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Driving Mechanism of the Coordinated Development of Regional Economy-Society-Environment System Based on Grey Incidence Analysis Model

—A Case Study of Wanjiang Urban Belt

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Abstract

Using grey incidence analysis method, this paper analyzed the impact of various factors on the coordinated development of economy-society-environment system of Wanjiang urban belt to explore the mechanism of the coordinated development of regional economy-society-environment system. From 2011 to 2018, in the coordinated development of economic, social and environmental systems under the overall level of Wanjiang urban belt, the degree of influence of the development of each subsystem on the coordinated development is ranked: environmental subsystem ≻ economic subsystem ≻ social subsystem. In the environmental subsystem, environmental state = environmental pressure ≻ environmental response, and surface water quality, per capita industrial solid waste production, green coverage of constructed areas are three most influential social indicators. In the economic subsystem, economic structure ≻ developing quality ≻ economic benefits, proportion of foreign direct investment in GDP, the proportion of R & D expenditure in GDP, the proportion of tertiary industry in GDP are three most influential economic indicators. In the social subsystem, public service ≻ living standards ≻ quality of life, and urbanization rate of permanent population, per capita road mileage, and the number of hospital beds per 10,000 people are three most influential social indicators.

Keywords

Driving Mechanism, Grey Incidence Analysis Model, Economy-Society-Environment System, Wanjiang Urban Belt

1. Introduction

Along with the concept of sustainable development, promoting the coordinated development of economic, society and ecological environment has become the key research point among the scholarly community. There are numerous research about the coordinated development of economy-society-environment. Based on the theory of ecological civilization, (Li et al., 2015) constructed the evaluation index system of coordinated development of three subsystems of environmental protection, economic development and social progress at the provincial level, and used country and provincial scale data to quantitatively analyze the spatial and temporal variation of the coordinated development degree at these two spatial scales. (Peng et al., 2017) built the evaluation index system of China's economic-society-environment system based on the concept of sustainable development, and evaluated the coordination state of economy, society and environment in China from 2008 to 2014 by using the coupling coordination model. (He et al., 2019) constructed the "environment-economy-society" composite system coupling coordination evaluation index system from the perspective of river basin, and analyzed the evolution trend of the "environment-economy-society" composite system coupling coordination degree in Jinsha River Basin (JRB) from 2001 to 2016 adopting by coupling coordination model, GIS and theil index. (Li et al., 2019) established a comprehensive evaluation system for large regions, which included economic development, social progress and ecological environment. Based on the relevant data of 109 cities in the Yangtze River Economic Belt (YREB) from 2000 to 2015, they evaluated the coupling and coordinated development of the YREB from two latitudes of time and space.

However, the majority of the literatures, including the above, researched the coordinated development regional economy-society-environment simply from the perspective of evaluation, included analyzing their temporal and spatial characteristics, few scholars carried out the research on the driving mechanism of the coordinated development of economy-society-environment, especially using quantitative analysis method to analyze the impact of various factors on the coordinated development of regional economy-society-environment system. In fact, it is more helpful to understand the sustainable development of regional economy-society-environment system and further enrich the sustainable development theory and regional development theory by analyzing the impact of various factors on the coordinated development of regional economy-society-environment system and clarifying the mechanism of the coordinated development of regional economy-society-environment system.

2. Research Area

Industrial transfer is an effective way to optimize the spatial distribution of productive forces and promote the level of regional coordinated development. Since reform and opening up, regional unbalanced development strategy inclined to

the East has been enforced for a long time in China. As a result, the economic development gap between the East and the central and western regions is widening increasingly. As the new century has arrived, China started a series of regional coordinated development strategies such as the Great West Development, Revitalization of Northeast and Rise of Central China, the central and western regions gradually accelerate the pace of undertaking international and domestic industrial transfer. Nevertheless, industrial transfer will inevitably bring different environmental effects to the undertaking regions while promoting the economic growth of the undertaking regions. "Pollution Haven", "Pollution Halo" and "Environmental Kuznets Curve" are three common environmental effects in the process of industrial transfer. In order to further guide the central and western regions to undertake industrial transfer in an orderly manner, 10 national demonstration zone of undertaking industrial transfer had been established successively, which should strengthen resource conservation and environmental protection, and promote coordinated development of economy, society and environment.

The demonstration zone of undertaking industrial transfer in Wanjiang urban belt (Hereinafter referred to as Wanjiang urban belt) is the first national demonstration zone of undertaking industrial transfer in central and western regions in China. Wanjiang urban belt includes eight prefecture level cities of Hefei, Wuhu, Maanshan, Anqing, Chuzhou, Chizhou, Tongling, Xuancheng, and Jin'an District and Shucheng County in Lu'an (Figure 1). Wanjiang urban belt which linked

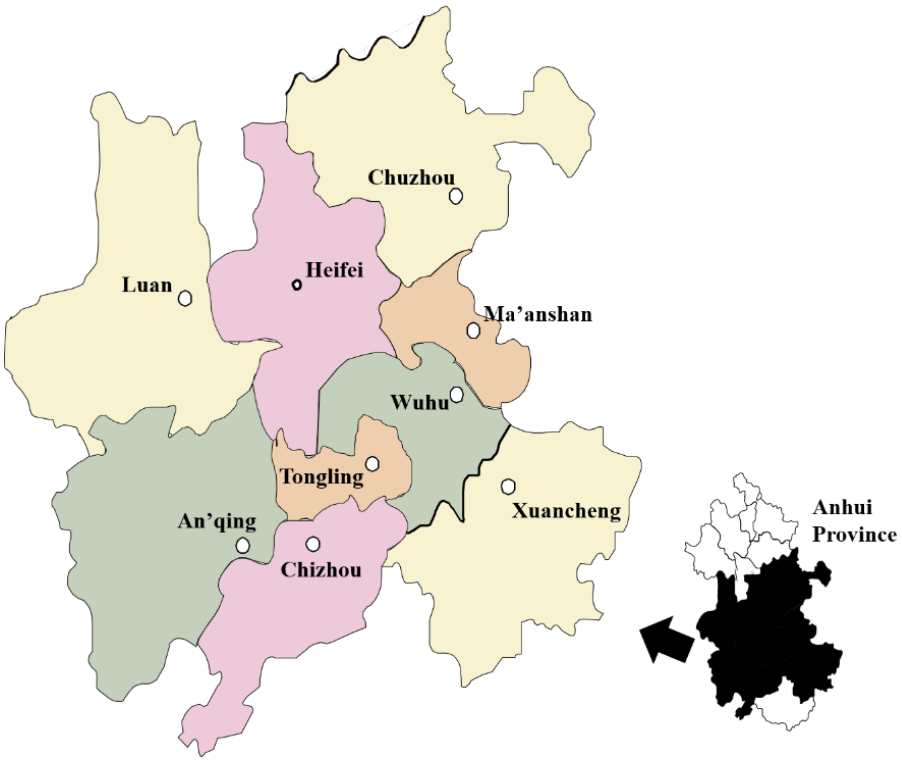

Figure 1. Administrative area of Wanjiang urban belt.

