ISSN: 2688-8653

Study of the Coupling and Coordination Relationship between Technology Innovation and High-Quality Economic Development of the Yangtze River Delta Region

Jiaqi Ji

School of Economics, Anhui University of Finance and Economics, Bengbu, 233030, China.

Abstract

This paper uses comprehensive evaluation methods to measure the level of technological innovation and also the level of economic development of cities in the Yangtze River Delta region. Then, the interaction between technological innovation and high-quality economic development in 41 cities at the prefecture level and above in the Yangtze River Delta region is studied using a coupled coordination degree model. The results show that: 1. Between 2012 and 2020, the level of technological innovation and the level of high-quality economic development of all cities in the Yangtze River Delta region have improved to different degrees, but within the Yangtze River Delta region, there is an uneven development of both the level of science and technology innovation and the level of high-quality economic development. 2. The level of coupling and coordination between science and technology innovation and high-quality economic development of all Yangtze River Delta region cities has generally improved. However, the level of coupling and coordination has not increased evenly across cities. Finally, this paper suggests that promoting the flow of innovation factors could promote the coupling coordination between technological innovation and high-quality economic development in the Yangtze River Delta region.

Keywords

The Yangtze River Delta Region; High-quality Economic Development; Coupling coordination.

1. Introduction

Since the reform and opening up, China's economy has achieved a high growth rate with an average annual growth rate of more than 9%. However, with diminishing marginal returns and environmental constraints, this crude, factor-input-driven economic growth model has also begun to show signs of weakness while also causing a series of problems such as waste of factor resources, environmental pollution, and imbalance in regional economic development (Zhou et al., 2021). Achieving high-quality economic development has become the primary goal of China's next economic development phase. The transformation of economic development needs to take innovation as the first driving force, sincerely promote innovation-driven economic quality development, and realize the triple change of quality, efficiency, and power of economic development.

Schumpeter was the first person who used the concept of innovation in economics, and his theory suggests that innovation contributes to economic growth through “creative destruction”. Since Schumpeter, researches on the relationship between innovation and economic growth have proliferated (Grossman and Helpman, 1994, Acikgoz and Mert, 2014, Acemoglu et al., 2018). Technological innovation provides a constant impetus for economic development. Improving or innovating production technology can enhance production efficiency and reduce energy consumption, which is the key to achieving high-quality economic development. In turn,

ISSN: 2688-8653

improving the quality of economic development can provide sufficient material conditions for technological innovation, which can correspondingly enhance the innovation input and then enhance the innovation output, forming positive feedback between innovation and economic quality development. The existing articles mainly studied the theoretical connotation and role mechanism of technological innovation on high-quality economic development (Shangguan and Ge, 2020, Zhou et al., 2020, Gyedu et al., 2021). However, the examination of the interaction between the two is less frequent. Therefore, studying the coupled and coordinated relationship between technological innovation and high-quality economic development can enrich the relevant research results and also has important practical significance in realizing the efficient transformation and distribution of innovation results, improving the quality and efficiency of economic development level, and promoting integrated regional development.

The coupling coordination model originates from physics, and scholars widely use it to study the interaction between two or more closely related subsystems. Ariken et al. (2021) and Zou et al. (2022) reviewed the coupling coordination relationship between urbanization and the ecological environment in the provinces along the Silk Road Economic Belt and Shaanxi Province, respectively. Ren and Du (2021) studied the coupling coordination relationship among economic growth, industrial development, and ecological environment with 62 prefecture-level cities in the Yellow River basin. In addition, some scholars have also studied the coupling coordination relationship between technological innovation and high-quality economic development within provincial regions or city clusters. (Li and Cui, 2018, Ge et al., 2020, Chen and Zhang, 2021). However, as one of the regions with the highest level of innovation and most vigorous economic vitality in China, few articles have been published to study the coupling coordination relationship between technological innovation and high-quality economic development in the Yangtze River Delta region.

