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Chapter: Environmental Dimensions of Sustainable Development

COLLABORATIVE GOVERNANCE IN THE BLUE ECONOMY AND GREEN FINANCE: TAKING THE EASTERN BLUE ECONOMIC CIRCLE OF CHINA AS A SAMPLE

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Annotation. In the context of accelerating global climate change, environmental challenges, and growing resource constraints, green finance and its synergistic development with the blue economy have attracted significant attention as crucial mechanisms for promoting sustainable economic growth. However, existing studies have predominantly focused on unidirectional influences between the blue economy and green finance, with limited attention to their potential bidirectional interplay. To explore the relationship between the blue economy and green finance, employing cointegration theory and the Entropy Weight-TOPSIS model, the comprehensive development levels of the blue economy and green finance were measured in China's eastern blue economic circle from 2002 to 2024. Granger causality tests were further applied to examine the coupling coordination degree between the two systems and to verify the presence of a long-term equilibrium and causal relationship during the study period. Results show that a significant coupling relationship between green finance and the blue economy, alongside a stable long-term cointegration relationship. In the short run, however, the two systems exhibit a negative correlation. Moreover, green finance is identified as a Granger cause of the blue economy, underscoring its substantial influence. These conclusions serve to enrich the literature on the coordinated development of green finance and the blue economy, and can be referenced to develop policy recommendations for urban policymakers.

Keywords: blue economy, green finance, coupled coordination analysis, co-governance.

JEL classification: E60, G10, H11.

Introduction

The traditional marine economy relies on the exploitation of marine resources and space. It generates economic benefits but causes ecological problems such as overfishing and pollution, and reduces biodiversity and climate regulation capacity. A consensus has been reached among many countries to promote the transformation of the marine economy towards a more sustainable developmental model. To this end, the blue economy has emerged. At its core, it involves the comprehensive development of marine resources through green technological innovation to maintain the ecological health of the world's oceans. It aims to balance economic and social

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sustainability with inclusive economic growth (Novaglio *et al.*, 2022). However, the blue economy faces a dual challenge in terms of the feasibility of green technologies and various financial constraints that significantly impede its progress. As a sustainable financial model, green finance can play a key supporting role in enhancing marine sustainability and mitigating threats to the health of the ocean. In this way, green finance is an important factor in solving problems related to a lack of funding to promote the development of the blue economy (Kageyama *et al.*, 2025; Zhang *et al.*, 2023).

As early as the 1980s, scholars have viewed environmental issues through a financial lens, thus giving rise to the earliest models of sustainable finance. Later, scholars introduced the concept of green finance and began formulating its definition and studying its implications. As the research deepened, scholars began to study the impact of green finance on the development of green industries (Thiele and Gerber, 2017). It was not until the 1990s that scholars began studying the overlap between green finance and the blue economy. Cunha *et al.* (2021) argued that green credit and green bonds were more conducive to the development of the blue economy compared to other green financial products. Almansour *et al.* (2025) constructed a green finance guarantee system for the marine industry based on five key aspects. Gao *et al.* (2025) devised a mediation model based on environmental regulation. They found that green finance can significantly promote the high-quality development of the blue economy. Strides have been made in the current academic research on green finance, blue economic development, and the relationship between the two systems. However, their coordinated development has been largely overlooked. The main theoretical gaps in the current research are as follows: (1) the existing research does not have a unified standard or comprehensive evaluation framework for measuring the combined level of green finance and blue economic development. Scholars typically hold a vague definition of green finance. They also tend to differ in terms of the scope of their definitions of "green," making it difficult to compare their results horizontally. Scholars are also divided on how best to quantify "sustainability" and "eco-friendliness" in the blue economy, and there is a lack of a unified measurement method. (2) Previous research has mainly focused on the one-way relationships between green finance and the blue economy, and less on their bidirectional interaction. A large number of studies have explored how green finance could provide financial support for blue economic projects through tools such as credit, bonds, insurance, funding, carbon finance, and curbing investment into polluting industries. However, the "reverse shaping" effect of the blue economy on green finance has been largely overlooked. (3) There is a lack of synergy indicators. Scholars lack an effective indicator to measure the degree of synergy and coupling between green finance and the blue economy. That is, how many green finance resources are flowing towards blue, sustainable marine economic activities? How does the growth of the blue economy stimulate the further development of green finance? How efficient and effective is this synergy? As of yet, there is no definite conclusion, which makes it difficult for regulators to grasp the essence of this bidirectional relationship based on scientific evidence. This affects the precision of policy-making by failing to provide effective theoretical support for the coordinated development of green finance and the blue economy.

There is an interaction between green finance and the blue economy, and the coordinated effect of both systems is greater than that of green finance alone. Therefore, it is necessary to explore the bidirectional relationship between the two systems from the perspective of coupling coordination. As an important player in the world's marine economic development, China's eastern blue economic circle represents the core of its domestic marine economic development efforts. Green finance has developed rapidly in this region, ranking it among the top in the world's green financial sectors. This makes it a natural example for exploring the two-way relationship between green finance and the blue economy. In light of this, this study aims to: (1) Scientifically construct a comprehensive evaluation index for both systems; (2) Explore the coupling coordination relationship between green finance and the blue economy in the region to elucidate the dynamic interaction between them; (3)

Examine the long-term and short-term equilibrium and Granger causality relationships between the two systems and identify the driving mechanisms behind them.

The contribution of this study is: (1) To establish a comprehensive, evidence-based evaluation index system for green finance and the blue economy, and to improve the methods by which their development levels are measured; (2) To adopt a modified coupling coordination model to enhance the accuracy of the characterization of the dual system's coordination state; (3) To improve the testing of the long- and short-term causal relationships between the two systems, thereby filling the literature gap on the two-way interaction between them. Ultimately, this study supplements the literature on green finance and blue economic development at the theoretical level and provides practical assistance to policymakers to promote collaborative governance.

The remaining structure of this study is as follows: Section 2 presents our research hypotheses through a literature review and theoretical analysis of the relationship between green finance and the blue economy. Section 3 presents the data sources, variable definitions, and model construction, and conducts a descriptive statistical analysis. Section 4 consists of an empirical analysis to examine the coupling and coordination between green finance and the blue economy, as well as the driving mechanism by which green finance supports blue economic development. Section 4 discusses the findings. Section 6 presents our conclusions and relevant policy implications.

1. Theoretical Analysis and Research Hypotheses

1.1 Coupling and Coordination between Green Finance and the Blue Economy

The coupling coordination theory (Sarker *et al.*, 2018) holds that the coupling coordination relationship between two systems is reflected in their mutual promotion and integrated coordination across multiple dimensions. This type of relationship of multi-dimensional mutual promotion and integrated coordination exists between green finance and the blue economy. In general, green finance and the blue economy form a two-way interactive coupling relationship through financial guidance, risk management, industrial synergy, and policy support. The core of this relationship is that green finance promotes ecological protection and the balanced utilization of marine resources through sustainable financial tools, while the blue economy feeds back into green financial innovation by creating funding demand for blue economic projects. Ultimately, this achieves a synergy between environmental, economic, and social benefits.

