


Spatio-Temporal Evolution Measurements for High-Quality Developmental Concepts in China's Emergency Industry

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Abstract

This paper establishes a high-quality development (HQD) evaluation index system for the emergency industry to analyze its spatio-temporal evolution. The entropy weighting method is applied to comprehensively assess the development level of China's emergency industry during the observation period. Results indicate that the overall HQD index follows an upward trajectory, although it remains relatively low (rising from 0.211 to 0.255). The 2020 regional analysis highlights a hierarchical pattern in industrial development: coastal regions (0.321) > inland regions (0.246) > border regions (0.153). The overall Gini coefficient has remained stable at 0.22. Specifically, coastal areas (0.19) and inland areas (0.16) exhibit notable disparities, whereas border regions show minimal variation (0.10). The Gini coefficient between coastal and Border regions increased from 0.31 to 0.36, whereas that between coastal and inland areas declined after 2011, falling from 0.29 to 0.23. Regional variation, accounting for 59% of the total, emerges as the primary source of inequality. The Moran index identifies a significant spatial autocorrelation, indicating clear spatial self-correlation in the development levels of China's emergency industry. Kernel density analysis further illustrates that the national development level has steadily improved. However, the industry as a whole does not exhibit σ -convergence. The novelty of this study lies in constructing an HQD index system for China's emergency industry and employing multiple analytical methods to examine its spatiotemporal evolution.

Keywords

emergency industry, high-quality development, evaluation indicators, new development concepts, entropy weight, Dagum Gini coefficient, kernel density estimation

Introduction

High-quality development (HQD) has become a significant research focus in sustainable development globally (Luo et al., 2024). This concept underscores not only economic growth (Hafiz et al., 2024) but also a holistic model of development that integrates innovation and green initiatives (Z. Chen & Xing, 2025) while promoting coordination, openness, and shared prosperity (Dai, 2025). China faces frequent natural disasters across its diverse geography. The southwest region experiences earthquakes and geological hazards, while the southeast coast is prone to typhoons and other meteorological events. In the post-pandemic era, public health emergency response demands have intensified significantly.

Consequently, China's emergency industry has entered a phase of rapid development. In its narrow sense, the emergency industry refers to the industrial complex that supplies emergency-specific products and services in response to natural disasters, accidents, public health crises, and social security incidents. It emphasizes emergency demands under non-routine, critical conditions. In its broader definition, the emergency industry also

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encompasses routine preparedness, including all industrial systems capable of providing emergency products and services. This industry is characterized by eight key attributes: rigid demand, public welfare, specialization, practicality, timeliness, contingency, transformability, and comprehensiveness.

The HQD of the emergency industry should align with the new development concept, which is based on five major principles that impact the quality of development through both government and foreign direct investment (Jahanger, 2021; X. Yang et al., 2022).

Research on the Connotation and Extension Characteristics of HQD

The definition of HQD remains a subject of academic debate, lacking a universally accepted consensus. In the first stage, many relied on single indicators such as total factor productivity (Yu et al., 2019), and ecological welfare intensity (Xiao, 2019; Z. Li & Wang, 2019), which oversimplified the concept and failed to reflect its complexity (Nie & Jian, 2020), often resulting in unstable evaluation outcomes (Guo et al., 2020). Following the 19th National Congress in October 2017, the second stage saw a shift from single-dimensional to multidimensional frameworks (F. Wang & Shi, 2022), with scholars redefining HQD through the lenses of quality, efficiency, and driver transformations (Ren, 2022; Y. Liu & Nie, 2023; Yin et al., 2023). Despite these advances, distinctions remain between the quality of economic growth and the broader notion of HQD. The third stage, initiated by the Sixth Plenary Session of the 19th CPC Central Committee in November 2021, clarified that HQD entails innovation as the primary driver, coordination as an intrinsic characteristic, greenness as the prevailing mode, openness as a necessary path, and sharing as the fundamental goal (X. Li, 2021). The core tenets of HQD can be encapsulated in five key principles: innovation-driven, balanced coordination, greenness, low-carbon transition, openness, sharing, and resilient security. However, the specific characteristics of HQD in manufacturing industries, particularly those involving emergency response, have not been sufficiently explored, and there remains a significant gap in the development of industry-specific measurement frameworks.

Research on Indicator Systems and Measurement Methods for HQD

In the context of China's macroeconomic HQD, scholars have developed comprehensive indicator systems (J. Zhang, 2019; T. Zhang, 2020) and applied various statistical and econometric methods (e.g., the entropy-weighted TOPSIS method; Wei & Li, 2018) to measure

development levels. Although many of these studies offer insights at the macro level, relatively few focus on the meso-level development of the manufacturing industry. Some scholars from economic performance (Jiang et al., 2019), technological innovation, green development (F. Wang & Shi, 2022), brand quality, integration of informatization and industrialization have continuously deepened the indicator systems (three-dimensional system, Chao et al., 2021; seven-dimensional system, Fang & Dai, 2024), and measurement methods (horizontal-vertical ranking methods, Chao et al., 2021; entropy method, Z. Liu et al., 2024) for HQD in manufacturing.

While these studies reflect the development and structural trends of the manufacturing sector, they adopted a narrow definition of HQD. As Z. He and Hui (2023) argue, such frameworks fail to adequately capture the broader requirements placed on manufacturing within China's high-quality economic development agenda. An increasing number of scholars (L. Chen & Huo, 2022) have adopted indicator systems based on the five development concepts for comprehensive evaluation, better aligning with national development goals. L. Qu et al. (2021) and Z. He and Hui (2023) expanded the framework to include a sixth dimension, security. Such research frameworks (Z. He & Hui, 2023) have gained widespread application in macro and regional studies of China's economy (Ou et al., 2020; T. Zhang, 2020). However, the literature on the HQD of the emergency industry remains scarce, particularly regarding the development and empirical testing of a dedicated measurement indicator system. There remains considerable room for further advancement:

1. **Incomplete indicator coverage:** Many existing frameworks fail to capture HQD's comprehensive and extended connotation fully. They do not reflect a "complete, accurate, and comprehensive implementation" of the new development philosophy. Furthermore, indicator selection often suffers from data unavailability or subjective arbitrariness.
2. **Simplistic methodologies:** The analytical methods adopted are often limited in scope, and the resulting measurements may be biased or imprecise. Issues such as inappropriate weight assignment or unscientific data standardization compromise the robustness and reliability of results.
3. **Lack of meso-level focus:** Current literature primarily concentrates on macroeconomic assessments, with scant attention to the meso-level, particularly provincial and sector-specific analyses. There is a notable absence of dedicated research addressing the HQD of the emergency industry.

The innovations in this article are as follows: First, the construction of the indicator system. Based on the five major development concepts, an HQD index system for the emergency industry should be built to meet the research needs of China's high-quality economic development. Second, innovation in research methods. Based on comprehensive evaluation and horizontal analysis, this paper uses the Moran index, the Dagum Gini coefficient, and other techniques to analyze the longitudinal study of HQD in the emergency industry across various provinces. Third, a broader temporal span and a more focused research object, which are more conducive to guiding the HQD of the emergency industry in each province.

Methods

Construction and Measurement of Evaluation Criteria

HQD is highly nuanced and complicated to measure with a single indicator, and scholars such as Nardo et al. (2005) argue that composite indicators can aggregate complex indicator information. This study draws on the work of Y. Yang and Zhang (2021), who presented a measurement and spatio-temporal analysis of HQD in China's industry.

HQD is intrinsically linked to industrial policy, resilience, and theories of spatial inequality. Industrial policy serves as the driving engine, resilience constitutes the stabilizing foundation, and spatial coordination functions as the vehicle for fairness. Industrial policy must shift from a scale-driven to a quality-led paradigm, fostering targeted support for research and development and for upgrading high-value segments within the value chain, thereby breaking free from the low-end lock-in trap. The resilience of industrial chains provides systemic stability for HQD, with its dual dimensions of risk resistance and adaptive innovation jointly underpinning the sustainability of economic quality upgrading. Addressing spatial inequality requires transcending traditional gradient theory by enabling cross-regional coordination of production factors and building feasible capabilities, thereby facilitating nonlinear leaps in less developed regions rather than mere passive industrial relocation.

This paper draws on the conceptual framework and index design of T. Zhang (2020) to construct an evaluation index system for the HQD of China's emergency industry, comprising 6 dimensions, 12 first-level indicators, and 24 second-level indicators.

Innovation. Innovation is the key driver for HQD, crucial for tackling structural imbalances and environmental issues. Technological advancements play a vital role in this process. As a technology-intensive sector, the

emergency industry naturally demands the transformation and application of scientific and technological achievements. Following the approach of Wei and Li (2018), we evaluate innovation using four secondary indicators: R&D investment intensity, the proportion of R&D personnel among total employees, the share of invention patent applications among total patent applications, and the proportion of new product sales revenue relative to primary business income. The indicators above encompass innovative inputs (funding, personnel), outputs (patents), and outcomes (new product sales revenue). This structure aligns with the systematic design principles of the HQD indicator system for the manufacturing sector. It is positively associated with HQD outcomes in the emergency industry, such as improvements in overall labor productivity.

