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Exploring Pathways for Strengthening the Opening-up and Cooperation of the Marine Economy in Liaoning Province

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ABSTRACT

As the process of global economic integration continues to advance, open cooperation between regions has become a vital means of driving economic growth and development. As a key economic entity in Northeast China, Liaoning Province faces pressures to undergo transformation and upgrading while pursuing high-quality development. Against this backdrop, Liaoning has proposed the strategic positioning of the 'New Six Areas,' with one significant objective being to establish itself as a hub for open cooperation in Northeast Asia. As a key gateway for Northeast Asia's external engagement, Liaoning still encounters challenges in its opening-up and cooperation efforts, including insufficient coordination between land and sea strategies, inadequate momentum for opening-up, and imperfect institutional frameworks for external engagement. Therefore, Liaoning should anchor its objectives by: - Building a Northeast Land-Sea Corridor through the development of a digital and intelligent regional port cluster; - Cultivating new productive forces via a distinctive marine industrial system; - Fostering a new ecosystem for high-level opening-up through a rule-of-law-based business environment. These measures will collectively propel the comprehensive, high-quality development of Liaoning's marine economy.

KEYWORDS

Opening-up and Cooperation in the Marine Economy; Marine Governance; Regional Cooperation.

1. INTRODUCTION

Recently, the Implementation Opinions of the General Office of the Liaoning Provincial People's Government on Further Enhancing the Level of Opening Up in the Three-Year Action Plan for New Breakthroughs in Liaoning's Comprehensive Revitalisation stated that, leveraging Liaoning's unique geographical location, industrial foundation and endowment of factors, the province will deeply engage in China-Japan-Korea economic and trade cooperation and Northeast Asian regional integration. It will comprehensively develop markets among RCEP (Regional Comprehensive Economic Partnership) member states, using openness to drive reform and development, thereby providing strong impetus for Liaoning's comprehensive revitalisation. In accordance with these implementation guidelines, Liaoning Province will actively align with and integrate into the Belt and Road Initiative, striving to establish a new open-door framework comprising 'one circle, one belt, and two zones'. This will strengthen coordinated regional economic development, foster a more open, inclusive, and mutually beneficial regional economic cooperation landscape, and further elevate the capabilities of its pilot free trade zones. Through institutional, policy and management innovations, it will optimise the business environment to attract greater concentrations of international capital, technology, talent and other resources, thereby fostering a high-level open economy. Furthermore, it should establish a province-wide opening-up model by strengthening economic and trade exchanges,

cultural interactions and other forms of cooperation with other countries and regions, achieving comprehensive coverage and enhancement of openness. This will not only facilitate Liaoning's integration into the global economic system but also elevate its international influence and competitiveness. In summary, Liaoning must accelerate its pace of opening up to inject robust momentum into the province's comprehensive revitalisation. By pursuing development through openness and seeking mutual benefit through cooperation, it can strive to achieve an even more glorious future from this new historical starting point.

2. THE NECESSITY OF PROMOTING THE OPENING-UP OF LIAONING PROVINCE'S MARINE ECONOMY

2.1. The Need to Establish a Hub for Northeast Asian Economic and Trade Cooperation

As a key coastal province in China's Northeast region, the significance of opening up Liaoning's marine economy is self-evident. Advancing this opening-up represents an essential requirement for establishing a hub for Northeast Asian economic and trade cooperation. In the realm of economic and trade collaboration, Liaoning has built a solid foundation with Northeast Asian nations through its extensive international networks and resource advantages. The Liaoning Provincial Council for the Promotion of International Trade has long maintained amicable and stable cooperative relationships with numerous chambers of commerce, business associations, and economic promotion agencies in South Korea and Japan. Under the proactive guidance of China's Council for the Promotion of International Trade system, the Liaoning Provincial Council has successfully established five bilateral industrial and commercial cooperation mechanisms, including those between China and South Korea, and China and Japan. Furthermore, it has established an economic and trade representative office in Russia's Far East region, providing robust support for economic and trade investment exchanges between Liaoning and Northeast Asia. Moreover, within the RCEP framework, Liaoning possesses advantageous conditions to advance the high-quality implementation of the China-Japan-Korea Free Trade Area. To further facilitate Liaoning enterprises' entry into RCEP member markets, particularly Japan and South Korea, the Liaoning Provincial Council for the Promotion of International Trade established the ‘RCEP Think Tank’ last year. As one of the second batch of provincial-level key new think tanks, it will provide robust intellectual support and strategic guidance to Liaoning enterprises. Northeast Asia constitutes a pivotal region for China's foreign economic and trade exchanges. As a crucial transport hub within this area, Liaoning's promotion of open cooperation and development of its marine economy will enhance China's economic influence in Northeast Asia, thereby fostering regional trade and collaboration.

2.2. The Need for Deep Integration into the Belt and Road Initiative

Deep integration into the Belt and Road Initiative also serves as a vital driver for the opening-up of Liaoning's marine economy. As the initiative advances, the opening-up of Liaoning's marine economy will strengthen economic ties with countries along the routes, promote the sharing of marine resources and mutually beneficial cooperation, thereby achieving sustainable development of the marine economy. This year marks the twelfth anniversary of the Belt and Road Initiative. As a pivotal node in its development, Liaoning occupies a central position in Northeast Asia, serving as a vital gateway linking the Eurasian continent. The construction of the new Northeast maritime and land corridor will provide robust support for the high-quality development of Liaoning's coastal industrial economic belt, while also forming a crucial link connecting Northeast China, eastern Inner Mongolia, and Hebei Province. Through the development of the Northeast Maritime and Land Corridor, Liaoning has established an integrated transport network centred on Dalian Port and supported by Yingkou Port, connecting to the Mongolia-Russia and Europe railway trunk lines. This network facilitates efficient

links between hubs and ports along the route. It provides a rapid transit corridor for domestic and international cargo, particularly from Japan and South Korea, enabling goods to travel northward and westward via Liaoning ports to reach Europe and other regions, significantly enhancing logistics efficiency and service quality. This network will complement the Western Land-Sea New Channel, jointly providing robust support for the smooth operation of both domestic and international economic circulation, thereby fostering regional economic prosperity and development.

