban and rural employment headcount coefficient	Ratio of urban to rural population employed/%	Negative	General

### 3.2. Research Methodology

- Measuring the level of the development of urban-rural integration

Since the subjective assignment method cannot overcome the problem of credibility reduction caused by human subjectivity, the coefficient of variation method is adopted in this study to determine the weights of the respective indicator. The coefficient of variation method is an objective auxiliary method that measures the degree of differentiation of data by calculating the ratio of the standard deviation to the mean of the data, so as to calculate the weights of indicators. The advantage of this method is that it eliminates the degree of dispersion in unit means and the effect of different units or means on the comparison of the degree of variation brought about by multiple samples [25]. The raw data are normalized using the most common extreme value normalization method. The specific equation for the coefficient of variation method is written as follows:

$$\rho_{ij} = \frac{\sigma_{ij}/\bar{x}_{ij}}{\sum_{i=1}^j (\sigma_{ij}/\bar{x}_{ij})} \quad (5)$$

In this equation,  $\sigma_{ij}$  denotes the standard deviation of the  $j$ th indicator of the  $i$ th dimension;  $\bar{x}_{ij}$  denotes the mean value of the  $j$ th indicator of the  $i$ -th dimension;  $\rho_{ij}$  represents the weight of the  $j$ th indicator of the  $i$ -th dimension. After the weight of the respective indicator is obtained using Equation (5), the Euclidean distance method in Equation (6) is adopted to obtain the evaluation value of urban-rural integration in the central cities of the Yangtze River Delta between 2003 and 2020, and the values of the economic, social, ecological and spatial dimensions are calculated.

$$Y_i = 1 - \frac{\sqrt{(\rho_{i1} - \rho_{i1}X_{i1})^2 + (\rho_{i2} - \rho_{i2}X_{i2})^2 + \dots + (\rho_{ij} - \rho_{ij}X_{ij})^2}}{\sqrt{\rho_{i1}^2 + \rho_{i2}^2 + \dots + \rho_{ij}^2}} \quad (6)$$

- Exploratory spatial analysis

The first law of geography indicates that things are interconnected and the closer they are, the more interconnected they will be [25]. Based on the two-way flow of urban and rural factors, urban and rural areas are becoming more closely connected, so the Moran's  $I$  index should be applied to the ESDA method to measure the spatial dispersion pattern of the central cities in the Yangtze River Delta. Moran's  $I$  index, used for the spatial agglomeration or spatial distribution characteristics of the whole sample and local area, respectively, is written as the following:

$$I = \frac{\sum_{i=1}^n \sum_{j=1}^n \omega_{ij} (x_i - \bar{x})(x_j - \bar{x})}{s^2 \sum_{i=1}^n \sum_{j=1}^n \omega_{ij}} \quad (7)$$

$$I_i = \frac{(x_i - \bar{x}) \sum_{j=1}^n \omega_{ij} (x_j - \bar{y})}{s^2} \quad (8)$$

In these equations,  $x_i$  and  $x_j$  denote the regions;  $i$  and  $j$  represent the spatial sequences of region  $i$  and region  $j$ , respectively;  $\bar{x}$  expresses the mean of the observed values;  $n$  is the number of cities in the total sample;  $s^2$  is the variance of the sample;  $\omega_{ij}$  is the spatial matrix. If the region  $i$  and  $j$  are adjacent to each other,  $\omega_{ij} = 1$  and vice versa. The Moran's  $I$  index takes the value  $[-1, 1]$  with an  $I$  index over 0, indicating a positive correlation effect between regions, i.e., high value-high value adjacency, low value-low value adjacency and vice versa, or indicating a negative effect, high value-low value agglomeration or low value-high value agglomeration.



- PVAR model construction

Hermann Haken's synergetic theory suggests that there are elements (two and more) in a system that interact with and affect each other over time, and the coordination between elements determines the structural tendencies of the system's development [26,27]. The PVAR models are adopted to analyze the dynamic shocks of stochastic perturbations to a system of variables through impulse response functions to explain the effects of various dynamic shocks on the formation of system variables [23]. It can be used to explain the dynamic shock effects between the different system dimensions of urban-rural integration. The PVAR model built in this study is as follows:

$$Z_{it} = Y_0 + \sum_{j=1}^m \gamma_j Z_{it-j} + \lambda_i + \xi_{it} + \zeta_{it} \quad (9)$$

where  $i$  represents the central city ( $i = 1, 2, \dots, 27$ ), the  $t$  represents the year ( $t = 0, 1, \dots, 18$ ), and  $j$   $Z_{it} = (LNP_{it}, LNH_{it}, LNL_{it}, LNE_{it})$ , denotes the number of lag periods ( $j = 1, 2, \dots, m$ ) for the first  $i \times 1$  dimensional endogenous variables of the city in year  $t$ , i.e., urban-rural economic integration variables, urban-rural social integration variables, urban-rural ecological and environmental integration variables, as well as urban-rural spatial integration variables;  $Z_{it-j}$  denotes the  $Z_{it}$  lagged  $j$  period of the variables;  $\gamma_0$  denotes the vector of intercept terms;  $\gamma_j$  denotes the lag period coefficient matrix,  $\lambda_i$  denotes a vector of fixed effects among the 10 cities, indicating the heterogeneity of the individual cities.  $\xi_{it}$  denotes a vector of time effects, suggesting year-specific shock effects in each year.  $\zeta_{it}$  denotes a vector of random disturbance errors.

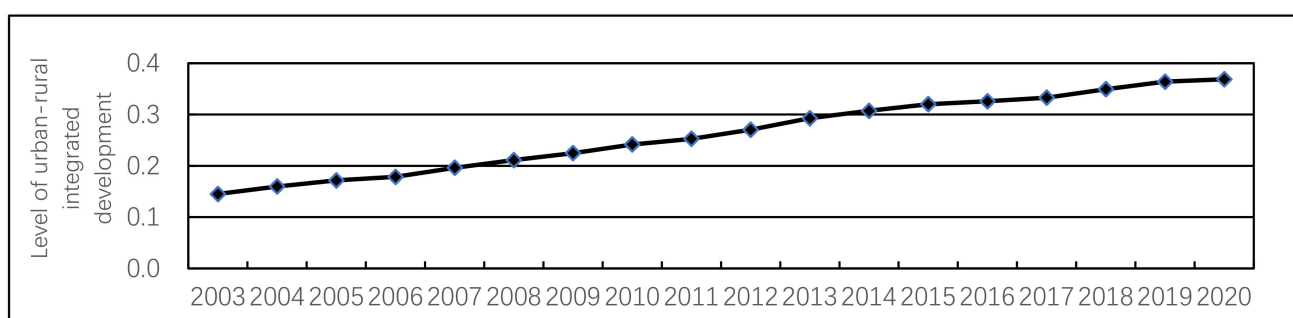
- Data sources

The data required for this study are largely obtained from the statistical yearbooks of the central cities of the Yangtze River Delta from 2004 to 2021, the China City Statistical Yearbook, government websites of the cities, websites of statistical bureaus and statistical bulletins. The missing data for some years are filled in by interpolation of adjacent years or linear interpolation.

