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The Practical Dilemma and Optimization Path of Ferry Subsidy Strategy under the Livelihood Attribute: A Study Based on the Cost-Benefit Perspective

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Abstract

As a transportation infrastructure that combines livelihood security and public service attributes, the sustainable operation of ferries highly relies on government subsidies and support. This article is based on cost theory and the principle of public policy efficiency, combined with three typical cases of Shantou Ferry (urban commuting type), Bohai Ferry (regional passenger rolling type), and Zhuhai Wanshan Islands Ferry (island livelihood type), to systematically analyze the policy framework, implementation mechanism, and cost composition of ferry subsidies in China. Research has found that the current subsidy system has three major structural problems: a "target deviation funnel", an "efficiency loss funnel", and a "regulatory deficiency funnel". Among them, island ferries face a special dilemma of "spatiotemporal mismatch funnel" due to their wide service radius and large passenger flow fluctuations. By constructing a three-dimensional optimization model of "precise cost accounting-dynamic adjustment-full process supervision", this paper proposes measures such as classification subsidy mechanism, market-oriented compensation path, and digital supervision system, providing theoretical references and practical paradigms for improving the effectiveness of different types of ferry subsidy policies.

Keywords

Ferry Transportation, Livelihood Projects, Financial Subsidies, Funnel Effect, Cost Accounting, Island Transportation

1. Introduction

1.1. Research Background

Ferry transportation plays an irreplaceable role in ensuring people's livelihoods in coastal and inland water network areas of China. It is not only the core carrier of cross water commuting, but also the "lifeline" connecting remote islands with the mainland. According to data from the Ministry of Transport, there are over a thousand coastal and inland ferry routes in China, with an annual passenger volume exceeding 200 million. More than 60% of these routes rely on government subsidies to maintain operation due to insufficient passenger flow and high operating costs. As a typical quasi public good, ferry services have strong positive externalities—their safe and stable operation not only reduces travel costs for the public, but also promotes regional economic synergy and tourism resource development [1].

However, the conflict between the livelihood attributes and market laws has always plagued the development of the ferry industry, and there are significant differences in the contradictions faced by different types of ferries. Urban commuter ferries are plagued by the inverse relationship between low ticket prices and high operation and maintenance costs. Since the implementation of the 1 yuan ticket price policy in 1996, the per capita one-way operating cost of Shantou Ferry has risen to 2.5 yuan, and enterprises have fallen into a vicious cycle of "wage arrears-aging facilities-service degradation"; Regional passenger ferries are significantly affected by fluctuations in fuel and ship depreciation costs, with Bohai Ferry's fuel expenses increasing by 18% year-on-year in 2024; Island livelihood ferries face more complex challenges. The Wanshan Islands in Zhuhai cover five inhabited islands, including Guishan Island and Wailingding Island, with a maximum distance of over 50 nautical miles. During peak seasons, the daily passenger flow exceeds 8000, while during off-season, it is less than 1000. The contradiction between "tidal" passenger flow and rigid operating costs is particularly prominent. What is more noteworthy is that there is a "funnel effect" in the circulation and use of the three types of ferry subsidy funds—defined as the gradual loss, deviation, or waste of subsidy benefits in the process of policy implementation, resulting in the actual effect of subsidies being significantly lower than the expected policy goals [2]. This further exacerbates the deviation between policy implementation effectiveness and expected goals.

1.2. Literature Review

Foreign research has focused on the efficiency evaluation and mechanism design of ferry subsidies, resulting in multidimensional research achievements. Part of the research is based on operational data from the Nordic ferry system, proposing the idea of developing differentiated subsidy policies according to passenger flow elasticity. Empirical evidence shows that this model can improve the efficiency of fund utilization by 30%. There is also research on the East Asian ferry market, which found through cost decomposition model analysis that separately listing

fuel costs as a special subsidy item can effectively alleviate the impact of oil price fluctuations on ferry operation stability and provide feasible solutions to cope with cost fluctuations. Overall, foreign research focuses more on the adaptability of subsidy mechanisms to market demand, emphasizing the use of dynamic adjustment strategies to enhance the efficiency of fund utilization [3].

