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Preliminary Research on Coordinated Development Pattern and Optimization Strategy of Cities in the Yangtze River Economic Belt

Abstract

The coordinated development of cities is one of the important ways to achieve the goal of high-quality development in the Yangtze River Economic Belt. Based on the theories of Society-Economy-Environment, Regional Innovation System, and Relational Economic Geography, this study constructs an evaluation index system of the coordinated development capability of cities in the Yangtze River Economic Belt, and with the help of quantitative methods such as spatial correlation and Zipf scale rank, calculates and analyzes the coordinated development capability of cities in 2019. Results show that the coordinated development pattern of cities in the Yangtze River Economic Belt is characterized by Shanghai's prominent leading position, obvious differences in city grades, distinctive core-edge structure, and complex relationships in different fields. In order to enhance the city's capability of coordinated development, this paper points that it should focus on creating a collaborative innovation network, developing two-way enclaves, paying attention to multi-field collaborative interaction, and striving to achieve the national strategic goal of the development of the Yangtze River Economic Belt.

Keywords

coordination; innovation; green; the Yangtze River Economic Belt

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Preliminary Research on Coordinated Development Pattern and Optimization Strategy of Cities in the Yangtze River Economic Belt

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Abstract: The coordinated development of cities is one of the important ways to achieve the goal of high-quality development in the Yangtze River Economic Belt. Based on the theories of society-economy-environment, regional innovation system, and relational economic geography, this study constructs an evaluation index system of the coordinated development capability of cities in the Yangtze River Economic Belt, and with the help of quantitative methods such as spatial correlation and Zipf's law, calculates and analyzes the coordinated development capability of cities in 2019. Results show that the coordinated development pattern of cities in the Yangtze River Economic Belt is characterized by Shanghai's prominent leading position, obvious differences in city grades, distinctive core-edge structure, and complex relationships in different fields. In order to enhance the city's capability of coordinated development, this paper points that it should focus on creating a collaborative innovation network, developing two-way enclaves, paying attention to multi-field collaborative interaction, and striving to achieve the national strategic goal of the development of the Yangtze River Economic Belt.
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Keywords: coordination; innovation; green; the Yangtze River Economic Belt

The coordinated development capacity of cities refers to the capacity of a city to stimulate and lead adjacent cities in economic development, scientific and technological innovation, infrastructure construction, and ecological protection^[1]. The development of the Yangtze River Economic Belt is one of the national strategies for regional development in the new era, and the coordinated development of cities is a hot issue among economic geographers recently^[2,3]. At the symposium on promoting the development of the Yangtze River Economic Belt on April 26, 2018, General Secretary Xi Jinping stressed the importance of promoting well-coordinated environmental conservation, avoiding excessive development, and pursuing high-quality development, and pointed out that the development of the Yangtze River Economic Belt should give priority to ecology^[4]. On November 5, 2019, General Secretary Xi Jinping pointed out in the keynote speech at the opening ceremony of the Second China International Import Expo that China will continue to promote the integrated development of the Yangtze River Economic Belt and the Yangtze River Delta for great synergy of opening-up among different parts of the country. At present, the development of the Yangtze River Economic Belt is

gradually changing from the cost-driven scale expansion to the innovation-driven high-quality development, and the traditional “beggar-thy-neighbor” competitive relationship needs to be transformed into an innovative partnership with neighboring countries. The coordinated development has become an inherent requirement and an important way for the high-quality development of the Yangtze River Economic Belt^[1].

The Yangtze River Economic Belt stretches across the eastern, central and western regions of China, covering a total area of 2.05 million square kilometers (21% of China's territorial area), with more than 40% of China's population and economy. It is one of the densest economic corridors in China and an inland river basin economic belt with the largest development scale and the widest influence, playing a prominent role in China's overall development pattern^[5]. Therefore, the discussion on the pattern and optimization strategy for coordinated development of cities in the Yangtze River Economic Belt contributes to the realization of the national strategic goal of the development of the Yangtze River Economic Belt.