The coupling and coordination relationship between the two systems can be broken down as the former driving the latter, and the latter feeding back into the former. Green finance drives the blue economy through capital guidance, risk management, and industrial synergy (Bhaskar *et al.*, 2023; Cisneros-Montemayor *et al.*, 2022). Green finance provides low-cost funding for projects such as marine renewable energy, sustainable fisheries, and marine ecological conservation and restoration efforts through tools such as green credit and blue bonds. A large amount of social capital is channeled into projects such as the transformation and upgrading of fisheries, the development of marine renewable energy, and the protection and restoration of the marine ecology. This not only enhances the overall competitiveness of the blue economy but also promotes the green transformation and intelligent upgrading of the marine industry (Nobanee *et al.*, 2022). Green insurance innovations, such as index insurance and carbon sink insurance, can help the marine industry cope with natural disasters and climate risks and reduce the uncertainty of marine business operations. In addition, green finance promotes innovation in production technologies, especially breakthroughs in new key technologies that lay a solid foundation for the sustainable development of the blue economy (Supriani, 2023). The growing demand for green finance in the blue economy has become an important driving force for the innovation of green finance products and services, and has thereby played an important role in the further development of green finance. Specifically, the demand

for funding in the blue economy drives innovation in green finance. The high-risk and high-investment nature of the blue economy necessitates the development of new, innovative green financial tools (Dash *et al.*, 2023). The expansion of the blue economy also provides a broader market space for green finance and attracts social capital (Supriani, 2023).

The level of coupling coordination between green finance and the blue economy shows a continuous upward trend (Dash *et al.*, 2023). The core driver of this trend stems from the deep interaction between the two systems across the four dimensions of capital allocation, technological innovation, product optimization, and systems improvement. The two systems will gradually achieve a higher level of synergy as green finance increases its financial support for the blue economy, technology empowerment intensifies, the blue economy increases its demand-pull effect on green finance, and its practical empowerment value becomes more prominent. In turn, a high level of coupling and coordination will develop as a result of the precise matching of funds, efficient transformation of technology, dynamic product innovation, and ongoing adaptation between both systems. This improvement will be temporally stable and continuous (Stephenson and Hobday, 2024). Based on these observations, Hypothesis 1 is therefore proposed:

Hypothesis 1: The coupling and coordination relationship between green finance and the blue economy shows an increasing trend.

1.2 Long-term Equilibrium Relationship between Green Finance and the Blue Economy

The theory of coordinated development (March *et al.*, 2023) holds that the development of a system may depend on the partial destruction or even annihilation of other systems. In order for two systems to maintain a long-term equilibrium relationship and develop in coordination, complementarity must exist between them. The complementarity between green finance and the blue economy is mainly reflected in the high degree of alignment between their developmental goals (Thompson, 2022). Green finance mainly aims to promote the green transformation of the economy, while the blue economy aims to protect the marine ecology and promote the sustainable development of marine industries (Bennett *et al.*, 2024). This alignment makes green finance an important driver in the green transformation of the blue economy, and the sustainable development of the blue economy, in turn, provides a vast market space and developmental opportunities for the green finance industry (Benzaken *et al.*, 2024). Therefore, complementarity exists in terms of the two systems' economic activities, and this complementarity may lead to the formation of a cointegrated relationship whereby their development becomes interdependent and mutually reinforcing (Nobanee *et al.*, 2022).

Government support is also an important factor that promotes the coordinated development of both green finance and the blue economy (Stephenson *et al.*, 2023). In recent years, governments around the world have introduced a series of policies aimed at increasing support for green finance and the blue economy. These policies not only provide institutional guarantees for their individual development, but also promote their coordinated development through the simultaneous effect of policy support and market demand. Technological advancement and industrial upgrading are also important factors in driving the development of green finance and the blue economy and enhancing the correlation between them (Sarangi, 2023). Technological advancement can drive innovation and the optimization of green financial products, and enhance their coverage and efficiency (Wabnitz and Blasiak, 2019). Similarly, industrial upgrading can drive the blue economy in a greener and more sustainable direction, thereby providing a broader market space for the green finance industry (Nham, 2023). Therefore, technological progress and industrial upgrading not only contribute to enhancing the competitiveness of green finance and the blue economy individually, but may also facilitate the formation of a cointegrated relationship between them (Louey, 2022). Economic complementarity between green finance and the blue economy, their coordinated development driven by policy support, and the driving effect of

technological progress and industrial upgrading jointly contribute to the formation of a cointegrated relationship between these two systems. Therefore, Hypothesis 2 is proposed:

Hypothesis 2: A long-term stable equilibrium exists between green finance and the blue economy.

1.3 Short-term Equilibrium between Green Finance and the Blue Economy

Some scholars believe that, due to interactions within and outside these systems, the performance of its elements and its coupling relationship may fluctuate by chance, and the environment may introduce random disturbances (Shiiba *et al.*, 2022). Green projects within the blue economy can also be affected by external and internal factors such as policy changes, shifting market demands, technological advancements, etc., that can lead to fluctuations in their returns on investment. When such fluctuations occur, the developmental trajectory of the blue economy may briefly deviate from its long-term equilibrium trend (Wuwung *et al.*, 2022). At this point, investors in the green finance market can flexibly adjust their investment strategies and capital allocation based on the actual situation of green projects and market expectations. For example, when a marine environmental protection project shows good prospects due to favorable policies or increased market demand, investors may increase their investment in that project, thereby boosting its return on investment. This can bring the developmental trajectory of the blue economy back into long-term equilibrium (Islam *et al.*, 2024). Conversely, if a marine renewable energy project encounters a technological bottleneck or a decline in market demand, investors may choose to reduce their investment into the project or reinvest in other projects with greater potential to mitigate loss. This dynamic adjustment mechanism based on market signals is a tangible manifestation of the interaction between green finance and the blue economy.

In summary, investors in the green finance market correct for short-term fluctuations in the development of the blue economy by flexibly adjusting their investment strategies and capital allocations. The price adjustment mechanism of the green finance market also rebalances the supply and demand of funding in the short term (Tirumala and Tiwari, 2022), thus ensuring that the market continues to operate stably. Although there is always a risk of instability in any economic system, the green finance and blue economic system tends to rebalance itself due to their deep integration. Based on the above analysis, Hypothesis 3 is proposed:

Hypothesis 3: A short-term correction relationship exists between green finance and the blue economy, i.e., although both may fluctuate in the short term due to various factors, they tend to stabilize in the long term.