Green. Sustainable development is a foundational principle for the HQD of the emergency industry. China's "14th Five-Year Plan" emphasizes the urgent need for green transformation. Drawing on the work of Lin and Xu (2022) and Z. He and Hui (2023), four secondary indicators are employed: investment in industrial pollution control per 1,000 RMB of industrial added value, the share of energy conservation and environmental protection expenditure in the local general public budget, energy consumption per unit of industrial added value, and power consumption per GDP (gross domestic product). These indicators, from the critical perspectives of *green governance capabilities* and *energy consumption rate*, quantitatively assess sustainable development, thereby capturing the green dimension of the HQD of the emergency industry.

Openness. Openness is vital to the HQD of the emergency industry, reflecting a broader global integration trend. Based on the frameworks proposed by J. Liu and Bian (2022) as well as T. Zhang (2020), openness is evaluated through four indicators: the ratio of foreign capital to paid-in capital, the ratio of total import and export of goods to regional GDP, total foreign investment, and on-financial OFDI (Outward Foreign Direct Investment) flows. These indicators help assess the sector's levels of foreign trade and capital openness.

Sharing. The concept of sharing promotes a people-centered approach to development, ensuring that the benefits of economic and security progress are distributed fairly. The emergency industry must support equitable employment, income distribution, and broader societal inclusion to contribute to HQD. Building on the work of Gao and Yang (2020) and T. Zhang (2020), we assess this dimension using indicators such as the average wage of

employed persons in urban units and the number of listed companies per 10,000 companies limited by shares. These metrics reflect both revenue sharing and social sharing within industry. When the average wages in the emergency industry reach twice the local average, distributive justice in the form of primary allocation is achieved through risk–value compensation. When publicly listed emergency enterprises allocate more than 12% of their profits back to society, the secondary allocation is elevated through the universalization of capital gains. These four key indicators together constitute the “compass of distributive justice” for China’s emergency industry.

Coordination. Coordination is a key feature of high-quality industrial development, highlighting the sector’s internal efficiency and balance. According to the “14th Five-Year Plan” and the long-term goals for 2035, coordinated development, especially in labor and energy efficiency, is critical for sustainable growth. Guided by research from Chao et al. (2021) and Z. He and Hui (2023), per capita sales revenue represents the industry’s coordination and operational efficiency. A per capita sales revenue of at least 1.5 million RMB serves as a threshold for ensuring the economic sustainability of the emergency industry. When the value of finished products exceeds 460 million RMB, it reflects the delivery capacity of an individual emergency enterprise. Achieving energy-saving production capacity and efficiency at twice the industry average enables the emergency industry to overcome the resource constraints associated with “energy.” The coordination dimension of HQD in the emergency industry is embodied in the unified advancement of labor utilization and energy efficiency.

Security. Security reflects HQD’s stability dimension. Recent global shifts, including heightened technology export controls and constrained international cooperation, have increased uncertainty and potential vulnerabilities in the emergency industry. In addition, domestic financial risks, such as high corporate debt, pose serious challenges. Drawing on the studies by L. Qu et al. (2021), T. Zhang (2020), and Z. He and Hui (2023), we use the ratio of current assets to current liabilities and the proportion of public security expenditure in the general public budget to assess internal financial stability and external safety assurance, respectively. The return on assets serves as a strategic breakthrough mechanism against technological blockades in the emergency industry; the operating margin functions as the lifeline sustaining wartime capital flows; the liquidity ratio acts as an extinguisher in supply chain crises; and the industry’s financial dependence constitutes the Achilles’ heel of industrial security.

Data Acquisition and Processing

At present, China has not yet issued an official statistical yearbook specifically entitled Emergency Industry Statistical Yearbook; however, relevant statistical data on the emergency industry can be obtained through authoritative channels. The research data are sourced from *Chinese statistical yearbooks*, including the *China Industrial Statistical Yearbook*, *China Energy Statistical Yearbook*, *China Science and Technology Statistical Yearbook*, and *China Foreign Economic Trade Statistical Yearbook*. Due to the inherent time lag in data collection, statistical yearbook data are limited in their ability to capture real-time economic dynamics. The sample period for this study spans 2010 to 2020 and covers 30 provinces in mainland China (excluding Tibet).

This study selects six representative manufacturing sectors from category C: C27, C35, C37, C38, C39, and C40. The wage indicators presented in this study are measured at current prices and have been adjusted using urban resident consumer price indices to ensure temporal comparability across years. Sparse missing values were addressed through imputation via the interpolation method. The data is standardized to eliminate differences in dimensions between indicators. For beneficial criteria, the data are normalized using Equation 1.

$$x' = \frac{x_{ij} - \min x_j}{\max x_j - \min x_j} \quad (1)$$

For cost criteria, the data is normalized using Equation 2.

$$x' = \frac{\max x_j - x_{ij}}{\max x_j - \min x_j} \quad (2)$$

where x' is the normalized data, x_{ij} is the i th sample of the j th indicator, $\max x_j$ is the maximum value of the j th indicator, and $\min x_j$ is the j th minimum value of the item metric.

Evaluation Methods

Weighting Method. The entropy weighting method (EWM) is an objective weighting technique grounded in information entropy theory, employed to determine the relative importance of indicators within a multi-criteria evaluation framework. Its fundamental principle involves calculating the entropy of each indicator and assigning weights based on the magnitude of their entropies. EWM enables the data to “speak for themselves”: if a dataset is completely uniform, its corresponding weight is zero; conversely, the greater the variability of an indicator’s values, the higher its weight. Consequently, this study employs the entropy weighting method to evaluate the

HQD of emergency industries comprehensively. The method evaluates the annual HQD level of emergency industries across provinces by determining indicator weights based on the information content of the sample data and by calculating comprehensive scores based on the quantity of indicator information. The amount of information an indicator carries determines its weight, and the comprehensive scores are calculated as follows. The HQD index system is presented in Table 1.

Step 1. Find the contribution of the i th sample to the indicator under the item j

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^n x_j} \quad (3)$$

where P_{ij} is the contribution of the i th sample to the indicator under item j , and x_{ij} is the i th of the j th indicator samples, x_j is the j th indicator.

Step 2. Calculate the entropy value of the j -item indicator:

$$e_j = -k \sum_{i=1}^n p_{ij} \ln(p_{ij}), j = 1, 2, \dots, m. \quad (4)$$

where $k = 1/\ln(n) > 0$ satisfies $e_j > 0$

Step 3. Calculate the information entropy redundancy of each indicator:

$$d_j = 1 - e_j, j = 1, 2, \dots, m. \quad (5)$$

Step 4. Calculate the weight of each indicator:

$$w_j = \frac{d_j}{\sum_{j=1}^m d_j}, j = 1, \dots, m \quad (6)$$

where w_j is the weight of the j indicator.

Step 5. The scores of each region are calculated.

$$s_j = \sum_{i=1}^n w_j x_{ij}, i = 1, \dots, n \quad (7)$$

where x_{ij} is the i th sample of the j th item metric after normalization.

Dagum Gini Coefficient. The Gini coefficient is an internationally recognized metric for measuring income inequality within a country or region. The traditional Gini coefficient, however, can only reflect the overall degree of inequality in an economic variable and cannot identify the specific sources of this disparity (Dagum, 1997). The Dagum Gini coefficient, which is often referred to as the “magnifying glass of regional disparities,” not only accurately reveals the spatial sources of variation in economic variables but also allows for an intuitive observation of the dynamic changes in the contribution rates of three distinct components. This decomposition disaggregates the overall Gini coefficient into three parts: the intra-regional inequality contribution, the inter-regional inequality contribution, and the overlapping density. The transvariation density (G_i) captures the frictional costs between regions, reflecting additional disparities arising from policy or geographical barriers between adjacent areas. The total equals the sum of these three components ($G = G_w + G_{nb} + G_i$), where the latter two constitute the total inter-regional difference contribution. This approach measures the sources of regional disparities and addresses sample crossover overlap issues plus subsample distribution considerations (Jin, 2018). This characteristic meets the needs of this study, so this paper uses the Dagum Gini coefficient and its decomposition method to examine the spatial pattern of HQD levels in the emergency industry across 30 provinces, municipalities, and autonomous regions. The overall Gini coefficient is computed as follows:

$$G = \frac{\sum_{j=1}^k \sum_{h=1}^k \sum_{i=1}^{n_j} \sum_{r=1}^{n_h} |y_{ji} - y_{hr}|}{2n^2 \mu} \quad (8)$$

μ indicates the HQD level of China’s emergency industry; $y_{ji}(y_{hr})$ is expressed as the HQD level of the emergency industry in any province or city in $j = (h)$ region; $n = 30$ represents the total number of provinces and territories; $k = 3$ represents the number of areas divided; $n_j(n_h)$ represents the number of provinces in the $n_j(n_h) j(h)$ area. The Gini coefficient is sorted according to each region’s HQD level of the emergency industry before being decomposed to facilitate the calculation.