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1 Methods for evaluation of the coordinated development capacity of cities in the Yangtze River Economic Belt

According to the theories of social-economic-natural complex ecosystem [6], regional innovation system [7], and regional economic geography [8], as well as the sustainable development index system of the United Nations Commission on Sustainable Development (CSD), the urban competitiveness index of World Bank, and the standard index system of sustainable cities of the International Organization for Standardization (ISO) [11], we construct an index system (Table 1) for evaluating the coordinated development capacity of cities in the Yangtze River Economic Belt with consideration to the development levels of cities and the external conditions for cooperation [9,10]. This system, combining the scientificity and operability, the reality and perspectiveness, the internationality and locality, and the inheritance and innovativeness, overcomes the deficiency of the traditional method for calculating the economic relation and spatial correlation between cities by gravity model with the data of urban population and gross domestic product (GDP). This system consists of 19 indexes in four fields of economic development, scientific and technological innovation, exchange service, and ecological protection. Of them, 9 indexes [headquarters of China's top 500 manufacturing enterprises, actual use of foreign capital in the current year, total number of branch banks, number of disciplines involved in the "Double First-Class" initiative, patents applied for cooperative invention, passenger and freight volume at airport, train frequency, Internet users, and air quality index (AQI)] are used to measure the external conditions for cooperation and the rest 10 indexes to measure the self-development levels of cities.

The data are mainly obtained from *China Statistical Yearbook*, *China City Statistical Yearbook*, and *China Urban Construction Statistical Yearbook* published by the National Bureau of Statistics, the China's top 500 Manufacturing Enterprises published by China Enterprise Confederation/China Enterprise Directors Association, the *List of Key Monitored Enterprises* of each province and city published by the Ministry of Ecology and Environment, the list of disciplines involved in the "Double First-Class" initiative published by the Ministry of Education, the National Patent Information Database, the point of interest (POI) of Baidu Map, the website of bendibao ^①, the official website of the Ministry of Ecology and Environment, the statistical yearbooks of relevant provinces and cities, and Statistical Communique of the People's Republic of China on the 2010 National Economic and Social Development. The average value of each index in

the past three years is adopted to avoid the interference of the abnormal value of each index in a single year. The coordinated development capacity of 110 cities in the Yangtze River Economic Belt in 2019 is quantitatively calculated using weighted average method, normalization method, spatial analysis, correlation analysis, natural breaks method, and Zipf's law.

2 Characteristics of the coordinated development of cities in the Yangtze River Economic Belt

From the differences in city grades, spatial pattern, and degree of correlation between different fields, the coordinated development of cities in the Yangtze River Economic Belt exhibits four major characteristics.

Table 1 Evaluation index system for the coordinated development capacity of cities in the Yangtze River Economic Belt in 2019

Field	Index
Economic development	Comprehensive level of GDP
	Actual use of foreign capital in the current year
	Fixed investments per unit of GDP
	Headquarters of China's top 500 manufacturing enterprises
	Total number of branch banks
	Retail sales of social consumer goods
Scientific and technological innovation	Financial expenditure on science and technology
	Number of disciplines involved in the "Double First-Class" initiative
	Patents applied for cooperative invention
Exchange service	People engaged in scientific and technological activities
	Passenger and freight volume at airport
	Train frequency
	Internet users
Ecological protection	Proportion of fixed investments for environmental conservation in GDP
	Loss of meteorological disasters
	Power consumption per unit of GDP
	Wastewater discharge per unit of industrial output value
	Air quality index (AQI)
	Number of high-risk enterprises

^① <http://hcp.bendibao.com>

2.1 Prominent leading position of Shanghai

Shanghai is streets ahead of other cities in the Yangtze River Economic Belt in the coordinated development capacity (Table 2). In 2019, Shanghai scored more than twice as much as Nanjing (the second) and 100 times as much as Lincang (the last) in the coordinated development capacity, thus showing a prominent leading position. With solid development foundation and vital strategic position, Shanghai has obvious advantages in the introduction of foreign capital, integration of scientific and technological innovation resources, transportation, and communication services. The scores of coordinated development capacity of other cities in the Yangtze River Economic Belt are low, generally presenting the trends of high in the east and low in the west, and high in provincial capitals, coastal cities, and cities along the Yangtze River [10].