the east to the west and connected the south to the north is the key development areas to boost the Rise of Central China and the important part of the Yangtze River Delta. Taking the coordinated development of economy-society-environment of Wanjiang urban belt as the research object, this paper would use entropy method, coupled coordinated development model to calculate the development index of economic subsystem, social subsystems, environmental subsystems and their coordinated development degree. And especially use the grey incidence analysis model to analyze the impact of various factors on the coordinated development of regional economy-society-environment system for exploring the mechanism of the coordinated development of regional economy-society-environment system.

3. Index System, Data Source, Methodology

3.1. Index System

The economy-society-environment system is a composite system which is composed of economic subsystem, social subsystem and environmental subsystem. On the basis of previous research results (Li et al., 2015; Peng et al., 2017; He et al., 2019; Li et al., 2019), index system of the coordinated development of economy-society-environment system for industrial transfer area was built according to the principles of systematization, scientificity and feasibility and the development characteristics of Wanjiang urban belts (**Table 1**).

The index system of the coordinated development of economy-society-environment system consisted of three layers: target, criteria and index, including economic, society, environment etc. 3 targets, 9 criteria and 21 indicators.

3.2. Data Source

This research would study the impact of different factors on the coordinated development of economy-society-environment system both from the overall level of the Wanjiang urban belt and from the 9 individual cities under the jurisdiction of Wanjiang urban belt. Hence, 10 samples' coordinated development level of economy-society-environment system need to be evaluated, which included the overall of Wanjiang urban belt and 9 cities under its jurisdiction, like Hefei, Wuhu, Ma'anshan, Anqing, Chuzhou, Chizhou, Tongling, Xuancheng and Lu'an (since the data of Jin'an District and Shucheng County in Lu'an can not be obtain, so using the data of Lu'an instead). The period of this research is 2011-2018. The data of this research comes from *Anhui Statistical Yearbook* (2012-2019) and *Anhui Environmental Quality Report* (2011-2018) and 2018 *Statistics Bulletin of the National Economic and Social Development* of Hefei, Chuzhou, Lu'an, Ma'anshan, Wuhu, Xuancheng, Tongling, Chizhou, Anqing. As the latest *Anhui Statistical Yearbook* only updated the data of the industrial wastewater production, industrial waste gas production and industrial solid waste production to 2017, the data of these three indicators for 2018 were replaced by the data in

Table 1. Index system of the coordinated development of economy-society-environment for industrial transfer area.

Target layer	Criteria layer	Index layer	Unit	P/N	Weight
economic	Economic Benefits	per capita GDP	yuan	+	0.1641
		per capita revenue	yuan	+	0.1549
	Economic Structure	the proportion of second industry in GDP	%	+	0.1221
		the proportion of tertiary industry in GDP	%	+	0.1134
	Developing Quality	proportion of foreign direct investment in GDP	%	+	0.1411
		the proportion of R&D expenditure in GDP	%	+	0.2117
		the proportion of local fiscal expenditure in GDP	%	−	0.0926
society	Living Standards	urbanization rate of permanent population	%	+	0.1787
		urban registered unemployment rate	%	−	0.1399
	Quality of Life	per capita disposable personal income	yuan	+	0.1479
		per capita residential power consumption	KWh	+	0.1210
	Public Service	the proportion of education financial expenditure in local financial expenditure	%	+	0.1547
		number of hospital beds per 10,000 people	pcs	+	0.1207
		per capita road mileage	km	+	0.1373
environment	Environmental Pressure	per capita industrial wastewater production	ton	−	0.1226
		per capita industrial waste gas production	Standard m^3	−	0.1648
		per capita industrial solid waste production	ton	−	0.1236
	Environmental State	surface water quality	%	+	0.1519
		air quality index	index	−	0.1294
	Environmental Response	green coverage of constructed areas	%	+	0.1483
		the proportion of energy conservation and environmental protection expenditure in local financial expenditure	%	+	0.1594

Note 1: urban registered unemployment rate = number of urban registered unemployed people/(number of urban employees + number of urban registered unemployed people) × 100%; **Note 2:** per capita disposable personal income = per capita disposable income of urban residents × proportion of urban population + per capita disposable income of rural residents × proportion of rural population. **Note 3:** surface water quality means the proportion of water quality monitoring spot which were III water quality standard and above. **Note 4:** air quality index = annual mean concentration of $PM_{10}/70$ + annual mean concentration of $SO_2/60$ + annual mean concentration of $NO_2/40$, where 70, 60 and 40 are respectively the annual mean concentration limits of PM_{10}, SO_2 and NO_2 in Chinese Ambient Air Quality Standard (GB 3095-2012) Class II.

2017. According to the index system in Table 1, ten 21 × 8 evaluation matrices were built through collecting and sorting the data. Here, x_{ijk} stands for the original data value of index i in region k in year j.

3.3. Coupling and Coordinated Development Model

The concept and model of capacity coupling in physics are used to calculate the coordinated development degree of economy-society-environment system. According to (Jiang et al., 2017), D_{jk} was used to evaluate the coordinated development degree of economy-society-environment system in region k in year j, which is defined as:

$$D_{jk} = \left(C_{jk} \times T_{jk}\right)^{1/2} \tag{1}$$

where C_{jk} is the coupling degree of economy-society-environment system, and T_{jk} is the complex development index of economy-society-environment system, they were defined as:

$$C_{jk} = \left(\left(U_{econ,jk} \times U_{soc,jk} \times U_{env,jk} \right) \Big/ \left(\left(U_{econ,jk} + U_{soc,jk} + U_{env,jk} \right) \Big/ 3 \right)^3 \right)^{1/3} \quad (2)$$

$$T_{jk} = \alpha_{econ} U_{econ,jk} + \alpha_{soc} U_{soc,jk} + \alpha_{env} U_{env,jk} \quad (3)$$

where α_{econ}, α_{soc}, α_{env} both were undetermined coefficients, whose value represent the importance of economic subsystem, social subsystem and environmental subsystem respectively. Considering that the development of economic subsystem, social subsystem and environmental subsystems are equally important, so $\alpha_{econ} = \alpha_{soc} = \alpha_{env} = 1/3$.