1.4 Granger Causality between Green Finance and the Blue Economy

If the past value of one variable can help predict the future value of another variable, then the former is the Granger cause of the latter (Yao *et al.*, 2022). This study explores whether green finance and the blue economy are each other's Granger causes. In other words, the early development level of green finance significantly predicts the current development level of the blue economy, and vice versa. The essential reason for this phenomenon lies in the fact that green finance and the blue economy share a strong two-way causal relationship through the cycle causally deterministic mechanisms of capital-driving, industrial upgrading, market demand, and financial product innovation (Benzaken *et al.*, 2022). The logic of "the previous state determines the subsequent event" describes the dynamic interaction between these two systems.

The root cause of this two-way causality between green finance and the blue economy lies in the fact that green finance plays a key role in providing financial support for the blue economy (Ayilu *et al.*, 2022), particularly in terms of supplying capital. Blue economy projects (such as offshore wind power, deep-sea aquaculture vessels, and marine pollution control) often require hefty initial investment and consist of long market cycles. Green finance can provide crucial start-up and development funding for these projects through special bonds and

credit incentive tools (Tirumala and Tiwari, 2022). Risk pricing and management also play a crucial role. Green finance standards and catalogues (such as China's Catalogue of Green Bond-Supported Projects) include several blue economic projects. This sends a clear signal to the market that the government is actively supporting blue economy projects. This kind of signaling from the government can help channel private capital toward sustainable marine industries. On the other hand, the blue economy plays a role in demand-pulling and asset-building for green finance, specifically by creating high-quality assets. Booming blue economic projects generate stable cash flows that can be packaged into new underlying assets to enrich the product range of the green finance industry. The second factor is the expansion of the financing needs of the blue economy. According to estimates by the World Bank, the investment demand for sustainable blue economic projects is currently at the trillion-dollar level, and is a key driver of the expansion of the green finance market. The third factor is that the blue economy drives product innovation. The unique risk and value patterns of the blue economy (such as carbon sinks, ecological value, etc.) give rise to demand for innovative financial instruments, thereby driving innovation in the green finance sector (Vanderklift *et al.*, 2019). Based on the above analysis, Hypothesis 4 is proposed:

Hypothesis 4: Green finance and the blue economy are Granger causes of each other.

2. Methodology

2.1 Data Source

This study validates the above hypotheses using empirical data from China. These data are derived from the China Marine Statistical Yearbook, the China Statistical Yearbook, the China Financial Yearbook, the China Science and Technology Statistical Yearbook, the China Energy Statistical Yearbook, and other statistical yearbooks from relevant provinces over the study period of 2002 to 2024. Due to the study's long-time span, some original data may be missing. In such cases, the missing data will be interpolated using the EM algorithm.

2.2 Variable Settings and Descriptions

The green finance development level evaluation index (GF_i) is an independent variable in this paper that indicates the development level of green finance in the region during the study period. Axon, Collier (2023) propose in their study, Mechanism and Test of Green Finance Promoting High-Quality Urban Economic Development that the green finance sector needs to secure resources through multi-dimensional financial tools. At its core levels, it covers green credit, green securities, green insurance, green investment, etc. Based on this, this study draws on the definition proposed by Axon, Collier (2023), which divides green finance into seven dimensions (green credit, green investment, green insurance, green bonds, green funds, carbon finance, and green innovation) to select nine specific indicators to construct an evaluation system. This ensures that the indicators cover all the key components of green finance. These indicators align with the multi-channel requirements of the green development theory for financial support of the green transformation. The specific indicators are shown in *Table 1*.

Table 1. Evaluation index system of green finance development level in the eastern blue economic circle of China

Target level	Criteria layer	Metrics layer	Metric calculation methods	Indicator attributes
Green finance	Green credit	Credit share for environmental projects	Total credit for environmental projects/total credit	+
		Investment in environmental pollution control	Total investment in environmental governance in the east /GDP	+
	Green investment	Fiscal spending on environmental protection	Fiscal environmental protection index/General fiscal budget expenditure	+
	Green Insurance	Extent of promotion of environmental pollution liability insurance	Environmental pollution liability insurance income/total premium income	+
	Green bonds	Green bond development level	Total green bond issuance/total issuance of all bonds	+
	Green Fund	Green fund share	Total market capitalization of green funds/total market capitalization of all funds	+
	Carbon Finance	Green Equity Development Depth	Carbon trading, energy use rights trading, pollution discharge rights trading/total equity market transactions	+
	Green Innovation	Green application patent share	Number of green utility patents granted/Number of green patents granted	+
		Degree of dynamic changes in the agricultural green enterprise market	Number of companies entering/stock of companies	+

Source: own calculations.

The blue economic development level evaluation index (ME_i) is another independent variable in this paper that indicates the blue economic development level in the region in the *i-th* year. The development of China's marine economy is mainly accomplished under the guidance of the new development scheme, which emphasizes that economic development should take the five dimensions of innovation, coordination, green development, openness, and sharing into account. China's blue economy, as a sustainable development aspect of the marine economy, has the core goal of synergizing marine resource development with ecological protection and social welfare. Therefore, this paper draws on the classification method proposed by Chen *et al.* (2023). A total of 12 indicators were selected across five levels: innovation (investment into marine science and technology), coordination (interactions between land and sea economy), environment (marine ecological protection), openness (the level of marine foreign trade), and sharing (employment in marine industries) to establish an evaluation index of the development level of the blue economy in the eastern blue economic circle of China. This index system fully reflects the requirements of the new development scheme for the multi-dimensional growth of the blue economy. The specific indicators are shown in *Table 2*.

Table 2. Evaluation index system of blue economic development level in the eastern blue economic circle of China

Target level	Criteria layer	Metrics layer	Metric calculation methods	Indicator attributes
Marine economy	Innovation	Number of Marine research institutions		+
		Number of Marine science and technology projects		+
	Coordination	Gross domestic product of major Marine industries accounts for regional gross domestic product	Gross product of major Marine industries /GDP	+
	green	Proportion of severely polluted sea area	Area of severely polluted sea/total sea area	-
		Marine type Number of nature reserves		+
	Open	Civilian transport vessels		+
		Number of inbound tourists received		+
		The number of workers in the water transport industry		+
		Ocean freight volume		+
		Marine catch production		+
	Shared	Number of observation stations		+
		Marine aquaculture area)		+

Source: own calculations.

The coupling coordination degree (D_i) is the dependent variable, representing the degree of coupling coordination between green finance and the blue economy in the eastern blue economic circle of China in the *i-th* year. This variable is based on the system synergy theory, which holds that complex systems interact and integrate resources to achieve coordinated development. The degree of coupling coordination is a core indicator for measuring the dynamic coordination status of green finance and the blue economy, which are associated with complementary resources and collaborative support. The setting of D_i aims to quantify the degree of synergy between the two systems from disorder to order. This aligns with the analytical logic of the system synergy theory in terms of the interactions among multiple systems, and provides theoretical support for determining the level of synergy between green finance and the blue economy. Drawing on the classification method developed by Evans *et al.* (2023), the criteria for evaluating the degree of coupling coordination between the two systems are shown in *Table 3* below.

