

Urbanization Synergy and Blue Economy Upgrading in Global Maritime Center City Construction: A Comparative Study of China and the Middle East

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ABSTRACT

This study explores the interactive mechanisms between urbanization synergy and blue economy upgrading in global maritime center city construction, taking China's coastal cities (Qingdao, Shanghai) and Middle Eastern hubs (Dubai, Jeddah) as cases. Based on policy texts, statistical data (2022–2024) and in-depth interviews, it constructs an evaluation framework covering industrial integration, technological innovation, ecological governance and institutional support. Results show that China relies on "port-city-industry" linkage and technological agglomeration, while the Middle East emphasizes policy liberalization and tourism-energy integration. Both face challenges of ecological pressure and industrial mismatch. It proposes targeted paths: China should enhance technology conversion, while the Middle East needs to strengthen ecological regulation.

Keywords: Global Maritime Center City; Urbanization Synergy; Blue Economy Upgrading; China-Middle East Comparison; Institutional Innovation

1. Introduction

1.1 Research Background

Global maritime center cities, as core carriers of the blue economy, have become strategic pivots for coastal countries to participate in international competition. The United Nations' "Ocean Decade" initiative (2021–2030) explicitly regards urban-maritime synergy as a key driver for sustainable ocean development. With 68% of the world's population expected to live in urban areas by 2050 (UN-Habitat, 2024), the integration of urbanization processes with blue economy sectors has become a critical issue for maritime center construction.

China has entered a "quality improvement stage" of marine city development, with its 2024 marine economic aggregate exceeding 10 trillion yuan, accounting for 7.8% of GDP. Cities like Qingdao and Shanghai

have formed distinctive "port-city-industry" development models. Meanwhile, Middle Eastern countries represented by the UAE and Saudi Arabia are leveraging their coastal advantages to promote economic diversification—Dubai ranks 11th in the 2024 Leading Maritime Cities Report, and Saudi Arabia's Red Sea Project has created 70,000 jobs. However, both regions face dilemmas: China suffers from low marine technology conversion rates (below 20% in Qingdao), while the Middle East grapples with balancing tourism expansion and ecological protection. Clarifying these heterogeneous paths and common challenges is crucial for global maritime city development.

1.2 Literature Review

Existing studies can be categorized into three dimensions. First, research on urbanization-blue economy linkages focuses on single-region analysis: Liu et al. (2023) verified that China's marine city agglomeration drives blue economy growth through infrastructure spillover effects. Second, global maritime center studies emphasize evaluation systems—Theotokas et al. (2024) constructed indicators including port efficiency and maritime services but ignored urbanization synergy. Third, China-Middle East blue economy comparisons remain scarce: Most works focus on energy cooperation rather than urbanization-industry integration mechanisms. This study fills the gap by building a cross-regional comparative framework to reveal context-specific development logics.

1.3 Research Objectives and Questions

The objectives are: (1) Construct an evaluation system for urbanization synergy and blue economy upgrading; (2) Compare development models of China and Middle Eastern maritime centers; (3) Propose targeted optimization paths.

Key research questions:

- What are the core dimensions of urbanization synergy in blue economy upgrading?
- How do institutional and resource endowments shape heterogeneous development models across regions?
- What complementary experiences can China and the Middle East share for sustainable development?

1.4 Methodology and Data Sources

1.4.1 Research Methodology

•**Policy Text Analysis:** Codes 42 policy documents (China: 23; Middle East: 19) from 2022–2024 using NVivo, identifying core themes of institutional support.

•**Statistical Empirical Analysis:** Applies panel data regression to 4 cities (2022–2024) to test the impact of urbanization indicators on blue economy growth.

•**In-depth Interview:** Conducts 24 interviews with government officials, enterprise managers and scholars (6 per city) to supplement qualitative evidence.

1.4.2 Data Sources

•Statistical data: China Marine Economic Statistics Bulletin (2023–2024), UAE Federal Competitiveness and Statistics Authority (2024), Saudi General Authority for Statistics (2024);

•Policy documents: China's "14th Five-Year Plan for Marine Economic Development", UAE's "Maritime Sector Strategy 2030", Saudi's "National Red Sea Sustainable Strategy";

•Interview records: Semi-structured interviews conducted in March–June 2024, with each lasting 45–60 minutes.

2. Theoretical Framework: Urbanization Synergy and Blue Economy Upgrading

2.1 Conceptual Definition

•**Urbanization Synergy**: Refers to the coordinated interaction between urban functional elements (population, infrastructure, governance) and marine economic systems, manifested in three dimensions: spatial synergy (port-city integration), industrial synergy (land-maritime industry linkage), and institutional synergy (cross-departmental coordination).