## 4. Analysis of Results

### 4.1. Chronological Evolutionary Characteristics of Integrated Urban-Rural Development

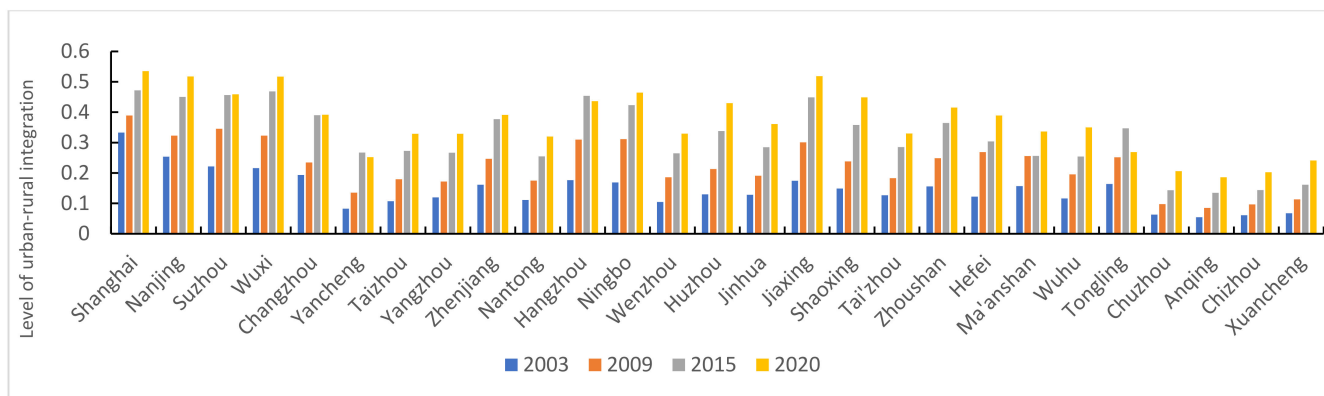
Figures 2 and 3 show a graph of the changes in the level of the development of urban-rural integration in the Yangtze River Delta region and the changes in the level of urban-rural integration in the respective central city, which is analyzed as follows.



**Figure 2.** Changes in the level of urban-rural integration development.

As depicted in Figure 2, the level of the development of urban-rural integration in the Yangtze River Delta region has been fluctuating while increasing between 2003 and 2020. It has increased from 0.145 in 2003 to 0.369 in 2020, marking an increase of 154%, with an average annual increase of 8.56%, of which the level of the development of urban-rural integration from 2019 to 2020 has increased the least by only 1.3%, due to the effect of the COVID-19 pandemic. Overall, the evolution of the development of urban-rural integration

in the Yangtze River Delta region has been largely consistent with the adjustment of China's macro policies, from the "integrated development of urban and rural areas" released by the 16th Party Congress (2003–2012) to the "integrated development of urban and rural areas" of the 18th Party Congress (2012–2017) to the "integrated development of urban and rural areas" issued by the 18th Party Congress (2012–2017), and then to the 19th Party Congress "integrated urban-rural development" (2017–present), coupled with the deployment of strategies (e.g., the construction of beautiful countryside and the rural revitalization strategy); the level of integrated urban-rural development in the Yangtze River Delta region has been continuously improved.