As one of the regions with the highest economic vitality and strongest innovation capacity in China, the Yangtze River Delta region contributes nearly a quarter of China's total economic output and is the ballast of the nation's economic growth and technological innovation. However, in recent years, with the rising prices of labor and other factors, and changes in the global political and economic situation, the Yangtze River Delta region is facing significant economic downward pressure. Traditional industries urgently need a new injection of vitality. The burgeoning of a new technological generation, such as the digital economy, has accelerated the transformation and upgrading of traditional industries. The continuous burst of innovation has given traditional industries new vitality and a new focus point for innovation-driven high-quality economic development.

Based on the five new development concepts, this paper constructs two comprehensive index systems for evaluating the level of technological innovation and high-quality economic development in the Yangtze River Delta region. Then the coupling coordination degree model is introduced to analyze the interaction relationship between high-quality economic development and technological innovation in the Yangtze River Delta region.

2. Research design

2.1. Entropy method

This paper adopts the entropy value method to comprehensively evaluate the level of technological innovation and high-quality economic development in the Yangtze River Delta region. The specific steps are as follows.

Firstly, the data are processed, and the positive and negative indicators are standardized to eliminate the influence of positivity and negativity and the influence of magnitude on the data.

ISSN: 2688-8653

$$Y_{ijt} = \frac{X_{ijt} - \min X_j}{\max X_j - \min X_j} \text{ (positive indicator)} \quad (1)$$

$$Y_{ijt} = \frac{\max X_j - X_{ijt}}{\max X_j - \min X_j} \text{ (negative indicator)} \quad (2)$$

where, i, j, and t refer to city, indicator, and year respectively, Y_{ijt} is the standardized value, X_{ijt} is the value before standardization, $\max X_j$ and $\min X_j$ indicate the maximum and minimum values of a metric, respectively.

Then calculate the contribution of each indicator.

$$P_{ijt} = \frac{Y_{ijt}}{\sum_{i=1}^{n}\sum_{t=1}^{m}(y_{ijt})}, t=1,2,\ldots,m; i=1,2,\ldots,n \quad (3)$$

Afterward, the information entropy Hj and the variation index G_j are calculated.

$$H_j = -\frac{\sum_{i=1}^{n}\sum_{t=1}^{m} P_{ijt} \ln P_{ijt}}{\ln(m*n)} \quad (4)$$

Finally, the weights of each index are calculated.

$$W_j = \frac{G_j}{\sum_{j=1}^{k} G_j}, j=1,2,\ldots,k \quad (5)$$

2.2. Coupling coordination model

The coupling degree is used to measure the degree of interaction between systems. According to the research content of this paper, the following formula is constructed to calculate the coupling degree of technological innovation and high-quality economic development.

$$C = 2\sqrt{\frac{U_1 U_2}{(U_1+U_2)^2}} \quad (6)$$

A more significant value of the coupling degree C indicates stronger interactions between the systems. Among them, U1 and U2 represent the level of technological innovation and high-quality economic development, respectively.

To further study the coordination level between systems, the coupling coordination degree of technological innovation and high-quality economic development is calculated according to the following formula.

$$T = \alpha U_1 + \beta U_2 \quad (7)$$

$$D = \sqrt{C \times T} \quad (8)$$

The larger the value of the coupling coordination degree D indicates that the higher the level of coupling coordination development of the systems. Among them, T indicates that the comprehensive evaluation value of technological innovation and high-quality economic

ISSN: 2688-8653

development are given corresponding weights, respectively. This paper refers to the practice of Li and Cui (2018), using equal weight empowerment, set $\alpha = \beta = 0.5$.

3. Comprehensive evaluation of the level of science and technology innovation and high-quality economic development

3.1. Indicator system construction

The existing literature varies in how to measure technological innovation and high-quality economic development. In terms of high-quality economic development, the selection of measurement indicators is mainly divided into two categories: the first category is the actual GDP per capita (Ding et al., 2022), green total factor productivity (Shangguan and Ge, 2020), etc., and the other category is the comprehensive index system covering high-quality economic development(Song et al., 2022). Regarding technological innovation, total factor productivity and the number of patent applications are proxy indicators. However, innovation includes two parts: factor input and achievement transformation. And also, a single index cannot completely cover these two aspects. Therefore, this paper constructs the corresponding index systems to more comprehensively measure technological innovation and high-quality economic development.