The coordinated development capacity and ranks of cities in the Yangtze River Economic Belt and their ranks follow the Zipf's law, and the goodness of fit between score logarithm and rank reaches 86.06% (Figure 1). The coordinated development capacity of the top 10 cities and the bottom 10 cities deviates from the fitted curve, suggesting that the coordinated development capacity of cities in the Yangtze River Economic Belt tends to be decentralized and varies greatly [10].

2.2 Obvious differences in city grades

The natural breaks of the 110 cities in the Yangtze River Economic Belt are 49, 17, 6, 4.6, and 3.2, respectively. That is, cities in the Yangtze River Economic Belt can be classified into six grades: leading city, advanced regional central cities, general regional central cities, regional important cities, local important cities, and local general cities (Figure 2).

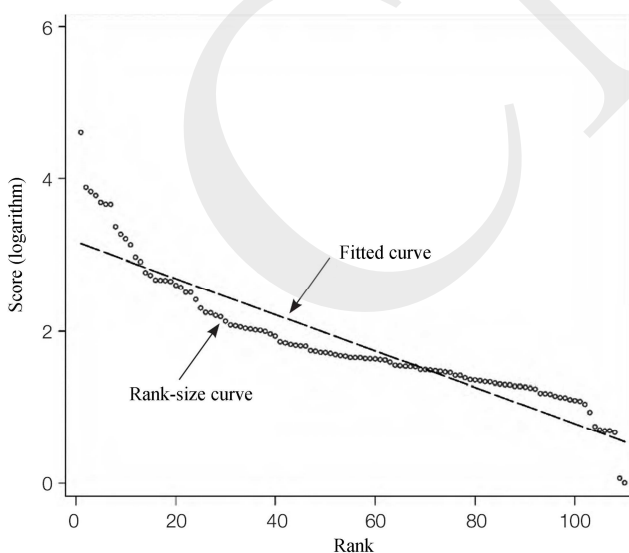


Figure 1 Zipf's rank-size distribution of the coordinated development capacity of cities in the Yangtze River Economic Belt in 2019

Table 2 Ranking list of the coordinated development capacity of cities in the Yangtze River Economic Belt in 2019

Rank	City	Score	Rank	City	Score	Rank	City	Score
1	Shanghai	100.00	38	Zhuzhou	7.32	75	Ji'an	4.26
2	Nanjing	48.35	39	Bengbu	7.07	76	Xianning	4.11
3	Hangzhou	45.82	40	Zhoushan	6.88	77	Shiyan	4.11
4	Wuhan	43.51	41	Changde	6.38	78	Huangshi	3.98
5	Chengdu	39.76	42	Suzhou	6.28	79	Panzhuhua	3.88
6	Chongqing	38.82	43	Huai'an	6.16	80	Jingdezhen	3.87
7	Suzhou	38.68	44	Yingtian	6.09	81	Ziyang	3.84
8	Changsha	28.86	45	Ganzhou	6.05	82	Fuyang	3.79
9	Wuxi	26.22	46	Lianyungang	6.02	83	Zhangjiajie	3.78
10	Ningbo	24.68	47	Jiujiang	5.68	84	Suning	3.71
11	Hefei	22.82	48	Fuzhou	5.64	85	Anshun	3.67
12	Kunming	19.38	49	Yichun	5.55	86	Liupanshui	3.64
13	Changzhou	18.29	50	Zunyi	5.54	87	Huanggang	3.62
14	Wenzhou	15.95	51	Deyang	5.47	88	Luzhou	3.56
15	Zhenjiang	15.38	52	Pingxiang	5.38	89	Chizhou	3.55
16	Xuzhou	14.44	53	Huangshan	5.32	90	Dazhou	3.52
17	Jinhua	14.40	54	Neijiang	5.29	91	Xiaogan	3.47
18	Nantong	14.37	55	Xiangtan	5.19	92	Shaoyang	3.44
19	Shaoxing	14.22	56	Chuzhou	5.18	93	Yibin	3.25
20	Guiyang	13.48	57	Xinyu	5.18	94	Bozhou	3.24
21	Jiaying	13.12	58	Huaihua	5.12	95	Suizhou	3.21
22	Nanchang	12.29	59	Tongling	5.11	96	Yiyang	3.13
23	Huzhou	12.28	60	Jingzhou	5.09	97	Jingmen	3.08
24	Taizhou	11.17	61	Nanchong	5.04	98	Lijiang	3.06
25	Yangzhou	9.96	62	Quzhou	5.02	99	Tongren	2.99
26	Wuhu	9.41	63	Ma'anshan	4.88	100	Guang'an	2.96
27	Yancheng	9.36	64	Lu'an	4.69	101	Huaibei	2.92
28	Yichang	9.05	65	Suqian	4.66	102	Huainan	2.81
29	Taizhou	8.90	66	Xuancheng	4.63	103	Meishan	2.53
30	Hengyang	8.37	67	Qujing	4.61	104	Bazhong	2.09
31	Yueyang	7.97	68	Yuxi	4.60	105	Pu'er	2.01
32	Shangrao	7.88	69	Yongzhou	4.44	106	Zhaotong	1.98
33	Mianyang	7.78	70	Ezhou	4.43	107	Leshan	1.98
34	Xiangyang	7.64	71	Loudi	4.40	108	Ya'an	1.93
35	Chenzhou	7.57	72	Guangyuan	4.36	109	Baoshan	1.06
36	Bijie	7.47	73	Zigong	4.34	110	Lincang	1.00
37	Lishui	7.44	74	Anqing	4.29			