The formula for calculating the Gini coefficient within the subgroup is:

Table 1. Index System for HQD of the Emergency Industry.

Dimension metrics	Primary composite indicators	Secondary composite indicators	Measurement values
Innovation (C ₁)	Invest in innovation (C _{1.1}) Innovation output capacity (C _{1.2})	Innovative input capacity (C _{1.1.1}) Innovative intellectual investment (C _{1.1.2}) Intellectual property creativity (C _{1.2.1}) Innovative value realization ability (C _{1.2.2})	The R&D expenditure input intensity No. of R&D personnel accounts for the total No. of employees The proportion of invention patent applications in the total number of patent applications New product sales revenue accounted for a proportion of the primary business income
Green (C ₂)	Green governance capabilities (C _{2.1})	Environmental protection investment (C _{2.1.1}) Green guarantees (C _{2.1.2})	The amount of investment in industrial pollution control per 1,000 yuan of industrial added value has been completed The proportion of energy conservation and environmental protection expenditure in the local general public budget expenditure
Openness (C ₃)	Energy loss rate (C _{3.2}) Level of foreign trade openness (C _{3.1})	Total energy consumption rate ^a (C _{3.2.1}) Electric energy consumption rate ^a (C _{3.2.2}) Proportion of foreign capital (C _{3.1.1}) Proportion of foreign investment (C _{3.1.2})	Energy consumption per unit GDP Power consumption per GDP The proportion of foreign capital to paid-in capital The proportion of total imports and exports of goods to the regional GDP
Sharing (C ₄)	Level of capital openness (C _{4.2}) Level of revenue sharing (C _{4.1}) Level of social sharing (C _{4.2})	Total foreign investment (C _{4.2.1}) Investment capacity (C _{4.2.2}) Distribution efficiency (C _{4.1.1}) Percentage of revenue distribution (C _{4.1.2}) Achieve public shareholding capabilities (C _{4.2.1}) Achieve service capabilities (C _{4.2.2})	Total foreign investment on-financial OFDI flows Average wages of employed persons in urban units Gross wages/GDP of employed persons in urban units No. of listed companies per 10,000 companies limited by shares
Coordination (C ₅)	Labor utilization (C _{5.1}) Energy efficiency (C _{5.2})	Labor productivity (C _{5.1.1}) Industrial production efficiency (C _{5.1.2}) Energy-saving production capacity (C _{5.2.1}) Energy efficient production efficiency (C _{5.2.2})	The added value of social services accounts for the proportion of GDP Per capita sales revenue (10,000 yuan/person) Value of finished products/No. of enterprises Unit industrial added value/standard energy consumption Gross regional product/consumption of major energy products
Security (C ₆)	Internal security level (C _{6.1}) External security level (C _{6.2})	Return on assets (C _{6.1.1}) Operating margin (C _{6.1.2}) Liquidity ratio (C _{6.2.1}) Financial dependence of the industry (C _{6.2.2})	Total profit as a percentage of total assets Operating profit as a proportion of operating income Current asset/liability flow Public security expenditure as a proportion of the general public budget expenditure

^aCost criteria, others are beneficial criteria.

$$G_{ij} = \frac{\sum_{i=1}^{n_j} \sum_{r=1}^{n_i} |y_{ji} - y_{hr}|}{2\mu_i n_j^2} \quad (9)$$

The contribution of within-subgroup differences to the overall Gini coefficient is calculated as:

$$G_w = \sum_{i=1}^{n_j} G_{ij} P_j S_j \quad (10)$$

The Gini coefficient between subgroup h and subgroup j is calculated as:

$$G_{jh} = \frac{\sum_{i=1}^{n_j} \sum_{r=1}^{n_h} |y_{ji} - y_{hr}|}{n_j n_h (\mu_j + \mu_h)} \quad (11)$$

The contribution of the equity gap between subgroups to the overall Gini coefficient is calculated as follows:

$$G_{nb} = \sum_{j=1}^k \sum_{h=1}^{j-1} G_{jh} (P_j S_h + P_h S_j) D_{jh} \quad (12)$$

The formula for calculating the contribution of super-variable density is:

$$G_t = \sum_{j=1}^k \sum_{h=1}^{j-1} G_{jh} (P_j S_h + P_h S_j) (1 - D_{jh}) \quad (13)$$

Where:

$$D_{jh} = \frac{d_{jh} - p_{jh}}{d_{jh} + p_{jh}} \quad (14)$$

$$d_{jh} = \int_0^\infty dF_j(y) \int_0^y (y-x) dF_h(x) \quad (15)$$

$$p_{jh} = \int_0^\infty d_h(y) \int_0^y (y-x) d_j(x) \quad (16)$$

The difference in the regional economic HQD composite index between regions j and h are denoted as d_{jh} . The super-variable first moment (p_{jh}) is the weighted average of all $(y_{hr} - y_{ji})$ values under the condition that $(y_{hr} - y_{ji}) > 0$, when $\mu_j > \mu_h$.

Spatial Self-Correlation Analysis.

1. Economic distance matrix construction: The level of economic development, the level of trade in goods, the level of labor mobility, the level of capital flow, etc., can be used to measure the

economic distance in space. The most common indicator used to construct economic distance is GDP per capita because the indicator reflecting the level of economic development is the most intuitive. The data is easy to obtain (J. He & Lv, 2015). Therefore, this paper chooses to use the GDP per capita of each province to construct the economic distance matrix, and its formula is:

$$w_{ij} = \frac{1}{|y_i - y_j|} \quad (17)$$

where y_i and y_j are the per capital GDP of region i and j , respectively, and the GDP per capita of both places. The absolute value of the difference can be reasonably reciprocal. Reflects the economic distance between the two regions.

2. Moran index: The Moran's index is a fundamental statistical metric for measuring spatial autocorrelation, employed to analyze the clustering or dispersion patterns of attribute values of geographic features across space. The global Moran index is one of the leading spatial autocorrelation indices. This paper uses the global Moran index to study the spatial aggregation characteristics of the HQD of emerging industries in various provinces. The Moran index formula is as follows:

$$\begin{aligned} I &= \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(y_j - \bar{y})}{S_0 \sum_{i=1}^n (x_i - \bar{x})^2} \\ &= \frac{\frac{1}{S_0} \sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(y_j - \bar{y})}{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2} \\ &= \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(y_j - \bar{y})}{S^2 \cdot \sum_{i=1}^n \sum_{j=1}^n w_{ij}} \end{aligned} \quad (18)$$

where $S^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$ represents the variance of

province I 's HQD index, and $S_0 = \sum_{i=1}^n \sum_{j=1}^n w_{ij}$ denotes

the spatial weight between provinces i and j . The middle expression shows that the numerator is the covariance of data x considering geographic adjacency relationships (weighted), while the denominator represents the simple

variance of data x without weighting. The Moran's I index is the ratio between the weighted and unweighted variance. The standardized value of Moran's I is calculated by dividing the difference between observed values and expected values by the standard deviation through linear transformation.

The Z^2_i calculation formula for the statistic is:

$$ZI = \frac{I - E[I]}{\sqrt{V[I]}} \quad (19)$$

Therefore:

$$E[I] = -1/(n-1) \quad (20)$$

$$V[I] = E[I^2] - E[I]^2 \quad (21)$$

Nonparametric Kernel Density Estimation. The Kernel density estimation (KDE) method employs a smooth kernel function to fit the probability density of sample data. Essentially, each sample data point, together with the bandwidth, is substituted into the kernel function for linear superposition, followed by a weighted averaging process to generate a continuous KDE curve. This curve is then used to characterize both the temporal evolution trends and the spatial agglomeration patterns of the HQD of the emergency industry. Conceptually, employing KDE is analogous to replacing a "two-dimensional X-ray image" (histogram) with a "three-dimensional CT scan," thereby enabling a more refined and multidimensional visualization of the gradual spatial heterogeneity in development. The kernel density curve is drawn using the information characteristics of the annual HQD score of the emergency industry in each region, which has the characteristics of weak dependence on the model and strong robustness. The calculation formula of kernel density estimation is:

$$f(y) = \frac{1}{nh} \sum_{i=1}^n K\left(\frac{y_i - \bar{Y}}{h}\right) \quad (22)$$

The Gaussian kernel density function is:

$$K(x) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right) \quad (23)$$

where y_i represents the score of HQD of the emergency industry in the i region, and \bar{Y} represents the average; n is the number of samples; $K(x)$ is the kernel function, and the Gaussian kernel density function is selected in this paper; h is the function bandwidth, which is determined by referring to scholars such as Xie et al. (2022) according to Silverman's thumb method.