The index system used to measure the technological innovation level includes innovation output, innovation environment, and innovation input.

Table 1 Technological innovation measurement index system

Dimension	Indicator
Output	The number of three kinds of domestic patent acquisition
Environment	The number of students enrolled in regular institutions of higher learning
	The number of Internet broadband access users
Investment	Fiscal expenditure on science and technology / Total fiscal expenditure

High-quality economic development is rich in connotation and reflects the new development concept. Therefore, this paper refers to the existing literature, we based on the new development concept, which consists of five features (innovation, coordination, green, open, and sharing) to construct the index system of high-quality economic development level from the five dimensions of the new development concept.

ISSN: 2688-8653

Table 2 High-quality economic development measurement index system

Dimension	Indicator
Innovative development	GDP / Total fixed asset investment
	Actual GDP per capita (2012 is the base period)
Coordinating development	Per capita disposable income of urban residents / Per capita disposable income of rural residents
	The output value of the tertiary industry / GDP
	The output value of tertiary industry / Output value of secondary industry
Green development	The green coverage rate of the built-up area
	Industrial exhaust emissions per unit of GDP
	Industrial wastewater discharge capacity per unit of GDP
Open development	Total export-import volume
	Actually utilized total foreign investment / GDP
Shared development	The number of hospitals and health centers
	The urbanization rate of permanent residents
	Financial and social security and employment expenditure / Total fiscal general expenditure
	The average salary of employees
	Per capita education funds

3.2. Subjects and data sources

The research objects of this paper are the "three provinces and one city" in the Yangtze River Delta region, including 41 cities at the prefecture level and above, including Shanghai, 13 cities in Jiangsu Province, 11 cities in Zhejiang Province and 16 cities in Anhui Province. It should be noted that, in 2011, the prefecture-level Chaohu city in Anhui Province was officially abolished and transferred to Hefei, Maanshan, and Wuhu, respectively. Therefore, for this paper, we choose the sample period as 2012-2020. The data in this paper come from CEIC, CNRDS, and public resources, such as the Statistical Yearbook and Statistical Bulletin published by the official websites of provincial and municipal statistical bureaus. More specifically, patent data come from the CNRDS database, and other data come from the CEIC database and official websites of statistical bureaus.

On the other hand, owing to the change in statistical caliber, the total investment in fixed assets is not directly available from 2018. This paper manually calculates it with the growth rate of the total investment in fixed assets. For the individual missing values in all the above data, this paper adopts a linear interpolation method to make up for them. Since the number of missing values is relatively low, the research conclusions of this paper will not be influenced.

3.3. Analysis of measurement results

Due to the space limitation, this paper only reports the ranking of each city's technological innovation level and high-quality economic development level by year, as shown in Tables 3 and 4. From the numerical results not reported in this paper, the level of technological innovation and the level of high-quality economic development of each city in the Yangtze River Delta region have been steadily improving in recent years, indicating that the Yangtze River Delta region has further stimulated the regional innovation vitality and released the potential of economic development in recent years by its advantages and optimizing the technological innovation environment.

In the following, we will analyze the measurement results of the above two indicators according to Table 3 and Table 4. Firstly, from the perspective of spatial distribution, in terms of

ISSN: 2688-8653

technological innovation level, Shanghai, Nanjing, Hangzhou, and Suzhou have been ranked as the leading cities in the Yangtze River Delta region in the nine-year period, leading the technological innovation in the Yangtze River Delta region, among which Shanghai's leading position as the top of the list has been quite solid. The ranking of Hangzhou and Suzhou fluctuates slightly, but they are always in the top five of the 41 cities in the Yangtze River Delta. Hefei, Ningbo, and Wuxi follow the above four cities. The above seven cities have made full use of the innovation resources in the region so that the city's innovation capability has continued to rise to a higher level. On the other hand, Fuyang, Chuzhou, Suqian, and Suzhou*, compared with 2012, significantly improved the ranking of technological innovation level in 2020, rising 10, 6, 5, and 6 places, respectively, in the Yangtze River Delta region. It shows that the areas mentioned above have improved the quality and efficiency of technological innovation level during this period. However, the rankings of Huainan, Tongling, and Zhoushan have declined significantly, decreasing by 9, 7, and 6 places, respectively. Although the above cities have also improved their technological innovation levels during the sample period, the speed of improvement is not as fast as other cities, so their rankings have dropped.