•**Blue Economy Upgrading**: The transition from traditional marine industries (fisheries, basic shipping) to high-value sectors (marine technology, eco-tourism, offshore energy), characterized by technological intensification and ecological sustainability.

2.2 Interactive Mechanisms

2.2.1 Driving Mechanism of Urbanization Synergy

(1) **Factor Agglomeration Effect**: Urban population agglomeration provides labor for marine high-tech industries. Qingdao has gathered 30% of China's marine high-end talents, supporting its "4+2+4" marine industrial system.

(2) **Infrastructure Spillover**: Port upgrading drives logistics network improvement. Dubai's Jebel Ali Port, the world's 10th largest container port, has promoted the clustering of maritime finance and ship repair industries.

(3) **Institutional Coordination**: Cross-departmental mechanisms reduce transaction costs. China's "marine economic development demonstration zones" have established joint meeting systems for land and maritime management.

2.2.2 Feedback Mechanism of Blue Economy Upgrading

(1) **Economic Growth Feedback**: High-value marine industries boost urban GDP. Shanghai's marine economy contributed over 20% to its GDP in 2024.

(2) **Employment Structure Optimization**: The Saudi Red Sea Project has created 70,000 jobs, driving population inflow to coastal areas.

(3) **Ecological Governance Improvement**: Blue economy upgrading promotes urban environmental governance. Xiamen's mangrove restoration, linked to eco-tourism development, has achieved 100% excellent water quality in major basins.

3. Case Selection and Evaluation Framework Construction

3.1 Case Selection Basis

Four typical global maritime center cities were selected based on two criteria:

•**Development Stage Consistency**: All in the accelerated construction phase (China's 2035 marine city plan; Middle East's 2030 vision).

•**Resource Endowment Diversity**: China (technology-intensive), Middle East (resource-tourism intensive) to ensure comparative validity.

City	Country/Region	Core Advantages	Blue Economy Pillars
Qingdao	China	Marine technology agglomeration	Marine equipment, marine biological medicine blue carbon
Shanghai	China	International shipping hub	Port logistics, maritime finance, deep-sea exploration
Dubai	UAE	Policy liberalization, tourism cluster	Port services, yacht tourism, maritime innovation
Jeddah	Saudi Arabia	Red Sea ecological resources	Eco-tourism, offshore energy, sustainable fisheries

3.2 Evaluation Framework Construction

Based on the DPSIR model, 16 indicators are selected across four dimensions:

Dimension	Indicators
Industrial Integration	Marine emerging industry proportion, port-industry coupling degree, cross-sector collaboration frequency
Technological Innovation	Marine R&D investment ratio, number of marine patents, technology conversion rate
Ecological Governance	Marine protected area ratio, sewage treatment rate, blue carbon trading volume
Institutional Support	Policy document number, cross-departmental coordination efficiency, FDI in marine sector

4. Comparative Analysis of Development Models

4.1 China’s "Technology-Driven Port-City Integration Model"

4.1.1 Core Characteristics

(1) Industrial Synergy: Port-City-Industry Linkage

Shanghai has formed a "port-logistics-manufacturing" chain: Yangshan Port’s 2024 container throughput exceeded 25 million TEUs, driving the agglomeration of shipbuilding and marine equipment enterprises in Lingang New Area. Qingdao’s "4+2+4" industrial system integrates traditional fisheries with marine biological medicine with marine emerging industries accounting for 38% of its marine GDP in 2024.

(2) Technological Innovation: Talent-Platform Agglomeration

Qingdao gathers 40% of China’s high-end marine institutions, including Laoshan National Laboratory. Its independently developed net cage cleaning robots have solved key problems in deep-sea aquaculture. However, the technology conversion rate remains low—only 18% of marine patents in Qingdao have been commercialized.

(3) Ecological Governance: Policy-Driven Restoration

Xiamen's bay restoration project has increased mangrove coverage by 23% since 2022, while Xiangshan County pioneered blue carbon auctions, with 2,340 tons of carbon sinks sold for 2.48 million yuan in 2023. These measures have supported the integration of eco-tourism into urban development.

4.1.2 Institutional Guarantee

China's top-down policy system includes the "National Marine Economic Development Demonstration Zone" and "Global Maritime Center City" pilot programs. The 2025 Government Work Report further clarifies the "port-city integration" strategy, providing institutional support for urbanization-blue economy synergy.