$U_{econ,jk}$, $U_{soc,jk}$, $U_{env,jk}$ respectively represent economic subsystem development index, economic subsystem development index and economic subsystem development index in region *k* in year *j*, which were defined as:

$$\begin{aligned} U_{econ,jk} &= \sum_{i=1}^{7} x'_{ijk} \lambda_{ik}, \ \sum_{i=1}^{7} \lambda_{ik} = 1 \\ U_{soc,jk} &= \sum_{i=8}^{14} x'_{ijk} \lambda_{ik}, \ \sum_{i=8}^{14} \lambda_{ik} = 1 \\ U_{env,jk} &= \sum_{i=15}^{21} x'_{ijk} \lambda_{ik}, \ \sum_{i=15}^{21} \lambda_{ik} = 1 \end{aligned} \quad (4)$$

where x'_{ijk} is the standardized value of x_{ijk}, λ_{ik} is the weight of index *i* in region *k*. In order to make $U_{econ,jk}$, $U_{soc,jk}$ and $U_{env,jk}$ comparability between different regions, two conditions need to be met: 1) standardization process of x_{ijk} in different region were referred to the same background value; 2) the values of λ_{ik} in different region were same.

Therefore, let the maximum value and minimum value of each index from 10 sample including 80 original values as the background value, and the standardization formula is:

$$x'_{ijk} = \begin{cases} \left(x_{ijk} - x_{i\min} \right) \Big/ \left(x_{i\max} - x_{i\min} \right) & \text{positive index} \\ \left(x_{i\max} - x_{ijk} \right) \Big/ \left(x_{i\max} - x_{i\min} \right) & \text{negative index} \end{cases} \quad (5)$$

The weights of each index (λ_{ik}) were computed by using entropy method to reduce the subjectivity during the evaluating process. Referencing (Tian & Tu, 2017), let $X_{ijk} = x'_{ijk} + 1$. The calculation process of entropy method is as follows:

Calculate the normalization matrix

$$P_{ijk} = X_{ijk} \Big/ \sum_{j=1}^{8} \sum_{k=1}^{10} X_{ijk} \quad (6)$$

Calculate the entropy of each index

$$e_i = -1/\ln(80) \times \sum_{j=1}^{8} \sum_{k=1}^{10} P_{ijk} \quad (7)$$

Calculate the weight of each index

$$\lambda_{ik} = \lambda_i = (1-e_i) \Big/ \sum_{i=m}^{n} (1-e_i) \tag{8}$$

when $i = 1, \cdots, 7$, then $m = 1, n = 7$; when $i = 8, \cdots, 14$, then $m = 8, n = 14$; when $i = 15, \cdots, 21$, then $m = 15, n = 21$, and $\sum_{i=1}^{7} \lambda_{ik} = \sum_{i=8}^{14} \lambda_{ik} = \sum_{i=15}^{21} \lambda_{ik} = 1$. The result of the weights value of each index were in Table 1.

3.4. Grey Incidence Analysis Model

The basic idea of grey incidence analysis is to use the degree of similarity of the geometric curves of available data sequences to determine whether or not their connection are close. The closer the curve is, the closer the incidence between the sequences, and vice versa. The calculation steps are as follows (Liu et al., 2010):

1) Determine the system's behavioral sequence. It includes the sequence system's behavioral characteristic: $X_0 = (x_0(1), x_0(2), \cdots, x_0(n))$ and the relevant factor sequence: $X_i = (x_i(1), x_i(2), \cdots, x_i(n))$.

2) Nondimensionalize the system's behavioral sequence. Take the averaging operator as example, the average image of X_0 and X_i were:

$$x_0'(k) = \frac{x_0(k)}{\bar{X}_0}, \quad \bar{X}_0 = \frac{1}{n}\sum_{k=1}^{n} x_0(k), \quad k = 1, 2, \cdots, n \tag{9}$$

$$x_i'(k) = \frac{x_i(k)}{\bar{X}_i}, \quad \bar{X}_i = \frac{1}{n}\sum_{k=1}^{n} x_i(k), \quad k = 1, 2, \cdots, n \tag{10}$$

3) Calculate the degree of grey incidence.

$$\gamma(x_0(k), x_i(k)) = \frac{\min\limits_i \min\limits_k \left|x_0'(k) - x_i'(k)\right| + \xi \max\limits_i \max\limits_k \left|x_0'(k) - x_i'(k)\right|}{\left|x_0'(k) - x_i'(k)\right| + \xi \max\limits_i \max\limits_k \left|x_0'(k) - x_i'(k)\right|} \tag{11}$$

$$\gamma(X_0, X_i) = \frac{1}{n}\sum_{k=1}^{n} \gamma(x_0(k), x_i(k)) \tag{12}$$

where $\gamma(X_0, X_i)$ is a degree of grey incidence between X_0 and X_i, ξ is known as the distinguishing coefficient.

4) Compare the degree of grey incidence. If $\gamma(X_0, X_i) > \gamma(X_0, X_j)$, it represents that the degree of X_i affects X_0 is greater than the degree of X_j affects X_0, and be written as $X_i \succ X_j$. Among them, "$\succ$" is a special symbol in grey incidence mode.

Since this paper need to analyze the driving factors of the coordinated development of economy-society-environment system in 10 regions, including Wanjiang, Hefei, Chuzhou, Lu'an, Ma'anshan, Wuhu, Xuancheng, Tongling, Chizhou and Anqing, different types of grey incidence analysis models were built according to different relevant factor sequences (Table 2).

4. Results

4.1. Index System

Using coupling and coordinated development model, it calculated ten samples'

Table 2. Different types of grey incidence analysis models.