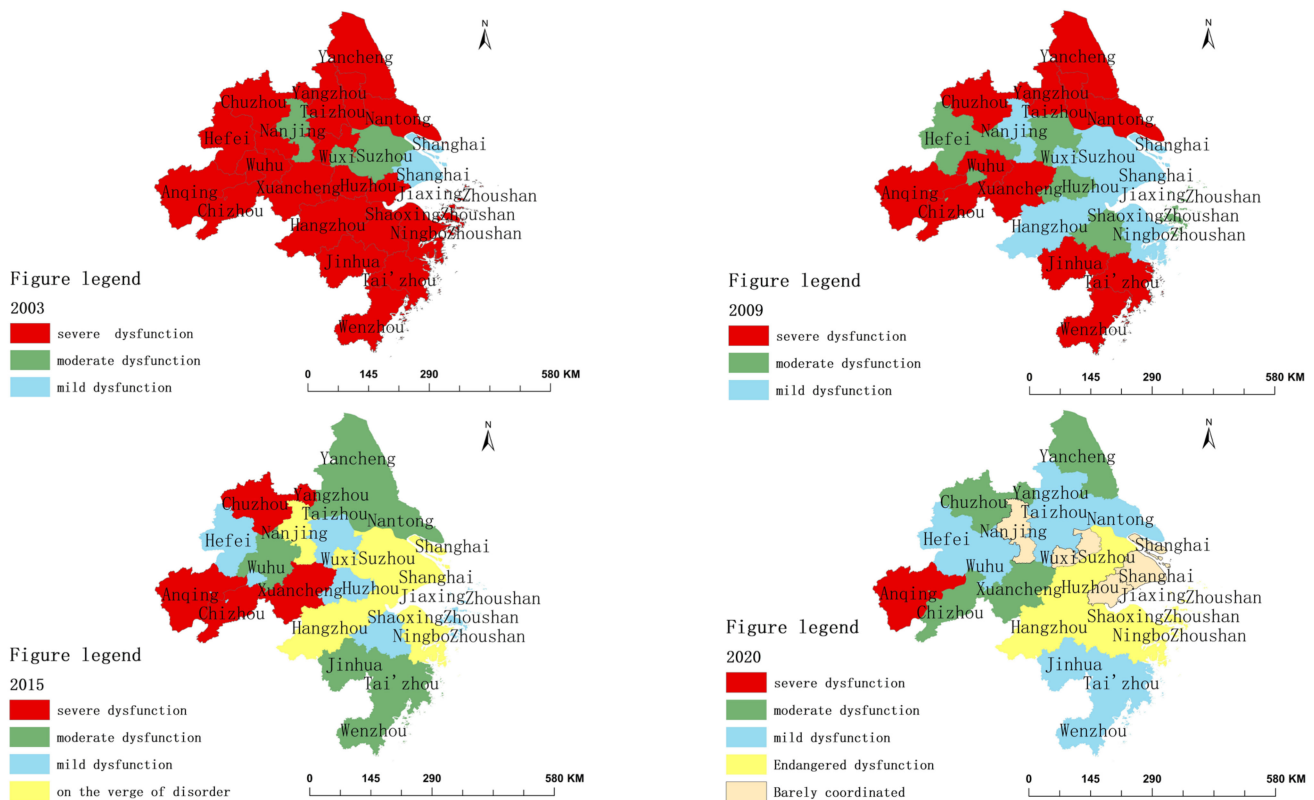


**Figure 3.** Changes in the level of urban-rural integration development in the central cities of the Yangtze River Delta.

The overall level of the development of urban-rural integration in the central cities of the Yangtze River Delta is low. In the study period, the average level of the development of urban-rural integration in the Yangtze River Delta basically remained around 0.262, and with reference to the classification criteria of related studies [28], the average level of the development of urban-rural integration in the Yangtze River Delta was only at the moderate disorder level, and the level of the development of urban-rural integration in the Yangtze River Delta experienced the evolution process from severe disorder–moderate disorder–light disorder during the period between 2003 and 2020. In 2003, only three cities, Nanjing, Wuxi and Suzhou, were in moderate disorder and Shanghai was in mild disorder, while the rest of the cities were in severe disorder, with the proportion of severe disorder reaching 85.2%. In 2009, the number of cities in severe disorder dropped to 12, accounting for 44.4%, while the number of cities in moderate disorder rose to 8, and 7 cities in mild disorder appeared. By 2020, cities on the verge of dislocation and barely dislocated cities become the main types, with 16 cities; the only central city in heavy dislocation was Anqing, with a reduced proportion of 3.7%; at this time, the level of the development of urban-rural integration in the Yangtze River Delta had raised to a light level. From the above analysis, we can observe that the trend of the development of urban-rural integration in the Yangtze River Delta tends to be positive, showing an essential change from quantitative change to qualitative change, which is fundamentally attributed to the implementation of a series of policies, such as the construction of beautiful countryside and rural revitalization strategy of the Chinese government.

#### 4.2. Analysis of the Spatial Characteristics of Integrated Urban-Rural Development

Using 2003, 2009, 2015 and 2020 as representative years, the spatial and temporal evolutionary characteristics of the development of urban-rural integration in the central cities of the Yangtze River Delta region are analyzed, as shown in Figures 4 and 5.



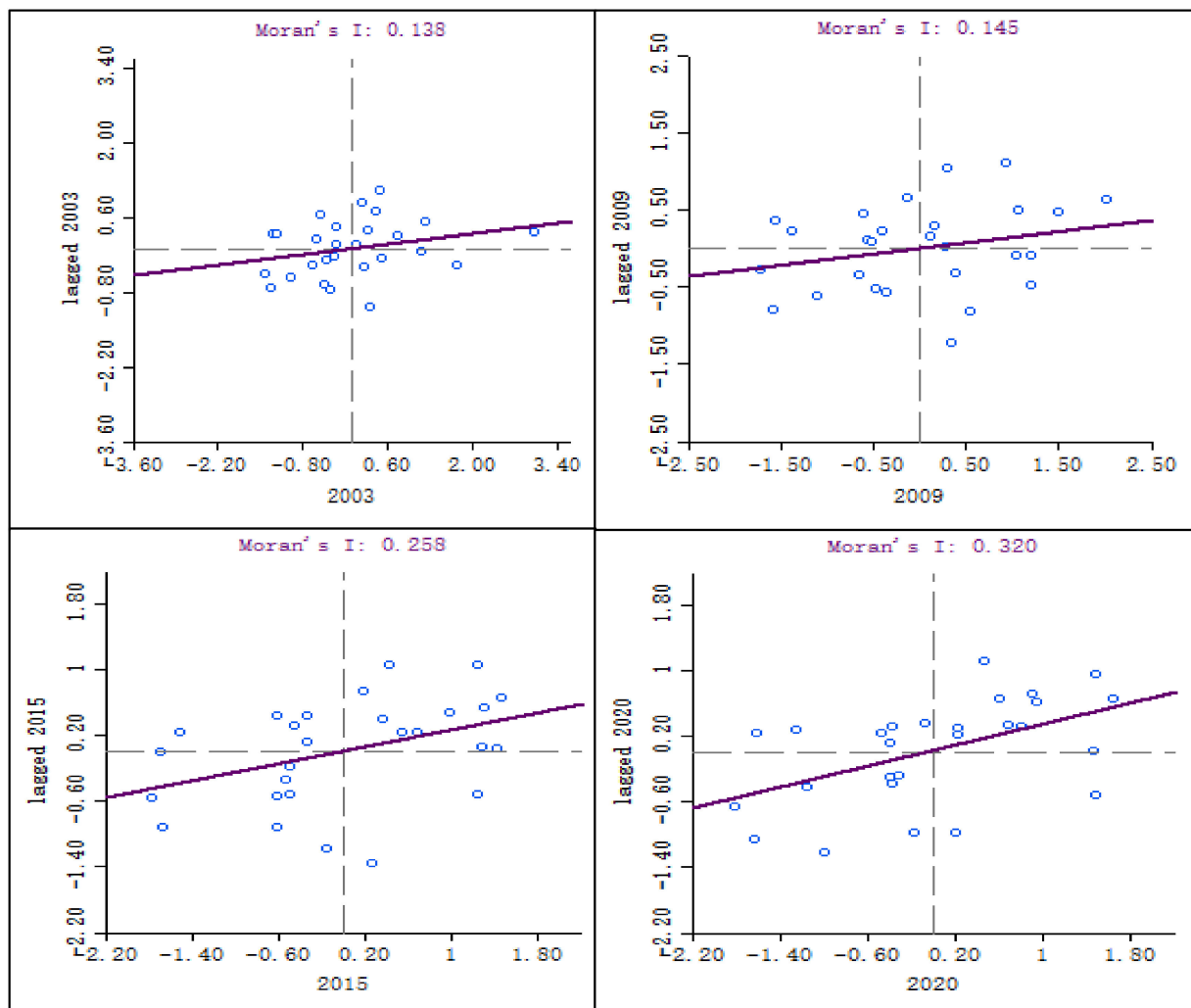
**Figure 4.** Spatial distribution of urban-rural integration development in the central cities of the Yangtze River Delta (2003–2020).