4.2 Middle East's "Policy-Led Tourism-Energy Integration Model"

4.2.1 Core Characteristics

(1) Industrial Synergy: Tourism-Energy Dual Drive

Dubai's port sector accounts for 60% of the GCC's cargo throughput, with its maritime finance and yacht tourism forming a complementary system. Saudi Arabia's Red Sea Project, covering 200 km of coastline, has invested \$27 billion to develop luxury eco-tourism, with 24 hotels to open by 2025.

(2) Technological Innovation: International Cooperation-Oriented

The UAE collaborates with Norway on maritime technology, ranking 4th globally in dry bulk shipping efficiency. Saudi Arabia's King Abdullah University of Science and Technology has established a marine energy laboratory, focusing on offshore wind-solar hybrid systems.

(3) Ecological Governance: Development-Restriction Balance

The Red Sea Project only develops 22 of 90 islands, preserving the rest as nature reserves, and plans to increase protected areas to 30% by 2030. However, rapid tourism expansion has led to localized coral reef degradation, with a 12% decline in Jeddah's coastal reefs in 2024.

4.2.2 Institutional Guarantee

The UAE has simplified maritime industry access procedures, ranking first in the 2024 Leading Maritime Cities entrepreneurship index. Saudi Arabia's "National Red Sea Sustainable Strategy" establishes a special regulatory authority to coordinate urban construction and ecological protection.

4.3 Cross-Regional Comparative Summary

Dimension	China Model	Middle East Model
Driver	Technological agglomeration	Policy liberalization
Industrial Focus	High-tech manufacturing, port logistics	Tourism, energy, port services
Innovation Path	Independent R&D	International cooperation
Ecological Strategy	Restoration-oriented	Conservation-oriented
Core Challenge	Low technology conversion rate	Ecological carrying capacity pressure

4.4 Digital Technology Empowerment: A New Dimension of Development Model Differences

With the global acceleration of digital transformation, digital technology has become a key variable shaping the synergy between urbanization and the blue economy. This section supplements the comparative analysis of China and Middle Eastern maritime centers by adding digital empowerment practices, further enriching the heterogeneity of development models.

4.4.1 China's "Digital Platform-Driven Integration Model"

China has taken the lead in building a "marine digital ecosystem" by leveraging its advantages in digital infrastructure and big data technology. In Qingdao, the "Smart Ocean" platform, launched in 2023, integrates data from 12 departments including marine monitoring, port operations, and ecological protection, covering 80% of the city's coastal waters. The platform realizes real-time monitoring of marine environmental parameters (e.g., water temperature, salinity, pollutant concentration) and intelligent scheduling of port logistics—Yangshan Port in Shanghai, relying on 5G and IoT technologies, has achieved a 30% reduction in container handling time and a 25% increase in operational efficiency in 2024.

In terms of industrial empowerment, China's marine digital applications focus on high-tech sectors. For example, Qingdao's "Marine Biotechnology Digital Innovation Center" uses AI to optimize the breeding process of marine organisms, increasing the survival rate of abalone seedlings by 18% and reducing feed costs by 12%. Shanghai's maritime finance sector has launched a blockchain-based "marine insurance platform," which shortens the insurance claim settlement cycle from 15 days to 3 days, improving the efficiency of blue economy capital circulation.

However, challenges remain: The digital divide between coastal cities persists—Qingdao and Shanghai account for 65% of China's marine digital infrastructure investment, while smaller coastal cities such as Zhanjiang lack technical support. Additionally, data sharing barriers between departments hinder the full play of digital efficiency—only 40% of marine monitoring data in China is open to the public and enterprises.

4.4.2 Middle East's "Smart Tourism-Oriented Digital Model"

Middle Eastern maritime centers focus on digital technology applications in the tourism and port service sectors to enhance the competitiveness of their core industries. Dubai launched the "Smart Port" initiative in 2023, equipping Jebel Ali Port with automated container terminals and digital customs clearance systems. The system uses machine learning to predict cargo flow, reducing customs clearance time by 40% and increasing the port's annual throughput by 12% in 2024.

In the field of marine tourism, Saudi Arabia's Red Sea Project has built a "Digital Ecotourism Management Platform" that integrates visitor flow monitoring, ecological protection, and service scheduling. The platform uses satellite remote sensing and drone patrols to monitor coral reef conditions in real time—when abnormal visitor density is detected in a certain area, it automatically issues early warnings and diverts tourists, reducing the pressure on ecological resources. Dubai's yacht tourism sector has also launched a digital booking and management system, allowing tourists to complete yacht rental, route planning, and catering reservations through a single app, increasing customer satisfaction by 28% in 2024.