The impact of each subsystem development on the coordinated development degree			
Model 0	characteristic sequence	$X_0=(x_0(1),x_0(2),\cdots,x_0(8))$	the coordinated development degree
	relevant factor sequence	$X_1=(x_1(1),x_1(2),\cdots,x_1(8))$	economic subsystem development index
		$X_2=(x_2(1),x_2(2),\cdots,x_2(8))$	social subsystem development index
		$X_3=(x_3(1),x_3(2),\cdots,x_3(8))$	environmental subsystem development index
The impact of economic factors on the coordinated development			
Model 1	characteristic sequence	$X_0=(x_0(1),x_0(2),\cdots,x_0(8))$	the coordinated development degree
	relevant factor sequence	$X_1=(x_1(1),x_1(2),\cdots,x_1(8))$	economic benefits index
		$X_2=(x_2(1),x_2(2),\cdots,x_2(8))$	economic structure index
		$X_3=(x_3(1),x_3(2),\cdots,x_3(8))$	developing quality index
Model 2	characteristic sequence	$X_0=(x_0(1),x_0(2),\cdots,x_0(8))$	the coordinated development degree
	relevant factor sequence	$X_1=(x_1(1),x_1(2),\cdots,x_1(8))$	per capita GDP
		$X_2=(x_2(1),x_2(2),\cdots,x_2(8))$	per capita revenue
		$X_3=(x_3(1),x_3(2),\cdots,x_3(8))$	the proportion of second industry in GDP
		$X_4=(x_4(1),x_4(2),\cdots,x_4(8))$	the proportion of tertiary industry in GDP
		$X_5=(x_5(1),x_5(2),\cdots,x_5(8))$	proportion of foreign direct investment in GDP
		$X_6=(x_6(1),x_6(2),\cdots,x_6(8))$	the proportion of R&D expenditure in GDP,
		$X_7=(x_7(1),x_7(2),\cdots,x_7(8))$	the proportion of local fiscal expenditure in GDP
The impact of social factors on the coordinated development			
Model 3	characteristic sequence	$X_0=(x_0(1),x_0(2),\cdots,x_0(8))$	the coordinated development degree
	relevant factor sequence	$X_1=(x_1(1),x_1(2),\cdots,x_1(8))$	living standards index
		$X_2=(x_2(1),x_2(2),\cdots,x_2(8))$	quality of life index
		$X_3=(x_3(1),x_3(2),\cdots,x_3(8))$	public service index
Model 4	characteristic sequence	$X_0=(x_0(1),x_0(2),\cdots,x_0(8))$	the coordinated development degree
	relevant factor sequence	$X_1=(x_1(1),x_1(2),\cdots,x_1(8))$	urbanization rate of permanent population
		$X_2=(x_2(1),x_2(2),\cdots,x_2(8))$	urban registered unemployment rate
		$X_3=(x_3(1),x_3(2),\cdots,x_3(8))$	per capita disposable personal income
		$X_4=(x_4(1),x_4(2),\cdots,x_4(8))$	per capita residential power consumption
		$X_5=(x_5(1),x_5(2),\cdots,x_5(8))$	the proportion of education financial expenditure in local financial expenditure
		$X_6=(x_6(1),x_6(2),\cdots,x_6(8))$	number of hospital beds per 10,000 people
		$X_7=(x_7(1),x_7(2),\cdots,x_7(8))$	per capita road mileage
The impact of social environmental on the coordinated development			
Model 5	characteristic sequence	$X_0=(x_0(1),x_0(2),\cdots,x_0(8))$	the coordinated development degree
	relevant factor sequence	$X_1=(x_1(1),x_1(2),\cdots,x_1(8))$	environmental pressure index
		$X_2=(x_2(1),x_2(2),\cdots,x_2(8))$	environmental state index
		$X_3=(x_3(1),x_3(2),\cdots,x_3(8))$	environmental response index

Continued

Model 6	characteristic sequence	$X_0=(x_0(1),x_0(2),\cdots,x_0(8))$	the coordinated development degree
	relevant factor sequence	$X_1=(x_1(1),x_1(2),\cdots,x_1(8))$	per capita industrial wastewater production
		$X_2=(x_2(1),x_2(2),\cdots,x_2(8))$	per capita industrial waste gas production
		$X_3=(x_3(1),x_3(2),\cdots,x_3(8))$	per capita industrial solid waste production
		$X_4=(x_4(1),x_4(2),\cdots,x_4(8))$	surface water quality
		$X_5=(x_5(1),x_5(2),\cdots,x_5(8))$	air quality index
		$X_6=(x_6(1),x_6(2),\cdots,x_6(8))$	green coverage of constructed areas
		$X_7=(x_7(1),x_7(2),\cdots,x_7(8))$	the proportion of energy conservation and environmental protection expenditure in local financial expenditure

economic subsystem development index, economic subsystem development index, environmental subsystem development index and the coordinated development degree of economy-society-environment system respectively, their averages and average annual growth rate were also be calculated (Table 3).

From 2011 to 2018, the development index of each subsystem in the overall level of Wanjiang urban belt showed an increasing trend, ranking by size as follows: environmental subsystem (0.6534) > economic subsystem (0.4796) > social subsystem (0.4013), by the average annual growth rate as: social subsystem (9.94%) > economic subsystem (6.70%) > environmental subsystem (1.50%). As time goes by, development index of social subsystem were closing the development index of economic subsystem, but their development index also has a gap with the development index of environmental subsystem.

From 2011 to 2018, the coordinated development degree of economic-social-environment system in the overall level of Wanjiang urban belt increased from 0.6359 to 0.7795 with an average annual growth rate of 2.94%, showing an increasing trend. The coordinated development level in the overall level of Wanjiang urban belt is at the primary level in 2011-2014 is, and reached to the intermediate level in 2015-2018. For the 9 individual cities under the jurisdiction of Wanjiang urban belt, their coordinated development degree of economic-social-environmental system also showed an increasing trend, and their average annual growth rate between 0.59% and 3.82%.

4.2. The Impact of Each Subsystem Development on the Coordinated Development Degree

Using the grey incidence analysis method, it calculated the degree of grey incidence between the development index of economic subsystem and the coordinated development degree of economic-social-environment system, the development index of social subsystem and the coordinated development degree of economic-social-environment system, the development index of environmental subsystem and the coordinated development degree of economic-social-environment system, and recorded their order number according the numerical calculation respectively (Table 4 and Table 5).

Table 3. The development index of economic subsystem, social subsystem and environmental subsystem.