Domestic research focuses on the pricing mechanism and cost structure analysis of ferries, forming a theoretical consensus centered on cost orientation. A study based on the pricing theory of public goods proposes that ferry fares should cover 60% of fixed costs and the full amount of variable costs, which not only ensures the basic operation of enterprises but also avoids excessive dependence on subsidies; Some studies have also found through sorting out the domestic ferry subsidy policy texts that more than 80% of ferry subsidies in China adopt the "base plus" model, which calculates the subsidy amount based on the previous year's operating data, lacking a linkage mechanism with performance indicators such as service quality and safety level, resulting in some enterprises focusing more on "fund acquisition" than "service improvement" [4].

Existing research has fully revealed the cost correlation and policy necessity of ferry subsidies, laying a theoretical foundation for subsequent research. However, there are still two limitations: firstly, there is insufficient differentiation analysis of subsidy mechanisms for different types of ferries, especially the lack of attention to the special operating scenarios of island ferries (such as long routes and tidal passenger flow), which makes it difficult to explain the unique challenges faced by island ferries; Secondly, there is a lack of systematic analysis on the "funnel effect" of subsidies, which fails to explore the spatiotemporal characteristics and group demand differences of ferry operations, resulting in insufficient targeted optimization suggestions proposed. This article aims to fill the existing research gap by integrating the cost structure, policy texts, and operational data of three typical cases of urban commuting, regional passenger rolling, and island livelihood, with a focus on analyzing the formation mechanism of subsidy loss [5].

1.3. Research Methods and Innovation Points

This article adopts a mixed research method: firstly, a multi case comparison method is used to select Shantou Ferry (urban commuting type), Bohai Ferry (regional passenger rolling type), and Zhuhai Wanshan Islands Ferry (island livelihood type), and compare and analyze the differences and problem manifestations of subsidy mechanisms in different scenarios; The second is the cost decomposition method, which deconstructs the fixed and variable cost composition of three types of ferries based on corporate financial reports and government disclosed data; The third is the policy text analysis method, which sorts out 31 ferry subsidy policies in China and special documents such as the "Interim Provisions on Land Island Transportation Support in Zhuhai Wanshan Marine Development Experimental Zone", and identifies regulatory loopholes.

The innovation of the research lies in the first proposal of the theoretical frame-

work of "triple basic funnel + a special funnel" for ferry subsidies, with a focus on revealing the formation mechanism of the "spatiotemporal mismatch funnel" for island ferries; Construct a subsidy effectiveness evaluation model that includes real data from three types of cases. The model takes "subsidy fund conversion rate" as the core dependent variable, and selects four dimensions of explanatory variables: cost accounting accuracy (including static/dynamic accounting methods, type adaptation degree), performance linkage strength (including indicator completeness, incentive/punishment intensity), regulatory technology level (including supervision method, data integration degree), and spatiotemporal resource adaptability (unique to island ferries, including time allocation matching degree, spatial allocation balance degree). Each dimension is quantified through 3 - 5 secondary indicators (e.g., cost accounting accuracy includes "deviation rate between accounting value and actual cost", "coverage rate of dynamic adjustment factors"). Reference [6] provides a theoretical basis for the construction of the performance evaluation dimension in the model, using the logical framework of "input-output-effect" to ensure the scientificity of the indicator system, providing a quantitative basis for differentiated policy design.

For the calculation of national or industry-level average data such as "62% average conversion rate of subsidy funds" and "22% lower spatiotemporal allocation efficiency of island ferries", the following methods are adopted: 1) Collect public data such as the "Waterway Transportation Statistical Yearbook" of the Ministry of Transport, local fiscal subsidy disclosure reports, and annual reports of listed ferry companies (such as Bohai Ferry); 2) Screen 56 representative ferry enterprises covering coastal, inland, urban, regional, and island types, and collect their 2020-2024 subsidy amount, operating cost, service output and other data; 3) Calculate the core indicators such as subsidy fund conversion rate (actual operating input amount/subsidy amount) for each enterprise; 4) Weighted average according to the operating scale (passenger volume, route length) of the enterprise to obtain industry average values; 5) For the comparative data of island ferries, the difference between the spatiotemporal allocation efficiency of island ferry samples and the overall industry average is calculated to obtain the "22% lower" result.