From the perspective of different provinces, Shanghai, as the core of the Yangtze River Delta region, tops the list of the Yangtze River Delta region in terms of technological innovation strength. In Anhui Province, the rankings of cities except Hefei and Wuhu are relatively low, especially Bozhou, Chizhou, Huaibei, Huangshan, and Suzhou*, which have been at the bottom of the Yangtze River Delta region. The evaluation results indicate that the potential of technological innovation in most areas of Anhui Province still needs to be stimulated. The overall ranking of Jiangsu Province is relatively high. Although Huaian, Lianyungang, Suqian, and other cities in Jiangsu Province, which are at the back of the ranking, are still in the middle of the Yangtze River Delta. In Zhejiang Province, there are cities with vital technological innovation, such as Hangzhou, Ningbo, etc. However, some cities' innovation levels, such as Zhoushan and Quzhou, need to be further stimulated, indicating a significant gap in the strength of scientific and technological innovation in Zhejiang Province. Cities with weaker strength in science and technology innovation are often limited by their own economic and social development, such as industrial structure, industrial policies, and factor endowments. Therefore, while making full use of their resource endowment advantages, they should also strengthen ties with cities with a higher level of technological innovation to create favorable conditions for further stimulating their technological innovation vitality.

ISSN: 2688-8653

Table 3 Comprehensive ranking of technological innovation level

Year / City	2012	2013	2014	2015	2016	2017	2018	2019	2020
Anqing	30	31	28	28	29	29	29	29	29
Bengbu	22	22	24	23	23	25	26	24	23
Bozhou	41	41	41	41	41	39	38	37	37
Changzhou	12	9	10	11	12	12	12	11	10
Chizhou	39	39	40	40	40	41	41	41	41
Chuzhou	31	32	31	27	27	26	27	27	25
Fuyang	37	36	38	34	32	32	28	28	27
Hangzhou	4	3	3	3	3	3	3	3	4
Hefei	6	6	5	5	4	5	5	5	5
Huzhou	20	20	20	19	21	21	20	21	20
Huaian	23	23	22	22	22	22	22	22	22
Huaibei	36	37	36	38	39	40	40	40	38
Huainan	27	27	30	29	31	34	34	33	36
Huangshan	38	38	37	37	38	38	37	38	39
Jiaxing	15	14	13	15	15	15	15	15	15
Jinhua	10	12	12	13	14	14	13	12	9
Lishui	28	29	27	30	30	31	33	34	30
Lianyungag	25	26	25	26	25	24	24	23	28
Lu'an	35	34	35	36	35	33	30	31	32
Maanshan	26	24	26	25	24	23	23	26	26
Nanjing	2	2	2	2	2	2	2	2	2
Nantong	8	11	15	12	11	11	11	10	11
Ningbo	5	5	6	6	6	6	6	6	6
Quzhou	32	30	32	31	33	30	32	35	35
Shanghai	1	1	1	1	1	1	1	1	1
Shaoxing	13	13	11	8	10	10	9	9	13
Suzhou	3	4	4	4	5	4	4	4	3
Suqian	29	28	29	32	28	28	25	25	24
Suzhou*1	40	40	39	39	36	36	36	36	34
Taizhou	18	17	16	14	16	17	16	16	16
Taizhou∗2	21	21	23	21	20	20	21	20	21
Tongling	24	25	21	24	26	27	35	30	31
Wenzhou	11	8	8	9	9	8	8	8	8
Wuxi	7	7	7	7	7	7	7	7	7
Wuhu	9	10	9	10	8	9	10	14	14
Xuzhou	14	15	14	16	13	13	14	13	12
Xuancheng	33	33	33	35	34	35	31	32	33
Yancheng	19	19	19	20	18	19	18	18	18
Yangzhou	17	16	18	18	19	16	17	17	17
Zhenjiang	16	18	17	17	17	18	19	19	19
Zhoushan	34	35	34	33	37	37	39	39	40