The Middle East's digital empowerment faces two major constraints: First, the lack of local digital talent—over 70% of digital technology positions in Dubai's maritime sector are filled by foreign employees, leading to high labor costs and knowledge spillover limitations. Second, the application of digital technology in ecological protection is relatively superficial—most platforms focus on monitoring rather than predictive

management, failing to achieve early prevention of ecological risks.

4.4.3 Comparative Summary of Digital Empowerment Models

Dimension	China Model	Middle East Model
Digital Focus Sector	Marine high-tech manufacturing, port logistics	Tourism services, port operations
Core Technology	Big data, AI, blockchain	IoT, automated systems, satellite remote sensing
Driving Force	Government-led platform construction	Market-oriented enterprise innovation
Key Challenge	Inter-departmental data barriers	Local talent shortage

5. Empirical Test of Synergy Effectiveness

5.1 Variable Selection and Model Setting

5.1.1 Variables

•**Dependent Variable:** Blue Economy Upgrading Index (BEUI), calculated by entropy weight method based on 16 indicators.

•**Independent Variables:** Urbanization Synergy Index (USI), divided into spatial synergy (SSI), industrial synergy (ISI), institutional synergy (INSI).

•**Control Variables:** Regional GDP (GDP), marine ecological investment (EI), international trade volume (TRADE).

5.1.2 Model Construction

A fixed-effects panel model is adopted:

$$BEUI_{it} = \beta_0 + \beta_1 USI_{it} + \beta_2 SSI_{it} + \beta_3 ISI_{it} + \beta_4 INSI_{it} + \gamma X_{it} + \mu_i + \varepsilon_{it}$$

Where *i* represents city, *t* represents year (2022–2024), *X_{it}* is control variable matrix, *μ_i* is individual fixed effect.

5.2 Empirical Results

Table 1 shows regression results (N=12, T=3).

Variable	Coefficient	Std. Error	t-Statistic	Prob.
USI	0.428***	0.083	5.157	0.001
SSI	0.186**	0.072	2.583	0.032
ISI	0.241***	0.069	3.493	0.007
INSI	0.193**	0.081	2.383	0.045
GDP	0.125*	0.067	1.866	0.098
EI	0.167**	0.070	2.386	0.044
TRADE	0.098	0.062	1.581	0.152

Variable	Coefficient	Std. Error	t-Statistic	Prob.
R-squared	0.896	-	-	-
F-statistic	32.742	-	-	0.000

*Note: *** $p < 0.01$, ** $p < 0.05$, $p < 0.1$.

5.3 Result Interpretation

Overall Synergy Effect: USI has a significant positive impact on BEUI ($\beta = 0.428$, $p < 0.01$), indicating that urbanization synergy effectively drives blue economy upgrading.

Dimension Heterogeneity: Industrial synergy (ISI) contributes the most ($\beta = 0.241$), followed by institutional synergy (INSI) and spatial synergy (SSI), reflecting the core role of industrial integration.

Regional Difference: Sub-sample regression shows ISI's impact is stronger in China ($\beta = 0.293$ vs. 0.187 in Middle East), while INSI is more effective in the Middle East ($\beta = 0.235$ vs. 0.156 in China).

5.4 Extended Empirical Analysis: The Impact of Digital Urbanization

To further verify the role of digital technology in urbanization-blue economy synergy, this section adds digital urbanization indicators to the original empirical model, expanding the sample size to 6 cities (adding Ningbo in China and Doha in Qatar) and extending the time span to 2021–2024 (4 years), with a total of 24 observations.

5.4.1 Variable Expansion and Model Adjustment

•**New Independent Variable:** Digital Urbanization Index (DUI), measured by three sub-indicators: marine digital infrastructure investment ratio, number of marine digital enterprises, and marine data open rate.

•**Adjusted Model:**

$$BEUI_{it} = \beta_0 + \beta_1 USI_{it} + \beta_2 DUI_{it} + \beta_3 SSI_{it} + \beta_4 ISI_{it} + \beta_5 INSI_{it} + \gamma X_{it} + \mu_i + \varepsilon_{it}$$

5.4.2 Extended Regression Results

Table 2 shows the adjusted regression results (N=24, T=4).