Dynamic Change Trend of HQD. This paper uses the non-parametric kernel density estimation method to analyze the distribution characteristics and dynamic trends of HQD levels of emergency industries in various regions of China. It also provides high-quality 3D kernel density estimation curves for emergency industries in multiple regions for easy plotting and analysis.

Furthermore, a σ -convergence analysis is conducted. The σ -convergence refers to the process by which certain gaps narrow over time. The σ -convergence model can reflect the evolution trend of the development level of the emergency industry in various regions during the national observation period, and the σ formula of the convergence test equation is as follows:

$$\sigma_j = \sqrt{\frac{1}{n} \sum_{i=1}^n \left(\ln(x_{ij}) - \frac{1}{n} \sum_{i=1}^n \ln(x_{ij}) \right)^2} \quad (24)$$

where σ_j refers to the convergence coefficient value of σ in the j th year, n refers to the number of regions, and x_{ij} refers to the j of the i region. The score of the HQD level of the emergency industry in the year.

Results

Based on the entropy weight method, the calculated weights for the innovation, green development, openness, sharing, coordination, and security dimensions are 26.7%, 13.2%, 20.4%, 18.4%, 11.1%, and 10.1%, respectively. Innovation, openness, and sharing indicators carry more weight than other first-level indicators, indicating that innovation and open concepts are of great significance to the HQD of the emergency industry. Innovation is the source of scientific and technological development, and the development of the emergency industry is inseparable from scientific and technological development. Openness is an essential decision for China to move toward international development. Sharing reflects the industry's development and adheres to people-centered development thinking. The low weight of coordination indicators indicates that there may be regional differences in the HQD of China's emergency industry, and the national development needs to be balanced.

Based on the entropy weighting method and the HQD evaluation system for the emergency industry, this paper considers data availability. It divides the 30 provinces, autonomous regions, and municipalities directly under the central government of the Chinese mainland Tibet into three regions: coastal, inland, and Border, which were comprehensively evaluated from 2010 to 2020. The HQD level of the emergency industry was comprehensively evaluated, and the data of 11 years were jointly

Table 2. Measurement Results of HQD of the Emergency Industry in Various Regions.

Region	Year	2010	2012	2014	2016	2018	2019	2020
Coastal	Tianjin	0.367	0.377	0.390	0.378	0.382	0.385	0.348
	Hebei	0.173	0.171	0.197	0.175	0.200	0.221	0.197
	Liaoning	0.216	0.201	0.213	0.205	0.221	0.238	0.236
	Shanghai	0.504	0.484	0.498	0.500	0.501	0.491	0.486
	Jiangsu	0.335	0.349	0.354	0.365	0.387	0.399	0.412
	Zhejiang	0.268	0.306	0.348	0.362	0.400	0.443	0.473
	Fujian	0.261	0.263	0.254	0.270	0.281	0.325	0.339
	Shandong	0.229	0.264	0.301	0.268	0.283	0.268	0.287
	Guangdong	0.385	0.383	0.385	0.367	0.395	0.404	0.406
	Guangxi	0.171	0.175	0.187	0.188	0.164	0.178	0.184
Inland	Hainan	0.187	0.229	0.245	0.198	0.187	0.172	0.159
	Beijing	0.433	0.377	0.399	0.401	0.430	0.461	0.444
	Shanxi	0.128	0.175	0.172	0.169	0.193	0.190	0.201
	Anhui	0.171	0.193	0.202	0.225	0.256	0.266	0.266
	Jiangxi	0.154	0.155	0.171	0.167	0.186	0.218	0.240
	Henan	0.140	0.141	0.163	0.168	0.193	0.195	0.229
	Hubei	0.190	0.165	0.175	0.206	0.240	0.251	0.249
	Hunan	0.164	0.184	0.198	0.204	0.223	0.238	0.263
	Chongqing	0.176	0.189	0.211	0.225	0.260	0.257	0.320
	Sichuan	0.149	0.154	0.181	0.183	0.199	0.209	0.227
	Guizhou	0.157	0.131	0.125	0.128	0.148	0.156	0.174
	Shaanxi	0.183	0.172	0.222	0.218	0.259	0.272	0.273
	Qinghai	0.101	0.099	0.123	0.135	0.157	0.131	0.112
	Ningxia	0.181	0.159	0.217	0.192	0.184	0.186	0.197
	Border	Inner Mongolia	0.118	0.126	0.160	0.147	0.132	0.124
Jilin		0.175	0.186	0.203	0.208	0.19	0.199	0.182
Heilongjiang		0.162	0.162	0.171	0.127	0.152	0.153	0.146
Yunnan		0.124	0.122	0.128	0.141	0.156	0.174	0.191
Gansu		0.132	0.146	0.13	0.118	0.106	0.127	0.113
Xinjiang		0.192	0.165	0.178	0.153	0.176	0.180	0.162
Coastal mean		0.281	0.291	0.307	0.298	0.309	0.32	0.321
Inland mean		0.179	0.177	0.197	0.202	0.225	0.233	0.246
Border mean		0.151	0.151	0.162	0.149	0.152	0.159	0.153
Nation		0.211	0.213	0.230	0.226	0.241	0.250	0.255

comprehensively evaluated, and these scores are shown in Table 2.

Overall Plot Analysis

The HQD level scores of the emergency industry in Table 2 and the three major regions are obtained and plotted. The HQD of the emergency industry in Border region fluctuated, but there was no upward trend, and the score was stable between 0.149 and 0.162.

Analysis of Measured Results for HQD of China's Emergency Industry

Overall Analysis. Analysis of Table 2 reveals that the HQD level of the emergency industry at the national level, as well as in coastal and inland areas, showed a gradual upward trend from 2010 to 2020, rising from 0.211 to 0.255, except for a decline observed in 2015. The HQD

level of coastal regions (0.301) was higher than the national average (0.230). In contrast, border regions showed fluctuating emergency industry development, with scores remaining stable at 0.149 to 0.162. Additionally, similar to the overall trend, coastal region development levels remained above the national and inland averages throughout the period under study. The scores of innovations, coordination, and sharing indicators for the five major development concepts increased steadily from 2010 to 2020, while green indicators fluctuated, and security and openness indicators decreased significantly.

Figure 1 shows the role of innovation in the development of the emergency industry has increased year by year, reflecting the importance of scientific and technological innovation as a pillar of the industry's development, and that China's emergency industry development has become less dependent on openness year by year.

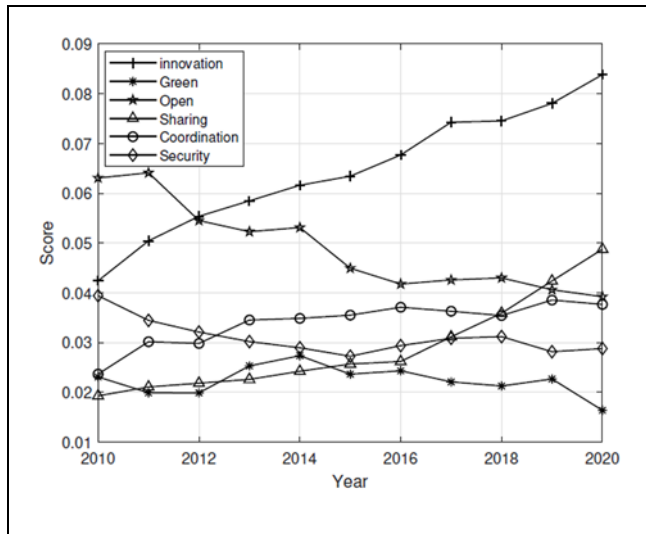


Figure 1. Average scores of various dimensions of indicators.

Three Regional and Provincial-Level Analyses. The HQD score for the emergency industry in each region in 2020 is presented in a bar chart.

Twelve provinces, including Qinghai, Gansu, and Ningxia, recorded scores below 0.2. Ten provinces, such as Shanxi and Shandong, scored between 0.2 and 0.3. Only three provinces: Chongqing, Fujian, and Tianjin; achieved scores above 0.3 but below 0.4. Provinces with scores surpassing 0.4 are exclusively the most economically developed regions, namely Guangdong, Jiangsu, Beijing, Zhejiang, and Shanghai. The development of the emergency industry across the country in 2020 was uneven, with significant differences in levels of development.

Based on measurement results for the HQD of the emergency industry across various regions of China, the HQD level in 30 provinces directly under the Central Government was evaluated. According to Xin and An (2019), based on the “natural break-point method” and combined with expert suggestions, the HQD level of the emergency industry is divided as follows. This evaluation system and grade division are still in the exploration stage, and the grade classification only reflects relative significance (Figure 2).