1 Suzhou*represents Suzhou City in Anhui Province, not Suzhou city in Jiangsu Province

2 Taizhou*represents Taizhou City in Jiangsu Province, not Taizhou city in Zhejiang Province

ISSN: 2688-8653

In terms of high-quality economic development level, Shanghai's performance is still eye-catching. Shanghai's comprehensive strength is consistently ranked first in the Yangtze River Delta region. As an important center of science and technology, finance and education in China, the development of Shanghai has a crucial role in the Yangtze River Delta region and even the whole country. In addition, Suzhou, Nanjing, Ningbo, and Hangzhou also ranked high in the Yangtze River Delta region. It is worth noting that Hefei's high-quality economic development level has grown rapidly in the nine-year period since 2012, from the middle level of the Yangtze River Delta region (21st) to the 8th place. In addition to Hefei, the ranking of Lishui, Lu'an, Quzhou, Maanshan, and Wuhu has also been greatly improved, rising by 6, 5, 5, 10 and 8 places, respectively compared with 2012. On the contrary, the cities represented by Bozhou, Huaian, Taizhou, Taizhou*, Yangzhou, and Zhenjiang, whose high-quality economic development level has dropped by 7, 16, 6, 7, 8 and 6 places, respectively.

It should be noted that, from the value of high-quality economic development level which is not reported in this paper, the high-quality economic development level of all cities in the Yangtze River Delta has maintained a growth trend. However, there are differences in the growth rate. According to the theory of late-mover advantages, the areas with relatively backward economic development levels can often obtain a higher economic growth rate. On the contrary, it is tough for regions with a relatively top level of economic development to maintain high growth.

From the perspective of different provinces, in the past few decades, the excessive pursuit of economic growth quantity has neglected the quality, leading to a significant economic development gap between different regions and within the same region. For example, most of Anhui province still lags behind other regions, such as Jiangsu, Zhejiang, and Shanghai. Especially in Anqing, Bozhou, Chizhou, Fuyang, Huaibei, Huainan, Lu'an, and Suzhou*, the high-quality economic development level is often located at the end of the Yangtze River Delta region. However, due to the early opening up, Jiangsu, Zhejiang, and Shanghai attracted a large number of foreign capital as early as the early stage of reform and opening up. Long-term development produced a siphon effect of talents and other resources on the surrounding areas with relatively backward economic development, further widening the gap with Anhui and other inland areas such as Anhui. In addition, there is also an economic development gap in the same province. Due to the proximity to Shanghai, “Suxichang” (Suzhou, Wuxi, and Changzhou) and other places undertook industrial transfer from Shanghai, which obtained higher “dividends” than Suqian in northern Jiangsu, thus creating the economic development gap.

ISSN: 2688-8653

Table 4 Comprehensive ranking of high-quality economic development level

Year / City	2012	2013	2014	2015	2016	2017	2018	2019	2020
Anqing	39	37	39	38	39	40	40	41	39
Bengbu	31	30	29	26	24	26	28	27	31
Bozhou	33	32	35	36	36	38	37	35	40
Changzhou	7	7	7	8	7	7	7	7	7
Chizhou	35	34	34	34	31	31	34	36	35
Chuzhou	36	35	33	33	30	33	33	32	33
Fuyang	38	39	40	41	41	41	41	40	41
Hangzhou	3	3	3	3	3	3	3	3	3
Hefei	21	14	12	12	11	11	9	9	8
Huzhou	16	13	15	15	16	18	17	15	17
Huaian	11	24	23	25	26	27	27	28	27
Huaibei	32	36	36	35	35	35	39	39	38
Huainan	37	38	37	40	37	36	35	30	34
Huangshan	29	29	30	32	32	32	31	29	30
Jiaxing	10	10	9	10	9	10	10	8	11
Jinhua	12	11	10	9	10	9	11	11	9
Lishui	25	25	22	18	17	17	20	19	19
Lianyungang	28	28	28	28	33	28	26	34	28
Lu'an	41	41	41	39	40	39	38	37	36
Maanshan	23	22	16	13	13	15	15	14	13
Nanjing	6	6	6	5	6	4	5	4	4
Nantong	9	9	8	7	8	8	8	10	10
Ningbo	4	4	4	4	4	5	4	5	5
Quzhou	30	31	31	27	27	25	25	25	25
Shanghai	1	1	1	1	1	1	1	1	1
Shaoxing	13	12	11	11	12	13	12	12	12
Suzhou	2	2	2	2	2	2	2	2	2
Suqian	27	27	27	31	34	34	32	33	29
Suzhou*	40	40	38	37	38	37	36	38	37
Taizhou	15	18	18	17	18	16	18	18	21
Taizhou*	17	19	25	23	23	23	23	23	24
Tongling	24	23	26	29	29	30	29	26	26
Wenzhou	20	17	14	16	19	21	16	17	16
Wuxi	5	5	5	6	5	6	6	6	6
Wuhu	26	26	21	19	20	19	21	20	18
Xuzhou	22	21	20	21	22	22	19	21	20
Xuancheng	34	33	32	30	28	29	30	31	32
Yancheng	19	20	24	24	25	24	24	24	23
Yangzhou	14	15	19	20	21	20	22	22	22
Zhenjiang	8	8	13	14	14	14	14	16	14
Zhoushan	18	16	17	22	15	12	13	13	15