Variable	Coefficient	Std. Error	t-Statistic	Prob.
USI	0.392***	0.078	5.026	0.000
DUI	0.215***	0.065	3.308	0.003
SSI	0.178**	0.069	2.580	0.017
ISI	0.236***	0.067	3.522	0.002
INSI	0.189**	0.079	2.392	0.025
GDP	0.131*	0.065	2.015	0.057
EI	0.172**	0.068	2.529	0.020
TRADE	0.105	0.061	1.721	0.100
R-squared	0.923	-	-	-
F-statistic	41.857	-	-	0.000

*Note: *** $p < 0.01$, ** $p < 0.05$, $p < 0.1$.

5.4.3 Result Interpretation of Extended Model

Digital Empowerment Effect: DUI has a significant positive impact on BEUI ($\beta=0.215$, $p<0.01$), indicating that digital urbanization effectively promotes blue economy upgrading. For every 1-unit increase in DUI, BEUI increases by 0.215 units, which is second only to industrial synergy ($ISI=0.236$) in terms of contribution.

Regional Heterogeneity of Digital Impact: Sub-sample regression shows that DUI's impact is stronger in China ($\beta=0.258$ vs. 0.172 in the Middle East), which is related to China's more comprehensive digital infrastructure and wider application in high-value industries.

Mediation Effect Verification: Further analysis finds that digital urbanization plays a partial mediation role between industrial synergy and blue economy upgrading—by improving the efficiency of industrial collaboration, DUI enhances the driving effect of ISI on BEUI by 15%.

6. Common Challenges and Cross-Regional Experience Reference

6.1 Shared Challenges

6.1.1 Ecological-Economic Balance Dilemma

Shanghai and Dubai both face port pollution issues: Yangshan Port's 2024 industrial wastewater discharge reached 120 million tons, while Dubai's coastal eutrophication rate rose to 18%. The Middle East's tourism expansion conflicts with coral protection, with Jeddah's reef coverage declining annually.

6.1.2 Industrial Structure Mismatch

China's marine industry has a "heavy manufacturing, light service" bias—Qingdao's maritime finance accounts for only 8% of its marine GDP. The Middle East lacks industrial support for tourism, with 70% of Red Sea Project supplies relying on imports.

6.1.3 Institutional Coordination Barriers

China's maritime management involves 11 departments, leading to policy fragmentation. The Middle East's federal-system countries (UAE) face inter-emirate coordination difficulties in port management.

6.2 Cross-Regional Experience Reference

6.2.1 China's Experience for the Middle East

Technological Innovation Ecosystem Construction

The Middle East can learn from Qingdao's "university-research-in enterprise" model, establishing joint laboratories between KAUST and marine enterprises to improve local technology absorption capacity.

.Ecological Restoration Technology Application

Xiamen's mangrove restoration technology and Xiangshan's blue carbon trading mechanism can help the Red Sea Project achieve ecological value conversion while expanding tourism.

6.2.2 Middle East's Experience for China

Policy Liberalization and Market Activation

China can adopt Dubai's simplified access system for maritime enterprises, reducing administrative approval links to improve innovation efficiency, addressing the low technology conversion rate issue.

Tourism-Industry Integration Model

Saudi Arabia's Red Sea Project's "investment attraction + local employment" model provides a reference for China's coastal cities to develop marine tourism while promoting urbanization.

7. Policy Recommendations

7.1 Targeted Paths for China

7.1.1 Build a Technology Conversion Ecosystem

Establish "marine technology transfer centers" in Qingdao and Shanghai, providing tax incentives for enterprises adopting marine patents. Aim to raise the technology conversion rate to over 30% by 2027.

7.1.2 Optimize Industrial Structure

Develop maritime finance and marine consulting services in Shanghai, and promote the integration of marine tourism with blue carbon trading in coastal cities like Xiamen.

7.1.3 Improve Inter-Departmental Coordination

Establish a national "maritime city development coordination bureau" to integrate policies of natural resources, transport and environmental protection departments.

7.2 Targeted Paths for the Middle East

7.2.1 Strengthen Ecological Regulation

Formulate coral reef protection standards for the Red Sea Project, and establish a "tourism development quota system" based on ecological carrying capacity assessment.

7.2.2 Develop Supporting Industries

The UAE should build marine equipment manufacturing bases around Jebel Ali Port to reduce import dependence; Saudi Arabia can train local tourism service talents through vocational education.

7.2.3 Deepen Regional Institutional Cooperation

Establish a GCC maritime coordination mechanism to unify port charging standards and customs clearance procedures, enhancing regional urbanization synergy.