2. Theoretical Basis and Policy Framework of Ferry Subsidies

2.1. Theoretical Support

Cost theory is the core theoretical foundation of ferry subsidies. The operating costs of ferries can be divided into three categories: fixed costs, variable costs, and risk costs. However, the cost structure of different types of ferries varies significantly: fixed costs for urban commuter ferries account for 58%, mainly for terminal maintenance and ship depreciation; The fixed cost of regional passenger ferries accounts for 63%, and the depreciation of ship purchases accounts for as much as 40%; Due to the long route and high wind and wave resistance standards of the island livelihood ferry, the fixed cost accounts for 65%, and the risk cost

(including meteorological emergency and channel maintenance) accounts for 15%. Due to the fact that fixed costs generally account for over 50%, even if customer traffic is insufficient, companies still need to bear basic expenses, which constitutes a necessary prerequisite for subsidies. This cost structure characteristic directly leads to the formation of "efficiency loss funnel": on the one hand, rigid fixed costs make enterprises rely heavily on subsidies, and on the other hand, the lack of differentiated accounting for different cost structures leads to unreasonable subsidy allocation, resulting in part of the funds not being effectively converted into operating input.

The theory of public goods further explains the policy logic of subsidies. Ferry services are non competitive and partially exclusive, but the non competitive characteristics of island ferries are more prominent—the marginal cost of adding one passenger to the Guishan Island to Xiangzhou Port route is only 2.1 yuan, which is less than 10% of the per capita operating cost. This quasi public goods attribute determines that the market mechanism cannot achieve optimal allocation of resources and requires government intervention to compensate for "market failure" [7]. This market failure is closely related to the "target deviation funnel" and "regulatory deficiency funnel": due to the non-exclusivity of public goods, it is difficult to accurately identify the core beneficiary groups, leading to the occupation of subsidy benefits by non-target groups; At the same time, the information asymmetry between the government and enterprises in the process of public service supply makes it difficult for the government to fully supervise the use of subsidies, resulting in regulatory loopholes.

2.2. Policy Types and Implementation Mechanisms of Ferry Subsidies in China

According to the subsidy objectives and methods, ferry subsidies in China can be divided into four categories, and the subsidy structure for different types of ferries varies:

One is the cost compensation subsidy, which mainly covers rigid costs such as fuel and labor. Bohai Ferry received a subsidy of 85.45 million yuan for the reform of refined oil prices in 2022, accounting for 47% of the total subsidy for that year.

The second is a service guarantee subsidy, which is used to maintain the operation of remote routes. The Wanshan Islands in Zhuhai implement a "differentiated subsidy for peak and off peak seasons", with a subsidy of 3000 yuan per voyage for routes below 30 nautical miles during the off-season and 4000 yuan for routes above 30 nautical miles.

The third is a strategic oriented subsidy that supports the renovation of green ships and the expansion of shipping routes. Wanshan Islands provides a three-year decreasing subsidy for newly added shipping routes, with a maximum of 5000 yuan per voyage in the first year.

The fourth is emergency assistance subsidies, which are used to ensure transportation capacity in extreme weather conditions. Wanshan Islands invested in emergency subsidies to restore routes after Typhoon Huajiasha, and will resume

flights within 48 hours after suspension in September 2025.

In terms of implementation mechanism, urban and regional ferries often adopt the process of "enterprise declaration-department review-financial allocation", while Wanshan Islands has established a more refined "classification declaration-dynamic verification-performance linkage" mechanism: specific group ticket price subsidies are calculated based on passenger station ticket sales data, and fixed livelihood flight subsidies need to meet the requirements of a passenger load factor of 10% -45%. This mechanism has significant advantages in accuracy [8].

2.3. Analysis of the Correlation between Subsidies and Operations

The subsidy scale is significantly positively correlated with operating costs, but the sensitivity of different cost items varies depending on the type of ferry. According to data from Bohai Ferry, for every 10% increase in fuel costs, subsidy demand increases by 8.3%; The impact coefficient of labor cost changes on subsidies for Shantou Ferry is 0.32; The Wanshan Islands Ferry exhibits a dual sensitivity—for every 10% increase in fuel prices, subsidy demand increases by 7.8%, while for every 5% increase in downtime caused by extreme weather, subsidy demand increases by 12%, reflecting the special nature of island ferries affected by natural conditions. This difference indicates that subsidy policies need to be precisely designed based on the characteristics of cost structure to avoid the waste of funds caused by a one size fits all approach [9].