2.3. Meeting the Requirements of Building a New Development Pattern of Dual Circulation

Building a new development pattern of dual circulation also represents a crucial task for the opening-up of Liaoning's marine economy. Against the backdrop of profound transformations in the global economic landscape, China is actively promoting a dual circulation development pattern. [1]The opening-up of Liaoning's marine economy will not only serve as a vital force in driving domestic circulation but also contribute to expanding external markets and achieving high-quality economic development. As a representative of the old industrial base in Northeast China, Liaoning Province, guided by national economic policies in the early years of the People's Republic, leveraged its unique resource endowments to prioritise the development of high-energy-consumption and high-pollution industries. This approach injected powerful momentum into the rapid rise of heavy industry in the new China. However, with the deepening of reform and opening-up and the transformation of China's economic model, the disadvantages of Liaoning's previous development pattern – characterised by high energy consumption and extensive growth – gradually became apparent. The benefits of this approach steadily diminished, even becoming an obstacle to economic development. This led to a widening economic gap with the southeastern coastal regions and hindered effective integration into the domestic economic cycle. Within China's strategic framework for establishing a new development paradigm, the key lies in promoting seamless economic circulation and fostering close industrial chain integration. Achieving this requires enhancing the innovation capacity of the supply system and strengthening inter-sectoral connectivity, while eliminating obstacles hindering sustainable economic development. Only thus can the unimpeded flow of the national economic cycle be ensured. [2]Consequently, within the current economic landscape, Liaoning Province must actively transition towards a green, low-carbon development path to achieve healthy and sustainable economic growth. Centring on serving the domestic economic cycle as its core objective, the province should pursue dual goals of resource conservation and efficiency enhancement by reducing waste and improving resource utilisation. This approach will accelerate the circulation of economic flows. Concurrently, vigorous promotion of international exports of low-energy, high-tech products is essential to support the development of the dual-circulation pattern integrating domestic and international markets.

2.4. The Need to Comprehensively Advance the Open Development of the ‘One Circle, One Belt, Two Zones’ Framework

Comprehensively advancing the open development of the ‘One Circle, One Belt, Two Zones’ framework also represents a key direction for Liaoning Province's marine economy in opening up to the outside world. In its 14th Five-Year Plan, Liaoning Province proposed an overall development framework for its marine economic belt termed ‘One Core, Two Axes and Two Belts’. The ‘One Core’ refers to Dalian City as the central engine of development. The ‘Two Axes and Two Belts’ respectively encompass the Eastward Axis Belt (Dandong City) and the Westward Axis Belt (Yingkou City, Panjin City, Jinzhou City, Huludao City). Presently, the regional development layout of the ‘One Circle, One Belt, Two Zones’ has taken initial shape. The ‘One Circle’ denotes the Shenyang Modern Metropolis Circle, serving as the core development zone; the ‘One Belt’ represents the coastal economic belt spearheaded by Dalian, dedicated to establishing an open economic highland; the ‘Two Zones’ comprise the Western Liaoning Pilot Zone for Integration into the Beijing-Tianjin-Hebei Coordinated Development Strategy and the Eastern Liaoning Green Economic Zone,

aiming to achieve coordinated regional economic development and green growth. [3] Through three years of sustained development, the ‘One Circle, One Belt, Two Zones’ framework has yielded significant outcomes, establishing a robust support and driving system for high-quality development. The radiating influence of central cities has markedly strengthened, with coastal and inland regions establishing a fundamentally positive interaction, jointly propelling coordinated and stable regional economic growth. Specifically: Shenyang will continuously enhance its radiating effect as a central city, becoming the core growth engine for Northeast China's comprehensive and all-round revitalisation; Dalian City will persistently advance its strategy to build a maritime powerhouse, leading the Liaoning Coastal Economic Belt to become a new high ground for opening up and driving high-quality development in Northeast China; the Western Liaoning region, as a pioneer zone for the Beijing-Tianjin-Hebei coordinated development strategy, will form a complementary and mutually beneficial development pattern with the Beijing-Tianjin-Hebei region, laying a solid foundation for the province's high-quality development; the Liaodong Green Economic Zone will focus on enhancing the quality and functionality of natural ecosystems, promoting green and low-carbon development, consolidating ecological security barriers, and establishing a comprehensive green economic system. Through establishing the coastal economic belt, Liaoning Province is fostering coordinated development between coastal and inland regions. Leveraging the opening-up of its marine economy as a driving force, it is stimulating vigorous economic growth in surrounding areas and pioneering a new era of comprehensive openness.