(1) Leading city (Score: 100 points). As a leading city, Shanghai scores the highest in the coordinated development capacity in economic development, scientific and technological innovation, and exchange service, and ranks low in ecological protection only. Shanghai has excelled in the fixed investments in environmental conservation, power consumption per unit of GDP, and wastewater discharge per unit of industrial output value. However, the too many high-risk enterprises cause the low score in ecological protection.

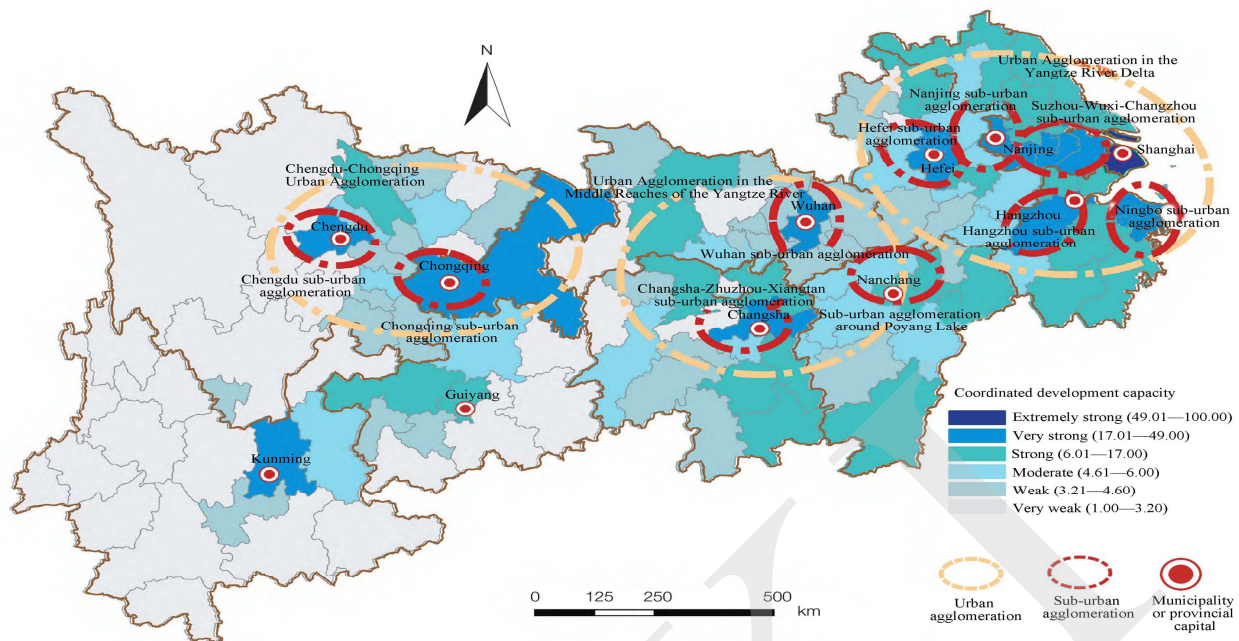


Figure 2 Distribution of the coordinated development capacity of cities in the Yangtze River Economic Belt in 2019