As depicted in Figure 4, the agglomeration effect of urban-rural integration level in the Yangtze River Delta region is obvious. The high value of the development of urban-rural integration level is primarily concentrated in the central-eastern region and coastal region centered on Shanghai, Suzhou, Wuxi and Jiaxing, thus revealing that the strong economic development strength of Shanghai and Suzhou supports the benign development of their urban-rural integration level, while the low value of urban-rural integration level is largely concentrated in the western and southwestern regions. The spatial distribution pattern shows a change from “low level and low gap” to “high level and high gap”.

Figure 5 indicates that there is spatial correlation between the level of urban-rural integration in the Yangtze River Delta region. The Moran’s *I* index for the level of urban-rural integration in the Yangtze River Delta region during the period 2003–2020 is always positive, and the indices are 0.138, 0.145, 0.258 and 0.320 in 2003, 2009, 2015 and 2020, respectively, with the Moran’s index showing a gradually increasing trend, thus suggesting that the agglomeration effect of urban-rural integration in the Yangtze River Delta region is gradually increasing, but the gap between regional development of urban-rural integration shows a widening trend, which further highlights the urgency and importance of the Yangtze River Delta integration strategy [27].

The spatial agglomeration effect of the development of urban-rural integration in the Yangtze River Delta region is gradually increasing. As depicted in Figure 5, the local spatial agglomeration effect of the development of urban-rural integration is more significant and is dominated by the HH area (high-high agglomeration type, first quadrant) and the LL area (low-low agglomeration type, third quadrant), and the number of both HH and LL types shows an increasing trend. In terms of the distribution of prefecture-level cities in the quadrants of the Moran index, the main formation is a high value area (H-H) formed by cities such as Shanghai–Suzhou–Wuxi and a low value area (L-L) formed by cities such as Chizhou, Anqing and Tongling. From east to west, roughly with Shanghai and Anqing as the markers, it shows a decreasing hierarchical distribution characteristic. This suggests

that the Yangtze River Delta region has a significant spatial neighborhood effect, resulting in a spatial agglomeration distribution characterized by “the weak being constantly weak and the strong being constantly strong”.



**Figure 5.** Moran scatterplot of urban-rural integration levels in the Yangtze River Delta 2003, 2009, 2015, 2020.

### 4.3. Analysis of the Dynamic Impact Effects of the Development of Urban-Rural Integration

#### 4.3.1. Panel Data Testing

First, the PVAR model in Equation (9) is built to explore the dynamic impact effects between the development of urban-rural integration systems in the Yangtze River Delta region, using the evaluation model above to calculate the evaluation values of the development of urban-rural integration sub-dimensions (economic, social, ecological and spatial dimensions) of the respective central city in the Yangtze River Delta region during the period 2003–2020.

To avoid the phenomenon of “pseudo-regression” in the PVAR model, a unit root test of the panel data should be conducted first to ensure the valid estimation of the model [29]. To avoid pseudo-regressions in the PVAR model, a unit root test of the panel data is first conducted to ensure the validity of the model estimates. As shown in Table 2, the first-order differences of the variables all reject the hypothesis that the variables are non-stationary, so  $Dlnecn$ ,  $Dlnsoc$ ,  $Dlneco$  and  $Dlnspa$  can be considered as stationary series, and the PVAR model can be estimated.

**Table 2.** Unit root test results.

Variables	LLC	IPS
Dlnecn	−4.2623 ***	−3.7429 ***
Dlnsoc	−1.38548 *	−6.0244 ***
Dlnspa	−10.5302 ***	−7.6842 ***
Dlneco	−5.09022 ***	−7.5705 ***

Note: \*\*\*, \* indicate significant at 1%, 10% level.

- Determination of the lag order

This study determines the optimal lag order for this study based on the consistent moment model selection criteria proposed by Andrews and Lu (2001). Table 3 shows that MBIC, MAIC and MQIC all have the smallest coefficients at first order, so this study determines the final optimal lag order to be period 1.

**Table 3.** Optimal lag order of PVAR model.

Lag	CD	J	p-Value	MBIC	MAIC	MQIC
1	0.999991	50.92931	0.359099	−226.546	−45.0707	−117.506
2	0.999991	31.27899	0.502873	−153.705	−32.721	−81.0111
3	0.999983	14.22208	0.582174	−78.2698	−17.7779	−41.923

- Analysis of GMM estimation results

Dlnecn (economic), Dlnsoc (social), Dlnspa (spatial) and Dlneco (ecological) are employed as the endogenous variables to build a PVAR model for generalized matrix estimation, and the results are listed in Table 4.

**Table 4.** GMM estimation results.

	Dlnecn Z-Value	Dlnsoc Z-Value	Dlnspa Z-Value	Dlneco Z-Value
L. Dlnecn	5.46 ***	L.dlnx1 1.17	L.dlnx1 0.25	L.dlnx1 −0.88
L. Dlnsoc	0.73	L.dlnx2 1.93 *	L.dlnx2 0.02	L.dlnx2 1.38
L. Dlnspa	0.28	L.dlnx3 −0.86	L.dlnx3 2.21 ***	L.dlnx3 0.72
L. Dlneco	2.9 ***	L.dlnx4 1.83 *	L.dlnx4 −0.8	L.dlnx4 10.23 ***

Note: L. Dlnecn denotes lag 1, \*\*\*, \* denotes significant at 1%, 10% confidence level, respectively.