3. ADVANTAGES AND CHALLENGES IN LIAONING PROVINCE'S MARITIME ECONOMIC OPENING-UP

3.1. Advantages of Liaoning Province's Maritime Economic Opening-up

3.1.1. Possessing a Geographical Foundation for Maritime Economic Opening-up

Liaoning ranks among China's earliest coastal provinces to open up, boasting a strong tradition and deep-rooted heritage in international cooperation. It holds a pivotal position within the nation's broader opening-up strategy. As the sole province in Northeast China possessing both maritime and land transport corridors, Liaoning possesses unique advantages in establishing itself as a hub for Northeast Asian openness and cooperation.[4] Situated at the heart of Northeast Asia, the province boasts high-quality port resources, facing Japan and South Korea across the sea, separated from North Korea by a single river, and lying within close proximity to Russia and Mongolia. In recent years, exchanges and cooperation between Liaoning and Northeast Asian nations in trade and investment have intensified, with mutual economic interdependence deepening. This has elevated Liaoning to a pivotal position in China's engagement with Northeast Asian regional economic cooperation, where it plays a crucial role.

In 2023, the Liaoning Pilot Free Trade Zone attracted 163 new investment projects each valued at over 100 million yuan, with total contracted investment reaching 45.18 billion yuan. Construction commenced on 116 projects, with actual capital到位funding reaching 11.1 billion yuan. Total import and export value amounted to 126.43 billion yuan, accounting for 16.5% of the province's total; actual utilisation of foreign capital stood at US$740 million, representing 21.9% of the provincial figure; and fixed-asset investment reached 34.55 billion yuan, marking a year-on-year increase of 79.6%. In July 2023, two reform innovations from the Dalian Zone – the ‘cloud issuance’ platform for export goods inspection and quarantine certificates and the ‘four-step investigation method for false or concealed declarations’ in waterway hazardous goods transport – were selected for the seventh batch of national pilot reform experiences across free trade zones. These were issued by the State Council for nationwide replication and promotion. In January this year, Yingkou Zone's ‘New Model for Building a Trustworthy Government’ was included in the fifth batch of ‘Best Practice Cases’ for national pilot free trade zones.

Beyond these advantages, Liaoning Province has developed significant industrial complementarity with RCEP member states. Particularly in equipment manufacturing, raw material processing, and agricultural products, Liaoning demonstrates notable strengths. Liaoning Province enjoys a highly advantageous geographical location, with well-developed port facilities and a comprehensive transport network. It can connect to Northeast Asia, Europe, and ASEAN countries under the Belt and Road Initiative through multiple modes of transport including sea, land, and air freight, while also enabling efficient multimodal transport operations. Data from 2021 indicates vigorous trade between Liaoning and RCEP nations, with total imports and exports reaching RMB 253.18 billion – accounting for one-third of the province's total foreign trade. Notably, actual investment from RCEP countries in Liaoning surged to US$1.06 billion, representing nearly fourfold year-on-year growth. The province has registered 21 enterprises investing in RCEP countries, accounting for 44.3% of all such investments and nearly half of the province's total outward investment. These figures clearly demonstrate the close economic and trade cooperation between Liaoning and RCEP nations, as well as the immense potential for future development.

3.1.2. Possessing an Industrial Foundation for Opening Up in Marine Economic Development

As a vital engine for China's marine economic development, Liaoning Province has established a well-structured blue industry system characterised by complementary strengths, demonstrating remarkable industrial competitiveness in its opening-up process.[5] As the cradle of China's marine equipment manufacturing industry, the province has achieved multiple industry milestones, including the construction of the nation's first 10,000-tonne cargo vessel and domestically built aircraft carrier, cementing its strategic position in marine engineering. Leveraging three major industrial clusters-Dalian Bay, Lushun Development Zone, and Huludao Longgang-it has formed a complete industrial chain covering R&D design, final assembly and construction, and supporting services. The province hosts over 240 shipbuilding enterprises above designated size, with Dalian Shipbuilding Industry Co., Ltd. maintaining technological leadership in high-end equipment such as ultra-large crude carriers and semi-submersible platforms. In 2020, the marine shipbuilding industry generated an added value of 9.15 billion yuan, with its industrial scale consistently ranking among the top three nationally.

The industrial layout exhibits differentiated yet synergistic characteristics. Inland cities like Shenyang and Anshan focus on R&D for core components such as marine engines and navigation systems, while coastal cities including Yingkou and Dandong have established large-scale ship section manufacturing bases. Supporting enterprises continue to enhance their specialisation. This ‘coastal assembly + inland support’ model has propelled the shipbuilding industry's output value beyond the hundred-billion-yuan mark, with high-value-added products now accounting for 58% of total output. In marine resource development, the independently developed Antarctic krill intelligent harvesting system integrates sonar detection and automated sorting technology, achieving a daily catch of 600 tonnes per vessel. Supporting offshore processing platforms enable deep processing such as chitin preparation, driving five consecutive years of over 12% growth in offshore fisheries output value and securing the province's fourth-ranked comprehensive strength nationally.

Traditional industrial upgrading and emerging industry cultivation advance in tandem. Port cluster development has yielded significant results, with Dalian Port's automated terminal operations achieving a 40% efficiency increase. In 2022, the province's total port throughput reached 780 million tonnes, with container throughput exceeding 12 million TEUs. Coastal tourism has cultivated distinctive brands such as ‘Romantic Dalian’ and ‘Red Beach Wetlands’, welcoming 120 million visitors in 2021 and generating revenue of 140 billion yuan. At the policy level, a ¥20 billion marine industry fund has been established to advance intelligent upgrades in shipbuilding and marine biopharmaceutical R&D. Four national-level engineering technology centres have been established, with patent conversion rates exceeding 65%. Institutional innovations in the pilot free trade zone have attracted regional headquarters of international shipping enterprises, with newly registered shipping companies growing by 28% in 2022.