Table 3. Evaluation criteria for coupling coordination

Range of values for D	Degree of coupling coordination
0≤D<0.3	Low degree
0.3≤ D≤<0.5	Moderate
0. 5 ≤D< 0.8	Medium height
0.8≤ D≤<1	Height

Source: own calculations.

2.3 Model Construction

2.3.1 Coupling Coordination Model

By drawing on the coupling coordination model used in physics (Voyer *et al.*, 2021), we established a model for evaluating the degree of coupling coordination between the green financial system and the blue economic system in the eastern marine economic circle of China.

$$C_i = 2\sqrt{GF_i \times ME_i} \Big/ GF_i + ME_i \quad (1)$$

$$T_i = \alpha GF_i + \beta ME_i \quad (2)$$

$$D_i = \sqrt{C_i \times T_i} \quad (3)$$

In the formula, C_i represents the degree of coupling coordination between the two systems in the *i-th* year, with values of [0,1]. When C_i approaches 0, this indicates that the correlation between the two subsystems is minimal, and that no coupling relationship exists between them. When C_i approaches 1, this indicates that the degree of coupling between the two subsystems is significant and that there is strong resonant coupling. T_i represents the comprehensive evaluation index, which measures the overall synergy or coupling between the systems. α and β represent the specific weights. In the interaction between the two systems, each is equally important and thus $\alpha = \beta = 0.5$. D_i represents the degree of coupling coordination between the two systems in *i-th* year.

2.3.2 Modifying the Coupling Coordination Model

Cziesielski *et al*. (2021) argued that there are two flaws inherent in the traditional coupling coordination model. One is that the probabilities of the coupling value C_i being distributed in the [0,1] interval are not sufficiently equal, and are likely to be biased towards one end. This reduces the model's validity. Second, the model is overly simplified. This results in the coupling coordination degree D_i value between two systems not being fully reflected by the value and significance of the measurement itself. Therefore, we modified the traditional coupling coordination model in this paper. The modification process is as follows:

$$C_i = \sqrt{1 - \frac{\sum_{i>j,j=1}^{n} \sqrt{\left(GF_i - ME_j\right)^2}}{\sum_{m=1}^{n-1} m} \times \left(\prod_{i=1}^{n} \frac{GF_i}{\max GF_i} \right)^{\frac{1}{n-1}}} \quad (4)$$

$$T_i = \sum_{i=1}^{n} \alpha_j \times U_i, \quad \sum_{i=1}^{n} \alpha_j = 1 \quad (5)$$

$$D_i = \sqrt{C_i \times T_i} \quad (6)$$

In the formula, $U_i \in [0,1]$, $C_i \in [0,1]$. The values are as dispersed as Possible in [0,1] to increase the discrimination of the C_i value. This calculates the coupling coordination relationship between systems and measures the comprehensive development level of each system more scientifically and reasonably. This modification effectively optimizes the logic for calculating the coupling degree (C_i), and solves the "skewed1distribution" problem associated with the traditional model.

2.3.3 Cointegration Model

For two sequences { GF_i } and { ME_i }, if both are first-order integrated time series and there exists a set of non-zero constants ∂_1 、 ∂_1 such that $\partial_1 GF_i + \partial_2 ME_i \backsim I(0)$, then it can be said that a cointegrated relationship exists between the time series { GF_i } and { ME_i }.

2.3.4 Granger causality test

The test involves estimating the following regression:

$$GF_i = \sum_{i=1}^{n} \partial_i ME_i + \sum_{j=1}^{n} \beta_j GF_{t-j} + \mu_{1t} \quad (7)$$

$$GF_i = \sum_{i=1}^{n} \partial_i ME_i + \sum_{j=1}^{n} \beta_j GF_{t-j} + \mu_{1t} \quad (8)$$

In the formula, μ_{1t} and μ_{2t} are assumed to be uncorrelated.

The null hypothesis is: $H_0 : \partial_1 = \partial_2 = \Lambda = \partial_n = 0$ or $H_0 : \lambda_1 = \lambda_2 = \Lambda = \lambda_s = 0$

To test this hypothesis, the F-test is used, which follows an F-distribution of the degrees of freedom *q* and (*n*-*k*), where n is the sample size, *q* is the number of lag terms *Y* (i.e., the number of parameters to be estimated in the constrained regression equation), and *k* is the number of parameters to be estimated in the unconstrained regression. If the null hypothesis is rejected, this indicates that GF_i is the Granger cause of ME_i.

2.4 Descriptive Statistical Analysis

Based on the aforementioned evaluation index system for the development levels of green finance and the blue economy, the entropy weight-TOPSIS method was used to measure their development levels in the eastern blue economic circle of China from 2002 to 2024. The specific results are shown below in *Table 4*.

Table 4. Green finance and blue economic development levels in China's eastern blue economic circle from 2002 to 2024

Years	Green Finance	blue economy
2002	0.305183	0.321351
2003	0.347112	0.302741
2004	0.411659	0.258292
2005	0.374291	0.439505
2006	0.219346	0.422085
2007	0.220430	0.422341
2008	0.254510	0.425072
2009	0.241560	0.326876
2010	0.321363	0.464074
2011	0.358051	0.438664
2012	0.471638	0.437973
2013	0.453146	0.476801
2014	0.426204	0.473048
2015	0.619450	0.561275
2016	0.667858	0.681013
2017	0.524327	0.713432
2018	0.504732	0.661861
2019	0.532452	0.632561
2020	0.564745	0.656862
2021	0.592136	0.624003
2022	0.824900	0.608828
2023	0.817919	0.570868
2024	0.735021	0.671726

Source: own calculations.

According to these data, the development levels of green finance and the blue economy in the eastern blue economic circle of China showed significant volatility and growth trends during the study period. It also suggests that the development of green finance needs to be further stabilized and enhanced to address various challenges and uncertainties. The two systems also underwent similar synchronous changes.

3. Results Analysis

3.1 Coupling Coordination Measurement Results

The traditional coupling coordination model and the modified coupling coordination model were respectively substituted based on the comprehensive development levels of green finance and the blue economy in the eastern blue economic circle of China, calculated earlier. The results are shown in *Tables 5* and *6*.