The first class of emergency industry development areas, except for Beijing, is concentrated along the coast, with Shanghai having the highest level of emergency industry development (0.486), followed by Zhejiang (0.473). These two regions are significantly ahead of the rest of the world. There are second-class areas for emergency industry development in coastal and inland areas, but none in the Border. The three types of emergency industry development areas are coastal. These development areas are distributed along a long inland strip, but most are concentrated there. Of the four regions, only

Qinghai is landlocked and has the lowest score (0.112), while the others belong to the Border region. The first category comprises all economically developed areas, and the third and fourth categories comprise all financially underdeveloped areas, indicating that the local economic development level positively affects the development of the emergency industry. The rapid improvement in the innovation level of coastal and other developed areas has promoted the HQD of the emergency industry, leading China’s safety and emergency industry to follow the pattern: Coastal > Inland > Border.

The “China Safety and Emergency Industry Map White Paper (2020)” published by the official authorities reveals that coastal regions have the most significant overall industrial scale. The size of China’s emergency industry is positively correlated with provincial GDP and HQD of its coastal economic belt. Among these regions, Jiangsu Province and Guangdong Province lead the nation on an industrial scale. Borderland areas have the most significant future potential, serving as the vital path connecting domestic security and the emergency industry protection with external development in inland China (Tables 3 and 4).

Regional Differences in the HQD of the Emergency Industry

Regional Difference Analysis. The Gini coefficients of the country and its three major regions are plotted in Figure 3. The Gini coefficient of the emergency industry fluctuated from 2010 to 2020 and remained 0.21 – 0.23 above 2013 levels thereafter. The Gini coefficient’s stability means that the emergency industry’s regional development structure is also stable. The regional differences in development have not changed significantly, indicating that the emergency industry’s development structure across the country has remained largely unchanged. Internal disparities among coastal (0.19), inland (0.16), and border regions (0.10) are significant, with the border region exhibiting the least internal heterogeneity.

From the perspective of the three primary regional levels, the Gini coefficient of inland regions also increased and decreased. The distribution was gradually balanced from 2016 to 2020. During the year, the inland Gini coefficient fluctuated. The development pattern of the emergency industry in coastal areas has changed little from 2010 to 2020.

The Gini coefficients between the coastal-inland, coastal-border, and inland-border regions are shown in Figure 4. The trend of the interregional Gini coefficient is calculated based on the Dagum Gini coefficient.

Analysis of the Gini Coefficient Between the Three Regions. The interregional Gini coefficients indicate differences in the

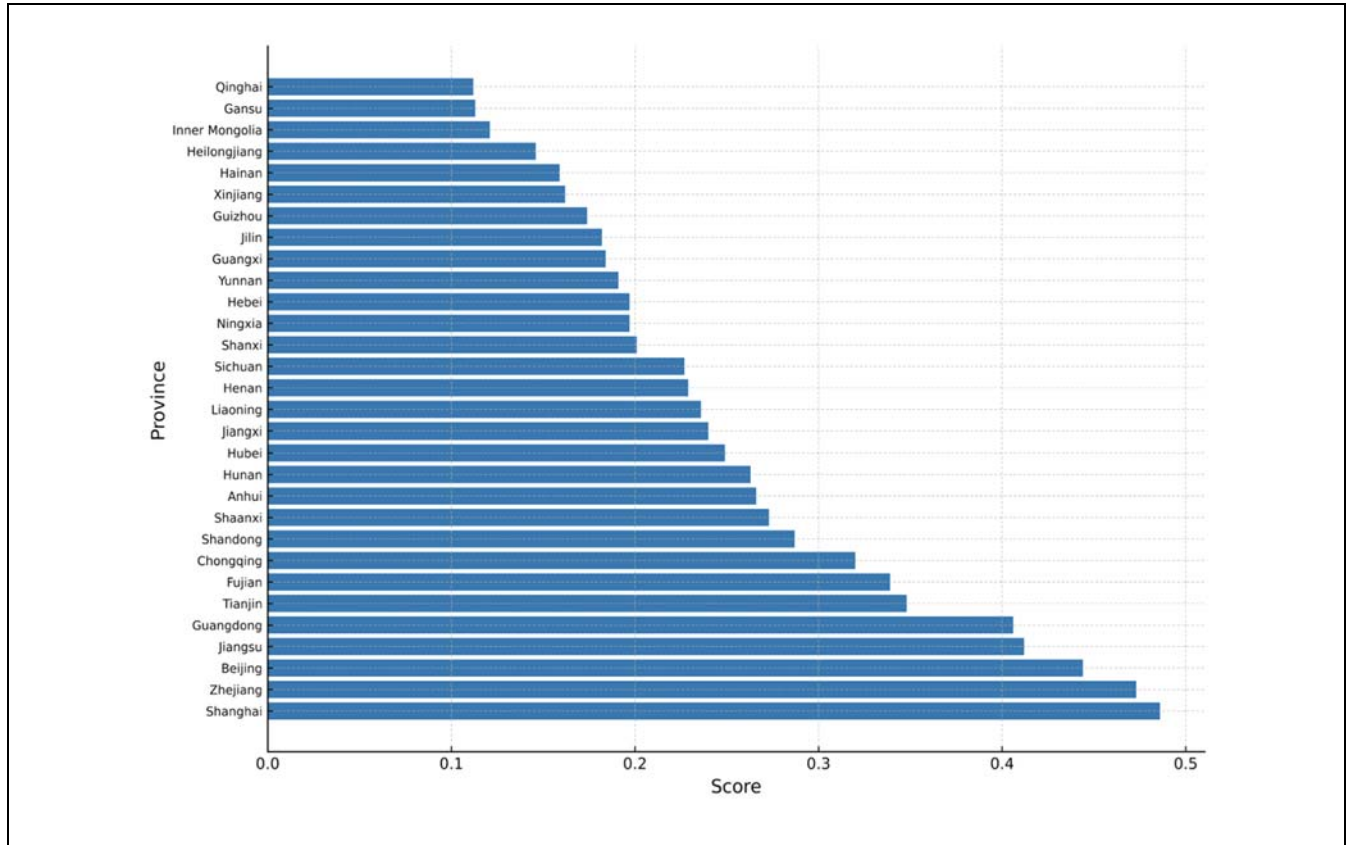


Figure 2. Score of HQD of the emergency industry by region in 2020.

Table 3. A Comprehensive Score Divided by the Regional Level.

Grade	Coastal	Inland	Border
$D \geq 0.35$ (category-I)	Shanghai, Zhejiang, Jiangsu, Guangdong	Beijing	—
$0.35 > D \geq 0.25$ (category-II)	Tianjin, Shandong, Fujian	Anhui, Chongqing, Hunan, Shaanxi	—
$0.25 > D \geq 0.15$ (category-III)	Hebei, Hainan, Liaoning, Guangxi	Guizhou, Henan, Shanxi, Hubei, Sichuan, Ningxia, Jiangxi	Jilin, Yunnan, Xinjiang
$D < 0.15$ (category-IV)	—	Qinghai	Inner Mongolia, Heilongjiang, Gansu

Table 4. Moran Index for the HQD of Emergency Industries in Various Regions.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Moran index	0.554	0.561	0.545	0.545	0.526	0.560	0.554	0.554	0.532	0.515	0.440
Z-value	5.949	6.024	5.857	5.861	5.668	6.013	5.953	5.950	5.731	5.559	4.799
p-value	0	0	0	0	0	0	0	0	0	0	0

level of development of the emergency industry across regions. During the observation period, the coastal-border Gini coefficient exhibited an upward trend

(increasing from 0.31 to 0.36), indicating a widening disparity in the emergency industry development between coastal and Border regions. The Gini coefficient of the