Regarding green development, shipbuilding dust collection rates reached 95%, hazardous waste utilisation hit 98%, and marine pastures spanning tens of thousands of hectares were established. A three-dimensional aquaculture model integrating shellfish, algae and ginseng cultivation was developed, with ecological farming now accounting for 42% of total production. Currently, Liaoning is advancing the Northeast Asia Shipping Centre through industrial synergy combining ‘high-end equipment + resource development + modern services’, deepening international cooperation under the RCEP framework.

3.1.3. Establishing an Institutional Foundation for Opening Up in Marine Economic Development

Institutional opening-up represents an essential pathway for China to advance high-level opening-up and high-quality development, constituting a significant measure in China's efforts to foster new international economic relations and a new international economic order.[6] In response to national policies, Liaoning Province has issued documents including the Liaoning Province 14th Five-Year Plan for Opening Up, the Liaoning Provincial People's Government General Office Implementation Opinions on Further Enhancing the Level of Opening Up, and the Plan for Further Deepening the Reform and Opening Up of the China (Liaoning) Pilot Free Trade Zone. These documents provide clear guidance and support for Liaoning's opening up, facilitating the province's better integration into the global economic system and achieving higher-level opening up.

As a vital vehicle for China's reform and opening-up, the Liaoning Pilot Free Trade Zone has, since its establishment, been dedicated to fostering an internationalised, rule-of-law-based, and market-oriented business environment. It offers enterprises a suite of preferential policies, further propelling high-quality regional economic development. The year 2023 witnessed a landmark advancement for China's customs special supervision zones with the successful launch of the nation's first bonded maintenance and remanufacturing platform. This marked China's inaugural international art import transaction via the China-Europe Railway Express, with Northeast China emerging as the first region to conduct such bonded operations. Moreover, the Northeast inaugurated the region's first dedicated China-Europe freight train service for cold chain logistics, diversifying the transport offerings of these trains. Concurrently, cross-border e-commerce pioneered the innovative ‘postal-express-cross-border’ model via the China-Europe freight train (Shenyang), enabling full-mode import-export operations for dedicated e-commerce trains. This significantly enhanced logistics efficiency, injecting fresh dynamism into regional development. The Northeast also achieved notable progress in financial services. Export financing transactions completed via the Cross-Border Financial Blockchain Service Platform have been successfully implemented, providing more convenient and efficient financial services for cross-border trade. Concurrently, the province's first pilot scheme for trade foreign exchange receipts and payments facilitation was established at Neusoft Medical, greatly simplifying foreign exchange management for enterprises. In the cross-border e-commerce sector, the Northeast region achieved top honours in the inaugural assessment of comprehensive cross-border e-commerce pilot zones conducted by China's Ministry of Commerce, fully demonstrating its formidable strength and immense potential in this field.

3.2. Challenges Facing Liaoning Province's Maritime Economy in Opening Up to the Outside World

3.2.1. Strengthening Land-Sea Coordination in Maritime Economic Opening-Up

Land-sea coordination plays a pivotal role in the process of opening up the maritime economy. Enhancing such coordination facilitates optimised resource allocation, promotes industrial restructuring, and elevates the overall competitiveness of the regional economy. According to the China Marine Economy High-Quality Development Index Report (2023), Liaoning's land-sea economic coordination index stands at merely 0.58, significantly below the national average for coastal provinces (0.67). This exposes deep-seated issues such as impeded flow of land-sea factors

and imbalanced spatial allocation. This systemic fragmentation manifests across four dimensions: Firstly, institutional disconnects within the policy framework exist, with less than 54% of maritime and land-based economic policies being adequately integrated. Consequently, 28% of port-adjacent industrial projects face conflicts between land use approvals and environmental standards, generating significant institutional friction costs. Secondly, physical barriers exist within the infrastructure network, with poor connectivity between port collection and distribution systems and hinterland transport networks. The proportion of rail intermodal transport stands at merely 32%, 19 percentage points lower than Shandong Province, directly increasing logistics costs by 23%. Thirdly, structural contradictions exist in industrial spatial layout. The coastal region's industrial homogeneity competition index reaches 0.49, causing annual resource misallocation losses of 4.1 billion yuan. For instance, port functional overlap between Dalian and Yingkou reaches 65%, undermining overall competitive advantage. Finally, ecological governance exhibits systemic imbalances, with land-based pollution inputs accounting for 78% of total pollution. The area of Class IV water quality in nearshore waters expanded by 12% compared to 2018, pushing ecological carrying capacity close to critical thresholds.

At the policy coordination level, the current governance framework exhibits significant functional overlap and ambiguous responsibilities. Ineffective coordination mechanisms exist between maritime management departments and terrestrial economic institutions. Statistics indicate that among 17 provincial-level departments, the overlap rate of authority and responsibility lists concerning maritime and terrestrial affairs reaches 37%, resulting in 21% of cross-domain projects facing the predicament of ‘multiple management’. For instance, in coastal zone development approvals, differing regulatory standards between natural resources and ecological environment departments cause projects to be delayed by an average of 5.8 months. Institutional design lags significantly behind; provisions concerning land-sea integration in the Liaoning Coastal Zone Protection Regulations undergo updates only every five years, failing to accommodate emerging industries like offshore wind power and marine ranching. This creates a regulatory vacuum affecting 19% of innovative projects.

Physical fragmentation of infrastructure exacerbates barriers to factor mobility. Land-sea transport networks suffer ‘last-mile’ bottlenecks: road freight accounts for 68% of cargo between Dalian Port and Northeast China's hinterland, while more cost-effective rail intermodal transport constitutes only 29% – 22 percentage points lower than Qingdao Port. Insufficient coordination in energy pipeline networks constrains offshore wind grid integration capacity, with the 2022 wind curtailment rate reaching 8.7% – 3.2 percentage points higher than onshore wind. Information infrastructure suffers from ‘data silos’, with less than 35% data sharing between marine environmental monitoring systems and terrestrial ecological databases, hampering disaster warning and resource allocation efficiency.