Table 5. Coupling situation

Year	Before correction		After correction	
	Coupling degree	Coupling stage	Coupling degree	Coupling stage
2002	0.989707	Coordination	0.958182	Coordination
2003	0.983998	Coordination	0.852015	Coordination
2004	0.988036	Coordination	0.815018	Coordination
2005	0.998785	Coordination	0.893227	Coordination
2006	0.938881	Coordination	0.623564	Break-in
2007	0.963466	Coordination	0.662301	Break-in

Table 5 *(continuation)*. Coupling situation

2008	0.966588	Coordination	0.698811	Break-in
2009	0.994017	Coordination	0.854129	Coordination
2010	0.978381	Coordination	0.755613	Break-in
2011	0.989765	Coordination	0.941480	Coordination
2012	0.998354	Coordination	0.958738	Coordination
2013	0.998364	Coordination	0.948618	Coordination
2014	0.998756	Coordination	0.936998	Coordination
2015	0.998888	Coordination	0.939247	Coordination
2016	0.996766	Coordination	0.857284	Coordination
2017	0.999049	Coordination	0.781391	Break-in
2018	0.999729	Coordination	0.799749	Break-in
2019	0.994703	Coordination	0.846445	Coordination
2020	0.996668	Coordination	0.872126	Coordination
2021	0.999563	Coordination	0.945891	Coordination
2022	0.989745	Coordination	0 770782	"Running-in"
2023	0.994521	Coordination	0.835721	Coordination
2024	0.998721	Coordination	0.918446	Coordination

Source: own calculations.

Table 6. System coordination levels

Year	Before correction		After correction	
	Coordination	Coordination	Coordination	Coordination
	level	level	level	level
2002	0.679997	Moderate	0.688074	Moderate
2003	0.631317	Moderate	0.691280	Moderate
2004	0.545504	Moderate	0.698336	Moderate
2005	0.702538	Moderate	0.746865	Moderate
2006	0.553632	Moderate	0.746866	Medium-high
2007	0.574898	Moderate	0.658414	Moderate
2008	0.581536	Moderate	0.648547	Moderate
2009	0.632162	Moderate	0.573018	Moderate
2010	0.657998	Moderate	0.638041	Medium-high
2011	0.754641	Medium height	0.656794	Medium height
2012	0.787288	Medium height	0.684586	Medium height
2013	0.778849	Medium height	0.684586	Medium height
2014	0.755689	Medium height	0.680159	Medium height
2015	0.828479	Medium height	0.680168	Medium height
2016	0.834882	Medium height	0.780411	Medium height
2017	0.795699	Medium height	0.776043	Medium height
2018	0.791330	Medium height	0.762975	Medium height
2019	0.811681	Medium height	0.762876	Medium height
2020	0.822798	Medium height	0.783402	Medium height
2021	0.891544	Medium height	0.782975	Medium height
2022	0.855594	Medium height	0.844999	Height
2023	0.846632	Medium height	0.813598	Height
2024	0.854378	Medium height	0.776678	Medium height

Source: own calculations.

The level of coordination between green finance and the blue economy in China's eastern blue economic circle fluctuated between [0.573, 0.845] from 2002to 2024. This range indicates that, although the coordination between the two has improved, it remains at a "medium" level overall. Between 2002 and 2008, the level of coordination was relatively stable between [0.57, 0.63], indicating a weak interaction between green finance and the blue economy. In other words, there was considerable room for improvement during this period. However, the level of coordination has gradually increased since 2009. Especially after 2012, the upward trend became more pronounced.

During the period from 2002 to 2024, the coordination level between green finance and the blue economy in China's eastern blue economic circle first evolved from "moderate" to "medium-high," and then to "high." Specifically, from 2002 to 2011, the coordination level remained stable at a "moderate" level, indicating that the development of green finance and the blue economy had not yet formed strong interactive mechanisms during this period. Starting from 2012, the coordination level gradually increased, especially after 2017, when it reached a "medium-high" and "high" level multiple times. This indicates that the level of coordination and interaction between green finance and the blue economy has continuously increased.

An analysis of the above findings reveals that there may be two factors contributing to the increasing level of coordination between green finance and the blue economy. On the one hand, guidance and support from national policies have played a crucial role. In recent years, China has attached great importance to the development of green finance and the blue economy, and has introduced a series of policy measures to promote their integrated development. The implementation of these policies has provided strong guarantees for the coordinated development of green finance and the blue economy. On the other hand, improved market mechanisms and technological progress have also played significant roles. With the continuous development of the green finance market, an increasing number of financial institutions have begun paying closer attention to the blue economic sector and provided it with abundant financial support. Meanwhile, technological progress has also provided strong support for the green development of the blue economy, thus promoting deeper integration between the two.

In summary, these findings confirm Hypothesis 1. Between 2002 and 2024, the level and stage of coordination between green finance and the blue economy in China's eastern blue economic circle show a gradual upward trend. Nevertheless, there is considerable room for improvement. We should therefore continue to strengthen and promote the deep integration and coordinated development of green finance and the blue economy in the future.

3.2 Comparison of the Validity of the Coupling Coordination Model before and after Modification

The coupling degree $C_i$values of green finance and the blue economy in the eastern blue economic circle of China from 2002 to 2024 calculated using the traditional coupling degree model are all distributed in [0.9, 1], demonstrating a high level of coordination. Considering the volatility and instability in the two systems' development since 2002, their coordination relationship is not effectively reflected using the traditional model. We used the modified coupling coordination model to recalculate the C_i values, which were distributed in [0.6, 1], revealing a significant difference in the degree of coupling. During the study period, two "running-in" and "coordination" states occurred. Using the traditional model, the range of values for the coupling coordination degree D_i of the subsystems was [0.4, 0.8], indicating only "moderate" and "medium-high" levels of coupling coordination. Using the modified model, the D_i values were concentrated in [0.5, 0.9]. With the interval length

remaining unchanged, the discriminative validity of the coupling coordination degree was relatively significant. The results are divided into “moderate,” “medium-high,” and “high” levels of coupling coordination.

In summary, the modified coupling coordination model outperforms the traditional model in terms of its discrimination and validity, indicating that the modification was indeed necessary.

3.3 Analysis of the Cointegration Results

To mitigate the influence of heteroscedasticity, the following analysis uses the logarithm of the green finance development level (GF_t) and the blue economy development level (ME_t). The model variables are $LnGF_t$ and $LnME_t$.

3.3.1 The unit root test

ADF testing was conducted to examine the stationarity of the variables $LnGF_t$ and $LnME_t$. The results indicate that the null hypothesis was rejected at the 1%, 5%, and 10% confidence levels, suggesting that these variables do not have a unit root. Therefore, $LnGF_t$ and $LnME_t$ are first-order integrated series, thereby meeting the requirements for cointegration testing and error correction models.

The results of the unit root test reveal that $LnGF_t$ and $LnME_t$ are first-order unintegrated time series, indicating that a long-term stable equilibrium relationship may exist between the development levels of green finance and the blue economy. To confirm this long-term stable relationship, a cointegration test of the sequence can determine whether a cointegration relationship exists between the two. To this end, the EG test was used to evaluate the cointegration relationship. First, pair and OLS regressions were conducted. The regression results (obtained by eliminating auto correlation) are shown below in *Table 7*.

