**Original Research Article**

**Research on the development level and coupling coordination of enterprise business environment in the Yangtze River Delta region**

**Abstract:** The business environment of enterprises is a key field for development and reform in China's economy in the new era. Improving the business environment is an important guarantee for the high-quality development of China's economy. This paper divides the development index of urban business environment in the Yangtze River Delta region into five dimensions: public service, market environment, factor supply, innovation environment and ecological environment, 12 sub-indicators and 23 basic indicators. It employs the entropy method to measure the level of the business environment in the Yangtze River Delta region from 2010 to 2022 and utilizes the coupling coordination model to analyze the coupling coordination relationship of the business environment development level. The results show that: (1) The development level of the business environment in the Yangtze River Delta region exhibits a monotonically increasing trajectory with sustained high growth. The development level of each dimension exhibits a fluctuating upward trend. (2) The development level of the business environment in various cities within the Yangtze River Delta region is persistently uneven and diverging. (3) The level of coupling and coordination between the various dimensions of the business environment development in the Yangtze River Delta region and among different cities has improved marginally, yet the region remains in a state of nascent coordination. However, the gap between most cities tends to narrow, and development is becoming more balanced and stable.

**Keywords:** Yangtze River Delta; business environment; coupling coordination; space-time evolution

# 1.Introduction

Since 2004, the World Bank has been assessing the business environment of countries around the world. In its 2020 Business Environment Report published in 2022, China's business environment has risen to 31st place globally and is among the top ten economies with the most significant improvements in the business environment1. In recent years, China's economy has developed rapidly, and reform and opening-up have been gradually deepened. the Chinese Government has systematically advanced the decentralization, regulation and service (DRS) reform to optimize the business environment. However, China's business environment is still in its primary development stage, with unbalanced regional development in the Yangtze River Delta and internal sub-environment discoordination within the system. The 14th Five-Year Plan states: "Continuously optimize the market-oriented, rule-of-law-based, and internationalized business environment, fully implement the government's power and responsibility list system, and implement a lis-based management of business-related licensing matters, and strengthen ex-post supervision." In addition, considering the development differences among different regions in China, the Chinese government encourages better-developed regions to take the lead in pilot programs and aim for the highest standards and levels. In the "Opinions of the State Council on Carrying Out the Pilot Work of Business Environment Innovation" issued on October 31, 2021, it is emphasized that "a more open, transparent, standardized, and efficient market-entity entry and exit mechanism should be established." Furthermore, to promote the high-quality development of small and medium-sized enterprises (SMEs), the "14th Five-Year Plan for the Development of Small and Medium-sized Enterprises" states that "the market access system should be more stable, open, transparent, and predictable. The tax and fee burden should be further reduced. The mechanism for safeguarding the legitimate rights and interests of SMEs should be gradually established, and the business environment should be continuously improved."2

The business environment refers to the sum of various external factors and conditions that enterprises encounter during the entire process from establishment, production and operation to bankruptcy and exit, including the market, rule of law, government affairs, and infrastructure3. The business environment is not a simple superposition of various social elements but a synergistic outcome arising from a complex system. The quality of a region's business environment directly reflects the survival conditions of enterprises and the state of economic development in that region. The business environment reflects the environmental demands for the development of the private sector in China, which is a vital force for national economic and social development4. Therefore, to achieve better development of the private sector, it is necessary to promote deeper optimization of the business environment and acilitate and safeguard private-sector development. Optimizing the business environment also helps to unleash the vitality of the market economy, improve the ability to allocate market resources and market benefits, perfect the socialist market economic system, endow economic development with new momentum, and enhance China's comprehensive national strength and international competitiveness.

# 2.Literature review & Theoretical analysis

The business environment plays a crucial role in promoting national economic development, and its improvement directly affects the survival and development of enterprises. With the World Bank's evaluation of the business environment in various countries, increasing attention has been drawn from governments and the public worldwide5. However, the World Bank's Doing Business Report lacks universality and neglects contextual heterogeneity across countries.To establish a more targeted evaluation index system and provide scientific basis and policy recommendations for China's business environment development strategy, Chinese scholars have first constructed a county-level business environment evaluation index system from seven aspects, based on the principles of integrity, hierarchy, operability, and dynamics. They have proposed the combined use of the Analytic Hierarchy Process (AHP) and expert estimation methods for measuring the indicators. Secondly, based on 13 prefecture-level cities in Jiangsu Province, they have constructed a business environment evaluation index system and measured it using the entropy method6.

The business environment is a complex system that integrates multiple aspects, and a favorable business environment is the foundation for sustainable and stable economic development. Therefore, it is of great significance to establish a more effective business environment evaluation system and put it into practice7. Thus, by comparing domestic and international business environment evaluation index systems and combining them with China's actual national conditions and development needs, a business environment evaluation index system suitable for Chinese provinces has been constructed from five dimensions, including economic market and government legal systems8. An empirical investigation and analysis of the business environment level in 31 Chinese provinces have been conducted. As China continues to advance reform and opening up, some cities have achieved remarkable economic development and high levels of opening up. It is necessary to construct a business environment evaluation index system for global cities based on their positioning and functions, from the perspective of uniqueness, among others9. For example, the business environment of Shanghai has been measured and empirically analyzed, and comparative analysis has been conducted with many other global cities to derive development suggestions for Shanghai.