3. Analysis of the Performance and Causes of the "Funnel Effect" of Ferry Subsidies

3.1. The Manifestation of the "Funnel Effect" of Subsidies

3.1.1. Target Deviation Funnel: Subsidies Fail to Benefit Core Beneficiary Groups

The low-priced 1 yuan ticket of Shantou Ferry has attracted a large number of tourist check-in passengers (accounting for 65%), while the commuting group in need (accounting for 35%) has not fully benefited due to the reduction in frequency; Although specific group preferential policies are implemented in the Wanshan Islands, audits have found that during peak seasons, non registered permanent residents accounted for 18% of fraudulent ticket purchases, resulting in a decrease in the success rate of ticket purchases for island residents to 72%, and a "reverse loss" of subsidy benefits.

3.1.2. Efficiency Loss Funnel: Low Efficiency of Fund Conversion

The average conversion rate of funds for ferry subsidies in China is only 62%, and there are differences in the performance of the three types of cases: among the 120 million yuan subsidy for Bohai Ferry in 2024, 35% was used to repay historical debts, and the proportion of funds directly invested in operation was less than 47%; 28% of the subsidy for Shantou Ferry is used for the maintenance of old ships, which has not resulted in service upgrades; Due to the poor connection of the subsidy mechanism between peak and off peak seasons, 12% of the subsidy

funds for the off-season in 2024 were not disbursed in a timely manner due to delayed flight adjustments, missing the window period for facility upgrades.

3.1.3. Regulatory Deficiency Funnel: Lack of Effective Constraints on the Use of Funds

There is a phenomenon of "heavy allocation of funds and light supervision" in many places: three ferry companies in a coastal city embezzled subsidies of 23 million yuan by falsely reporting ship maintenance costs; Although the Wanshan Islands stipulate that subsidy funds should be used exclusively, a special inspection in 2024 found that one company used 1.5 million yuan of newly added route subsidies for daily expenses, accounting for 5% of the company's annual subsidy total, reflecting that there are still blind spots in supervision [10].

3.1.4. Spatiotemporal Mismatch Funnel: The Special Dilemma of Island Ferries

This funnel is a unique problem for island ferries: during the peak season (May to October) in Wanshan Islands, the passenger flow accounts for 75%, but subsidies only cover flights to remote islands at specific times; During the off-season (November to April of the following year), passenger flow drops sharply. Although there are full flight subsidies, the empty ship rate is as high as 60%, resulting in a mismatch of "insufficient subsidies during peak season and wasted subsidies during off-season". According to data from 2024, the efficiency of allocating subsidy funds in terms of time and space is 22% lower than the industry average.

3.2. The Core Causes of the "Funnel Effect"

3.2.1. Inadequate Cost Accounting System

The current subsidy accounting mostly adopts the "historical cost method", without considering the differences in types and dynamic changes: the depreciation of Shantou Ferry ships is still calculated based on the purchase price in 1996, with a deviation of 78% from the actual value; Although the Wanshan Islands have formulated subsidy standards based on the voyage, they have not included the cost increase caused by the difference in ship wind and wave resistance levels. The operating cost difference of ships with different standards on the same voyage reaches 25%, resulting in the subsidy standards being unrealistic.

3.2.2. Decoupling Subsidies from Performance

83% of subsidy policies did not fully include service quality in the assessment: the on-time rate of a ferry enterprise in a certain province decreased from 92% to 81% without punishment after receiving subsidies; Although the Wanshan Islands require the guarantee of normal flight operations, quantitative indicators such as on-time performance and facility integrity have not been clearly defined. In 2024, the on-time performance of the Dangan Island route was only 82%, which is 5 percentage points lower than the regional average level.

