Analysis of supply chain resilience in China's cruise ship building industry

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Abstract. China's participation in the global cruise ship building sector is substantial, yet the industry finds itself grappling with challenges such as a modest market share, weak supply chain agglomeration effects, and a scattered domestic industry layout. Addressing these issues to foster the cruise economy's growth especially by restructuring the industry's supply chain represents a pressing concern. This study evaluates the resilience of the supply chain within China's cruise ship building industry, focusing on 10 port cities renowned for their developed cruise sectors. Through a comprehensive index evaluation approach alongside the entropy weight method, this study quantifies the resilience levels and identifies disparities across these cities. The findings indicate an ongoing enhancement in the industry's resilience, albeit variably influenced by the unique urban settings in which different organizational sectors are situated. These variances notably impact essential resilience aspects such as absorption capacity, leadership capacity, adaptability and recoverability. The study posits that amplifying the influence of industry leaders, refining the business climate, and bolstering regional policy support are crucial strategies for strengthening the cruise shipbuilding industry's resilience.

Keywords: Cruise Shipbuilding industry, supply chain, resilience

1 Introduction

The cruise industry, recognized as a strategic and emerging sector that melds high-end equipment manufacturing with modern services, boasts an extensive industrial chain, considerable momentum, and broad impact. It is often celebrated as the "golden industry floating on the golden waterway". Leading global cruise ship constructors such as Fincantieri, Meyer Werft, and Chantiers de l'Atlantique collectively command approximately 95% of the worldwide market share[1]. China's cruise shipbuilding industry has recently experienced rapid growth. Marked by the Adora Magic City's maiden voyage in 2024, China has carved out a substantial niche in the global value chain; nonetheless, this industry in China remains at the lower end of the value chain, marked by minimal local content, economic contribution, and market penetration. The issue of low market share is apparent, but a fragmented supply chain also contributes to these challenges. The domestic cruise shipbuilding industry is hampered by a lack of agglomeration, with foreign suppliers and service providers dominating the supply chain. Problems such as geographical distance, ineffective information exchange, and poor coordination among supply chain nodes lead to inefficient operations, a lack of supplier agglomeration, and elevated inventory costs. Enhancing the resilience and security of both the

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industry and its supply chains is crucial to mitigate the profound effects of restructuring on the development of the cruise economy. Hence, this study aims to assess the resilience of the supply chain within China's cruise shipbuilding industry. Focusing on 10 port cities where the cruise industry is more advanced, it employs a comprehensive index evaluation system and the entropy weight method to measure their supply chain resilience over time. The recommendations derived from these findings aim to bolster China's initiative to elevate its manufacturing sector

2 Development of a Resilience Evaluation for the Cruise Shipbuilding Industry's Supply Chain

The assessment of supply chain resilience has traditionally focused on dimensions such as absorption capacity, leadership capacity, adaptability, and recoverability [2] [3], which have been used to dissect and evaluate supply chain challenges across various sectors, especially manufacturing[4][5]. ①Absorption capacity reflects the supply chain's capacity to directly withstand external shocks in terms of both intensity and frequency[6]. In the cruise shipbuilding industry, bolstering absorption involves the economic environment, production capacity, and transportation capabilities. The economic environment is often gauged by the region's GDP[7], production capacity by the count of major shipbuilding firms, and transportation capabilities by metrics such as logistics reliability, cost, precision, visibility, and distance[8], with cruise passenger throughput serving as a tangible measure. ②Leadership capacity signifies the pivotal role of industry-leading firms, endowed with significant leadership and control, in steering the supply chain. This leadership is typically concentrated in a handful of multinational corporations or entities integrated into the global trade network, which command critical sectors worldwide. For China, establishing such leading firms within the cruise shipbuilding industry is essential, and their ability to maintain a leadership position through digitalization, engaging in high-end ventures, and pioneering innovations represents key strategies for bolstering supply chain leadership. Digital leadership metrics include internet broadband user counts, high-end leadership by the tally of high-tech firms, and innovation leadership by the volume of patent applications and grants. ③Recoverability is the supply chain's capacity for self-repair post external shocks, evaluated through metrics of human support, industrial performance, and social security, which affect the degree and speed of recovery. Human support, indicating the role of research and technical staff in effective post-shock recovery[9], is quantified by employment numbers in scientific and technical sectors. Industrial performance, or the financial resilience of supply chain nodes, is measured by the profit margins of sizeable industrial firms. Governmental backing for chain repair, restructuring, and upgrading underscores the significance of comprehensive state support in enhancing recoverability. Societal support refers to the investment level in public welfare and infrastructure. ④Adaptability, underscored by resilience theory, highlights a dynamic equilibrium between development and security, ensuring system evolution and sustained growth. In the context of sustainability, this translates into a focus on green development within the supply chain. Meeting "dual carbon" objectives necessitates enhanced energy efficiency and reduced emissions, alongside stronger governance of green equipment and investments. Therefore, within the sustainability dimension of the supply chain, energy-saving production, pollution emission, and green governance are identified as key indicators.