For the endogenous variables themselves, Dlnecn has a positive effect with a coefficient of 5.46 at the 1% level, thus suggesting that urban-rural economic integration is significantly dependent on its own inertia development. Dlnsoc, Dlnspa, and Dlnspa have a positive effect with the coefficients of 1.93, 2.21, and 10.21, respectively. The coefficients are 1.93, 2.21, and 10.21, respectively, and are significant at the 10% and 1% levels, respectively, thus suggesting that urban-rural social integration, urban-rural spatial integration and urban-rural ecological integration all have a “sticky” effect on their own development, with the “stickiness” of urban-rural ecological integration being the most prominent. For the correlation between the endogenous variables, Dlnspa positively affects Dlnsoc at the 1% significant level, thus suggesting that urban-rural ecological integration has a positive promotion effect on urban-rural economic integration with a lag of one period, which proves the importance of the theory of “green water and green mountains are the silver mountain of gold”. The positive effect of Dlnspa on Dlnsoc at the 10% significant level indicates that there is a positive effect of urban-rural ecological integration on urban-rural social integration at the 1-lagged period; urban-rural economic integration, urban-rural social integration and urban-rural spatial integration on urban-rural ecological integration at the 1-lagged period are not significant, thus indicating that the current socio-economic development of the Yangtze River Delta region has failed to achieve the coordinated development of ecological environment. The impact of urban-rural economic integration, urban-rural

social integration and urban-rural ecological integration on the development of urban-rural spatial integration is not significant, thus revealing that the regional economic, social and ecological development has not formed an effective linkage and coordinated development and cannot effectively contribute to the development of urban-rural spatial integration.

- Panel Granger causality test

In this study, the Granger causality test is performed to test whether there is a logical relationship between the variables that affect each other based on GMM estimation, and the results are described in Table 5.

**Table 5.** Panel Granger causality test.

Original Assumptions	Chi <sup>2</sup> Statistic	p-Value
Dlnsco cannot Granger cause Dlnecn	0.54	0.463
Dlnspa cannot Granger cause Dlnecn	0.08	0.777
Dlneco cannot Granger cause Dlnecn	8.394	0.0004
Dlnsco, Dlnspa and Dlneco cannot simultaneously Granger cause Dlnecn	11.929	0.008
Dlnecn cannot Granger cause Dlnsco	1.38	0.24
Dlnspa cannot Granger cause Dlnsco	0.732	0.392
Dlneco cannot Granger cause Dlnsco	3.348	0.067
Dlnecn, Dlnspa, Dlneco cannot Granger cause Dlnsco	8.196	0.042
Dlnecn cannot Granger cause Dlnspa	0.062	0.803
Dlnsco cannot Granger cause Dlnspa	0	0.986
Dlnsco cannot Granger cause Dlnspa	0.643	0.423
Dlnecn, Dlnsco and Dlnspa cannot Granger cause Dlnspa	3.333	0.343
Dlnecn cannot Granger cause Dlnsco	0.767	0.381
Dlneco cannot Granger cause Dlneco	1.915	0.166
Dlnspa cannot Granger cause Dlneco	0.525	0.469
Dlnecn, Dlnsco and Dlnspa cannot Granger cause Dlneco	8.381	0.039

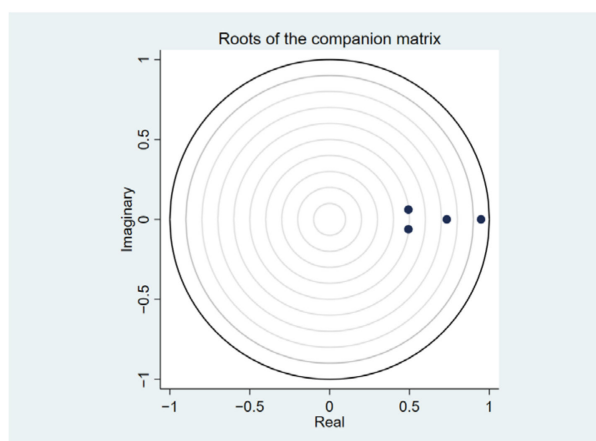
The Dlnecn equation suggests that urban-rural ecological integration is the Granger cause of urban-rural economic integration at the 1% significant level, while urban-rural social integration and urban-rural spatial integration are not the Granger cause of urban-rural economic integration, whereas the joint development of urban-rural social integration, urban-rural spatial integration and urban-rural ecological integration is the Granger cause of urban-rural economic integration at the 1% significant level, thus revealing that the improvement of ecological environment and environmental quality contributes to the economic development, and a certain degree of interaction has been formed between urban-rural ecological integration and urban-rural economic integration. At the same time, this is in line with the connotation of high-quality economic development advocated by the current Chinese government, while the improvement of the level of economic development is also dependent on the coordinated development of social systems, spatial systems, and ecosystems. The Dlnsco equation shows that urban-rural ecological integration is a Granger cause of urban-rural social integration at the 10% significant level, thus suggesting that the improvement of ecological environment quality has a role in the stable development of social systems. Meanwhile, the joint development of urban-rural economic integration, urban-rural spatial integration and urban-rural ecological integration at the 5% significant level is the Granger cause of urban-rural social integration, thus suggesting that the healthy development of urban-rural social system also depends on the coordination and stability of spatial system and ecosystem with economic development. As revealed by the Dlnspa equation, urban-rural economic integration, urban-rural social integration and urban-rural ecological integration and the joint development of the three are not Granger causes of urban-rural spatial integration, thus suggesting that urban-rural spatial integration depends more on the governance and development of the space. As indicated by the Dlneco equation, urban-rural economic integration, urban-rural social integration and urban-rural spatial integration are not the Granger causes of urban-rural ecological integration, whereas the joint development of the three is the Granger cause of urban-rural ecological integration at



the 5% significant level, thus suggesting that the improvement of ecological environment level is not only dependent on the input of regional economy, but also on the coordinated development of economic, social and spatial aspects to achieve the qualitative improvement of the ecological environment level.

- Panel AR root test

The AR root test is a vital condition to test whether the PVAR model is stable or not. It is only when all the AR roots are guaranteed to lie within the unit circle that the PVAR model is stable and the results are convincing. As depicted in Figure 6, the PVAR model built in this study has four unit roots and they all lie within the unit circle, so the PVAR model built in this study can be considered stable.