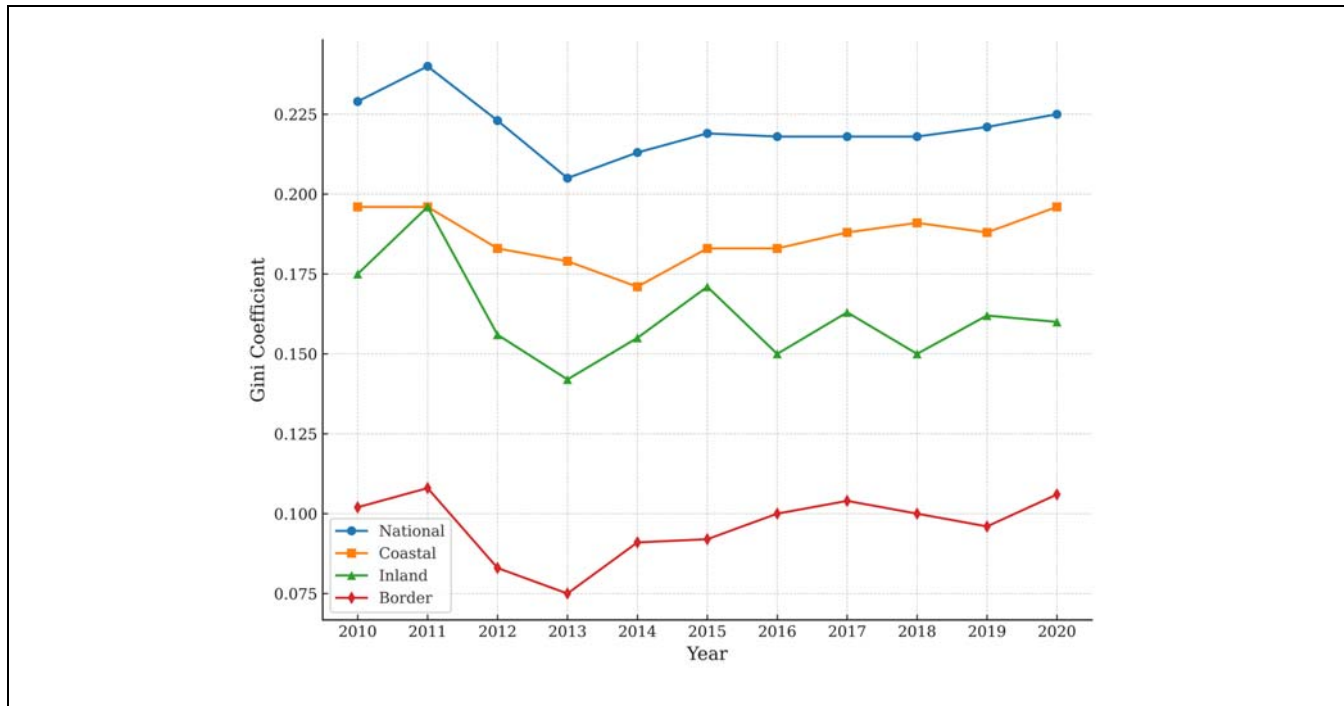


Figure 3. Trend of the Gini coefficient.

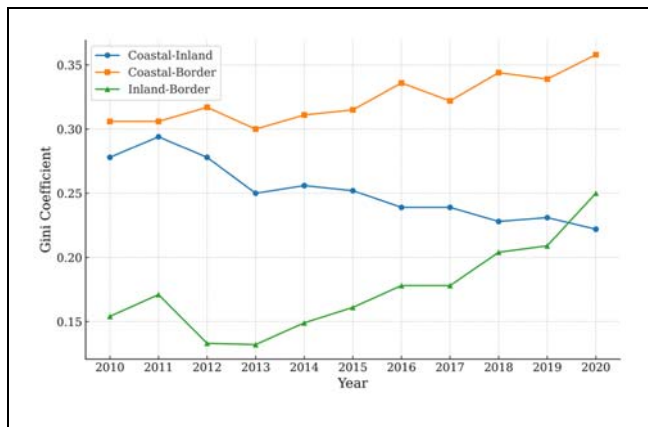


Figure 4. Trends in Gini coefficient changes between regions.

coastal-inland relationship demonstrated a downward trajectory after 2011 (decreasing from 0.29 to 0.23), suggesting that the development gap in the emergency industry between coastal and inland areas narrowed during this period. Meanwhile, the Gini coefficient for inland and Border regions showed an “increase-decrease-increase” pattern throughout the observation period. Notably, after 2013, there was a rapid increase in the Border-inland Gini coefficient (rising from 0.13 to 0.25).

According to the officially released White Paper on China’s Safety and Emergency Industry Map (2020), several major economic sectors have rapidly developed in

the Bohai Bay, Yangtze River Delta, and Pearl River Delta regions, effectively driving HQD in their respective areas. In the Bohai Bay region, Beijing, Tianjin, Hebei, Liaoning, Jilin, and Shandong demonstrate significant advantages in technological development, conversion, and human resources. These regional strengths complement one another, promoting balanced development across the region.

These initiatives serve as exemplary models for promoting balanced HQD in emergency industries across coastal and inland regions. However, due to geographical limitations on industrial transfer distances between coastal and bordering regions, disparities between these areas have become increasingly unbalanced. The Gini coefficient continues to widen in inland and bordering regions, particularly in provinces like Inner Mongolia and Gansu, where the emergency industry remains underdeveloped, further exacerbating regional inequalities.

Gini Coefficient Decomposition Analysis of the Regional Source. From the perspective of the changing trend in the contribution rate of each gap source, the internal structure of the gap between regions for China’s HQD emergency industry has not changed much from 2010 to 2020. According to a previous analysis (with a contribution rate of 59%), it is likely related to differences in the development of emergency industries across coastal, Border, and inland areas.

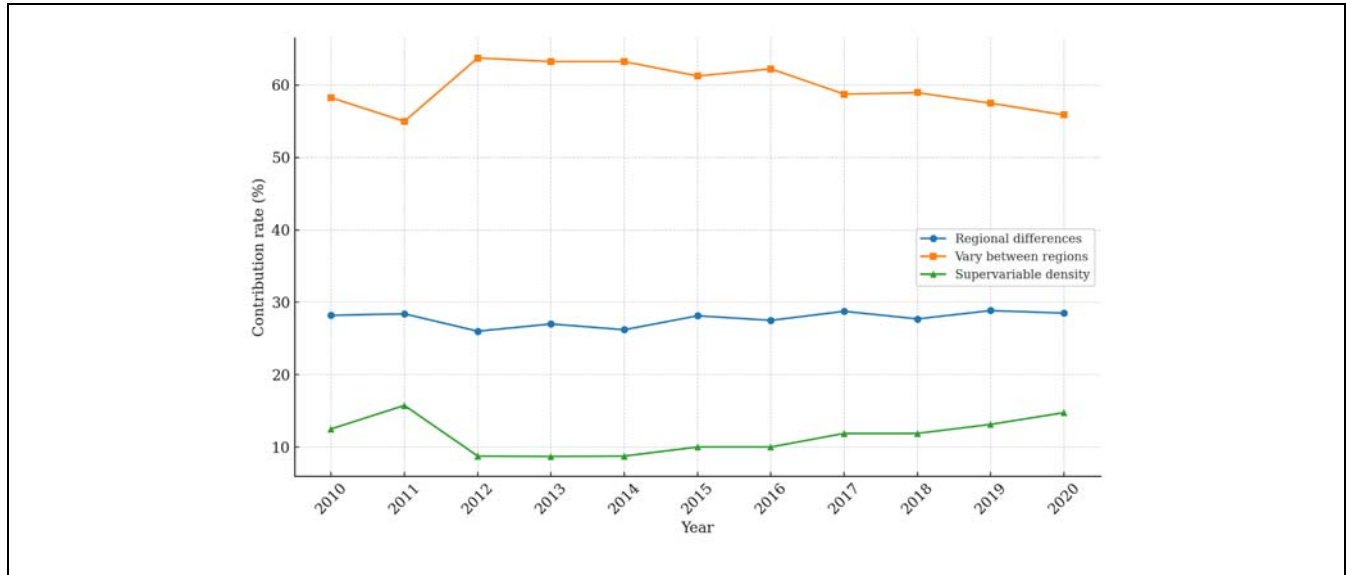


Figure 5. Contribution rate change trend.

The super variable density is mainly used to identify the cross-overlapping phenomenon between regions. For example, although the overall emergency industry development level of the coastal area is higher than that of the inland province, the HQD level of the emergency industry in an inland province is higher than that of some coastal provinces. From the super-variable density curve from 2010 to 2020, the phenomenon of crossover has always existed in the development of the emergency industry (Figure 5).

According to the Gini coefficient calculation formula, the number of samples can affect the results, leading to errors. However, the relevant studies show that the actual error will be much smaller than the theoretical error (Yan et al., 2017), so the impact of this error on this study can be ignored.

Spatial Agglomeration Analysis of the Emergency Industry Development Based on Moran's Index

For the spatial agglomeration analysis based on Moran's index, the per capita GDP of each region was used of each region is used to construct the economic distance matrix. The global Moran index is selected to analyze the HQD level of the emergency industry in various regions in China from 2010 to 2020, and the results are as follows:

The Moran index from 2010 to 2020 is significant at the 1% level, which is of research significance. The Moran index is positive, indicating strong spatial autocorrelation and suggesting that the spatial difference in the level of emergency industry development across provinces in China is evident. Obvious spatial

autocorrelation, indicating a significant agglomeration phenomenon that is directly related to the regional economic development level. The Moran index is above 0.4, and the maximum fluctuation does not exceed 0.12, indicating that, to a certain extent, the development level of the emergency industry across regions from 2010 to 2019 is highly similar, while regional development remains uneven. There has been no significant change in this nationwide development trend.