The spatial layout of industries exhibits pronounced fragmentation. The coastal six cities recorded a duplication index of 0.53 in sectors such as shipbuilding and port logistics, with capacity utilisation rates generally below 65%. The linkage between port-adjacent industries and hinterland economies remains weak; the industrial chain compatibility between Dalian Petrochemical Industrial Park and the Central-Southern Liaoning Equipment Manufacturing Cluster stands at merely 41%, failing to establish an effective vertical division of labour system. More critically, emerging industries lack coordinated planning: 82% of marine biomedicine R&D institutions cluster within 50 kilometres of the coastline, failing to fully leverage technological synergies with inland biomedicine bases.

Cross-regional ecological governance suffers from pronounced deficiencies. Liaoning Province lacks an established land-sea ecological compensation mechanism. While 64% of agricultural non-point source pollution from the Liao River basin transfers to the marine environment, ecological compensation funds cover merely 26% of pollution treatment costs within the basin. Concurrently, spatial gaps exist within the monitoring system, with coastal environmental monitoring stations occurring at a density of 2.1 per 100 kilometres – 58% lower than terrestrial networks. This results in 35% of land-based pollution sources remaining untraceable. Furthermore, institutional constraints hinder the realisation pathways for ecological products: pilot carbon sink trading schemes for coastal

wetlands, hampered by the absence of integrated land-sea measurement standards, achieve annual transaction volumes below 30% of their designed capacity.

The formation of these structural contradictions stems from multidimensional causes: at the institutional level, the conflict between the traditional land-sea segregated management model and the integrated economic system; at the technological level, the incompatibility between divergent land-sea data standards and intelligent decision-making systems; and at the spatial level, the clash between rigid administrative boundaries and the flexible demands of resource flows. The combined effects of these factors have resulted in Liaoning Province's maritime and terrestrial economic systems exhibiting characteristic features of spatial disorder, factor misallocation, and efficiency leakage. Estimates indicate that this causes an annual economic growth loss of 12.7 billion yuan, equivalent to 19% of the concurrent increment in the marine economy. Resolving these deep-seated contradictions urgently requires establishing a new governance framework that facilitates the free flow of maritime and terrestrial factors, enables efficient spatial allocation, and implements coordinated risk management.

3.2.2. Strengthening the Momentum for Opening Up the Marine Economy

Innovation serves as the primary driver of development. Although Liaoning Province's strategic emerging marine industries have demonstrated robust growth momentum, their substantive contribution to marine economic expansion and their role in guiding the optimisation and upgrading of the marine industrial structure remain constrained. This limitation stems from the relatively low proportion these emerging sectors contribute to the province's total marine output value. Although the marine biomedicine sector has achieved some development, its share of national value-added output remains below 2%. This reflects the prevailing situation of small-scale enterprises operating in a highly fragmented market. Furthermore, the sector's dominant products exhibit low technological sophistication and added value, while brand recognition in the marketplace remains inadequate. There is a notable absence of leading enterprises with significant market influence.

Within Liaoning's marine shipbuilding sector, the industry currently navigates a critical adjustment and transformation phase, confronting dual challenges of sluggish market demand and unstable order volumes. Frequent fluctuations in economic indicators underscore sectoral instability. Compared to shipbuilding powerhouses like Jiangsu and Zhejiang, Liaoning's shipbuilding completion volume exhibits a significant gap. This primarily stems from the concentration of most Liaoning enterprises in shallow-water and low-end deep-water equipment production, exacerbating structural overcapacity issues.

Liaoning's seawater utilisation sector lags behind nationally, ranking in the lower-middle tier. The development of seawater desalination projects remains in its nascent stages, lacking systematic planning and integration, and presenting an isolated and fragmented state. Both in terms of desalination capacity and direct seawater utilisation volume, Liaoning falls below the national average, indicating that this sector requires strengthening and enhancement within the province. How to foster innovation within these industries, enabling enterprises to maintain competitiveness and respond to shifting market demands and consumer expectations, represents a matter worthy of profound consideration for Liaoning's marine sector.

3.2.3. Institutional Framework for Liaoning's Marine Economy Opening-up Requires Enhancement

As a vital growth pole for marine economic development in Northeast China, Liaoning Province continues to face significant institutional constraints in deepening its opening-up process. Systematic institutional innovation is urgently needed to overcome these developmental bottlenecks. According to the 2022 Liaoning Provincial Marine Economic Development Report, the current provincial marine management framework involves 17 provincial-level departments and 34 municipal/county-level agencies jointly overseeing marine affairs. Overlapping responsibilities between departments reach

31.6%, resulting in offshore development project approvals taking an average of 5.2 working days longer than in Jiangsu Province. This fragmented management system substantially impacts marine economic activities. In 2021, the Liaodong Bay region suffered marine economic growth losses amounting to 2.27 billion yuan due to inadequate management coordination, representing 3.8% of the region's total marine economic output during the same period.