3.2.3. Lagging Regulatory Technology Measures

Traditional regulation relies on manual verification of receipts, which makes it

difficult to cope with dynamic operational scenarios: the fuel consumption differences of up to 40% among different routes of Bohai Ferry have not been identified in a timely manner; Although the Wanshan Islands use passenger stations to calculate passenger load factors, there is a lack of real-time passenger flow monitoring, which makes it difficult to accurately determine the necessity of subsidized flights, resulting in some low passenger flow routes being continuously supplemented.

3.2.4. Incomplete Group Recognition Mechanism

There is a loophole in the implementation of specific group discounts for island ferries: the discount restrictions for non island permanent residents in Wanshan Islands are limited to "40 times a month, 50% off for ticket purchases". However, due to the lack of linkage verification between residence permit information and ticketing systems, there are frequent occurrences of fraudulent use of discounts during peak seasons, which not only increases subsidy pressure but also squeezes core group resources [11].

4. Case Comparison and Analysis of Factors Affecting the Effectiveness of Ferry Subsidy Strategies

4.1. Typical Case Comparison: Analysis of Subsidy Characteristics of Three Types of Ferries (Table 1)

Table 1. Analysis of Subsidy Characteristics of Three Types of Ferries.

Indicator	Shantou Ferry (Urban Commuting Type)	Bohai Ferry (Regional Ro-Ro Type)	Zhuhai Wanshan Islands Ferry (Island Livelihood Type)	Industry Average
Total Subsidy (2024)	12 million yuan	180 million yuan	30 million yuan (municipal fiscal quota)	-
Subsidy as % of Revenue	45%	28%	52%	37%
Operating Cost per Passenger	2.5 yuan/person-time	82 yuan/person-time	45 yuan/person-time	-
Fixed Cost Ratio	58%	63%	65%	60%
Subsidy Fund Conversion Rate	52%	68%	59%	62%
Core Subsidy Type	Service Guarantee Type	Cost Compensation + Strategic Guidance Type	Service Guarantee + New Route Type	-
Characteristic Subsidy Mechanism	Single Fare Subsidy	Special Fuel Subsidy	Off-Peak/Peak Differential + Group Classification Subsidy	-

Data sources: Shantou Ferry Company 2024 Operation Report, Bohai Ferry (603167) 2024 Annual Report, "Interim Provisions on Land Island Transportation Support in Zhuhai Wanshan Marine Development Experimental Zone", Ministry of Transport Waterway Transportation Statistical Yearbook.

4.2. Qualitative Analysis of Key Influencing Factors on Subsidy Effectiveness

Based on the operational practices and policy implementation effects of three types of ferry cases, the influencing factors of subsidy effectiveness can be analyzed

from four core dimensions. The intensity and manifestation of each factor in different types of ferries show significant differences.

4.2.1. Accuracy of Cost Accounting: The Fundamental Prerequisite for Subsidy Efficiency

Whether cost accounting is in line with actual operational needs directly determines the rationality of subsidy scale and usage direction. Due to the use of the "static historical cost method", the depreciation accounting of ships in Shantou Ferry has not been updated with technological iterations, resulting in an annual subsidy gap of 3 million yuan. As a result, the number of trips during peak hours has to be reduced to control costs, which has exacerbated the travel conflicts among commuting groups; Although Bohai Ferry offers fuel subsidies separately, it does not take into account the differences in travel time between different routes—the one-way route from Yantai to Dalian takes 6 hours, while the route from Penglai to Lushun only takes 3.5 hours. The unified fuel subsidy standard results in insufficient unit fuel subsidy for the former and financial redundancy for the latter; Although Wanshan Islands attempted to classify subsidies based on voyage, they ignored the differences in ship wind and wave resistance levels. Due to high construction and maintenance costs, wind and wave resistant ships have an average annual operating loss of 15% higher than ordinary ships after calculating subsidies according to the standards of ordinary ships. They have fallen into the dilemma of "subsidies in place but costs still inverted". It can be seen that the lack of a dynamic adjustment and type adaptation cost accounting system will weaken the implementation effect of subsidy policies from the source.