According to the "2022 China Safety and Emergency Industry Cluster White Paper," China's emergency industry exhibits a clear spatial agglomeration pattern, gradually forming three major economic regions: the Yangtze River Delta, the Guangdong-Hong Kong-Macao Greater Bay Area, and the Beijing-Tianjin-Hebei. The emergency industry has established a new regional development landscape characterized by "three core drivers leading with inland border areas progressing together." The coastal provinces of Shandong, Jiangsu, Zhejiang, and Shanghai have formed an integrated cluster, demonstrating clear spatial positive autocorrelation. Similarly, the inland regions, including Anhui, Henan, Hebei, Jiangxi, Sichuan, Chongqing, and Guizhou, also exhibit distinct spatial autocorrelation relationships in their HQD of emergency industries.

Spatial Distribution Characteristics and Dynamic Evolution Trends of HQD in the Emergency Industry

Three-dimensional kernel density estimation curves for the emergency industry HQD are plotted for each region to facilitate visualization and analysis.

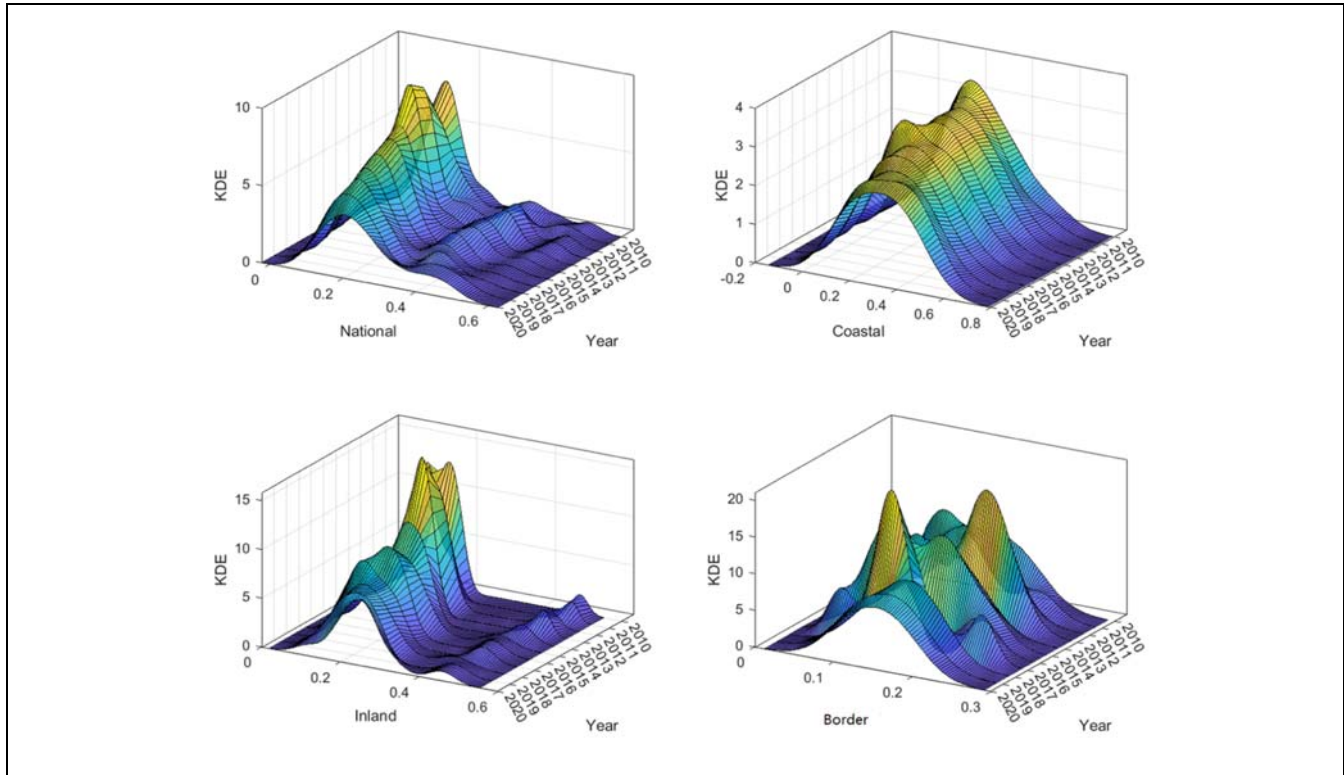


Figure 6. Nonparametric kernel density estimation curve.

Analysis at the National Level. Figure 6 reports the nonparametric kernel density estimation curves. The national kernel density curves exhibit a clear evolution from a pronounced bimodal distribution toward a unimodal form, reaching a peak around 2013 and continuing to shift to the right. This pattern indicates a general upward trend in the HQD level of China's emergency industry. The persistent decline in kurtosis, coupled with the gradual broadening of the curves, suggests an increasing dispersion in HQD levels across the country. The distribution's right skew implies that higher values exert an upward pull on the overall national average. The density range fluctuates between 0 and 7, with values approaching the maximum around 2013 before gradually declining to below 4. The inland curve closely resembles the national trend.

Analysis of the Three Regional Levels. In the coastal region, the kernel density curves approximate a normal distribution, making the mean a more representative measure of the overall trend. Kurtosis shows a general downward trajectory, with the density range narrowing from approximately 3 to 1 over time, while the curves become increasingly broad. This indicates a gradual rise in internal dispersion and widening intra-regional disparities.

Simultaneously, the peak density values increase, reflecting a steady improvement in the overall HQD level of the coastal region. Compared with the national curve in the first panel, the coastal region consistently exhibits higher scores. The inland curve mirrors the national pattern.

In contrast, the border region's kernel density distribution displays a more irregular pattern. The density range spans from 0 to 16, with the mean showing a steady annual increase. In 2019 and 2020, the distribution stabilized, accompanied by heightened dispersion. Internal regional differences expand progressively amid fluctuations. The consistent decline in peak density over time indicates that the HQD of the emergency industry in border provinces, as well as their multi-polar development patterns, has undergone notable transformation.^{3.6} Spatial convergence analysis.

The σ convergence was selected to analyze the trend in HQD levels in the emergency industry from 2010 to 2020, and the results are shown in Figure 7.

Figure 7 shows the evolution of the σ -convergence coefficients for the emergency industry at the national and regional levels during the sample period. Figure 7 shows that the development level of the emergency industry across regions does not exhibit consistent σ -convergence overall but rather shows phased convergence, with

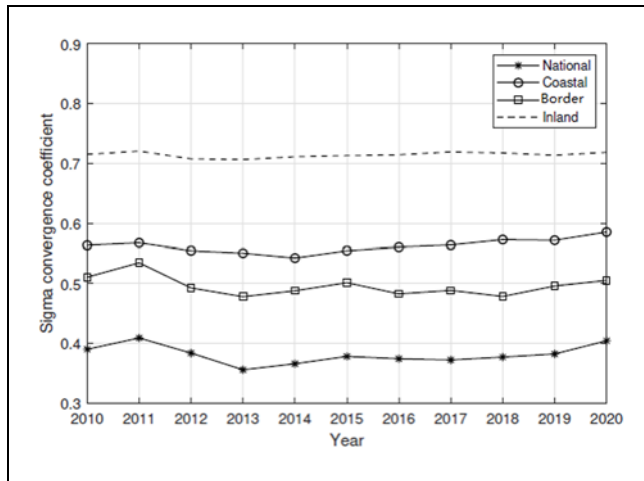


Figure 7. Development level of the emergency industry σ convergence coefficient.

the national region in 2011 to 2013 showing a more obvious convergence phenomenon, followed by 2013 to 2015.

There was a more pronounced divergence over the years. To a certain extent, the trend of the σ convergence coefficient across regions indicates that the development structure of the emergency industry in multiple regions has not changed much from 2010 to 2020, that development differences between regions are apparent, and that there is no obvious sign of catch-up convergence in less developed areas. This is consistent with the conclusion that the level of the emergency industry development during the observation period of the Moran index analysis shows a certain intensity of spatial agglomeration.

Discussion

Multidimensional Indicator Systems Provide More Comprehensive and Reliable Evaluations Than Unidimensional Results

Although single indicators are helpful such as labor productivity (S. Chen & Chen, 2018), total factor productivity (Marcel et al., 2024; Z. Liu & Ling, 2020), green total factor productivity (H. Li & Dong, 2021; Yu et al., 2019), or the employment share of the secondary and tertiary sectors (Z. Wang & Zhang, 2019), they cannot fully capture the complexity of HQD. In contrast, multidimensional indicator systems prioritize comprehensiveness by integrating various aspects such as industrial development, social progress, and ecological sustainability. We propose a comprehensive framework for assessing the HQD of China's emergency industry. At the principal level, the proposed indicator system emphasizes comprehensiveness, heterogeneity, stability, and dynamism; at

the technical level, it values transparency, accessibility, and simplicity. We adopt six dimensions: innovation, green development, openness, sharing, coordination, and safety, to reflect industry-level HQD based on the work of L. Qu et al. (2021). Using conventional statistical data, we analyze and evaluate the HQD of emergency industries across China's provinces, contributing theoretically and practically to the field. Therefore, evaluations based on multidimensional indicator systems are more comprehensive and reliable than unidimensional results and better aligned with China's research needs for high-quality economic development.