With the deepening and improvement of research, based on the ecosystem theory and starting from seven dimensions, a provincial-level evaluation framework tailored to China’s institutional context has been developed, and an evaluation and analysis of the business environment in 289 Chinese cities have been carried out10. It has been found that there are significant differences in the development of the business environment across regions in China, with distinct regional disparities. Countermeasures and suggestions for optimizing the development of the business environment in Chinese cities have been proposed.Existing literature on the business environment mainly focuses on two aspects11. One is the measurement of the development of the business environment through the construction of an index system12. The other is the study of the impact of the business environment in various aspects through empirical research13. The second aspect will not be discussed here. Regarding the first aspect, the current measurement of the business environment faces difficulties in unifying the index system14. Moreover, there is a lack of evaluation of the coupling and coordination relationship between sub -environments in the measurement process15.

Given the limitations of existing research, this paper will construct a business environment evaluation index system for cities in the Yangtze River Delta region under the strategic background of the 14th Five-Year Plan and in response to the needs of high-quality economic development. Combining data from 2010 to 2022 in the Yangtze River Delta region, the entropy method will be used to measure the level of the business environment in this region. A detailed analysis of the spatiotemporal pattern characteristics of the business environment in the Yangtze River Delta will be conducted. Based on this, the coupling coordination degree model will be utilized to evaluate the internal development situation of the business environment system. This aims to reasonably reflect the development status of the business environment in the Yangtze River Delta region and provide scientific support for improving the level of the business environment in this region.

# 3.Research design

**(1)Construct the evaluation system of urban business environment in the Yangtze River Delta region**

The business environment is a multidimensional system, which also determines that the evaluation of the business environment needs to include market environment, infrastructure environment and other aspects16. The World Bank 's evaluation of the business environment is the most authoritative, but its index system lacks Chinese characteristics at the global level and does not conform to China 's development conditions and urban characteristics17. In order to establish an evaluation index system suitable for China 's national conditions and in line with the development of the Yangtze River Delta region, this paper is based on the beneficial discussion of the existing literature on the business environment development index system18. On the basis of following the principles of scientificity, integrity and operability, and referring to the evaluation indicators selected by other scholars, considering the complexity of the business environment system, a multi-dimensional and multi-index business environment index system for Yangtze River Delta cities is constructed3. This paper divides the development index of urban business environment in the Yangtze River Delta region into five dimensions : public service, market environment, factor supply, innovation environment and ecological environment, 12 sub-indicators and 23 basic indicators (table 1). All the original data come from the ' China City Statistical Yearbook ( 2011-2022 ) ' and the statistical yearbooks and statistical bulletins of various cities. Some missing values were supplemented by interpolation.

Table 1 Business environment index system

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Primary Indicator | Secondary Indicator | Evaluation Indicator | Weight | Unit |
| Public Services | Traffic Convenience | Per Capita Road Area | 0.0045 | m²/person |
|  | Social Public Services | Natural Gas Supply Capacity | 0.0428 | ten thousand tons |
|  |  | Water Supply Capacity | 0.0417 | ten thousand m³ |
|  |  | Medical and Health Services | 0.0065 | beds/ten thousand people |
|  |  | Library Collection Volume | 0.0547 | copies/hundred people |
|  | Information Infrastructure Support | Telecommunications Business Volume | 0.0523 | ten thousand yuan |
|  |  | Postal and Telecommunications Business Volume | 0.0286 | ten thousand yuan |
|  |  | Number of Mobile Phone Users at Year-End | 0.0188 | ten thousand households |
| Market Environment | Economic Indicators | Per Capita Regional Gross Product | 0.0124 | yuan |
|  |  | Total Retail Sales of Consumer Goods | 0.0501 | ten thousand yuan |
|  | Imports and Exports | Actual Foreign Investment Used in the Current Year | 0.0591 | ten thousand yuan |
|  |  | Number of New Projects (Contracts) Signed in the Current Year | 0.0872 | number |
|  | Enterprise Institutions | Number of Large-Scale Industrial Enterprises | 0.0412 | number |
| Factor Supply | Human Resources | Urban Population Density | 0.0153 | people/square kilometer |
|  |  | Number of College Students per Ten Thousand People | 0.0319 | number |
|  |  | Labor Cost | 0.0118 | yuan |
|  | Finance | Number of Financial Industry Employees | 0.0619 | ten thousand people |
|  |  | Balance of Various Loans of Financial Institutions at Year-End | 0.0791 | ten thousand yuan |
| Innovation Environment | Innovation Input | Proportion of R & D Personnel in Total Employment | 0.0195 | % |
|  | Government Expenditure | Science Expenditure | 0.0971 | ten thousand yuan |
|  |  | General Budget Expenditure | 0.0834 | ten thousand yuan |
| Ecological Environment | Ecological Capacity | Sewage Treatment Capacity of Sewage Treatment Plants | 0.0532 | ten thousand m³/day |
|  |  | Harmless Waste Treatment Capacity | 0.0422 | tons/day |
|  | Ecological Status | Per Capita Park Green Space Area | 0.0046 | m²/person |

**(2)Selection of models and methods**

**①Entropy method**

The entropy method is an enhance the robustness of the results and a enhance the robustness of the results. It determines the index weight according to the variation degree of each index value, avoids the influence and variation caused by human factors as much as possible, so as to make the result more scientific and reasonable. This paper uses the panel data of the Yangtze River Delta region from 2010 to 2022 for comprehensive evaluation19.