3 Methodology

3.1. Data Sources

This study selects 10 port cities with advanced cruise industries as its focal points: Shanghai, Qingdao, Dalian, Xiamen, Shenzhen, Zhoushan, Haikou, Tianjin, Sanya, and Guangzhou. The data utilized for evaluating the supply chain resilience originate from the Statistical Yearbooks of these cities from 2008 to 2021, the China Shipbuilding Industry Yearbook, statistical bureau websites, and the Annual Report on China’s Cruise Industry. For any missing data points in the statistical yearbooks, linear interpolation is employed to fill in the gaps.

3.2. Method

The procedure involves the following steps:

(1) Establishing the Original Evaluation Matrix:

Construct an initial matrix X=(xij)m×n for m evaluation years and n resilience indicators, where xij represents the data value of the i-th year for the j-th indicator.

(2) Standardizing Data:

To mitigate discrepancies caused by varied units among indicators, standardization is applied to ensure comparability. The formula varies depending on whether the indicator is positively or negatively oriented.

Positive indicators:

$$x_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{1}$$

Negative indicators:

$$x_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} \tag{2}$$

(3) Applying the Entropy Weight Method:

In the first step, indicate the proportion of each indicator’s value within the total for a given year:

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{3}$$

In the second step, determine the entropy value for each indicator:

$$e_j = -\frac{1}{\ln n} \times \sum_{i=1}^{m} P_{ij} \ln P_{ij} \tag{4}$$

where m is the number of evaluation years.

In the third step, compute the weight of each indicator:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)} \tag{5}$$

(4) Calculating the Comprehensive Index:

$$W=\sum_{j=1}^{n} w_j x_{ij} \tag{6}$$

where n is the number of evaluation indicators; W represents the comprehensive evaluation value of the level of supply chain resilience in the cruise shipbuilding industry of various port cities; wj represents the weight of the j-th indicator, and xij represents the value of the original data after standardization.

3.3. Indicator Weighting and Analysis

Utilizing the entropy weight method, the study first determines the weights for the resilience indicators of the cruise shipbuilding industry's supply chain in Chinese port cities from 2008 to 2021. It then calculates the weights at different levels of resilience indicators for the industry's supply chain. A descriptive statistical analysis reveals the importance of various indicators (as shown in Table 1).Among the 12 evaluation indicators for supply chain resilience in the cruise shipbuilding industry across major port cities, the indicators weighted most heavily include high-end leadership, innovation leadership, human support, and societal support, followed by green governance, economic environment, production capacity, and digital leadership. Indicators assigned lower weights are transportation capabilities, pollution emission, industrial performance, and energy-saving production. This distribution of weights highlights the crucial role of technological innovation, human capital, and governmental support in bolstering supply chain resilience. It reiterates the importance of talent as a pivotal driver of innovation and positions science and technology as fundamental to industrial strength. Furthermore, the considerable impact of green governance, economic environment, and production capacity on supply chain resilience points to the benefits of enhancing the investment climate, stimulating market entity vitality, and improving economic performance for sustained resilience enhancement. The analysis of the four dimensions shows the hierarchy from most to least impactful on supply chain resilience in port cities in the order of leadership capacity, recoverability, absorption capacity, and sustainability. This indicates robust leadership and recovery capabilities within major port cities, underscored by a strong foundation in human capital and technological innovation. However, absorption and sustainability capacities—albeit crucial—are identified as areas needing improvement. Specifically, the limited weights attributed to transportation and production capacities within the absorption dimension and to energy-saving production and pollution emission within sustainability, signal specific areas for targeted enhancement.