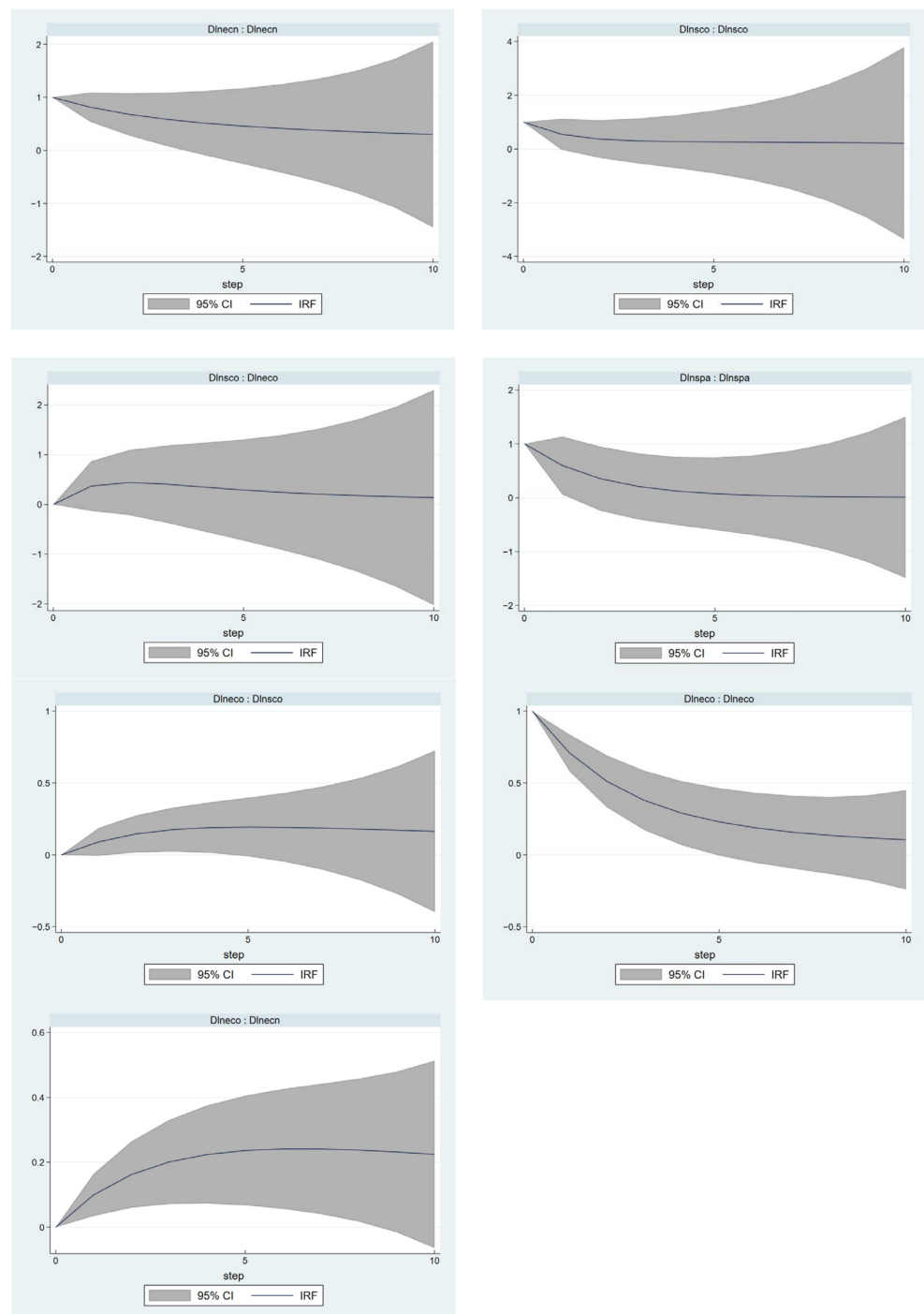


**Figure 6.** Panel AR root test.

#### 4.3.2. Analysis of Pulse Function Results

The impulse response function refers to a more accurate reflection of the long-term impact relationship between the variables by measuring the short- and long-term effects of the variables on other variables when subjected to shocks with unit differences, with the other variables constant in the current and previous periods [30]. This section will examine the impact of urban-rural economic integration. In this section, one unit standard deviation shocks will be applied to urban-rural economic integration, urban-rural social integration, urban-rural spatial integration and urban-rural ecological integration, respectively, and Monte-Carlo simulations will be set up in stata for 200 times to examine the dynamic shock effects among the variables. Furthermore, since the effects between the variables are not all significant, only the impulse response images with significant results are presented, where the horizontal axis indicates the period of the variable response and the vertical axis is the magnitude of the variable response.

As depicted in Figure 7, the response of all four variables is positive under the shock effect of one standard deviation variable, thus suggesting that urban-rural economic, social, spatial and ecological integration all show a continuous positive response to their own shocks, thus suggesting that the respective variable has a certain path dependence (inertia) on itself; urban-rural ecological integration and urban-rural spatial integration both reach the maximum in the current period and then weaken rapidly, showing a continuous inertia and lag. Both urban-rural economic integration and urban-rural social integration also reach their maximum in the current period and then gradually decrease, whereas this inertia is smaller than that of urban-rural ecological integration and spatial integration.



**Figure 7.** Impulse response diagram for each dimension of urban-rural integration in the Yangtze River Delta.

The impact effect between the variables is then analyzed. The impact of urban-rural ecological integration on urban-rural economic integration is all positive and shows a gradual increase, then gradually decreases and finally falls to zero; it reaches its maximum in the seventh period and then gradually falls to zero after the eighth period. This indicates that urban-rural ecological integration in the Yangtze River Delta region strongly supports urban-rural economic integration, suggesting that the increase in the level of urban-rural ecological integration contributes to the development of urban-rural economic integration. The impact effect of urban-rural social integration on urban-rural ecological integration is also positive, and shows a rapid increase and then a slow convergence to zero; it reaches

its maximum in the second period and gradually falls to zero after the fifth period, thus revealing that the increase in the level of urban-rural social integration has a facilitating effect on the development of urban-rural ecological integration. The impact of urban-rural ecological integration on urban-rural social integration is all positive, and slowly rises and then tends to be zero, reaching its maximum in the fourth period and tends to be zero after the sixth period, thus suggesting that the continuous upgrading of urban-rural ecological integration can be beneficial to improve the development level of urban-rural social integration.