(2) Advanced regional central cities (Score: 17–49 points). This group includes 12 cities ranking the 2nd to 13th, namely Nanjing, Hangzhou, Wuhan, Chengdu, Chongqing, Suzhou, Changsha, Wuxi, Ningbo, Hefei, Kunming, and Changzhou. These cities, located in the upper, middle, and lower reaches of the Yangtze River, are the regional node cities leading the surrounding areas in the three urban agglomerations (Chengdu-Chongqing Urban Agglomeration, Urban Agglomeration in the Middle Reaches of the Yangtze River, and Urban Agglomeration in the Yangtze River Delta) of the Yangtze River Economic Belt.

(3) General regional central cities (Score: 6–17 points). This group includes 33 cities ranking the 14th to 46th, such as Wenzhou, Zhenjiang, Xuzhou, Jinhua, Nantong, Shaoxing, Guiyang, and Jiaying. These cities are inferior to those in the first two grades in terms of comprehensive capacity while prominent in some fields. For example, Nantong and Zhenjiang perform well in ecological protection.

(4) Regional important cities (Score: 4.6–6 points). This group includes 22 cities ranking the 47th to 68th, such as Jiujiang, Fuzhou, Yichun, and Zunyi. These cities are not very prominent in the overall coordinated capacity and the capacity of leading the surrounding areas, and most of them are local economic centers that can lead the adjacent areas. Some cities with distinctive natural endowments (such as tourism resources and mining resources) can well serve others in some fields and have great potential for the improvement of coordinated development capacity.

(5) Local important cities (Score: 3.2–4.6 points). This group includes 25 cities ranking the 69th to 93rd, such as Yongzhou, Ezhou, and Loudi. These cities are weak in the overall coordinated capacity and the capacity of leading the

surrounding areas. Some of them underperform in economic development, scientific and technological innovation, exchange service, and ecological protection, and some poorly perform in a certain field and thus rank lower. For example, Yibin performs well in economic development, scientific and technological innovation, and exchange service, while ranks low due to the large wastewater discharge per unit of industrial output value. These cities should make full use of their advantages and remedy defects so as to enhance their coordinated development capacity.

(6) Local general cities (Score: < 3.2 points). This group includes 17 cities ranking the 94th to 110th, such as Bozhou, Suizhou, and Yiyang. These cities are weak in the coordinated development capacity, and lag far behind those in the first five grades. They poorly perform in economic development, scientific and technological innovation, ecological protection, and exchange service, and remain isolated in development. These cities should build contacts with other cities and actively join the coordinated development network of the Yangtze River Economic Belt.

2.3 Distinctive core-edge structure

The coordinated development capacity of cities in the Yangtze River Economic Belt presents an obvious spatial pattern. The lower reaches of the Yangtze River, where the leading city Shanghai and the advanced regional central cities (e.g., Nanjing, Hangzhou, Suzhou, Wuxi, Ningbo, and Hefei) are located, has high coordinated development capacity with little difference among cities, and these cities have enjoyed integrated development. Compared with these cities, the cities in the middle reaches have low coordinated development capacity. Except for three provincial capitals (Wuhan,

Changsha, and Nanchang) and those along the Beijing-Guangzhou Railway Line and Beijing-Kowloon Railway Line, other cities have low coordinated development capacity. The coordinated development capacity of cities in the upper reaches is the lowest in the three reaches. Except for Chongqing and Chengdu with scores of nearly 40 points, as well as Kunming and Guiyang with scores above 10 points, other cities score below 5 points.

The number of cities in the Yangtze River Economic Belt is similar in the four quadrants of the scatter plot (Figure 3) of local Moran's I of the coordinated development capacity. That is, the cities show obvious spatial heterogeneity. The first quadrant represents high-high agglomeration (the coordinated development capacity of a city and adjacent cities is high). The second quadrant represents low-high agglomeration (the coordinated development capacity of a city is low, and that of adjacent cities is high). The third quadrant represents low-low agglomeration (the coordinated development capacity of a city and adjacent cities is low). The fourth quadrant represents high-low agglomeration (the coordinated development capacity of a city is high and that of adjacent cities is low).