Assuming that there are N indicators in the evaluation index system of the development level of the business environment in the Yangtze River Delta, it represents the value of the jth indicator in the ith year.

In order to eliminate the influence of different index dimensions, the indexes are standardized20. Because the indexes are positive indexes, the standardization formula is:

Calculate the proportion of the jth index in the ith year of the index.

Calculate the entropy value of the jth index

Computational information entropy redundancy

Calculating the weights of indicators

Calculate the comprehensive score of each index.

In the formula, the weight of each index in the evaluation system of business environment development level in the Yangtze River Delta region is the comprehensive evaluation index of business environment development level of 41 cities in the Yangtze River Delta region from 2010 to 2022.

**②Coupling coordination degree model**

The coupling coordination degree model is used to analyze the coordinated development level of things. the composite score exhibited accelerated growth and mutual restriction between systems, and the degree of coordination can reflect the quality of coordination. The coupling coordination degree model involves the calculation of three index values, namely, the coupling degree C value, the coordination index T value, and the coupling coordination degree D value. Finally, combined with the coupling coordination degree D value and the coordination level division standard, the coupling coordination degree of each item is finally obtained.

The coupling degree model is:

The coordination index T formula is:

The coupling coordination degree D value is :

In the formula: D is the coupling coordination degree, the value range is [0,1], the larger the value, the higher the coordination degree; t is the comprehensive coordination index of the subsystem, which reflects the effect of the overall level between the subsystems on the coordination degree. Among them, β represents the weight of each subsystem, and the coordination degree is divided into 10 levels.

Note: In this paper, the analysis item is first analyzed by interval processing. The interval processing formula is, where *b* is 0.99, *a* is 0.01, *Max* and *Min* represent the maximum and minimum values corresponding to a certain item, respectively. After interval processing, all the data are between 0-1, and then the processed data is used for formal coupling coordination degree research.

Table 2 Coupling coordination degree classification standard

|  |  |  |
| --- | --- | --- |
| Coupling Coordination Degree (D) Interval | Coordination Level | Coordination Degree |
| (0.0, 0.1) | 1 | Extreme Discoordination |
| [0.1, 0.2) | 2 | Severe Discoordination |
| [0.2, 0.3) | 3 | Moderate Discoordination |
| [0.3, 0.4) | 4 | Mild Discoordination |
| [0.4, 0.5) | 5 | On the Verge of Discoordination |
| [0.5, 0.6) | 6 | Barely Coordinated |
| [0.6, 0.7) | 7 | Primary Coordination |
| [0.7, 0.8) | 8 | Medium Coordination |
| [0.8, 0.9) | 9 | Good Coordination |
| [0.9, 1.0) | 10 | High-Quality Coordination |

# 4.The spatial and temporal evolution characteristics of business environment in Yangtze River Delta region

**(1)The overall characteristics of the development level of business environment in the Yangtze River Delta region**

Based on the above calculations, the comprehensive development level of the business environment in the Yangtze River Delta region from 2010 to 2022 is obtained. Overall, the composite business-environment score of the Yangtze River Delta steadily increased from 0.0681 in 2010 to 0.1138 in 2022. This improvement is mainly due to the comprehensive implementation of various measures in recent years, including administrative simplification, market improvement, factor mobility, scientific and technological progress, and ecological civilization construction, which have led to a comprehensive improvement in the business conditions and development capabilities of enterprises in the region.

Specifically, the development of the business environment in the Yangtze River Delta region can be divided into three stages:The first stage is from 2010 to 2012, during which the development score of the business environment increased from 0.0681 in 2010 to 0.0763 in 2012, a 12% increase, with a growth rate of 9% from 2011 to 2012. In this stage, the development score of the business environment in the Yangtze River Delta region began to shift from low-speed growth to medium-high-speed growth.The second stage is from 2012 to 2017, during which the development score of the business environment entered a period of medium-high-speed growth. The score increased steadily from 0.0763 in 2012 to 0.0975 in 2017, a 28% increase with an average annual growth rate of 5%. The main reason for this growth was the implementation of a large number of policies by the State Council starting in 2013, aimed at simplifying administrative approval procedures, improving the production and operation conditions of investment enterprises, promoting fair market competition, and advancing the "Internet + Government Services" initiative. These policies provided favorable conditions and reform opportunities for the development of the business environment in the Yangtze River Delta region. This phase constituted an accumulation period for development. Although significant improvements were made in the business environment, there were still many areas for further improvement. The third stage is from 2017 to 2022, during which the development score of the business environment increased from 0.0975 in 2017 to 0.1138 in 2022, a 17% increase with an average annual growth rate of 8%. The development score of the business environment showed a trend of high-speed growth, indicating that the business environment in the Yangtze River Delta region continued to improve and deepen. The accumulation from the previous stages and the deepening of economic system reform, the "decentralization, management, and service" (DMS) reform, and the transformation of government functions by the State Council provided important impetus for the breakthrough development of the business environment in this stage.