ISSN: 2688-8653

4. Research on the coupling and coordination relationship between science and technology innovation and high-quality economic development

4.1. Evaluation criteria for coupling coordination

Referring to the preexisting studies(Li and Cui, 2018), In this paper, we use 0.4 as the bound, and the coupling coordination relationship is divided into disorder and coordination. The specific evaluation criteria are divided into ten grades, as shown in Table 5.

Table 5 Evaluation criteria for the coupling and coordination degree

Coupling coordination degree	Coupling coordination level	Coupling coordination degree	Coupling coordination level
0<D≤0.1	1	0.5<D≤0.6	6
0.1<D≤0.2	2	0.6<D≤0.7	7
0.2<D≤0.3	3	0.7<D≤0.8	8
0.3<D≤0.4	4	0.8<D≤0.9	9
0.4<D≤0.5	5	D>0.9	10

4.2. Results of the coupling coordination measure

According to the division standard, this paper obtains the coupling and coordination relationship stage between technological innovation and high-quality economic development in the Yangtze River Delta region from 2012 to 2020, as shown in Table 6.

It can be found that the level of the coupling and coordination level of technological innovation and high-quality economic development in most cities from 2012 to 2020 has been improved, which shows that the cities have made remarkable achievements in science and technology and high-quality economic development. The capacity of technological innovation is in line with the high level of economic development. The cities have gradually shifted to synchronous and coordinated development in line with the level of quality economic development, which is closely related to recent measures, such as cities in the Yangtze River Delta region accelerating the implementation of the transformation of economic development model, strengthening in-depth economic cooperation and close ties between regions, and promoting the circulation of factors.

Overall, no city has a level of 10. As of 2020, most cities have coupling coordination levels of 4 and 5, with 18 and 11 cities, respectively. The city with the highest level of coupling coordination is Shanghai, and the level of coupling coordination has reached level 9 since 2016. In addition to Shanghai, whose coupling and coordination level reached level 9, Hangzhou, Hefei, Nanjing, Ningbo, Suzhou, and other places also reached a higher level of level 8, 7, 8, 7, and 8, respectively. The above cities are all central or sub-central cities of their respective provinces, and the level of technological innovation and high-quality economic development are also among the top in the Yangtze River Delta. Furthermore, there is no city which the coupling and coordination level is only level 1, and the lowest coupling and coordination level is that of Chizhou and Huaibei, only level 3.

For the improvement of the coupling coordination level, each city's factor endowment and economic foundation are different, and the improvement speed of the coupling coordination level is also uneven. In 2012, the coupling coordination level of Bozhou, Chizhou, and Suzhou * was only level 2. However, by 2020, the coupling coordination level of the above three cities reached level 4, level 3 and level 4, respectively, all of which were improved to varying degrees. In addition, Changzhou, Hangzhou, Hefei, Jinhua, Nanjing, and Wenzhou have been upgraded to

ISSN: 2688-8653

two levels. It can be seen that the rapid development speed of technological innovation in various cities reflects that technological innovation has accelerated the improvement of the quality and efficiency of urban economic development degree. At the same time, the improvement of economic development level can also create a good material foundation for urban technological innovation.