Table 1. Weights of Resilience Indicators for the Cruise Shipbuilding Industry's Supply Chain

Goal Layer	Criterion Layer	Second-tier Weight	Indicator Layer	Third-tier Weight
Resilience Evaluation of the Cruise Shipbuilding Industry's Supply	Absorption Capacity	0.2174	Economic Environment	0.0919
			Production Capacity	0.0713
			Transportation Capabilities	0.0542
	Leadership Capacity	0.3626	Digital Leadership	0.0753
			High-end Leadership	0.1558
			Innovation Leadership	0.1315
	Recoverability	0.2708	Human Support	0.1251
			Industrial Performance	0.0245
			Societal Support	0.1213

Chain	Sustainability	0.1492	Green Governance	0.1080
			Energy-saving Production	0.0145
			Pollution Emission	0.0266

4 Result

4.1. General Trends in Resilience Enhancement

An analysis of the results from 2008 to 2021 reveals a consistent strengthening of the cruise shipbuilding industry's supply chain resilience in China (see Figure 1). The growth rate of the leadership capacity index is notably higher than that of other categories, which emphasizes its crucial role in enhancing resilience. However, the increase in absorption capacity is modest—from 0.0404 in 2008 to 0.0719 in 2021—despite the year-on-year GDP growth in major port cities. Recoverability, aside from a decline in 2011, has shown a general upward trend, albeit with a slowing pace of growth. Sustainability has experienced fluctuations, with a slight overall increase from 0.0570 in 2008 to 0.0618 in 2021. Overall, the economic scale and production capacity of major port cities have developed relatively steadily; technological innovation is making strides, but the weights of energy-saving production and industrial performance are low, and the indicator values have begun to decline.

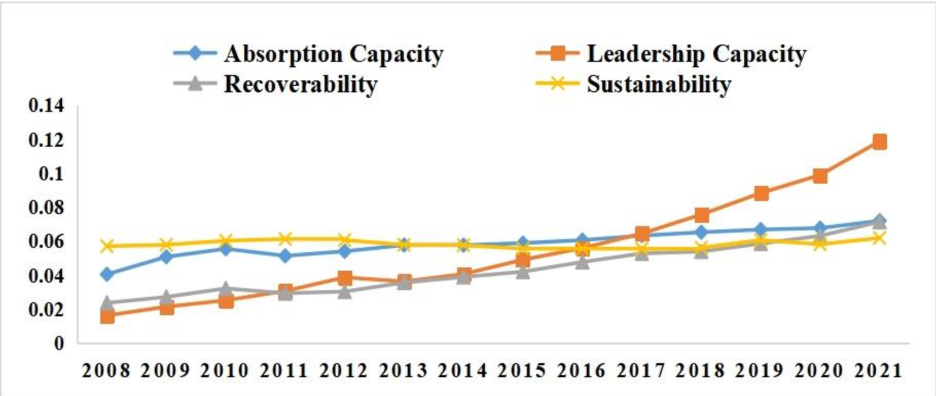
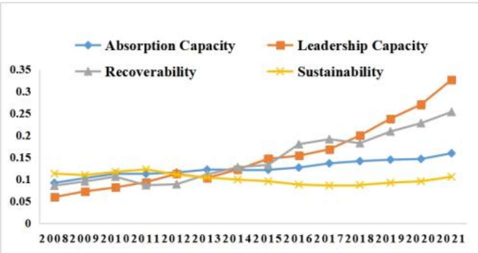