Furthermore, looking at the development trend, the continuous release of policy dividends, combined with the high-quality economic development of the Yangtze River Delta region, will provide strong support for the in-depth optimization of the business environment.

Table 3 Scores and ranking of the development level of business environment in the Yangtze River Delta region from 2010 to 2022

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| City | 2010 | | 2012 | | 2014 | | 2017 | | 2019 | | 2022 | |
| Score | Rank | Score | Rank | Score | Rank | Score | Rank | Score | Rank | Score | Rank |
| Shanghai | 0.5247 | 1 | 0.564 | 1 | 0.614 | 1 | 0.6996 | 1 | 0.7595 | 1 | 0.8978 | 1 |
| Nanjing | 0.1924 | 2 | 0.2058 | 2 | 0.1942 | 2 | 0.2152 | 3 | 0.2395 | 3 | 0.2976 | 3 |
| Wuxi | 0.0975 | 7 | 0.1019 | 8 | 0.1072 | 7 | 0.1087 | 7 | 12%89 | 7 | 0.145 | 7 |
| Xuzhou | 0.0607 | 11 | 0.0694 | 12 | 0.0698 | 12 | 0.0746 | 13 | 0.0831 | 13 | 0.0908 | 12 |
| Changzhou | 0.0909 | 8 | 0.0938 | 9 | 0.1026 | 8 | 0.1056 | 8 | 0.1165 | 8 | 0.133 | 8 |
| Suzhou | 0.1102 | 4 | 0.1504 | 4 | 0.156 | 4 | 0.173 | 4 | 0.1877 | 4 | 0.2339 | 4 |
| Nantong | 0.0624 | 10 | 0.067 | 13 | 0.0722 | 11 | 0.0798 | 11 | 0.0864 | 12 | 0.0955 | 11 |
| Lianyun Port | 0.0378 | 29 | 0.0415 | 30 | 0.0446 | 28 | 0.0525 | 23 | 0.0571 | 26 | 0.064 | 26 |
| Huai 'an | 0.0518 | 17 | 0.06 | 16 | 0.0622 | 17 | 0.0676 | 17 | 0.0703 | 16 | 0.0828 | 15 |
| Yancheng | 0.0404 | 24 | 0.0453 | 22 | 0.0464 | 25 | 0.0576 | 21 | 0.0613 | 21 | 0.072 | 19 |
| Yangzhou | 0.0589 | 13 | 0.1102 | 7 | 0.0684 | 13 | 0.069 | 15 | 0.0759 | 15 | 0.087 | 14 |
| Zhenjiang | 0.0534 | 15 | 0.0716 | 11 | 0.0677 | 14 | 0.0679 | 16 | 0.0695 | 17 | 0.0794 | 17 |
| Taizhou | 0.0382 | 28 | 0.0444 | 24 | 0.0474 | 23 | 0.0504 | 26 | 0.0603 | 23 | 0.0676 | 24 |
| Fu Suqian | 0.028 | 40 | 0.0331 | 38 | 0.0336 | 39 | 0.0396 | 37 | 0.0443 | 37 | 0.0506 | 38 |
| Hangzhou | 0.1604 | 3 | 0.1821 | 3 | 0.1917 | 3 | 0.2339 | 2 | 0.2847 | 2 | 0.3336 | 2 |
| Jiaxing | 0.0513 | 18 | 0.061 | 15 | 0.0649 | 16 | 0.0693 | 14 | 0.0762 | 14 | 0.0826 | 16 |
| Huzhou | 0.0418 | 23 | 0.0434 | 26 | 0.0464 | 27 | 0.0504 | 25 | 0.0553 | 27 | 0.0699 | 22 |
| Zhoushan | 0.0356 | 33 | 0.042 | 28 | 0.0432 | 30 | 0.0495 | 27 | 0.0494 | 28 | 0.0572 | 29 |