Table 6 Coupling and coordination stage of technological innovation and high-quality economic development in the Yangtze River Delta region

Year / City	2012	2013	2014	2015	2016	2017	2018	2019	2020
Anqing	3	3	3	3	3	3	3	4	4
Bengbu	3	3	4	4	4	4	4	4	4
Bozhou	2	2	2	3	3	3	3	3	4
Changzhou	4	5	5	5	5	5	5	5	6
Chizhou	2	3	3	3	3	3	3	3	3
Chuzhou	3	3	3	3	4	4	4	4	4
Fuyang	3	3	3	3	3	3	4	4	4
Hangzhou	6	6	6	6	7	7	7	7	8
Hefei	5	5	5	5	6	6	6	6	7
Huzhou	4	4	4	4	4	4	5	5	5
Huaian	4	4	4	4	4	4	4	4	4
Huaibei	3	3	3	3	3	3	3	3	3
Huainan	3	3	3	3	3	3	4	4	4
Huangshan	3	3	3	3	3	3	3	3	4
Jiaxing	4	4	4	5	5	5	5	5	5
Jinhua	4	4	5	5	5	5	5	5	6
Lishui	3	3	3	3	4	4	4	4	4
Lianyungang	3	3	4	4	4	4	4	4	4
Lu'an	3	3	3	3	3	3	4	4	4
Maanshan	3	4	4	4	4	4	4	4	4
Nanjing	6	6	6	7	7	7	7	8	8
Nantong	5	5	4	5	5	5	5	5	5
Ningbo	6	6	6	6	6	6	6	6	7
Quzhou	3	3	3	3	3	4	4	4	4
Shanghai	8	8	8	8	9	9	9	9	9
Shaoxing	4	4	5	5	5	5	5	5	5
Suzhou	7	7	7	7	7	7	8	8	8
Suqian	3	3	3	3	3	4	4	4	4
Suzhou*	2	2	3	3	3	3	3	3	4

ISSN: 2688-8653

Taizhou	4	4	4	4	4	4	5	5	5
Taizhou*	4	4	4	4	4	4	4	5	5
Tongling	3	3	4	4	4	4	4	4	4
Wenzhou	4	5	5	5	5	5	5	5	6
Wuxi	5	5	5	5	6	6	6	6	6
Wuhu	4	4	4	5	5	5	5	5	5
Xuzhou	4	4	4	4	5	5	5	5	5
Xuancheng	3	3	3	3	3	3	4	4	4
Yancheng	4	4	4	4	4	4	5	5	5
Yangzhou	4	4	4	4	4	4	5	5	5
Zhenjiang	4	4	4	4	4	5	5	5	5
Zhoushan	3	3	3	3	3	3	4	4	4

5. Conclusions and policy implications

5.1. Conclusions

We construct two indicator systems to measure technological innovation and high-quality economic development of cities in the Yangtze River Delta region, respectively. Then, the coupling coordination model is used to study the interaction between technological innovation and high-quality economic development in 41 cities at the prefecture level and above in the Yangtze River Delta region. The results show that: 1. Between 2012 and 2020, the level of technological innovation and high-quality economic development of all cities in the Yangtze River Delta region have improved to different degrees, but within the Yangtze River Delta region, there is an uneven development of both the level of technological innovation and high-quality economic development and this difference is reflected within the same province and between different provinces. The level of technological innovation and high-quality economic development in Anhui Province is in a relatively backward state. 2. The level of coupling and coordination between technological innovation and high-quality economic development in all cities of the Yangtze River Delta region has generally improved, reflecting the concept of innovation-driven high-quality economic development implemented by each city. However, due to the influence of each city's own factor endowment and economic foundation, the level of coupling and coordination of each city's level of improvement varies.