Region		Year								Average	AAGR
		2011	2012	2013	2014	2015	2016	2017	2018		
Wangjiang	Econ	0.3673	0.4033	0.4451	0.4683	0.4981	0.5248	0.5519	0.5782	0.4796	6.70%
	Soc	0.2839	0.2996	0.3538	0.3652	0.4156	0.4434	0.4977	0.5512	0.4013	9.94%
	Env	0.6343	0.6246	0.6137	0.6364	0.6610	0.6577	0.6956	0.7041	0.6534	1.50%
	Coord	0.6359	0.6501	0.6774	0.6910	0.7178	0.7313	0.7589	0.7795	0.7052	2.95%
Hefei	Econ	0.4867	0.5548	0.6056	0.6363	0.6662	0.6967	0.7326	0.7677	0.6433	6.73%
	Soc	0.3118	0.4128	0.4746	0.4870	0.5332	0.5544	0.6163	0.6803	0.5088	11.79%
	Env	0.5338	0.5771	0.6170	0.6514	0.6626	0.6369	0.7149	0.7484	0.6428	4.95%
	Coord	0.6578	0.7137	0.7495	0.7659	0.7858	0.7916	0.8282	0.8551	0.7685	3.82%
Chuzhou	Econ	0.2349	0.2614	0.3167	0.3443	0.3659	0.3962	0.4285	0.4835	0.3539	10.86%
	Soc	0.3586	0.2505	0.2909	0.3022	0.3374	0.3947	0.4361	0.5052	0.3594	5.02%
	Env	0.4624	0.5783	0.5244	0.5677	0.5793	0.5794	0.6386	0.6660	0.5745	5.35%
	Coord	0.5822	0.5795	0.6035	0.6241	0.6442	0.6702	0.7017	0.7388	0.6430	3.46%
Lu'an	Econ	0.1255	0.1164	0.1304	0.1429	0.1666	0.1782	0.2042	0.2270	0.1614	8.83%
	Soc	0.2227	0.2447	0.2485	0.2164	0.2750	0.2834	0.4086	0.4391	0.2923	10.19%
	Env	0.7058	0.6556	0.6352	0.6877	0.7305	0.7204	0.7340	0.7207	0.6987	0.30%
	Coord	0.5198	0.5151	0.5235	0.5263	0.5677	0.5756	0.6278	0.6447	0.5626	3.12%
Ma'anshan	Econ	0.5195	0.5665	0.6130	0.6356	0.6667	0.6944	0.7042	0.7294	0.6412	4.97%
	Soc	0.4631	0.4171	0.4501	0.4377	0.4679	0.4970	0.5302	0.6104	0.4842	4.02%
	Env	0.5386	0.4185	0.3861	0.4250	0.4849	0.5064	0.4690	0.5382	0.4709	−0.01%
	Coord	0.7114	0.6800	0.6885	0.7006	0.7299	0.7477	0.7480	0.7881	0.7243	1.47%
Wuhu	Econ	0.4886	0.5199	0.5831	0.6279	0.6706	0.7070	0.7424	0.7652	0.6381	6.62%
	Soc	0.3424	0.3076	0.3656	0.4165	0.4269	0.4627	0.5359	0.5922	0.4312	8.14%
	Env	0.7744	0.6996	0.6714	0.6139	0.6344	0.6405	0.6860	0.7113	0.6789	−1.21%
	Coord	0.7113	0.6942	0.7233	0.7372	0.7525	0.7707	0.8054	0.8280	0.7528	2.19%
Xuancheng	Econ	0.2718	0.2937	0.3325	0.3669	0.3920	0.4290	0.4555	0.4917	0.3791	8.84%
	Soc	0.3834	0.2986	0.3675	0.3775	0.4349	0.4821	0.5183	0.5515	0.4267	5.33%
	Env	0.5895	0.6167	0.5948	0.5969	0.6509	0.6720	0.6797	0.6933	0.6367	2.34%
	Coord	0.6281	0.6149	0.6460	0.6600	0.6932	0.7197	0.7371	0.7569	0.6820	2.70%
Tongling	Econ	0.5932	0.6932	0.7214	0.7116	0.4949	0.5165	0.5410	0.5155	0.5984	−1.99%
	Soc	0.4106	0.4617	0.5318	0.5410	0.2443	0.3987	0.4221	0.4880	0.4373	2.50%
	Env	0.5051	0.4017	0.4065	0.4217	0.6686	0.6074	0.6602	0.6267	0.5372	3.13%
	Coord	0.7052	0.7104	0.7337	0.7386	0.6575	0.7072	0.7296	0.7350	0.7147	0.59%
Chizhou	Econ	0.2410	0.2501	0.2825	0.3093	0.3287	0.3512	0.3715	0.3760	0.3138	6.56%
	Soc	0.2996	0.2880	0.3613	0.3157	0.4167	0.4127	0.4522	0.5218	0.3835	8.25%
	Env	0.6891	0.6958	0.6652	0.6876	0.7400	0.7735	0.7730	0.7936	0.7272	2.04%
	Coord	0.6065	0.6072	0.6387	0.6375	0.6828	0.6944	0.7116	0.7335	0.6640	2.75%
Anqing	Econ	0.1876	0.1891	0.2060	0.2067	0.2156	0.2396	0.2527	0.2854	0.2228	6.18%
	Soc	0.2240	0.1805	0.2215	0.2453	0.3576	0.3740	0.4499	0.4925	0.3182	11.91%
	Env	0.6160	0.6079	0.6057	0.6660	0.7009	0.7081	0.7295	0.6684	0.6628	1.17%
	Coord	0.5439	0.5242	0.5499	0.5685	0.6149	0.6315	0.6604	0.6742	0.5959	3.12%

Table 4. The degree of grey incidence between the development index of each subsystem and the coordinated development degree of economic-social-environment system.

	Wanjiang		Hefei		Chuzhou		Lu'an		Ma'anshan	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
Economic Subsystem	0.7281	2	0.6146	2	0.7684	2	0.6319	2	0.6944	1
Social Subsystem	0.5713	3	0.5314	3	0.6191	3	0.5835	3	0.6912	2
Environment Subsystem	0.8708	1	0.8089	1	0.8713	1	0.8699	1	0.6277	3
	Wuhu		Xuancheng		Tongling		Chizhou		Anqing	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
Economic Subsystem	0.6756	1	0.5733	3	0.6297	2	0.6831	2	0.8403	2
Social Subsystem	0.6176	3	0.5975	2	0.6362	1	0.6216	3	0.5027	3
Environment Subsystem	0.6690	2	0.8448	1	0.5114	3	0.9097	1	0.8805	1

Table 5. The degree of grey incidence between economic factors (criteria layer) and the coordinated development degree of economic-social-environment system.