| Jin Hua | 0.0393 | 26 | 0.0429 | 27 | 0.048 | 22 | 0.0516 | 24 | 0.058 | 24 | 0.0673 | 25 |
| Hsiao Shaoxing | 0.0519 | 16 | 0.0591 | 17 | 0.0754 | 10 | 0.0828 | 9 | 0.0913 | 9 | 0.1008 | 10 |
| Wenzhou | 0.0599 | 12 | 0.0744 | 10 | 0.0772 | 9 | 0.0824 | 10 | 0.091 | 10 | 0.1039 | 9 |
| Taizhou | 0.044 | 20 | 0.0485 | 20 | 0.0513 | 20 | 0.0579 | 20 | 0.0649 | 19 | 0.0756 | 18 |
| Lishui | 0.036 | 31 | 0.0419 | 29 | 0.0445 | 29 | 0.0488 | 28 | 0.0475 | 31 | 0.0535 | 36 |
| Quzhou | 0.0308 | 36 | 0.0344 | 34 | 0.0372 | 32 | 0.0431 | 33 | 0.0577 | 25 | 0.06 | 28 |
| Ningbo | 0.0991 | 6 | 0.1103 | 6 | 12%28 | 5 | 0.1378 | 5 | 0.1618 | 5 | 0.1865 | 6 |
| Xuancheng | 0.0404 | 24 | 0.0453 | 22 | 0.0464 | 25 | 0.0576 | 21 | 0.0613 | 21 | 0.072 | 19 |
| Suzhou | 0.0426 | 21 | 0.0274 | 41 | 0.0339 | 37 | 0.0424 | 34 | 0.0482 | 30 | 0.0538 | 34 |
| Chuzhou | 0.029 | 39 | 0.0371 | 32 | 0.0338 | 38 | 0.0401 | 36 | 0.0463 | 33 | 0.0567 | 30 |
| Chizhou | 0.032 | 35 | 0.034 | 35 | 0.033 | 40 | 0.0353 | 41 | 0.0388 | 41 | 0.047 | 40 |
| Fuyang | 0.0246 | 41 | 0.0298 | 40 | 0.0305 | 41 | 0.0379 | 39 | 0.0445 | 35 | 0.0549 | 31 |
| Lu 'an | 0.0363 | 30 | 0.0329 | 39 | 0.0348 | 34 | 0.0443 | 29 | 0.0489 | 29 | 0.0678 | 23 |
| Hefei | 0.0998 | 5 | 0.1135 | 5 | 0.1119 | 6 | 0.1306 | 6 | 0.1544 | 6 | 0.1894 | 5 |
| Bangbu | 0.0505 | 19 | 0.0522 | 19 | 0.0536 | 19 | 0.0595 | 19 | 0.0618 | 20 | 0.0635 | 27 |
| Huainan | 0.0392 | 27 | 0.0436 | 25 | 0.0468 | 24 | 0.044 | 31 | 0.0469 | 32 | 0.0536 | 35 |
| Tongling | 0.0424 | 22 | 0.0481 | 21 | 0.0509 | 21 | 0.0421 | 35 | 0.0455 | 34 | 0.0528 | 37 |
| Ma 'anshan | 0.0575 | 14 | 0.0581 | 18 | 0.0613 | 18 | 0.0609 | 18 | 0.065 | 18 | 0.072 | 21 |
| Huaibei | 0.0358 | 32 | 0.0395 | 31 | 0.0421 | 31 | 0.0433 | 32 | 0.0444 | 36 | 0.0541 | 33 |
| Wuhu | 0.0707 | 9 | 0.0669 | 14 | 0.0675 | 15 | 0.0755 | 12 | 0.0887 | 11 | 0.0905 | 13 |
| Anqing | 0.035 | 34 | 0.036 | 33 | 0.0368 | 33 | 0.0384 | 38 | 0.0436 | 38 | 0.0548 | 32 |
| Huangshan | 0.0291 | 38 | 0.0332 | 37 | 0.0341 | 35 | 0.0365 | 40 | 0.0408 | 40 | 0.0461 | 41 |
| Bozhou | 0.0303 | 37 | 0.0335 | 36 | 0.034 | 36 | 0.0441 | 30 | 0.0424 | 39 | 0.047 | 39 |
| Average | 0.0681 | - | 0.0763 | - | 0.079 | - | 0.0878 | - | 0.0975 | - | 0.1138 | - |