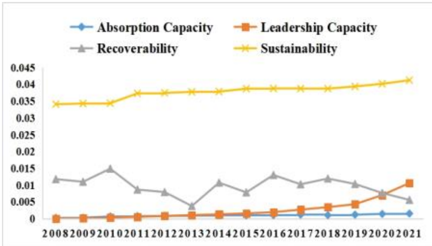
Figure 1. Trend of Supply Chain Resilience of Major Port Cities

4.2. Regional Variability in Resilience

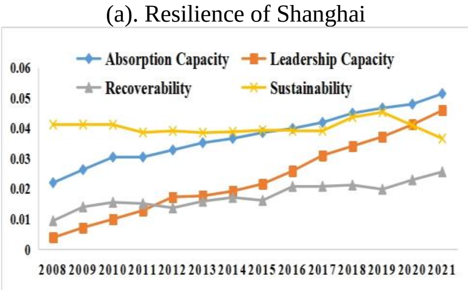
Despite the overarching trend of resilience enhancement, significant regional disparities are apparent (as shown in Figure 2). (1) From 2008 to 2021, Shanghai, Shenzhen, and Guangzhou demonstrated the most robust resilience, characterized by substantial and consistent growth across absorption, leadership, and recovery capacities. Leadership capacity, in particular, saw the fastest and largest increases in these cities, whereas recoverability varied the most. Absorption capacity had a higher growth rate and was relatively stable. However, their sustainability was declining, which indicates sustainability and absorptive capacity as areas for further development. (2) Sanya and Haikou, while showing improvements in leadership and sustainability, report minor gains in sustainability and absorption capacity, which resulted in lower overall resilience levels. This suggests a need to boost supply chain resilience through enhanced industrial performance in areas of production and transportation capacities. (3) Xiamen displayed growth in recovery, leadership, and absorption capacities but faced a downturn in sustainability, which highlights the need for improved green governance, energy-saving initiatives, and an optimized investment environment. (4) Dalian stands out for the most significant increase in leadership capacity and an overall rise in recoverability, though with a smaller increment. Its absorption capacity presents an unstable inverted U-shaped trend, with the smallest increases observed in adaptability and resistance, whereas autonomous control growth was notably prominent. underscoring a need to bolster production and transportation capabilities. (5) Tianjin and Qingdao, aside from sustainability, exhibited rapid growth in all other aspects. However, their absorption capacity increases are on the lower end, whereas leadership capacity growth is substantial, which suggests a focus on technological integration and enhancement of the investment climate. (6) Zhoushan shows an upward trend in recoverability with stable performances in absorption, leadership, and sustainability capacities, which points to potential areas for reinforcing its resilience across these three dimensions.