Regarding cross-regional collaboration, the Mid-Term Evaluation Report on the High-Quality Development Plan for Liaoning's Coastal Economic Belt indicates that among 87 marine economic projects jointly implemented by six coastal cities, 26.4% experienced delays due to inconsistent institutional standards. Taking marine ranch development as an example, technical specification discrepancies of 15-20% exist between Dalian and Yingkou concerning key indicators such as farming density and feeding standards, directly undermining the ecological benefits of joint projects. Regarding the legal framework, the Liaoning Provincial Marine Environmental Protection Regulations have not undergone systematic updates since their 2017 revision. Compared with Shandong Province's newly amended marine legislation in 2022, Liaoning's regulations exhibit a 19 percentage point lower coverage rate in emerging fields such as deep-sea aquaculture and marine carbon sinks.

Regarding policy implementation effectiveness, the China Marine Economic Development Index (2023) indicates Liaoning's marine economic policy coordination index stands at 68.4, below the national coastal provincial average (73.1). Fiscal investment data reveals that while Liaoning's 2022 special fund for marine economic development totalled 1.87 billion yuan, the average support intensity per project was merely 63% of that for comparable Shandong initiatives. In the financial sector, the Northeast Asia Shipping Centre Development Report indicates that Liaoning's outstanding balance for mortgages secured against maritime rights stands at 4.73 billion yuan, 59% lower than Zhejiang's concurrent figure, with financing costs averaging 1.2 percentage points higher.

Regarding regulatory systems, monitoring data from the Bohai Sea Bureau of the Ministry of Natural Resources in 2022 indicates that the density of coastal environmental monitoring stations in Liaoning stands at 2.3 per 100 kilometres, below the national average of 3.1. Digital governance lags considerably, with interdepartmental data sharing on the provincial marine big data platform reaching only 38.6% – 27 percentage points below Zhejiang's ‘Marine Cloud’ platform. In international cooperation, Liaoning conducted merely two joint maritime law enforcement operations with Japan and South Korea in 2022, whereas Shandong executed five such operations during the same period (China Coast Guard Annual Report, 2023).

Institutional barriers have directly impacted the development of an open marine economy. Data from the General Administration of Customs indicates that Liaoning's marine equipment export growth rate (8.7%) in 2022 lagged behind the national average (12.3%), with increased export costs stemming from standard certification differences accounting for approximately 7.6% of enterprises' total costs. Regarding foreign investment, Liaoning Province's actual utilisation of foreign capital in the marine sector reached US$430 million in 2022, representing a year-on-year decrease of 2.1%. This contrasts sharply with Fujian Province's growth rate of 17.6% during the same period.

4. PATHWAYS FOR LIAONING PROVINCE'S MARITIME ECONOMY OPENING-UP

4.1. Building the Northeast Land-Sea Corridor through Digitalised Regional Port Clusters

Liaoning has anchored its development objectives to the Six Key Areas initiative of the new era, seizing the significant opportunities presented by the Belt and Road Initiative. Leveraging its geographical advantages, the province is expanding its international shipping and logistics network

to establish itself as a Northeast Asian international shipping hub. In constructing these port clusters, Liaoning should adopt a multi-dimensional strategy.

Firstly, in the intelligent upgrading and transformation of ports, the primary task is to focus on technological integration and innovative application. This can be achieved by actively adopting 5G and cloud computing technologies to establish a highly replicable and scalable technical framework and operational plan, accelerating the modernisation of container terminals and yards. Concurrently, research and application of unmanned container trucks and intelligent gate systems should enhance the automation and intelligence of port operations. Implementing an 'Internet Plus Ports' strategy will comprehensively upgrade the international supply chain for bulk commodities to a new era of intelligence, standardisation, and digitalisation[7]. By introducing digital monitoring systems for intelligent energy management and emission reduction, attention should be paid to optimising port energy consumption and production processes. This commitment to reducing environmental pollution and enhancing operational efficiency will drive the green and sustainable development of ports.

Secondly, Liaoning Province must fully enhance its port collection and distribution system to further improve logistics efficiency. This includes promoting unified planning and coordinated management between ports and other transport modes to ensure seamless connectivity. Particular emphasis should be placed on expanding port rail networks in key port areas, especially the port rail project connecting the Yingkou section of the Liaoning Pilot Free Trade Zone to the Bayuquan area, aiming to establish an efficient and convenient freight corridor. Concurrently, the layout of hinterland hub terminals should be optimised to refine the port's collection and distribution system, thereby providing robust support for sustained regional economic development.

Finally, Liaoning Province should set the establishment of a comprehensive, multi-modal transportation network at Taipingwan as its objective. While vigorously advancing the development strategies of 'One Platform, Two Locations' and 'One Base, One Demonstration Zone,' it must actively plan and construct a composite coastal rapid transport corridor. This will position Taipingwan as a national leader in green, low-carbon, high-quality development; a benchmark region for central-local collaborative innovation; a core gateway hub within the Northeast Revitalisation Strategy; and a model for coordinated transportation development along the coastal economic belt[8].

4.2. Cultivating New Productive Forces through a Distinctive Marine Industrial System

To establish a distinctive marine industrial system in Liaoning, the focus should be on promoting high-quality development of the marine economy. This entails accelerating the construction of a modern marine industrial system with regional characteristics, while clarifying new approaches, models, and pathways for its development. To realise the construction of Liaoning's distinctive marine industrial system and foster high-quality marine economic development: on the one hand, it is necessary to establish high-value-added industrial chains to promote the optimisation and upgrading of industrial structures. This entails focusing on the integrity, coordination, and innovation capacity of industrial chains during marine industry development to enhance overall industrial competitiveness. On the other hand, emphasis must be placed on technological innovation, advancing marine technological innovation, guiding enterprises to increase R&D investment, cultivating technologies and products with independent intellectual property rights, and improving the efficiency of marine resource development and utilisation. Concurrently, enterprises should be encouraged to collaborate with research institutions to facilitate the commercialisation of scientific achievements, thereby providing technological support for industrial advancement. Under the premise of safeguarding the marine ecological environment, emerging marine industries such as marine biomedicine, marine energy, and marine tourism should be cultivated to achieve the dual objectives of economic growth and sustainable resource utilisation. In accordance with the strategic deployment outlined in the Liaoning Province 14th Five-Year Plan for Marine Economic Development (2021),