**(2) Regional differences in the development of business environment in the Yangtze River Delta region**

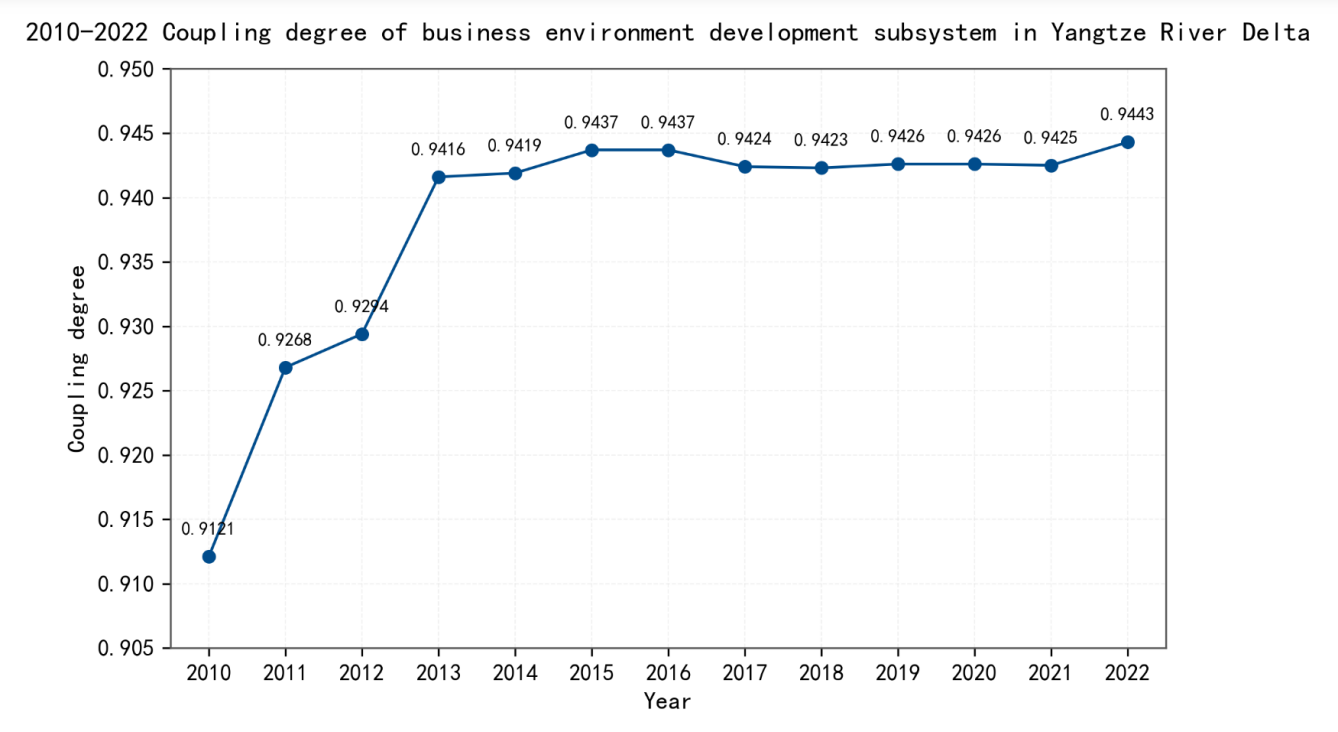
In examining the development of the business environment across various cities in the Yangtze River Delta from 2010 to 2022, it is observed that each city has experienced growth to varying degrees. Shanghai, Nanjing, Hangzhou, Suzhou, Hefei, and Ningbo have consistently ranked in the top six. Chizhou, Bozhou, Huangshan, Suqian, and Fuyang have generally been at the bottom. Lu'an and Suzhou saw a significant decline in their business environment scores from 2010 to 2012, followed by a rapid increase. This was primarily due to their initial development stage, where these cities, located on the western fringe of the Yangtze River Delta, had a weak economic foundation and relatively slow policy changes. Improvements were seen later with policy adjustments and the driving effect of the development of provincial capital cities.

The business environment levels of other cities have fluctuated moderately, either increasing or decreasing, without drastic changes. The gap in scores between cities has been relatively small, and the annual rankings of business environment scores have not changed much. Shanghai, Nanjing, and Hangzhou have consistently been the top three cities in terms of business environment scores from 2010 to 2022, marking them as key cities for business environment development in the Yangtze River Delta region. Between 2010 and 2022, the disparity widened from 0.5002 to 0.8517. This indicates a significant disparity in the comprehensive development levels of the business environment across various cities in the Yangtze River Delta, with regional disparities gradually widening. Additionally, the gap between Shanghai and the other top cities, Nanjing and Hangzhou, has also shown a clear trend of increasing annually. This suggests that Shanghai's economic radiating effect. Compared to the overall development level of the Yangtze River Delta region, from 2010 to 2022, eight cities had business environment development levels above the average level of the Yangtze River Delta: Shanghai, Nanjing, Wuxi, Changzhou, Suzhou, Hangzhou, Ningbo, and Hefei. The business environment levels of other cities, with the exception of a few, fluctuated around the average level, and most cities' business environment levels were below the average level of Anhui Province.

In terms of the growth rate of business environment development scores in the Yangtze River Delta region, overall, the scores increased rapidly across all cities, with an average annual growth rate of 5% or higher. The differences in the growth rates of business environment scores among cities were relatively small, with the average annual growth rate ranging from 5% to 18%. Suzhou, Hangzhou, and Fuyang all achieved a doubling of their scores from 2010 to 2022, with increases of 112%, 108%, and 123%, respectively. Among them, Fuyang and Suzhou had the fastest average annual growth rates at 18% and 17%, respectively.

# 5.Coupling coordination analysis of business environment development in Yangtze River Delta

First of all, from the perspective of coupling degree, the coupling degree between the various dimensions of the business environment in the Yangtze River Delta from 2010 to 2022 remained basically stable (Figure 1), and the coupling degree was controlled between 0.9121 and 0.9443. Among them, the coupling degree in 2010 was 0.9121, and the coupling degree in 2022 was 0.9443, indicating that the coupling degree between cities in the Yangtze River Delta has increased to a certain extent, but the enhancement effect is relatively weak. Overall, the coupling degree of the business environment subsystem in the Yangtze River Delta region is basically in a state of increasing growth year by year, only maintaining a level of 0.9437 in 2015-2016, and decreasing from 0.9424 to 0.9423 in 2017-2018, but it does not affect the overall growth trend. The coupling degree reaches a maximum of 0.9943 in 2022.