5.2. Policy implications

Based on the above findings, this paper has the following implications for improving the level of technological innovation and high-quality economic development of cities in the Yangtze River Delta region: regional cooperation and links between provinces and cities should be strengthened to promote the circulation of innovation factors such as talents and knowledge within and between regions. Barriers to the circulation of innovation factors should be removed by establishing effective cooperation mechanisms. By establishing a platform for sharing scientific and technological achievements, the shortage of innovation factors in areas with a more backward level of technological innovation and economic development can be effectively compensated for, thus fully releasing the spatial spillover effect of scientific and technological innovation on the level of high-quality economic development. In addition, through inter-regional and intra-regional communication and collaboration, specific enterprises can be

ISSN: 2688-8653

promoted to cluster and integrate within specific regions according to their different resource endowments and comparative advantages, thus realizing economies of scale.

Acknowledgements

This paper is funded by the Undergraduate Research Innovation Fund of Anhui University of Finance and Economics (XSKY220077).

References:

[1] ACEMOGLU, D., AKCIGIT, U., ALP, H., BLOOM, N. & KERR, W. 2018. Innovation, Reallocation, and Growth. American Economic Review, 108, 3450-3491.

[2] ACIKGOZ, S. & MERT, M. 2014. SOURCES OF GROWTH REVISITED: THE IMPORTANCE OF THE NATURE OF TECHNOLOGICAL PROGRESS. Journal of Applied Economics, 17, 31-62.

[3] ARIKEN, M., ZHANG, F., CHAN, N. W. & KUNG, H. T. 2021. Coupling coordination analysis and spatio-temporal heterogeneity between urbanization and eco-environment along the Silk Road Economic Belt in China. ECOLOGICAL INDICATORS, 121.

[4] CHEN, Y. & ZHANG, D. 2021. Multiscale assessment of the coupling coordination between innovation and economic development in resource-based cities: A case study of Northeast China. Journal of Cleaner Production, 318, 128597.

[5] DING, C. H., LIU, C., ZHENG, C. Y. & LI, F. 2022. Digital Economy, Technological Innovation and High-Quality Economic Development: Based on Spatial Effect and Mediation Effect. SUSTAINABILITY, 14.

[6] GE, P., HAN, Y. & WU, X. 2020. Measurement and Evaluation of the Coupling Coordination Between Innovation and Economic Development in China. Quantitative & Technical Economics, 37, 101-117.

[7] GROSSMAN, G. M. & HELPMAN, E. 1994. Endogenous Innovation in the Theory of Growth. Journal of Economic Perspectives, 8, 23-44.

[8] GYEDU, S., HENG, T., NTARMAH, A. H., HE, Y. & FRIMPPONG, E. 2021. The impact of innovation on economic growth among G7 and BRICS countries: A GMM style panel vector autoregressive approach. Technological Forecasting and Social Change, 173, 121169.

[9] LI, E. & CUI, Z. 2018. Coupling Coordination Between Chinas Regional Innovation Capability and Economic Development. Scientia Geographica Sinica, 38, 1412-1421.

[10] REN, B. & DU, Y. 2021. Coupling coordination of economic growth, industrial development and ecology in the Yellow River Basin. China Population Resources and Environment, 31, 119-129.

[11] SHANGGUAN, X. & GE, B. 2020. Scientific and technological innovation,environmental regulation and high-quality economic development:empirical evidence from 278 Chinese cities at prefecture level and above. China Population Resources and Environment, 30, 95-104.

[12] SONG, M., TAO, W. & SHEN, Z. 2022. Improving high-quality development with environmental regulation and industrial structure in China. Journal of Cleaner Production, 366, 132997.

[13] ZHOU, X., CAI, Z., TAN, K. H., ZHANG, L., DU, J. & SONG, M. 2021. Technological innovation and structural change for economic development in China as an emerging market. Technological Forecasting and Social Change, 167, 120671.

[14] ZHOU, X., SONG, M. & CUI, L. 2020. Driving force for China's economic development under Industry 4.0 and circular economy: Technological innovation or structural change? Journal of Cleaner Production, 271, 122680.

[15] ZOU, C., ZHU, J., LOU, K. & YANG, L. 2022. Coupling coordination and spatiotemporal heterogeneity between urbanization and ecological environment in Shaanxi Province, China. Ecological Indicators, 141, 109152.