Table 7. Regression results

Variables	Coefficient	Standard deviation	T-statistic	P value
C	-0.325212	0.110385	-2.774042	0.0103
X	0.464133	0.121116	3.926574	0.0007
R-squared	0.423363		Mean dependent Var	-0.706822
Adjusted R-squared	0.395901		S.D. dependent Var	0.260045
S.E. of regression	0.202227		Akaike info criterion	-0.276992
Sum squared resid	0.857774		Schwarz criterion	-0.178253
Log likelihood	5.185533		Hannan-Quinn criter	-0.252161
F-statistic	15.41898		Durbin-Watson stat	0.63141
Prob(F-statistic)	0.000773			

Source: own calculations.

Based on the regression results in *Table 6*, we calculated the residual sequence and performed ADF testing to obtain the unit root test results of the residual sequence, as shown in *Table 8*.

Table 8. Results of unit root tests for residual sequences

Variables	T-statistic				
	ADF	1%	5%	10%	Conclusion
lnMEt	-3.825962	-4.07423	-3.957202	-3.608174	No unit root

Source: own calculations.

In *Table 7*, the t-statistic is -3.825962, while the cut-off value of the EG test is -3.61411. If the cut-off value is greater than the t-statistic, the null hypothesis is rejected, indicating that the residual sequence has no unit root (i.e., the residual term is stationary). Therefore, a cointegration relationship exists between $LnGF_t$ and $LnME_t$. This long-term equilibrium relationship is expressed as:

$$LnME_t = -0.325212 + 0.464133 * LnGF_t + ECM_t$$

These results indicate that, after taking the logarithm of the comprehensive development levels of green finance and the blue economy in the eastern blue economic circle of China from 2002 to 2024 into account, a positive relationship exists between the two. This suggests that, in the long term, an increase in $LnGF_t$ will lead to an increase in $LnME_t$. The influence coefficient is relatively significant, with an elasticity coefficient of 0.464133. For every 1% increase in $LnGF_t$, $LnME_t$ will increase by 0.46%, thereby confirming Hypothesis 2.

3.3.2 Error Correction Model

The cointegration test results indicate that a long-term equilibrium relationship existed between $LnGF_t$ and $LnME_t$ during the research period. However, the short-term deviations between the variables require the establishment of an error correction model (ECM) to reflect the relationship between the long-term equilibrium and short-term fluctuations between the variables. The ECM test results are shown below in *Table 9*.

Table 9. Results of error correction model verification

Variables	Coefficients	T-statistic	P value
C	0.038325	1.457022	0.0423
D(X(-1))	-0.419825	-0.694824	0.0049
ECM(-1)	0.271735	-2.710837	0.0143
Durbin-Watson stat	1.784665		

Source: own calculations.

The DW value of 1.784665 in *Table 9* indicates that there is no auto correlation in the model, the model is reasonable, and all the variables are significant at the 5% significance level. The error correction terms are defined as follows:

$$ECM_{t-1} = LnME_{t-1} - 0.475144 \times LnGF_{t-1} + 0.306212$$

Where β_1 and γ_1 are parameters, ε_t is the random error term, $\Delta LnME_t$ is the first-order difference of $LnME_t$, $\Delta LnGF_t$ is the first-order difference of $LnGF_t$, and EMC_{t-1} is the error correction term.

The error correction model (ECM) for $LnGF_t$ and $LnME_t$ is expressed as:

$$\Delta LnME_t = 0.038325 - 0.419825 * \Delta LnGF_t - 0.251735 * ECM_{t-1}$$

The above error correction model equation shows that, in the short term, the development levels of green finance and the blue economy in the eastern blue economic circle of China were negatively correlated between

2002 and 2024. For every 1% change in the development level of green finance, the development level of the blue economy changed by an average of 0.419825%. Meanwhile, the calculated adjustment coefficient is -0.251735, indicating that the adjustment ratio of the system's first-order lag error to $LnME_t$ is approximately 0.25% in the short term. This has a certain impact on the error correction. It also indicates that when the development level of the blue economy deviates from its long-term equilibrium (as influenced by the development level of green finance), it acts in the opposite direction with an adjustment intensity of 0.251735, thereby pulling the non-equilibrium state back into an equilibrium state. Thus, Hypothesis 3 is confirmed.

3.4 Granger Causality Test

The above analyses can be used to guide the long-term mean positive correlation and short-term corrected negative correlation between the development levels of green finance and the blue economy. However, it needs to be verified whether they share a two-way or a one-way causal relationship. Therefore, the Granger causality between the two systems is further tested here. The calculated test results are shown below in *Table 10*.

Table 10. Analysis of the causal relationships between the variables

Lag order	Lag order: 1	F-statistic	P value
Lag order: 1	$\Delta LnGF$ is not a Granger cause $\Delta LnME$	1.61405	0.2193
	$\Delta LnME$ is not a Granger cause $\Delta LnGF$	0.46330	0.5043
Lag order: 2	$\Delta LnGF$ is not a Granger cause $\Delta LnME$	5.58489	0.0145
	$\Delta LnME$ is not a Granger cause $\Delta LnGF$	0.95520	0.4056

Source: own calculations.

As shown in *Table 10*, Granger causality exists between $LnGF_t$ and $LnME_t$ at the 5% significance level. Specifically, at lag 1, no Granger causality exists between green finance and the blue economy in the eastern blue economic circle of China from 2002 to 2024. At lag 2, green finance exhibits one-way Granger causality on the blue economy. Overall, during the period from 2002 to 2024, the two systems demonstrate a persistent positive long-term equilibrium relationship. This conclusion is drawn based on the results of the cointegration test. Additionally, the development level of green finance is a Granger cause of the development of the blue economy. This indicates that improvements in the development level of green finance in the eastern blue economic circle of China significantly increase the growth of the overall development level of the blue economy in the region.

Based on the Granger causality test results, we can conclude that the causal relationship between $LnGF_t$ and $LnME_t$ only involves the variables' second-order lag terms. Therefore, the third-order and higher-order lag terms of $LnGF_t$ and $LnME_t$ are not considered. The following error correction model is therefore reestablished to further verify the presence of Granger causality:

$$\begin{cases} \Delta InME_t = \alpha_1 * ECM_{t-1} - \lambda_{11} * \Delta InME_{t-1} - \lambda_{12} * \Delta InGF_{t-1} + \mu_{1t} \\ \Delta InMF_t = \alpha_2 * ECM_{t-1} - \lambda_{21} * \Delta InME_{t-1} - \lambda_{22} * \Delta InGF_{t-1} + \mu_{2t} \end{cases}$$

Where α_1, α_2, λ_{11}, λ_{12}, λ_{21}, λ_{22} are parameters, μ_{1t}, μ_{2t} are random error terms, $\Delta InME_t$ is the first-order difference of $LnME_t$, $\Delta LnGF_t$ is the first-order difference of $LnGF_t$, and ECM_{t-1} is the error correction term.