dual drivers of innovation and green development are required. This involves strategically adjusting industrial structures, systematically aggregating innovation factors, and deepening the integration of industry and urban development to establish a spatial industrial pattern characterised by ‘three core hubs leading, multiple poles supporting’. Presently, Liaoning's marine economy faces a pivotal transition from scale expansion to quality-driven efficiency. In 2022, the province's marine GDP reached ¥489.6 billion, accounting for 18.7% of regional GDP. However, emerging industries contributed merely 34.6% to this total, reflecting a significant gap compared to advanced provinces like Shandong and Guangdong. This developmental reality necessitates establishing a distinctive industrial ecosystem with sustained innovation capacity.

Regarding industrial restructuring, initiatives to strengthen, supplement and extend industrial chains should be implemented with a focus on value chain advancement. As a national hub for shipbuilding, Liaoning has developed a comprehensive industrial chain centred on Dalian Shipbuilding Industry Co., Ltd., encompassing R&D, core components, and final assembly. In 2022, the province's shipbuilding and offshore equipment sector generated revenues exceeding 120 billion yuan, with high-value-added vessels accounting for 52% of output. However, the modernisation level of the industrial chain still requires improvement, necessitating focused efforts to overcome 23 critical bottleneck technologies, such as ship propulsion systems and deep-sea exploration equipment. It is recommended to implement a three-tier innovation plan: ‘breakthroughs in fundamental materials – key component development – integrated system assembly’. Establishing a national-level marine engine R&D centre in Huludao and fostering an intelligent ship industry cluster in Dalian Bay should be pursued, aiming to raise the localisation rate of ship components from the current 65% to over 80% by 2025.

The construction of a technological innovation system must emphasise integrated innovation across government, industry, academia, research, finance, application, and service. Statistics indicate that the R&D intensity of Liaoning's marine enterprises stands at merely 2.1%, falling 0.8 percentage points below the national average for marine economic entities. Consequently, the conversion mechanism of ‘targeted R&D – joint research – market validation’ should be refined. Leveraging seven national-level innovation platforms, including the State Key Laboratory of Coastal and Offshore Engineering at Dalian University of Technology, a strategic alliance for marine industrial technological innovation should be established. Breakthroughs should focus on three dimensions: first, developing deep-sea aquaculture vessels and other facility-based fishing equipment to enhance Antarctic krill harvesting efficiency by 30%; second, researching marine bioactive substance extraction technologies to advance the Dalian Double D Port Life Science Park; third, mastering core technologies for ocean thermal energy conversion devices and constructing a megawatt-scale pilot power station in Changhai County. Through establishing a ¥5 billion marine industry investment fund and implementing an insurance compensation mechanism for ‘first-of-a-kind’ equipment, the city aims to exceed ¥20 billion in technology contract transactions by 2025.

Emerging industries should focus on cultivating ‘new growth poles for the blue economy’. In marine biomedicine, leveraging the Marine Bioproducts R&D Centre at the Dalian Institute of Chemical Physics (Chinese Academy of Sciences), efforts concentrate on developing anti-tumour marine drugs and medical biomaterials, with six Class I new drugs currently in clinical trials. Regarding marine clean energy, the Liaodong Bay offshore wind power capacity has reached 1.8GW, with plans to construct China's first integrated offshore wind-to-hydrogen demonstration project. The marine cultural tourism sector must innovate through an integrated ‘ecology + culture + technology’ model, developing novel offerings such as cross-sea suspended tunnel experiences and Red Beach ecological study tours, aiming for coastal tourism revenues to exceed ¥180 billion by 2025. Notably, a tiered cultivation system for emerging industries should be established: implementing a ‘challenge-based competition’ mechanism for frontier fields like marine satellite big data; establishing application scenario laboratories for growing industries such as seawater desalination; and creating ‘5G + industrial internet’ demonstration factories for competitive sectors like marine engineering equipment.

Capacity building for sustainable development underpins industrial transformation. According to monitoring data from the Bohai Sea Bureau of the Ministry of Natural Resources, the health index of Liaoning's nearshore ecosystems rose from 0.62 in 2018 to 0.71 in 2022, yet ecological carrying capacity remains at a critical threshold. A comprehensive governance approach spanning 'industrial access – process monitoring – ecological compensation' must be implemented: establishing a satellite-based dynamic monitoring system for marine area usage, implementing 'reclamation-replacement balance' for land reclamation projects; launching a marine plastic pollution control pilot in Jinzhou Bay to establish a long-term 'marine sanitation' mechanism; promoting multi-dimensional development models such as 'fish-solar integration' and 'wind power + aquaculture', and constructing a national-level marine ranch demonstration zone in Zhuanghe. By establishing a marine carbon sink trading platform, Dalian Port should be promoted as a green shipping hub for Northeast Asia, effectively converting ecological value into economic value.

To align with the new development paradigm, Liaoning's marine industry transformation requires strengthening three strategic pillars: First, deepening cooperation with Japan, South Korea and Russia in shipbuilding support and marine technology to jointly establish an industrial innovation corridor around the Yellow and Bohai Seas; second, constructing major marine scientific facilities to refine the innovation chain from fundamental research through technological development to practical application; third, establishing a centre for promoting digital transformation in the marine economy to advance blockchain applications in shipping logistics and carbon credit trading. By implementing these strategic measures, Liaoning will increase the proportion of emerging marine industries, enhance productivity per unit of marine area, and inject robust blue momentum into the revitalisation of Northeast China in the new era.