 Figure 1 The line chart of the coupling degree of business environment in the Yangtze River Economic Belt ( 2010-2022 )

Shanghai, Nanjing, Hangzhou, and Suzhou have relatively high levels of coupling coordination, while the rest of the cities exhibit little variation in their levels of coupling coordination. Overall, even though the business environment subsystems in various cities of the Yangtze River Delta have achieved certain degrees of development in terms of coupling coordination over the past decade, they have not fundamentally improved and remain in a state of discoordination. In 2010, the coupling coordination levels of cities in the Yangtze River Delta were primarily moderate and severe discoordination. Wuxi, Suzhou, and Ningbo were at a mild level of discoordination; Nanjing and Hangzhou were approaching the coordination threshold; and Shanghai was at a medium level of coordination. In 2015, the cities still mainly exhibited moderate and severe discoordination, with Changzhou shifting from moderate to mild discoordination, Suzhou moving from mild to verge of discoordination, and Shanghai reaching a good level of coordination. By 2022, the situation was predominantly moderate discoordination, with other levels of discoordination and coordination coexisting. Shanghai achieved a high-quality coordination level; Nanjing and Hangzhou reached a barely coordinated level; Suzhou, Ningbo, and Hefei were on the verge of discoordination; and there were five cities with mild discoordination.

From a relative standpoint, the coordination levels of the business environment dimensions in various cities of the Yangtze River Delta showed an upward trend from 2010 to 2022, albeit to varying degrees. Compared to 2010, 71% of the cities only achieved a one-level increase in their coupling coordination level by 2022, with no city experiencing a downgrade; Nanjing and Suzhou made a breakthrough from being on the verge of discoordination to barely coordinated between 2015 and 2022, achieving a marked transition in coordination status. The severe discoordination seen in 2010 had essentially disappeared by 2022, with the highest coordination level achieved by any city being high-quality coordination.

Table 4 Coupling and coordination of the business environment subsystem in the Yangtze River Delta in 2010,2015 and 2022

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| City | 2010 Coupling Coordination Degree | 2010 Coordination Level | 2015Coupling Coordination Degree | 2015 Coordination Level | 2022 Coupling Coordination Degree | 2022 Coordination Level |
| Shanghai | 0.75 | Medium Coordination | 0.873 | Good Coordination | 0.992 | High-Quality Coordination |
| Nanjing | 0.433 | On the Verge of discoordination | 0.469 | On the Verge of discoordination | 0.556 | Barely Coordinated |
| Wuxi | 0.303 | Mild discoordination | 0.327 | Mild discoordination | 0.385 | Mild discoordination |
| Xuzhou | 0.231 | Moderate discoordination | 0.264 | Moderate discoordination | 0.296 | Moderate discoordination |
| Changzhou | 0.29 | Moderate discoordination | 0.318 | Mild discoordination | 0.363 | Mild discoordination |
| Suzhou | 0.313 | Mild discoordination | 0.418 | On the Verge of discoordination | 0.496 | On the Verge of discoordination |
| Nantong | 0.23 | Moderate discoordination | 0.271 | Moderate discoordination | 0.301 | Mild discoordination |
| Lianyungang | 0.171 | Severe discoordination | 0.214 | Moderate discoordination | 0.24 | Moderate discoordination |
| Huai'an | 0.198 | Severe discoordination | 0.238 | Moderate discoordination | 0.272 | Moderate discoordination |
| Yancheng | 0.176 | Severe discoordination | 0.227 | Moderate discoordination | 0.257 | Moderate discoordination |
| Yangzhou | 0.228 | Moderate discoordination | 0.25 | Moderate discoordination | 0.287 | Moderate discoordination |
| Zhenjiang | 0.214 | Moderate discoordination | 0.249 | Moderate discoordination | 0.272 | Moderate discoordination |
| Taizhou | 0.17 | Severe discoordination | 0.205 | Moderate discoordination | 0.249 | Moderate discoordination |
| Suqian | 0.136 | Severe discoordination | 0.175 | Severe discoordination | 0.207 | Moderate discoordination |
| Hangzhou | 0.402 | On the Verge of discoordination | 0.492 | On the Verge of discoordination | 0.593 | Barely Coordinated |
| Jiaxing | 0.21 | Moderate discoordination | 0.25 | Moderate discoordination | 0.278 | Moderate discoordination |
| Huzhou | 0.182 | Severe discoordination | 0.207 | Moderate discoordination | 0.253 | Moderate discoordination |
| Zhoushan | 0.161 | Severe discoordination | 0.2 | Moderate discoordination | 0.221 | Moderate discoordination |
| Jinhua | 0.177 | Severe discoordination | 0.211 | Moderate discoordination | 0.244 | Moderate discoordination |
| Shaoxing | 0.197 | Severe discoordination | 0.274 | Moderate discoordination | 0.308 | Mild discoordination |
| Wenzhou | 0.23 | Moderate discoordination | 0.276 | Moderate discoordination | 0.315 | Mild discoordination |
| Taizhou Zhejiang | 0.19 | Severe discoordination | 0.225 | Moderate discoordination | 0.263 | Moderate discoordination |
| Lishui | 0.161 | Severe discoordination | 0.194 | Severe discoordination | 0.207 | Moderate discoordination |
| Quzhou | 0.149 | Severe discoordination | 0.186 | Severe discoordination | 0.227 | Moderate discoordination |
| Ningbo | 0.308 | Mild discoordination | 0.371 | Mild discoordination | 0.439 | On the Verge of discoordination |
| Xuancheng | 0.176 | Severe discoordination | 0.227 | Moderate discoordination | 0.257 | Moderate discoordination |
| Suzhou Anhui | 0.15 | Severe discoordination | 0.183 | Severe discoordination | 0.213 | Moderate discoordination |
| Chuzhou | 0.14 | Severe discoordination | 0.179 | Severe discoordination | 0.22 | Moderate discoordination |
| Chizhou | 0.143 | Severe discoordination | 0.161 | Severe discoordination | 0.193 | Severe discoordination |
| Fuyang | 12%2 | Severe discoordination | 0.169 | Severe discoordination | 0.213 | Moderate discoordination |
| Lu'an | 0.151 | Severe discoordination | 0.183 | Severe discoordination | 0.228 | Moderate discoordination |
| Hefei | 0.301 | Mild discoordination | 0.353 | Mild discoordination | 0.436 | On the Verge of discoordination |
| Bengbu | 0.194 | Severe discoordination | 0.228 | Moderate discoordination | 0.239 | Moderate discoordination |
| Huainan | 0.162 | Severe discoordination | 0.181 | Severe discoordination | 0.206 | Moderate discoordination |
| Tongling | 0.175 | Severe discoordination | 0.175 | Severe discoordination | 0.209 | Moderate discoordination |
| Ma'anshan | 0.21 | Moderate discoordination | 0.225 | Moderate discoordination | 0.248 | Moderate discoordination |
| Huaibei | 0.149 | Severe discoordination | 0.174 | Severe discoordination | 0.201 | Moderate discoordination |
| Wuhu | 0.235 | Moderate discoordination | 0.264 | Moderate discoordination | 0.292 | Moderate discoordination |
| Anqing | 0.157 | Severe discoordination | 0.173 | Severe discoordination | 0.219 | Moderate discoordination |
| Huangshan | 0.134 | Severe discoordination | 0.167 | Severe discoordination | 0.195 | Severe discoordination |
| Bozhou | 0.139 | Severe discoordination | 0.179 | Severe discoordination | 0.191 | Severe discoordination |