Combining Multiple Research Methods Enhances the Understanding of Spatiotemporal Evolution

The HQD of the emergency industry exhibits distinct spatiotemporal characteristics. Existing studies have employed clustering and correspondence analysis to explore regional differences but have not effectively identified their sources. By integrating Moran's I , the Dagum Gini decomposition, and kernel density estimation, we reveal the sources and dynamic evolution of disparities in HQD across time and space. These methods accurately diagnose regional weaknesses and provide valuable insights for building a modern industrial system, strengthening manufacturing, and fostering service industry prosperity (L. Liu et al., 2022).

J. Chen et al. (2020) used entropy weights, the Dagum Gini coefficient, and kernel density estimation to measure the national HQD index of the Chinese economy from 2004 to 2017 and analyze its spatial and temporal trends. They found a generally low but upward trend in the overall index, with an unbalanced regional distribution following an eastern-northeastern-central-western hierarchy. Their findings corroborate our conclusions, although differences in research objects and time frames may explain contrasting results, such as their finding of a narrowing gap in overall economic development. At the same time, our study reveals a persistent disparity in the emergency industry.

Broader Temporal Span, More Focused Research Object, and Stronger Industry Relevance

Wei and Li (2018) were limited to the year 2016 and lacked dynamic insights. The framework of T. Zhang (2020) is unsuitable for industrial and regional sub-sector studies over multiple time points. J. Chen et al. (2020) expanded the research scope but did not focus on the emergency industry.

This study finds that the HQD index of the emergency industry closely aligns with indices reported in the 2024

China Safety and Emergency Industry Development Report by CCID Research Institute, indicating the robustness and practical validity of our findings. Our computed indices (0.222–0.284) are comparable to those found in other studies (e.g., J. Chen et al.'s (2020) 0.213–0.279; Wei and Li's (2018) 0.142–0.434), confirming that China's HQD level remains relatively low. Moreover, consistent with Jahanger (2021), X. Yang et al. (2022), and Y. Yang et al. (2021), innovation is the key driver of HQD. Notably, our study reveals a declining trend in the openness dimension, reflecting unique spatiotemporal patterns in the emergency industry. These insights provide stronger, industry-specific guidance for regional policy formulation.

Limitations and Future Research

This study has several limitations, primarily due to data availability. This paper focuses on China's emergency industry manufacturing segment. In reality, the emergency industry encompasses not only manufacturing but also services such as monitoring, early warning, education, training, consulting, logistics management, and information platforms. It increasingly intersects with the IT, telecommunications, and finance sectors, fostering new models such as innovative emergency finance and systems. The conclusions of this study are constrained by the availability of provincial-level panel data in China and by limitations in selecting HQD indicators at the industrial level. These findings are therefore more applicable to the HQD of the emergency industry across 30 provinces in mainland China during the 11 years prior to 2020. Caution should be exercised when generalizing them to the HQD of other industries or to regional HQD.

Future research can be further expanded in the following aspect: First, as data becomes available, future work should expand the scope of the emergency industry to include the service sector (e.g., emergency consulting, logistics, and information platforms) to provide a more holistic assessment of its HQD. Second, employing alternative methodologies, such as spatial econometric models, could help identify the specific drivers and spillover effects influencing the HQD of the emergency industry, moving beyond measuring disparities to explain their causes. Third, future research could conduct comparative analyses with the emergency industries of other countries to derive internationally relevant insights and policy lessons. Finally, extending the temporal scope of the analysis beyond 2020 would be valuable for capturing post-pandemic trends and evaluating the long-term effectiveness of recent policy interventions.

Policy Recommendations

Based on the above findings, we propose the following policy recommendations to advance the HQD of China's emergency industry:

1. **Acknowledge the uneven development landscape:** Recognize the heterogeneity in development levels across regions and address the contradiction between regional equity and sufficiency. Strategic intervention is needed to rebalance industrial competition and achieve gradual, coordinated growth.
2. **Expand openness and collaboration at a higher level:** With openness in decline, policymakers must respond to external challenges by strengthening domestic circulation and enhancing international cooperation. Industrial security should also be prioritized, with efforts to improve profitability, manage financial risk, guide the classification of emergency products, and establish strategic reserves. A dual-track model combining market mechanisms and government procurement is essential for stability.
3. **Strengthen interregional collaboration:** Address inter- and intra-regional disparities by leveraging the advantages of border regions, promoting industrial transfers, and optimizing spatial layouts. Increased investment in underdeveloped areas like the Border should be paired with targeted financial and policy support.
4. **Enhance top-level design and macro policy guidance:** Industrial clusters in regions such as the Yangtze River Delta, the Pearl River Delta, the Bohai Rim, and the Chengdu–Chongqing area should leverage their manufacturing strengths to build complementary, specialized emergency industries. Regional coordination and supply chain integration are crucial to avoiding homogeneous competition and fostering sustainable growth.
5. **Breaking regional barriers to promote HQD of the emergency industry:** A three-dimensional strategy: “policy guidance + factor reconfiguration + scenario adaptation” should be implemented in a coordinated manner to narrow interregional disparities. Precision in fiscal transfers: The central government should establish a dedicated compensatory fund, prioritizing infrastructure investment in Border and other disaster-prone areas. Tax incentives should be used to encourage coastal enterprises to establish production bases in inland and border regions. In

addition, a cross-provincial mechanism for dispatch compensation should be instituted to ensure efficient interregional resource allocation.

Gradient innovation support: An integrated innovation chain, “Coastal R&D, inland transformation, Border application,” should be established. Coastal regions would focus on breakthroughs in core technologies, such as intelligent early-warning algorithms; inland regions would absorb the relocation of manufacturing for equipment, such as sensors and unmanned aerial vehicles (UAVs); Border would conduct specialized testing and certification for extreme scenarios, such as high-altitude, cold climates and mountainous terrain. National laboratories should establish branch facilities strategically distributed across regions based on regional characteristics.

Differentiated disaster prevention planning: Coastal regions should pilot the construction of “smart emergency city clusters”; inland regions should develop industrial clusters specializing in the manufacturing of emergency equipment; Border should strengthen disaster prevention capabilities for border ecological reserves and energy bases. A regularized mechanism for cross-regional emergency drills should be established to enhance the nationwide coordinated response capacity.

Conclusions

A comprehensive evaluation index system is constructed to assess the HQD of China’s emergency industry. The paper employs the entropy weighting method to measure the quality development index for 30 provinces from 2010 to 2020, then uses the Dagum Gini coefficient decomposition method to analyze the sources of disparity, applies kernel density estimation to illustrate the distribution dynamics and evolution trend of HQD in the emergency industry, and finally conducts convergence analysis. This study provides policy references for promoting HQD in provincial emergency industries. Therefore, this paper has fully achieved its intended research objectives.

First, six dimensions, that is, Innovation, Green, Openness, Sharing, Coordination, and Security are employed to construct a scientifically sound measurement framework for accurately assessing provincial-level high-quality emergency industry development in China.

Second, the overall index of China’s emergency industry HQD shows an upward trend (reaching 0.255), and coastal regions exhibit higher levels of development (0.301) compared to the national average (0.230). Inland areas demonstrate more substantial improvements in

their overall development levels. However, the rate of improvement in the coastal regions’ emergency industry HQD index is slower than that in inland regions. The border regions exhibit fluctuating development patterns, with no notable overall improvement.

Third, a statistically significant Moran’s *I* index indicates strong spatial autocorrelation among regional developments. There are apparent spatial dependence and agglomeration phenomena in the development of the emergency industry, and high-high and low-low agglomeration at the national level. Significant differences exist in the development of the emergency industry across different provinces, with no sign of this disparity alleviating.

Fourth, the overall Gini coefficient of emergency industry development across all provinces remained stable at around 0.22 from 2010 to 2020, without a significant reduction. There are substantial disparities in emergency industry development between coastal, inland, and border regions. The gap between coastal and inland regions has decreased annually. During the observation period, the Gini coefficient between coastal and Border regions fluctuated upward (from 0.31 to 0.36), indicating an expanding trend in the development gap in the emergency industry between these areas. Disparities in China’s emergency industry HQD primarily stem from regional differences (accounting for 59% of the variance), with a crossover phenomenon across regions. This suggests an imbalanced pattern of development across the three major regions. Furthermore, given each region’s Gini coefficient, these disparities predominantly originate in coastal high-income areas.

Finally, this paper offers a comprehensive, data-driven assessment of HQD in China’s emergency industry, revealing critical regional disparities, temporal dynamics, and structural challenges. While progress has been made, especially in inland areas, the uneven pace of development, widening internal gaps, and systemic governance limitations underscore the urgent need for targeted policy refinement, interregional coordination, and innovation-driven strategies to promote balanced, sustainable advancement across all regions.

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Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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