In general, the coordinated development capacity is high in the cities in the Yangtze River Delta, polarized in the cities adjacent to provincial capitals in central and western China, and low in other cities. The cities in the first quadrant (high-high agglomeration) are mostly eastern coastal cities, of which Shanghai, Nanjing, Hangzhou, Suzhou, Wuxi and Ningbo present high coordinated development capacity with adjacent cities, and thus they belong to the leading city, advanced regional central cities and general regional central cities. On the contrary, the cities in the third quadrant (low-low agglomeration) are mostly in the central and western China. Pu'er, Zhaotong, Leshan, Ya'an, Baoshan, Loudi, and Lincang, as well as their adjacent cities, have low coordinated development capacity, and thus they belong to the local general cities. The cities in the second and the fourth quadrants (high-low agglomeration and low-high agglomeration, respectively) are mainly located in central and western China, and most of them belong to general regional central cities, important regional cities and their adjacent cities.

2.4 Complex relationships in different fields

Cities in the Yangtze River Economic Belt have complex correlations among economic development, scientific and technological innovation, exchange service and ecological protection. They are spatially agglomerated and integrated significantly in economic development and ecological protection, whereas the neighborhood effect is not obvious in scientific and technological innovation or exchange service. The correlation between economic development and exchange service is the strongest and positive, with the correlation coefficient of 0.923. Scientific and technological innovation has strong positive correlations with economic

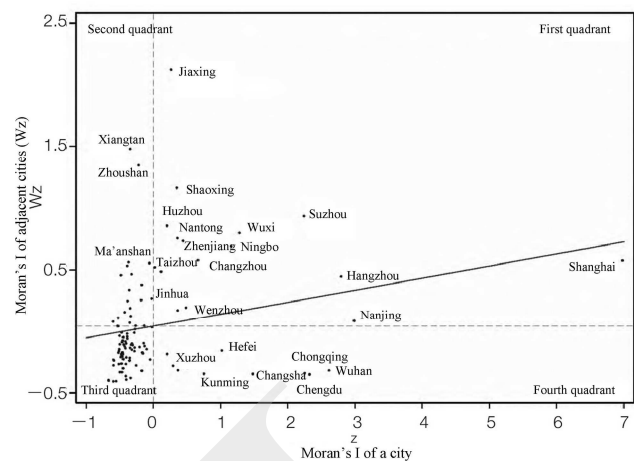


Figure 3 Scatter plot of local Moran's I of the coordinated development capacity of cities in the Yangtze River Economic Belt in 2019

development and exchange service, with the correlation coefficients of 0.875 and 0.910, respectively. Ecological protection has weak negative correlations with economic development, scientific and technological innovation, and exchange service, with the correlation coefficients of -0.222 , -0.126 , and -0.152 , respectively. The results suggest that economic development, scientific and technological innovation, and exchange service have negative effects on ecological protection.

3 Strategies for improving the coordinated development capacity of cities in the Yangtze River Economic Belt

Remarkable progress has been achieved in water pollution control and industrial technology since the implementation of the national strategy for the development of the Yangtze River Economic Belt. However, there are still many problems. Due to the influence of the traditional control method and other factors, the water pollution in the Yangtze River Economic Belt has not been fundamentally solved, and the major environmental pollution incidents and overlapping investment in research and development are common. The industrial technology is at a low level. Data from the Ministry of Ecology and Environment show that the total wastewater discharge in the Yangtze River Economic Belt accounted for 43% of the total in China, 2018. In 2006–2015, a total of 3 139 emergent environmental incidents occurred in nine provinces and two municipalities in the Yangtze River Economic Belt, accounting for 60% of the total in China. Xin Guobin, Vice Minister of the Ministry of Industry and Information Technology, pointed out in 2018 Expert Forum for National Manufacturing Power Construction that more than 95% of the manufacturing and testing equipment for the finishing production lines of key components of high-grade

numerical control machine tool, high-grade equipment, carrier rocket, giant aircraft, aero-engine, and automobile are imported, which seriously restricts the construction and development of industrial clusters in China. Therefore, it is an inevitable choice to take concrete measures to break down the administrative barriers and improve the coordinated development capacity of cities for the high-quality development of the Yangtze River Economic Belt in the new era.