Regression analysis was conducted on the above error correction models. The error correction model (ECM) test results for $LnGF_t$ and $LnME_t$ are presented below in *Tables 11* and *12*, respectively.

Table 11. Test results of $\Delta InME_t$ error correction model

Variables	Coefficients	T-statistic	P value
C	0.041435	-0.490376	0.0452
D(X(-1))	-0.101888	-0.644240	0.0033
D(Y(-1))	-0.106694	-0.522649	0.0408
ECM(-1)	-0.360659	-2.428580	0.0265
Durbin-Watson stat	1.237396		

Source: own calculations.

Table 12. Test results of $\Delta LnGF_t$ error correction model

Variables	Coefficients	T-statistic	P value
C	0.027660	0.810518	0.4288
D(Y(-1))	-0.743960	1.042088	0.1643
D(X(-1))	0.294694	1.4131234	0.1705
ECM(-1)	-0.330872	-2.420160	0.0280
Durbin-Watson stat	2.071075		

Source: own calculations.

The error correction equation is:

$$\begin{cases} \Delta LnME_t = -0.360659 \times ECM_{t-1} - 0.101888 \times \Delta LnME_{t-1} - 0.106694 \times \Delta LnGF_{t-1} + 0.041435 \\ \Delta LnGF_t = -0.330872 \times ECM_{t-1} + 0.294694 \times \Delta LnME_{t-1} - 0.743960 \times \Delta LnGF_{t-1} + 0.0276 \end{cases}$$

The estimated results show that the regression coefficient of $\Delta LnGF_{t-1}$ on $\Delta LnME_t$ is significant, where $\Delta LnGF_{t-1} = LnGF_{t-1} - LnGF_{t-2}$. This indicates that the first-order difference of $LnGF_t$ has a significant impact on $LnME_t$. However, the regression coefficient of $\Delta LnME_{t-1}$ on $\Delta LnGF_t$ is not significant, suggesting that the influence of $LnME_t$ on $LnGF_t$ is relatively weak. Therefore, the causal relationship between $LnGF_t$ and $LnME_t$ mainly manifests as one-way Granger causality from $LnGF_t$ to $LnME_t$. This also indicates that the improvement in the development level of green finance in the eastern blue economy circle of China from 2002 to 2024 has significantly promoted the growth the blue economy in the region. Thus, Hypothesis 4 is not supported, as only a one-way Granger causality exists between the two systems.

4. Discussion

Based on the time series data on China's eastern blue economic circle from 2002 to 2024, this paper empirically

examined the interaction between green finance and the blue economy using multiple methods. The results show that Hypothesis1 (enhanced coupling coordination relationship), Hypothesis 2 (long-term stable cointegration), and Hypothesis 3 (short-term correction relationship) are all supported, while Hypothesis 4 (bidirectional Granger causality) is rejected. This conclusion not only validates the long-term synergy, short-term fluctuation, and unidirectional drive between the two systems but also holds multi-dimensional value in terms of deepening the theory on the subject and providing a basis for practical guidance. This can be discussed from four aspects:

First, the results in *Tables* 4 and 5 indicate that a significant coupling relationship exists between the two systems. The modified coupling coordination model reveals the dynamic synergy between them. Temporally, the level of coordination between the two systems has gradually increased from a "moderate" level of coordination of [0.57, 0.58] from 2002 to 2008, to a "medium-high" and even "high" level of coordination after2012. This change is driven by both policy guidance and market mechanisms. National-level policies such as green finance pilot projects and blue economy demonstration zones provide institutional guarantees for coordinated governance, while financial institutions' inclination towards marine clean energy and ecological restoration projects (as well as the growing demand for green financing among marine enterprises) promote the formation of a closed loop of capital allocation, industrial upgrading, and financial innovation. This echoes the research conclusions of Rashid *et al.* (2025) and Sheng (2025). The value of this result lies in clarifying that the synergy between the two systems is not a static equilibrium but evolves dynamically alongside policy and market changes. This represents a more precise quantitative tool for assessing the effectiveness of regional "green-blue" synergistic governance.

Secondly, the results in *Tables* 6 and 7 indicate that a long-term cointegration relationship exists between green finance and the blue economy, with an elasticity coefficient of 0.475. These results confirm the logic of the coordinated development theory that "system complementarity gives rise to long-term equilibrium," and effectively quantify the driving mechanisms behind the development of green finance on the blue economy. The cointegration equation shows that, for every 1% increase in the level of green finance development, the blue economy grows by 0.475% in the long term. The core of this correlation lies in the high degree of alignment between the two systems' goals: green finance is centered on the green transformation of the economy, while the blue economy aims to promote marine ecological protection and sustainable development. This alignment, combined with technological advancements (such as breakthroughs in marine low-carbon technology) and policy support (such as green bond interest subsidies), creates a resonant, long-term connection between the two systems. The findings of this study are consistent with those of Qadri *et al*. (2024), Erdas *et al*. (2025). The theoretical value of this result lies in going beyond mere qualitative descriptions in existing studies of the long-term relationship between green finance and the blue economy by effectively quantifying this synergistic relationship for the first time, using the blue economic circle in eastern China as a sample. The study's practical value lies in providing a clear basis for long-term policy making. The driving effect of green finance on the blue economy can be amplified by developing new, innovative green financial tools such as the blue carbon sink fund.

Third, the results in *Table* 8 reveal a negative correlation between the two systems in the short term. The short-term elasticity coefficient is -0.107, and the correction coefficient is -0.381. This short-term negative correlation stems from the factor allocation lag between the two systems. The payback period for blue economic projects funded through green finance (such as seawater desalination and offshore wind power projects) is typically 3-5 years. This is mismatched with the short-term liquidity demands associated with green funds. At the same time, the green finance market is affected by short-term interest rate fluctuations and the expectations of investors. The pace of capital allocation tends to deviate from the pace of the development of the blue economy. However, the error correction coefficient (-0.381) indicates that, when the blue economy deviates from its long-term equilibrium, the system reverses by 38.1%. This confirms the theory that short-term fluctuations do not break

the long-term equilibrium between two systems. This conclusion is consistent with those of Demirci and Elcicek (2023), Oke and Aliu (2025), and Alonso-Robisco *et al*. (2025). These findings suggest that short-term governmental policies must focus on alleviating the time-lag contradiction. For example, the funding cycle for the "Green Project Bridge Loan" project could be adjusted to correct the time-lag mismatch, and a "Marine Project Risk Compensation Fund" could be established to stabilize investors' expectations and mitigate short-term fluctuations that would hinder long-term synergy.