	Wanjiang		Hefei		Chuzhou		Lu'an		Ma'anshan	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
Economic Benefits	0.5390	3	0.5203	3	0.5689	3	0.5263	3	0.6614	3
Economic Structure	0.9660	1	0.8598	2	0.8486	1	0.9046	1	0.9281	1
Developing Quality	0.8590	2	0.8915	1	0.8295	2	0.8440	2	0.6771	2
	Wuhu		Xuancheng		Tongling		Chizhou		Anqing	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
Economic Benefits	0.5840	3	0.6003	3	0.4833	3	0.6479	3	0.5330	3
Economic Structure	0.9492	1	0.9442	1	0.9341	1	0.9118	1	0.9522	1
Developing Quality	0.8243	2	0.7160	2	0.7339	2	0.6754	2	0.6964	2

From the overall level of Wanjiang urban belt, the impact of the development of environmental system on the coordinated development is the largest, the second largest is the development of economic system, and the impact of the development of environmental system on the coordinated development is the smallest.

From the 9 individual cities under the jurisdiction of Wanjiang urban belt, the degree of influence of the development of each subsystem on the coordinated development of Hefei, Chuzhou, Lu'an, Chizhou, Anqing are both ranked: environmental subsystem $\succ$ economic subsystem $\succ$ social subsystem; Xuancheng's is ranked: environmental subsystem $\succ$ economic subsystem = social subsystem; Wuhu's is ranked: economic subsystem = environmental subsystem $\succ$ social subsystem; Ma'anshan's and Tongling's are both ranked: social subsystem = economic subsystem $\succ$ environmental subsystem.

4.3. The Impact of Economic Factors on the Coordinated Development

According to the Model 1 and Model 2 in Table 2, the degree of grey incidence

between economic factors (criteria layer and index layer) and the coordinated development degree of economic-social-environment system were calculated, and their order number were recorded according the numerical calculation respectively (Table 5 and Table 6).

4.3.1. The Impact of Economic Factors (Criteria Layer) on the Coordinated Development

From the overall level of Wanjiang urban belt, the degree of influence of the economic factors (criteria layer) on the coordinated development is ranked: economic structure ≻ developing quality ≻ economic benefits.

From the 9 individual cities under the jurisdiction of Wanjiang urban belt, in addition to Hefei, the other eight cities also have the greatest influence on coordinated development by economic structure, followed by developing quality, and the least by economic benefits. For Hefei city, the degree of influence of the economic factors (criteria layer) on the coordinated development is ranked: developing quality ≻ economic structure ≻ economic benefits.

4.3.2. The Impact of Economic Factors (Index Layer) on the Coordinated Development

From the overall level of Wanjiang urban belt, proportion of foreign direct investment in GDP, the proportion of R & D expenditure in GDP, the proportion of tertiary industry in GDP are the three most influential economic indicators, the degree of grey incidence were both greater than 0.7.

Table 6. The degree of grey incidence between economic factors (index layer) and the coordinated development degree of economic-social-environment system.

	Wanjiang		Hefei		Chuzhou		Lu'an		Ma'anshan	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
per capita GDP	0.6032	5	0.5830	6	0.6494	5	0.6414	5	0.7631	3
per capita revenue	0.5581	7	0.5454	7	0.5395	7	0.4950	7	0.7691	2
the proportion of second industry in GDP	0.5582	6	0.5830	5	0.7038	4	0.6759	4	0.5840	7
the proportion of tertiary industry in GDP	0.7241	3	0.8482	1	0.8144	1	0.7977	2	0.6663	5
proportion of foreign direct investment in GDP	0.7894	1	0.8256	2	0.6265	6	0.6972	3	0.6977	4
the proportion of R&D expenditure in GDP,	0.7273	2	0.8166	3	0.7221	3	0.5527	6	0.7831	1
the proportion of local fiscal expenditure in GDP	0.6575	4	0.7482	4	0.7479	2	0.8132	1	0.5873	6
	Wuhu		Xuancheng		Tongling		Chizhou		Anqing	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
per capita GDP	0.6531	4	0.6573	2	0.6892	5	0.6538	3	0.8291	3
per capita revenue	0.5731	6	0.5905	7	0.5766	6	0.5914	6	0.7386	5
the proportion of second industry in GDP	0.5396	7	0.6425	3	0.7631	4	0.6020	4	0.7942	4
the proportion of tertiary industry in GDP	0.5900	5	0.8622	1	0.8445	1	0.8196	1	0.8898	2
proportion of foreign direct investment in GDP	0.7093	2	0.6406	4	0.5338	7	0.7515	2	0.5516	7
the proportion of R&D expenditure in GDP,	0.7718	1	0.6090	6	0.8033	2	0.5920	5	0.7043	6
the proportion of local fiscal expenditure in GDP	0.6591	3	0.6378	5	0.8009	3	0.5596	7	0.8931	1

From the 9 individual cities under the jurisdiction of Wanjiang urban belt, count the number of occurrences of factors which are the top three factors which affect the coordinated development in each city, the proportion of tertiary industry in GDP appeared 7 times, the proportion of R & D expenditure in GDP appeared 5 times, the proportion of local fiscal expenditure in GDP appeared 5 times, proportion of foreign direct investment in GDP appeared 4 times, per capita GDP appeared 4 times, the proportion of second industry in GDP appeared 2 times, and the proportion of second industry in GDP and per capita revenue appeared 1 time respectively.

4.4. The Impact of Social Factors on the Coordinated Development

According to the Model 3 and Model 4 in Table 2, the degree of grey incidence between social factors (criteria layer and index layer) and the coordinated development degree of economic-social-environment system were calculated, and their order number were recorded according the numerical calculation respectively (Table 7 and Table 8).

4.4.1. The Impact of Social Factors (Criteria Layer) on the Coordinated Development

From the overall level of Wanjiang urban belt, public service is the most influential social factor (criteria layer) on the coordinated development, living standards is the second most important influential social factor (criteria layer) on the coordinated development, the impact of quality of life on the coordinated development is the smallest. Namely, the degree of influence of the social factors (criteria layer) on the coordinated development is ranked: public service $\succ$ living standards $\succ$ quality of life.

From the 9 individual cities under the jurisdiction of Wanjiang urban belt, for Hefei, Chuzhou, Wuhu, Xuancheng and Chizhou, the degree of influence of the social factors (criteria layer) on the coordinated development is ranked: public service $\succ$ living standards $\succ$ quality of life; for Lu'an and Anqing, the degree

Table 7. The degree of grey incidence between social factors (criteria layer) and the coordinated development degree of economic-social-environment system (2011-2018).