## 5. Discussion

### 5.1. Analysis of Spatial and Temporal Changes and Dynamic Effects of the Development of Urban-Rural Integration

The urban-rural relationship has been recognized as the most fundamental economic relationship and has always aroused wide attention from scholars. Chinese scholars have primarily focused on the evolution of urban-rural relations, the connotation of urban-rural integration, as well as the development level measurement of urban-rural integration, etc. [13,31]. As the research on urban-rural relations has progressively deepened, the research on the development of urban-rural integration has shifted to the research on spatial and temporal patterns and driving factors [32,33]. Research on the development of urban-rural integration was initiated earlier in developed nations, whereas it has been largely based on qualitative research and approached from a single perspective of primarily urban-rural industrial development and urban-rural public services. Scholars have commonly adopted the method of the multi-indicator evaluation system to measure the level of the development of urban-rural integration, and the selection of indicators usually aims to study the urban-rural system as an organic whole using the comprehensive index method and the coupling and coordination method primarily. In brief, few of the existing studies have analyzed the inner mechanism of the development of urban-rural integration, and previous research tends to neglect the analysis of the dynamic effects between the development of urban-rural integration systems [34,35]. Accordingly, based on the definition of the development of urban-rural integration and the internal evolution mechanism, an evaluation index system is developed in this study for the development of urban-rural integration in four dimensions, including economic-social-spatial-ecological dimensions, the indexes are divided into comprehensive, comparative and driving categories, the inaccuracy caused by the selection of urban-rural indexes focusing only on urban-rural differences and static perspective is corrected, and the spatial and temporal evolution characteristics of the development of urban-rural integration are analyzed from 27 central cities in the Yangtze River Delta region between 2003 and 2020. The Yangtze River Delta region is recognized as a relatively developed region in China in terms of its domestic economic development level, high urbanization level, and comprehensive development level. Thus, the study on urban-rural integration development in this region can provide possible references and lessons for the study on urban-rural relations in developed cities abroad, while providing useful references for urban-rural planning. Furthermore, the study on dynamic impact effects of urban-rural integration and development subsystems can reveal the mechanism of urban-rural development subsystems, and thus provide possible theoretical support for achieving better urban-rural relationships in the future. The spatial and temporal evolution characteristics of the development of urban-rural integration in the 27 central cities of the Yangtze River Delta region between 2003 and 2020 are investigated, followed by a panel vector autoregressive model (PVAR) model to analyze the dynamic impact effects between urban-rural economic integration, urban-rural social integration, urban-rural spatial integration, and urban-rural ecological integration in the Yangtze River Delta region.

First, for the overall time-series change characteristics, the level of the development of urban-rural integration in the Yangtze River Delta region has been elevated between 2003 and 2020, which is significantly correlated with a series of policies implemented

in China since 2003, with the aim to boost rural development, including the strategies of integrated urban-rural development, coordinated urban-rural development and new urbanization, which have played a crucial role in achieving the development of urban-rural integration [36]. The conclusion of this study is consistent with the findings of Daizhong Tang et al. [37]. In addition, the increase in the level of the development of urban-rural integration in the Yangtze River Delta between 2019 and 2020 is the smallest compared with other years, primarily due to the shock of the sudden outbreak of the domestic epidemic in China (which began in Wuhan) at the end of 2019. Second, by region, the Yangtze River Delta is one of the most dynamic regional economies in China and one of the most innovative urban agglomerations, whereas its intra-regional urban-rural integration still has significant differences, with the spatial distribution pattern of the Yangtze River Delta region shifting from “low level, low disparity” to “high level, high disparity”. These differences are generated because cities (e.g., Shanghai, Suzhou, Wuxi) in the Yangtze River Delta are leading cities in terms of economic development and their strong level of economic development, thus supporting the improvement of their level of the development of urban-rural integration. However, the high degree of interaction between the urban and rural areas in terms of factor flow, industrial interaction and transport and information networks improves their higher level of the development of urban-rural integration [38]. Cities (e.g., Chizhou, Anqing, Chuzhou) are lagging behind other cities in the region in terms of economic development, and the above cities are at the primary stage of urban-rural integration development. Moreover, it is considered that the Yangtze River Delta region has experienced a “northward, southward, and westward” expansion trend over the past few years, and that cities in the region that were originally economically developed (e.g., Shanghai, Suzhou, Wuxi) have become increasingly vulnerable to the development of urban-rural integration. It is also possible that due to the expansion trend of the Yangtze River Delta region recently, the original economically developed cities in the region (e.g., Shanghai, Suzhou, Wuxi) have a more significant siphoning effect on the newly introduced cities and a weaker diffusion effect, thus resulting in a “Matthew effect” of the level of the development of urban-rural integration [39]. Third, as revealed by the dynamic impact effect of urban-rural integration in the Yangtze River Delta region, urban-rural ecological integration plays a positive role in promoting the improvement of urban-rural economic integration and urban-rural social integration [40,41], and the development of urban-rural social integration can promote the improvement of urban-rural ecological integration development. Moreover, the result of this study fills the gap of the study by Changjun Jiang et al. and Daizhong Tang et al. and indicates the mechanism of action between urban-rural integration subsystems [37,42], thus revealing the “high-quality development path oriented to ecological priority and green development” advocated by the Chinese government in recent years [43]. Furthermore, to develop urban-rural social integration, it is crucial to achieve universal sharing of infrastructure and public services between urban and rural areas [44], open up channels for the circulation of factors between urban and rural areas, solidify the social foundation for the development of urban-rural ecological integration, and facilitate urban-rural ecological integration toward a virtuous cycle [45].

### *5.2. Policy Recommendations to Improve the Integration of Regional Urban and Rural Development*

Considering that rural decline is prevalent in nations worldwide, especially in developing nations, rural revitalization has become a vital strategy to solve this problem. Thus, comprehensively promoting the integrated development of urban and rural areas takes on critical significance in accelerating the flow of factors and the rational allocation of resources between urban and rural areas, narrowing the development gap between urban and rural areas, promoting the improvement of the quality of the ecological environment in urban and rural areas, and facilitating the realization of urban-rural equivalence. The specific policy recommendations are presented below.