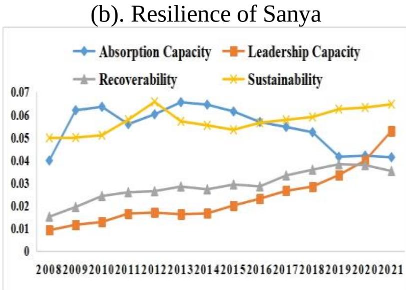
(a). Resilience of Shanghai



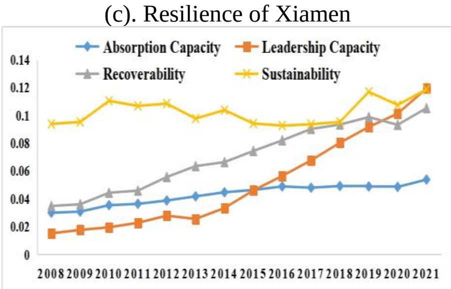
(b). Resilience of Sanya



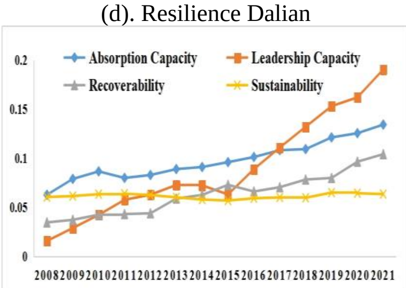
(c). Resilience of Xiamen



(d). Resilience Dalian



(e). Resilience of Tianjin



(f). Resilience of Guangzhou

Figure 2. Resilience of Cruise Port City Supply Chain

The comprehensive measurement of resilience indexes across these cities (as shown in Figure 3) reveals a continuous upward trend, with Shanghai, Guangzhou, Shenzhen, and Tianjin leading the charge. Notably, Shenzhen's resilience more than tripled from 0.1556 in 2008 to 0.2926 in 2021, marking the fastest and most substantial growth among the cities examined. Next is Guangzhou, with the index value in 2021 more than double that from 2008. Shanghai has maintained a growth trend, exhibiting the highest level of resilience. Following are Qingdao, Tianjin, Xiamen, Haikou, Dalian, Zhoushan, and Sanya; although their increase is not significant, it has maintained an upward trend. Despite the overall positive trend, the evident regional differences highlight the complexity of bolstering supply chain resilience; this necessitates a systematic, coordinated approach to effectively address both internal and external challenges.

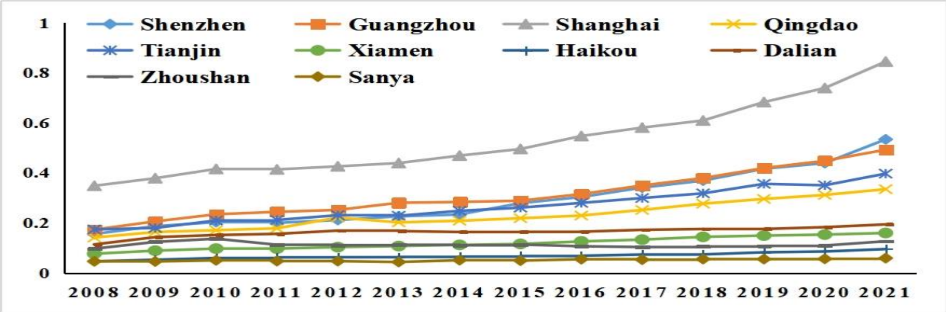


Figure 3. Comparison of Comprehensive Resilience Indexes of Major Port Cities

5 Conclusions

China's cruise industry has experienced rapid growth, propelled by national policies and the synergistic efforts of central and local governments. This strategic focus on manufacturing has positioned the country as a key player in the global cruise shipbuilding sector. Despite ongoing improvements in industrial chain resilience, the varied local environments in which these organizational sectors operate influence resilience dimensions such as absorption, leadership, adaptability, and recoverability to different extents. Our analysis suggests that maximizing the benefits of centralized enterprise leadership, refining the business landscape, and bolstering regional policy frameworks are crucial for fortifying the industry's resilience.(1) Prominent enterprises form the backbone of the cruise shipbuilding industry. Developing local headquarters and nurturing Chinese cruise conglomerates with a global reach and competitive edge are vital for spreading the industry's influence. Moreover, attracting foreign cruise company headquarters to China can amplify the sector's global integration, creating a hub for international collaboration and boosting the cruise economy through strategic aggregation. (2) Effective government strategies are essential for enhancing the policy and regulatory environment, ensuring the cruise shipbuilding industry's growth. By implementing precise policies, expanding the scope of fiscal and financial support, and simplifying investment processes, the government can facilitate comprehensive industry optimization. Initiatives could include facilitating financing and leasing options, streamlining foreign exchange processes, and improving insurance products for the cruise sector. (3) Improving the allocation of global resources and the leadership of high-end manufacturing within the cruise industry through environmental enhancements is pivotal. Shanghai's initiative to become an Asia-Pacific cruise material supply hub, utilizing free trade zones and other specialized areas, can serve as a model. Establishing platforms for cruise service trade and crew service centers and attracting international management and technical talent can further elevate the industry. Developing a talent pool and fostering a culture of open collaboration and specialization will ensure a steady supply of skilled professionals essential for the industry's sustained growth and global competitiveness.

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