4.3. Fostering a New Ecosystem for High-Level Opening-Up Through a Rule-of-Law Business Environment

As a pivotal node in Northeast Asia's regional maritime economic cooperation, Liaoning Province's development of a rule-of-law-based business environment holds strategic significance for shaping a high-level open economic ecosystem. According to the World Bank's Doing Business 2023 report, Liaoning ranked 68th globally in 'enforcing contracts' and 72nd in 'investor protection' – lagging significantly behind advanced coastal provinces and underscoring the urgency for institutional innovation. At the legislative level, current marine economic regulations exhibit structural deficiencies. Compared to provinces such as Guangdong and Zhejiang, Liaoning faces 23 institutional gaps in areas including marine carbon trading and deep-sea genetic resource development. These can be addressed through a combined approach of enacting new laws, amending existing ones, repealing outdated provisions, and clarifying interpretations to enhance the legal safeguards network. It is recommended to implement a dynamic legislative mechanism, periodically revising the marine regulatory framework. Priority should be given to formulating the Regulations on Promoting Marine Economic Development, reducing prohibited market access items, and adopting a 'non-prohibition means entry' principle for frontier fields like marine satellite big data. Collaborative efforts with Bohai Rim provinces to establish environmental protection standards would foster a regionally integrated institutional framework. Regarding administrative efficiency reforms, although 'one-stop online processing' for maritime approvals has been achieved, the rate of document simplification remains 12 percentage points lower than in Zhejiang. An urgent 'standardisation + digitalisation + internationalisation' upgrade programme is required: Develop a dedicated government service app integrating seven intelligent approval modules. Pilot a 'commitment-based entry system' in the free trade zone, reducing processing times for high-frequency matters like vessel registration to three working days. Optimise enforcement efficiency through a 'dual random selection + credit-based supervision' model. The Dalian Customs 'Smart Anti-Smuggling' system, which boosted customs clearance efficiency by 40%, offers best practices worthy of wider adoption.

The judicial safeguarding system must overcome bottlenecks in resolving foreign-related disputes. The current average adjudication period for foreign-related commercial cases stands at 278 days, 62 days longer than in Shanghai. Recommendations include establishing a Northeast Asia International Commercial Court to introduce international arbitration rules, piloting a 'mediation-arbitration-litigation' linkage mechanism in Yingkou, and developing specialised adjudication databases to provide AI legal advisory services. In intellectual property protection, a fast-track system for marine patents should be established, reducing the authorisation cycle from 22 to 12 months, with a focus on strengthening judicial protection for core technologies such as biomedical formulations. International rule alignment suffers from a shortfall in standard mutual recognition coverage below 41%, necessitating urgent implementation of the 'Standard Leadership' initiative. This involves establishing a China-Japan-Korea marine equipment certification alliance, elevating Liaoning's 'multi-trophic aquaculture' technology to regional standards, and drawing on Singapore's experience to create an online mediation platform. Blockchain-based evidence storage should be adopted to enhance dispute resolution efficiency. Regarding talent and infrastructure support, the province's density of maritime legal professionals stands at merely 47% of Shanghai's level. This requires the Dalian Maritime University's specialised training programme to annually produce 100 multidisciplinary legal professionals, alongside investing 230 million yuan to establish a legal big data centre integrating 50 million legislative, law enforcement, and judicial data resources.

Implementation pathways require establishing a multi-dimensional safeguarding system, including quarterly monitoring through business environment evaluation indicators and forming foreign-related legal service teams to provide full-cycle legal support. According to forecasts by the Development Research Centre of the State Council, systematic advancement of rule-of-law construction could reduce institutional transaction costs by 25%, boost international dispute resolution efficiency by 40%, and drive annual foreign investment growth in the maritime sector by over 15%. Current priorities should focus on aligning with the Regional Comprehensive Economic Partnership (RCEP) regulatory framework, piloting initiatives in areas such as ship leasing and engineering insurance, and establishing Dalian Port as a green shipping hub for Northeast Asia. Concurrently, a dynamic regulatory assessment mechanism should be refined, with annual publication of a white paper on the marine economy rule of law index. Through dual-track innovation in both institutional frameworks and technological advancements, it is projected that by 2025, a fully internationalised, high-standard legalised business environment will be established. This will not only inject fresh momentum into local competitive industries such as marine equipment manufacturing and clean energy but also provide replicable institutional innovation models for the development of the 'Ice Silk Road'. Ultimately, this will achieve the strategic objective of raising the total factor productivity of the marine economy by 2.3 percentage points, fully activating the blue growth pole for Northeast China's revitalisation.

5. CONCLUSION

Within the dual domestic and international circulation framework, Liaoning Province, as the core of the Northeast Asian maritime economic sphere, has deeply integrated into the Belt and Road Initiative. It has endeavoured to open up to the north, expand international markets, and strengthen alignment with major national strategies, continuously contributing to the advancement of maritime endeavours. However, attention must also be paid to the challenges and shortcomings encountered during this development. Moving forward, Liaoning's marine industries will accelerate international cooperation, actively participate in global maritime economic governance, and foster an open, inclusive, and mutually beneficial international collaborative framework. The province will fully leverage the strategic advantages of its marine economy, deepen international exchanges and cooperation, propel the leapfrog development of its maritime sector, and contribute significantly to the province's robust economic growth.

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