# 6.Conclusions and recommendations

This study examines the 41 prefecture-level cities in the Yangtze River Delta (YRD) region, evaluating the development level of the business environment from five dimensions: public services, market environment, factor supply, innovation environment, and ecological environment. It analyzes the spatiotemporal characteristics and coupling coordination relationships, leading to the following main conclusions: 1. The development level of the business environment in the YRD exhibits a stable upward trend, maintaining a relatively high growth rate overall. The development levels of each dimension of the business environment show a fluctuating upward trend, with public services, factor supply, and market environment developing more rapidly, while the market environment and ecological environment develop more slowly. 2. The coupling coordination level among the various dimensions of business environment development in the YRD and its cities has improved slowly and remains in an uncoordinated state overall. However, most cities show a tendency toward balanced and stable development. Seventy-one percent of the cities have achieved only a one-level increase in their coupling coordination level from severe discoordination to moderate discoordination. A few cities still remain in a state of severe discoordination. Nanjing and Hangzhou have achieved a leap in their coordination levels, with no city experiencing a downgrade. Shanghai has consistently maintained a high level, leading the YRD region.

In summary, although the business environment in the YRD has achieved certain successes in recent years, there is still room for improvement in the level of the business environment, and the coupling coordination of the regional business environment system needs further refinement. There is a serious imbalance in urban development within the region, with significant development gaps that need to be further reduced, and great potential for the development of the spatial business environment.

1. To promote the development of the business environment in the YRD and optimize the economic development conditions of the private sector, it is necessary to not only promote the development of the business environment from a single aspect but also to consider the overall and individual aspects, promoting the improvement of the business environment from a systematic and comprehensive perspective. While ensuring the stable development of each dimension and indicator of the business environment in the YRD region, efforts should be made to improve the indicators with poor development and increase resource allocation to weak areas of development. This will promote the improvement of regional coupling coordination and the business environment in terms of both "quality" and "quantity," ensuring steady and sustainable economic growth in the YRD region.

2. There is still a significant overall development gap within the YRD region, which has long been in a state of unbalanced development, with significant spatial differentiation and regional spatial solidification. To reduce the development gap in the business environment among cities in the YRD region, it is necessary to implement context-specific interventions. This involves considering the different social, economic conditions, and natural environments of different provinces and formulating different development strategies based on the objective development situations of different dimensions of the business environment subsystem in each city.

3. In addition, some cities and provinces in the YRD region have outstanding development and should fully leverage their central driving role to enhance urban radiation capacity. This will allow more regions to share the fruits of reform and opening up and benefit from development dividends.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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