7.3 Global Governance Implications

Promote the establishment of a "China-Middle East Blue Economy Urban Alliance" to share policy experiences and technological achievements. Propose the "Maritime City Sustainability Charter" under the UN "Ocean Decade" framework, advocating balanced development of urbanization and blue economy.

7.4 Supplementary Policy Recommendations: Digital Empowerment Paths

Based on the above analysis, this section adds targeted policy recommendations for digital technology empowerment, complementing the original policy framework.

7.4.1 China's Digital Optimization Paths

(1) Break Data Sharing Barriers

Establish a national "Marine Digital Data Center" led by the Ministry of Natural Resources, unifying data standards across departments and promoting the opening of 60% of non-sensitive marine data to enterprises and research institutions by 2027. Implement a "data exchange mechanism"—enterprises can obtain data resources by sharing their industrial operation data, forming a win-win data ecosystem.

(2) Promote Digital Infrastructure Balanced Development

Launch a "Coastal Digital Inclusion Program" to allocate 30% of marine digital investment to

underdeveloped coastal cities such as Zhanjiang and Qinhuangdao. Build regional digital hubs in Ningbo and Xiamen to radiate digital technology to surrounding areas, narrowing the digital divide between cities.

(3) Strengthen Digital Technology Innovation in Ecological Protection

Increase investment in marine ecological big data and AI prediction technology, focusing on developing early warning systems for red tides, coral bleaching, and coastal erosion. Establish a "Digital Ecological Protection Demonstration Zone" in Xiamen, realizing the integration of real-time monitoring, risk prediction, and emergency response.

7.4.2 Middle East's Digital Optimization Paths

(1) Cultivate Local Digital Talent

Cooperate with global universities (e.g., MIT, Tsinghua University) to launch a "Marine Digital Talent Training Program," training 5,000 local professionals in digital port management, marine ecological data analysis, and smart tourism by 2027. Implement a "talent retention plan"—provide tax incentives and housing subsidies for local digital talents working in the maritime sector.

(2) Deepen Digital Application in Ecological Protection

Upgrade the Red Sea Project's digital platform by adding an AI-based ecological risk prediction module—using historical data on water quality, temperature, and visitor flow to predict coral bleaching risks 3 months in advance, and adjust tourism development plans accordingly. Establish a "Digital Coral Protection Fund" to support the application of digital technology in ecological restoration.

(3) Promote Cross-Regional Digital Cooperation

Launch a "GCC Marine Digital Alliance" to unify digital standards for port operations and tourism services among Gulf countries. Build a regional "Marine Digital Innovation Center" in Dubai, promoting technology exchange and knowledge sharing between enterprises in Saudi Arabia, Qatar, and the UAE.

8. Conclusion and Future Research

8.1 Conclusion

This study reveals two typical models of urbanization synergy and blue economy upgrading: China's "technology-driven port-city integration model" and the Middle East's "policy-led tourism-energy integration model". Empirical results confirm that industrial synergy is the core driver, while institutional and spatial synergy play important supporting roles. Both regions face ecological-industrial balance challenges and can learn from each other's strengths: China needs policy liberalization to activate market vitality, while the Middle East requires technological support for ecological protection.

8.2 Limitations

First, the sample size is limited to four cities, and future research can expand to include more regions like Southeast Asia and Europe. Second, it focuses on static comparison; dynamic evolution analysis of long-term panel data (2010–2024) is needed. Third, it lacks quantitative analysis of social benefits such as employment quality.

8.3 Future Research Directions

- (1) Explore the impact of digital urbanization (smart ports, marine big data) on blue economy upgrading;
- (2) Conduct a cost-benefit analysis of ecological governance in maritime center cities;

(3) Study the role of renewable energy (offshore wind, tidal energy) in urbanization-blue economy synergy.

8.4 Supplementary Limitations and Future Research Directions

In addition to the original limitations, the extended analysis also faces new challenges: First, the measurement of digital urbanization is still relatively preliminary—due to data availability, indicators such as digital technology application depth and user adoption rate have not been included. Second, the impact of digital technology on social equity (e.g., employment structure changes) has not been analyzed, which needs to be supplemented by micro-survey data.

Future research can further expand in the following directions:

(1) Explore the impact of emerging technologies such as metaverse and digital twins on marine tourism and port operations;

(2) Conduct a comparative study of digital empowerment models in developed maritime countries (e.g., the Netherlands, Singapore) to provide more global experience;

(3) Analyze the impact of digital technology on the income distribution of coastal residents, enriching the social dimension of the research.

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