	Wanjiang		Hefei		Chuzhou		Lu'an		Ma'anshan	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
Living Standards	0.6797	2	0.7188	2	0.6805	2	0.6072	3	0.9193	1
Quality of Life	0.5561	3	0.5639	3	0.5623	3	0.6204	2	0.6532	3
Public Service	0.8666	1	0.8096	1	0.8756	1	0.9356	1	0.7434	2
	Wuhu		Xuancheng		Tongling		Chizhou		Anqing	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
Living Standards	0.6826	2	0.7476	2	0.7091	3	0.6654	2	0.4616	3
Quality of Life	0.5736	3	0.5682	3	0.7632	1	0.5642	3	0.5905	2
Public Service	0.7353	1	0.8239	1	0.7337	2	0.8880	1	0.8895	1

Table 8. The degree of grey incidence between social factors (index layer) and the coordinated development degree of economic-social-environment system (2011-2018).

	Wanjiang		Hefei		Chuzhou		Lu'an		Ma'anshan	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
urbanization rate of permanent population	0.9695	1	0.9230	1	0.9808	1	0.9798	1	0.9635	1
urban registered unemployment rate	0.6298	7	0.5656	7	0.6536	6	0.6337	7	0.9014	3
per capita disposable personal income	0.6477	5	0.6024	6	0.7323	4	0.7199	4	0.8195	6
per capita residential power consumption	0.6881	4	0.6918	5	0.6359	7	0.6732	5	0.8365	5
the proportion of education financial expenditure in local financial expenditure	0.6450	6	0.7133	4	0.7096	5	0.6524	6	0.7411	7
number of hospital beds per 10,000 people	0.7999	3	0.8413	3	0.8246	3	0.7680	3	0.9107	2
per capita road mileage	0.8872	2	0.8522	2	0.8462	2	0.8389	2	0.8704	4
	Wuhu		Xuancheng		Tongling		Chizhou		Anqing	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
urbanization rate of permanent population	0.9583	1	0.9890	1	0.5579	7	0.9546	1	0.9305	1
urban registered unemployment rate	0.7009	7	0.7920	5	0.7105	4	0.6697	6	0.5806	7
per capita disposable personal income	0.7208	5	0.7467	6	0.8253	2	0.7464	5	0.7328	4
per capita residential power consumption	0.7729	4	0.7961	4	0.6949	5	0.7748	4	0.7610	3
the proportion of education financial expenditure in local financial expenditure	0.7095	6	0.7339	7	0.8644	1	0.6368	7	0.6827	6
number of hospital beds per 10,000 people	0.8248	3	0.8840	3	0.6203	6	0.8479	3	0.8275	2
per capita road mileage	0.9069	2	0.9371	2	0.7156	3	0.8824	2	0.7189	5

of influence of the social factors (criteria layer) on the coordinated development is ranked: public service $\succ$ quality of life $\succ$ living standards; for Tongling city, the degree of influence of the social factors (criteria layer) on the coordinated development is ranked: quality of life $\succ$ public service $\succ$ living standards; For Ma'anshan city, the degree of influence of the social factors (criteria layer) on the coordinated development is ranked: living standards $\succ$ quality of life $\succ$ public service.

4.4.2. The Impact of Social Factors (Index Layer) on the Coordinated Development

From the overall level of Wanjiang urban belt, urbanization rate of permanent population, per capita road mileage, number of hospital beds per 10,000 people are the three most influential social indicators, the degree of grey incidence were both greater than 0.7.

From the 9 individual cities under the jurisdiction of Wanjiang urban belt, count the number of occurrences of factors which are the top three factors which affect the coordinated development in each city, urbanization rate of permanent population appeared 8 times, number of hospital beds per 10,000 people appeared 8 times, per capita road mileage appeared 7 times, urban registered un-

employment rate, per capita disposable personal income, per capita residential power consumption, the proportion of education financial expenditure in local financial appeared 1 time respectively.

4.5. The Impact of Environmental Factors on the Coordinated Development

According to the Model 5 and Model 6 in Table 2, the degree of grey incidence between environmental factors (criteria layer and index layer) and the coordinated development degree of economic-social-environment system were calculated, and their order number were recorded according the numerical calculation respectively (Table 9 and Table 10).

4.5.1. The Impact of Environmental Factors (Criteria Layer) on the Coordinated Development

From the overall level of Wanjiang urban belt, the degree of grey incidence between environmental pressure and the coordinated development degree of economic-social-environment system is closed to the degree of grey incidence between environmental state and the coordinated development degree of economic-social-environment system, and they both are bigger than the degree of grey incidence between environmental response and the coordinated development degree of economic-social-environment system. So it considered that the degree of influence of the environmental factors (criteria layer) on the coordinated development is ranked: environmental state = environmental pressure $\succ$ environmental response.

From the 9 individual cities under the jurisdiction of Wanjiang urban belt, for Wuhu and Chuzhou, the degree of influence of the environmental factors (criteria layer) on the coordinated development is ranked: environmental state = environmental pressure $\succ$ environmental response; for Wuhu and Chuzhou, the degree of influence of the environmental factors (criteria layer) on the coordinated development is ranked: environmental state = environmental pressure $\succ$

Table 9. The degree of grey incidence between environmental factors (criteria layer) and the coordinated development degree of economic-social-environment system (2011-2018).

	Wanjiang		Hefei		Chuzhou		Lu'an		Ma'anshan	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
Environmental Pressure	0.7248	2	0.8302	1	0.7503	1	0.8384	1	0.7165	2
Environmental State	0.7296	1	0.7535	2	0.6399	2	0.7526	2	0.8008	1
Environmental Response	0.5510	3	0.6707	3	0.6014	3	0.5890	3	0.6655	3
	Wuhu		Xuancheng		Tongling		Chizhou		Anqing	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
Environmental Pressure	0.8827	1	0.9084	1	0.4057	3	0.8038	2	0.6412	2
Environmental State	0.8812	2	0.6909	2	0.6976	2	0.8049	1	0.7499	1
Environmental Response	0.6586	3	0.5884	3	0.7451	1	0.6265	3	0.5037	3

Table 10. The degree of grey incidence between environmental factors (index layer) and the coordinated development degree of economic-social-environment system (2011-2018).