The following policy recommendations are obtained based on the above findings. First, one must pay attention to regional heterogeneity and formulate a policy for the integrated development of urban and rural areas that promotes classification. The Yangtze River Delta region encompasses a wide range of regions, and the level of economic development in the region shows wide differences. Accordingly, on the one hand, for cities with high levels of economic development in the region (e.g., Shanghai, Suzhou, and Wuxi) in which the spillover effect of cities on the countryside dominates, the focus of the future development of urban-rural integration should be placed on stabilizing the economic development benefits of cities and towns and implementing policies for remedying the shortcomings of rural development, while the construction of basic transport infrastructure should be vigorously developed, and the industrial layout should be a way of the agglomeration of labor, production materials and other factors to increase their radiation and diffusion effects. For cities in the region (e.g., Chizhou, Anqing, and Chuzhou), which are relatively behind in economic development, most of the region remains at the stage of urbanization polarization development, and the focus should be placed on future development of urban-rural integration through the promotion of urbanization. However, we should be wary of the “siphon effect” and “border effect” exerted by the development of polarization to achieve the optimal combination of population distribution, industrial layout, capital allocation and other factors, and boost regional socio-economic development to improve the level of their development of urban-rural integration.

Second, in view of the spatial agglomeration characteristics of the Yangtze River Delta region, which is characterized by “weakness and strength”, a regional linkage and coordination mechanism should be built to reconstruct the urban-rural spatial system of the Yangtze River Delta region. On the one hand, the key to the integrated development of urban and rural areas in the Yangtze River Delta lies in breaking the shackles of regional administrative boundaries and forming an effective regional linkage mechanism. The interaction and integration of population, market interconnection and resource sharing in the region will be promoted by different participating bodies (e.g., the government and the market) through the establishment of a precise linkage mechanism between urban and rural areas at the provincial and municipal levels, so as to lead to the coordinated development in the economic, social and spatial aspects in the region and improve the overall level of regional urban-rural integration and development. On the other hand, based on the major strategic context of the current double cycle, the Yangtze River Delta region should take full advantage of the Yangtze River Delta integration strategy in regional development by reconstructing the spatial structure of urban and rural areas and forming a network of close cooperative relationships for intra-regional interconnection and interaction. It is necessary to continuously strengthen the in-depth cooperation between developed cities (e.g., Shanghai, Suzhou, and Wuxi) and less developed cities (e.g., Anqing, Chizhou, and Chuzhou) and deepen the urban and rural governance of the less developed cities in the region. Moreover, it should strengthen the development of industrial clusters in the region, actively use the introduced capital, technology, talents and other elements to promote the optimization and upgrading of the industrial structure, make up for the shortcomings of regional development and improve the level of urban-rural integration and development.

Third, based on the analysis of the dynamic impact effect in the Yangtze River Delta region, it is required to actively explore the effective development mechanism between urban-rural economic integration, social integration, spatial integration and ecological integration among the central cities in the Yangtze River Delta region, boost the coordinated development of the urban-rural economy, society and ecology promoted by urban-rural ecological integration, facilitate the construction of public infrastructure, optimize the environment for the development of urban-industry integration and the equalization of urban-rural services, and theoretically support the improvement of the level of the development of urban-rural integration in the Yangtze River Delta region. On the one hand, based on the role played by urban-rural ecological integration in boosting urban-rural economic and social integration, it is of great significance to strengthen the intensive

and economical use of resources, boost the transformation of the regional economy to a development mode with low energy consumption, low pollution and low emissions, and transform the ecological and environmental green advantages of the Yangtze River Delta region into social and economic development benefits continuously. On the other hand, considering the positive effect of urban-rural social integration on urban-rural ecological integration, it is crucial to co-ordinate the integration of urban-rural infrastructure and the sharing of urban-rural public services, accelerate the two-way flow of labor, capital and other factors between urban and rural areas, and lay a social foundation for the development of urban-rural integration.

The realization of integrated urban-rural development relies on the two-way flow of factors between urban and rural areas to achieve an optimal combination of urban and rural resources and factors, thus realizing urban-rural equivalence development. However, from the current perspective, it is still a complex task to study its impact on the integrated development of urban and rural areas from the perspective of factor mobility, which is also the next breakthrough in this study. In addition, although this study has portrayed and analyzed the dynamic effects between the subsystems of urban-rural integrated development, it fails to reveal their intrinsic mechanisms of action, while from the perspective of the scope of the study, further analysis of urban-rural integrated development with counties as the research unit is needed in the future to enhance the depth of the study.

## 6. Conclusions

This study constructs a relatively comprehensive and scientific evaluation index system for the development of urban-rural integration from “economic”, “social”, “spatial” and “ecological” levels, based on the connotation and internal mechanism of the development of urban-rural integration. A relatively comprehensive and scientific evaluation index system for development of urban-rural integration is built in four dimensions, and the coefficient of variation and Euclidean distance method are used to measure the evaluation value of the development of urban-rural integration of 27 central cities in the Yangtze River Delta between 2003 and 2020. Finally, an empirical study of the dynamic impact effects between the dimensions of urban-rural integration was conducted using a spatial panel vector autoregression (PVAR) model, with the following findings.

- (1) In terms of time-series changes, the overall level of the development of urban-rural integration in the Yangtze River Delta region shows a fluctuating upward trend, undergoing an evolutionary process from severe disorder to moderate disorder to mild disorder; however, the overall development level is low and the regional disparities are more obvious, with the high value regions formed by the cities of Shanghai, Nanjing, Suzhou and Wuxi showing more significant differences from the low value regions formed by the cities of Anqing, Chizhou and Chuzhou.
- (2) For spatial distribution patterns, in the study period, a relatively significant agglomeration effect of the level of the development of urban-rural integration has been found in the Yangtze River Delta region, with Shanghai, Suzhou, Wuxi, and Jiaxing as the center. The high value areas of the development of urban-rural integration are largely concentrated in the central and eastern regions and coastal regions, whereas the low value areas are primarily distributed in the western and southwestern regions. The spatial distribution pattern shifts from “low level, low gap” to “high level, high gap”, and the spatial agglomeration effect tends to be strengthened from east to west. Shanghai and Anqing are the markers, showing the characteristics of decreasing class distribution, which leads to the spatial agglomeration distribution characteristics of “the weak are always weak, the strong are always strong”.
- (3) For the analysis of the dynamic shock effect of the development of urban-rural integration, all variables show a continuous positive response to shocks themselves, thus suggesting that the respective variable has a certain path dependence (inertia) on itself, whereas this path dependence varies between variables; urban-rural ecological integration change shocks can facilitate the improvement of the development level of



urban-rural economic integration and urban-rural social integration, as well as urban-rural social integration change shocks. The shocks contribute to the improvement of the level of urban-rural ecological integration.

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