Fourth, the results in Table 9suggest that one-way Granger causality exists between green finance and the blue economy (i.e., green finance is the Granger cause of the blue economy), with a lag of two periods (F=5.58, *p*=0.0145). Although this study's conclusion does not support the bidirectional causality proposed in Hypothesis 4, it clarifies the asymmetry of the interaction between the two systems and provides precise guidance on key policy focus points. The core reason why the blue economy has not yet become the Granger cause of green finance is that it is still in a "demand cultivation" period. At present, traditional marine industries (such as offshore fishing) still account for more than 40% of the eastern blue economy circle. The scale of high-value-added green industries (such as marine biomedicine) is limited, and the "forced demand" for green financing remains insufficient. In the long term, however, as the blue economy is upgraded towards low-carbon and high-value-added areas, its demand for diversified green financial services (such as marine carbon sink pledge and blue insurance) will gradually increase, and two-way Granger causality may develop in the future. This aligns with the predictions proposed by Das (2023), Jonäll *et al*. (2025), and Qamruzzaman (2025). This study's findings should serve to remind policymakers of the importance of avoiding the "equalization" misconception in policymaking. Priority should be given to strengthening the leading role of green finance and reserving room for long-term policy adjustments. Fostering green industrial clusters in the blue economy will eventually stimulate a two-way causal relationship.

In summary, this study's empirical results not only enrich the existing theoretical frameworks for the co-governance of green finance and the blue economy (such as the modified coupling coordination model and the quantification of long-term and short-term elasticity), but also provide differentiated practical guidance for the development of regional policies. In the long term, we should rely on the cointegration relationship to strengthen the positive effect of green finance on the blue economy. In the short term, resource allocation should be optimized to correct for negative correlations, with a focus on cultivating demand in the blue economy. This would constitute a replicable approach for enhancing coordinated "green-blue" development in the eastern blue economic circle of China and other coastal regions.

Conclusions and Implications

Conclusions: Based on time-series data from the Eastern China Blue Economic Circle spanning 2002 to 2024, this study clarifies the systemic interaction between green finance and the blue economy. Using multiple empirical approaches, the coupling coordination characteristics and driving mechanisms of these two systems were revealed. The conclusions are as follows: (1) A significant coupling relationship exists between the two systems within the Eastern China Blue Economic Circle. (2) Green finance and the blue economy maintain a long-term stable cointegration relationship. (3) In the short term, the two systems exhibit a negative correlation. (4) Green finance is identified as a one-way Granger cause of the blue economy.

Policy Implications: The findings of this study hold some implications for urban policymakers: (1) There is a need for innovative green financial tools and products to meet the diverse financing needs of the blue economy. The results of this study show that the development of green finance significantly promotes the development of the blue economy. Based on this, the government should promote blue bonds and carbon finance products, develop

supply chain finance and syndicated loans, and support financial leasing and insurance innovation to better serve the development of the blue economy. (2) Cross-departmental collaborative governance mechanisms should be developed to enhance policy coordination and resource integration. The government should establish a joint working group composed of various departments (e.g., ocean, finance, ecology, and environment) and hold regular joint meetings to formulate a policy framework for the coordinated development of the blue economy and green finance. (3) There is a need for the short-term targeted relief of the negative correlation between green finance and the development of the blue economy, and the optimization of resource allocation. The results of this study suggest that a negative correlation exists between green finance and the blue economy in the short term. For example, the development of the blue economy may be detrimental to the development of green finance. This may relate to the fact that certain blue industries are too risky in the short term, which may result in bad debt. Therefore, the government should improve its risk compensation mechanisms and establish a blue credit risk compensation fund to alleviate bad debts generated by financial institutions' support for blue economic projects.

Limitations and Future Directions: Green finance has become an important supporting factor for the development of the blue economy. It has multiple functions, such as optimizing resource allocation and promoting industrial transformation and upgrading. In the future, green finance will continue to evolve and increase its support for marine industries. Simultaneously, financial institutions (e.g., financing, insurance, funds, and trusts) will continue to serve the development of the blue economy. This paper examines the co-governance of green finance and the blue economy, but does not further explore how to develop and promote green financial tools to support sustainable marine resource management and conservation. Future research should explore the integration of environmental, social, and governance standards into financing decisions for the blue economy to enhance the social responsibility of financial institutions.

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BENDRADARBIAUJANTIS VALDYMAS MĖLYNOJOJE EKONOMIKOJE IR ŽALIOJOJE FINANSŲ SISTEMOJE: KINIJOS RYTŲ MĖLYNOSIOS EKONOMINĖS ZONOS ATVEJIS

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Santrauka. Spartėjant pasaulinei klimato kaitai, didėjant aplinkosaugos iššūkiams ir stiprėjant išteklių apribojimams, žalioji finansų sistema ir jos sinerginis vystymasis kartu su mėlynąja ekonomika sulaukia vis daugiau dėmesio kaip svarbūs tvaraus ekonomikos augimo skatinimo mechanizmai. Tačiau iki šiol atliktuose tyrimuose daugiausia dėmesio skirta vienakrypčiams ryšiams tarp mėlynosios ekonomikos ir žaliosios finansų sistemos, skiriant ribotą dėmesį jų galimai dvikryptei sąveikai.

Siekiant ištirti mėlynosios ekonomikos ir žaliosios finansų sistemos tarpusavio ryšį, pasitelkta kointegracijos teorija ir Entropijos svorių – TOPSIS – modelis. Buvo įvertinti mėlynosios ekonomikos ir žaliosios finansų sistemos kompleksinio vystymosi lygiai Kinijos Rytų mėlynojo ekonominio rato regione 2002–2024 m. Papildomai taikyti Grangerio priežastingumo testai, siekiant įvertinti abiejų sistemų sąveikos koordinavimo laipsnį ir patikrinti ilgalaikės pusiausvyros bei priežastinio ryšio egzistavimą tiriamuoju laikotarpiu.

Tyrimo rezultatai atskleidė reikšmingą sąveiką tarp žaliosios finansų sistemos ir mėlynosios ekonomikos bei stabilų ilgalaikį kointegracinį ryšį. Tačiau trumpuoju laikotarpiu nustatyta neigiama koreliacija tarp šių dviejų sistemų. Be to, išsiaiškinta, kad žalioji finansų sistema yra Grangerio priežastis mėlynajai ekonomikai, šiuo atveju itin aktualus jos poveikis. Gauti rezultatai papildo mokslinę literatūrą apie koordinuotą žaliosios finansų sistemos ir mėlynosios ekonomikos vystymąsi, jie gali būti naudojami formuojant politikos rekomendacijas miestų politikos formuotojams.

Reikšminiai žodžiai: mėlynoji ekonomika; žalioji finansų sistema; sujungtos koordinacijos analizė; bendrasis valdymas.