	Wanjiang		Hefei		Chuzhou		Lu'an		Ma'anshan	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
per capita industrial wastewater production	0.4880	7	0.5930	5	0.7666	6	0.4440	7	0.8963	1
per capita industrial waste gas production	0.6813	5	0.5316	6	0.7167	7	0.4926	6	0.7319	5
per capita industrial solid waste production	0.8633	2	0.6547	4	0.9127	3	0.5076	5	0.7815	4
surface water quality	0.8644	1	0.7274	3	0.8992	4	0.8569	2	0.8341	3
air quality index	0.7034	4	0.7303	2	0.9472	2	0.7783	3	0.7251	6
green coverage of constructed areas	0.8391	3	0.8643	1	0.9746	1	0.9184	1	0.8719	2
the proportion of energy conservation and environmental protection expenditure in local financial expenditure	0.5828	6	0.5282	7	0.8790	5	0.6859	4	0.5623	7
	Wuhu		Xuancheng		Tongling		Chizhou		Anqing	
	Degree	Order	Degree	Order	Degree	Order	Degree	Order	Degree	Order
per capita industrial wastewater production	0.8590	6	0.5768	7	0.4083	7	0.5906	6	0.6682	6
per capita industrial waste gas production	0.9221	3	0.7926	6	0.5999	5	0.7305	5	0.7587	3
per capita industrial solid waste production	0.9151	5	0.8054	5	0.4835	6	0.7694	4	0.5185	7
surface water quality	0.9393	2	0.8522	2	0.8842	2	0.9182	2	0.8406	2
air quality index	0.9194	4	0.8099	4	0.8522	3	0.8354	3	0.7081	5
green coverage of constructed areas	0.9560	1	0.9437	1	0.9007	1	0.9471	1	0.9140	1
the proportion of energy conservation and environmental protection expenditure in local financial expenditure	0.7339	7	0.8122	3	0.6674	4	0.5834	7	0.7459	4

environmental response; for Hefei, Chuzhou, Lu'an, Xuancheng, the degree of influence of the environmental factors (criteria layer) on the coordinated development is ranked: environmental pressure ≻ environmental state ≻ environmental response; for Ma'anshan, Chuzhou, Lu'an, Xuancheng, the degree of influence of the environmental factors (criteria layer) on the coordinated development is ranked: environmental state ≻ environmental pressure ≻ environmental response.

4.5.2. The Impact of Environmental Factors (Index Layer) on the Coordinated Development

From the overall level of Wanjiang urban belt, surface water quality, per capita industrial solid waste production, green coverage of constructed areas are the three most influential environmental indicators, the degree of grey incidence were both greater than 0.8.

From the 9 individual cities under the jurisdiction of Wanjiang urban belt, count the number of occurrences of factors which are the top three factors which affect the coordinated development in each city, green coverage of constructed areas appeared 9 times, surface water quality appeared 8 times, air quality index appeared 5 times, per capita industrial waste gas production appeared 2 times,

per capita industrial wastewater production, per capita industrial solid waste production and the proportion of energy conservation and environmental protection expenditure in local financial expenditure appeared 1 time respectively.

5. Conclusion

This paper mainly used grey incidence analysis method to analyze the impact of various factors on the coordinated development of economy-society-environment system of Wanjiang urban belt in 2011-2018 from the perspective of the subsystem development and from the perspective of the influence factor under each subsystem development to explore the mechanism of the coordinated development of regional economy-society-environment system in industrial transfer area, it would be helpful to put forward appropriate policy recommendations for improving the level of coordinated development of regional economy-society-environment system.

1) Driving mechanism of the coordinated development of economy, society and environment from the perspective of the subsystem development

From the overall level of Wanjiang urban belt, the degree of influence of the development of each subsystem on the coordinated development is ranked: environmental subsystem ≻ economic subsystem ≻ social subsystem. From the 9 individual cities under the jurisdiction of Wanjiang urban belt, the degree of influence of the development of each subsystem on the coordinated development of Hefei, Chuzhou, Lu'an, Chizhou, Anqing are both ranked: environmental subsystem ≻ economic subsystem ≻ social subsystem; Xuancheng's is ranked: environmental subsystem ≻ economic subsystem = social subsystem; Wuhu's is ranked: economic subsystem = environmental subsystem ≻ social subsystem; Ma'anshan's and Tongling's are both ranked: social subsystem = economic subsystem ≻ environmental subsystem.

2) Driving mechanism of the coordinated development of economy, society and environment from the perspective of the influence factor under each subsystem development

a) Economic factors: From the overall level of Wanjiang urban belt, the degree of influence of the economic factors (criteria layer) on the coordinated development is ranked: economic structure ≻ developing quality ≻ economic benefits, and proportion of foreign direct investment in GDP, the proportion of R & D expenditure in GDP, the proportion of tertiary industry in GDP are the three most influential economic indicators; from the 9 individual cities under the jurisdiction of Wanjiang urban belt, the degree of influence of the economic factors (criteria layer) on the coordinated development is also ranked: economic structure ≻ developing quality ≻ economic benefits, the proportion of tertiary industry in GDP, the proportion of R & D expenditure in GDP and the proportion of local fiscal expenditure in GDP are the three most influential economic indicators.

b) Social factors: From the overall level of Wanjiang urban belt, the degree of

influence of the social factors (criteria layer) on the coordinated development is ranked: public service ≻ living standards ≻ quality of life, and urbanization rate of permanent population, per capita road mileage, number of hospital beds per 10,000 people are three most influential social indicators. From the 9 individual cities under the jurisdiction of Wanjiang urban belt, public service is the most influential social factors (criteria layer) on the coordinated development, and urbanization rate of permanent population, number of hospital beds per 10,000 people and per capita road mileage are three most influential social indicators.

c) Environmental factors. From the overall level of Wanjiang urban belt, the degree of influence of the environmental factors (criteria layer) on the coordinated development is ranked: environmental state = environmental pressure ≻ environmental response, and surface water quality, per capita industrial solid waste production, green coverage of constructed areas are three most influential social indicators. From the 9 individual cities under the jurisdiction of Wanjiang urban belt, the degree of influence of the economic factors (criteria layer) on the coordinated development is mostly ranked: environmental pressure ≻ environmental state ≻ environmental response, and green coverage of constructed areas, surface water quality and air quality index are three most influential environmental indicators.

Of course, this paper used grey incidence analysis model to analyze the impact of various factors on the coordinated development of economy-society-environment system quantitatively because eight years of data is not enough to use regression models and grey incidence analysis model's requirements for data quality are not very strict. In the future, more data can be collected to use different quantitative analysis model to analyze the impact of various factors on the coordinated development of economy-society-environment system. Moreover, different types of regions would have different mechanism of the coordinated development of regional economy-society-environment system, comparing their differences would find more interesting research topics.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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