3.1 Playing the leading role of Shanghai to build a collaborative innovation network

To narrow the gap between the leading city, advanced regional central cities, and edge cities in the Yangtze River Economic Belt in terms of innovative resource endowments and innovation capacity, it is suggested to construct a collaborative innovation sub-network targeting original innovation and application, diffusion and transformation of scientific and technological achievements. We can make full use of the role of Shanghai and Hefei, two comprehensive national science centers, in providing scientific and technological support for basic research and major application research. Scientific and technological innovation activities of core cities in the urban agglomerations in the middle and upper reaches of the Yangtze River can be stimulated by co-constructing and sharing major scientific facilities, which helps to make breakthroughs in major scientific and technological projects in the Yangtze River Economic Belt. We can facilitate the academic exchange, research cooperation, and joint training of talents in related disciplines, construct a knowledge cooperation network and a development community among world-class universities involved in “Double First-Class” initiative. In addition, with the advantages of the National Eastern Tech-Transfer Center (Shanghai) and the National Central Tech-Transfer Center (Wuhan) in market and network, enterprises, industrial associations, and relevant non-profit organizations can be encouraged to engage in the scientific and technological intermediary and achievement transformation activities. In this way, an efficient integrated technology transaction market can be fostered to promote the optimal allocation, transfer, and transformation of technological innovation achievements in the Yangtze River Economic Belt.

3.2 Developing two-way enclaves to promote the interactive development of core and edge cities

To promote the coordinated development of core and edge cities and solve the problems brought by the core-edge structure, China can use the experience of Singapore’s Regional Programme 2000 as well as the design concept and organization mode of Jurong Industrial Park to build enclaves

by joint ventures.^① In addition to enabling regions to complement each other with their respective strengths and improving the efficiency of resource development and utilization, enclaves can enhance the scientific and technological cooperation and promote the construction of development community. Efforts can be made to promote the transformation of the administration committees into the development and operation group companies, and speed up the capital exchange, mutual investment, and cooperative restructuring of the development and operation organizations. A zone management network with large-scale development and operation group companies as the core can be built to play the leading role of major enterprises and industrial associations in the integration of cross-regional supply chain, industry chain, innovation chain, and value chain as well as the integration of government, industry, university, institute, and user. Full play should be given to the regulation role of the Ministry of Industry and Information Technology to build the world-class industrial clusters, such as new-generation information technology, quantum communication, big data, cloud computing, intelligent manufacturing, and hi-tech materials in the Yangtze River Economic Belt.

3.3 Attaching importance to multi-field collaborative interaction to improve environmental conservation

To realize the high-quality development in the Yangtze River Economic Belt, we must improve the positive interaction of ecological protection with economic development, scientific and technological innovation, and exchange service. The overall planning should be strengthened for the transformation and upgrading of traditional industries, the development of strategic emerging industries, and the construction of ecological protection projects. Cities such as Shanghai, Nanjing, Wuhan, and Chongqing can spearhead the industrial ecologicalization and ecological industrialization, make technological breakthroughs in environmental conservation, construct new infrastructure such as 5G network, and collaborate with other cities for artificial intelligence, network economy, and healthy economic development. It is suggested to optimize the carbon emissions trading market and establish a long-term mechanism of eco-compensation in the upper, middle, and lower reaches of the Yangtze River. The roles of Shanghai Environment and Energy Exchange, China Hubei Carbon Emission Exchange, and Chongqing Carbon Emissions Trading Center should be played to guide the transfer of environmental conservation funds from developed areas to underdeveloped areas.

^① An enclave refers to the research and development base set up by underdeveloped cities in a developed city with rich scientific and technological innovation resources beyond the administrative boundaries, which is an external organization of the underdeveloped cities for introducing high-level talents and achievements of scientific and technological innovation.

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