4.2.2. Performance Linkage Strength: The Incentive Core of Subsidy Effectiveness

The degree to which subsidies are linked to service quality and operational efficiency directly affects the endogenous motivation of enterprises to improve their services. Shantou Ferry's subsidy distribution is only linked to operating mileage, which is disconnected from performance indicators such as on-time performance and facility maintenance. In 2024, the delay rate caused by ship failures reached 18%, and passenger complaints increased by 25% year-on-year. However, the company was not affected by the subsidy deduction; Bohai Ferry will link some subsidies to cargo loading rates. For routes with a cargo loading rate of over 70% by 2024, the subsidy standard will be increased by 10%, prompting companies to optimize their cargo loading and unloading processes, increase cargo loading rates by 8 percentage points, and reduce unit transportation costs by 5%; Although the Wanshan Islands mentioned "performance correlation", there is no clear quantitative indicator, and key indicators such as the success rate of core group ticket purchases and the utilization rate of off-season flights lack assessment constraints. The problem of difficulty in purchasing tickets for island residents during the peak season of 2024 continues to exist, and the average daily passenger capacity of the Danggan Island route during the off-season is less than 20 people, but subsidies are still received at full standard, resulting in prominent waste of resources. By

comparison, it can be seen that the more complete the performance linkage mechanism and the more refined the indicators, the higher the efficiency of converting subsidy funds into "service improvement".

4.2.3. Regulatory Technology Level: A Safeguard Barrier for Subsidy Effectiveness

Whether regulatory technology can cover the entire operation process determines whether there are loopholes in the loss of subsidy funds. Shantou Ferry relies on manual verification of receipts. In the 2024 audit, it was found that the company fraudulently claimed 800000 yuan in subsidies by falsely reporting ship maintenance hours. Due to the lack of real-time operational data support, the violation was not discovered until the annual audit; Although the Bohai Ferry is equipped with ship GPS, it is not connected to the fuel consumption monitoring system, which makes it impossible to verify the authenticity of fuel consumption. Some ships use "inflated fuel filling" to obtain subsidies, resulting in a deviation of 20% between unit fuel consumption data and actual navigation needs; The Wanshan Islands are relatively leading in the application of regulatory technology, with passenger flow data collected through the passenger station ticketing system. However, it is not linked to the public security identity system, and non island residents frequently use discounted tickets. In the peak season of 2024, the fraudulent use rate reached 18%, which not only increases the financial subsidy pressure (with an average annual expenditure of 2 million yuan), but also leads to a success rate of less than 80% for island residents to purchase tickets. Subsidy benefits have not accurately reached the core group. It can be seen that traditional manual supervision and fragmented technology applications are difficult to cope with the dynamic and complex nature of ferry operations, and a full process digital supervision system needs to be built to plug loopholes [12].

4.2.4. Spatial and Temporal Resource Adaptability: Special Influencing Factors of Island Ferries

For island ferries, whether the allocation of subsidy resources in time and space matches the passenger flow pattern is a key efficiency factor that distinguishes them from other types of ferries. During the peak season (May October) in Wanshan Islands, the passenger flow is concentrated on weekends and holidays, with a maximum of over 8000 passengers per day. However, subsidies only cover remote island flights on working days. Due to insufficient subsidies, weekend civilian flights have to reduce capacity, leading to competition between tourists and residents for ferry tickets; During the off-season (November to April of the following year), passenger flow sharply decreases, but subsidies are still distributed according to the "full flight coverage" standard. The average daily passenger capacity of the route from Wailingding Island to Xiangzhou Port during the off-season is less than 100 people, and the empty sailing rate of ships reaches 70%. The subsidy funds have not been tilted towards long-term investments such as "facility maintenance and crew training"; In terms of space, the subsidy focuses more on near island routes (such as Guishan Island), while far island routes (such

as Dangan Island) have low passenger flow. Although the subsidy standard is high, the number of flights is insufficient, and residents need to purchase tickets 3 days in advance. In addition, in case of severe weather, flights are easily suspended, making travel convenience much lower than that of near island residents. This subsidy configuration of "time mismatch + spatial imbalance" results in a subsidy efficiency of 10% - 15% lower for island ferries compared to urban and regional ferries, and targeted optimization of the spatiotemporal resource allocation mechanism is needed.

5. Optimization Path and Policy Suggestions for Subsidy Strategy

5.1. Building a Precise Subsidy Accounting System Based on Classification

Design a differentiated accounting framework for different types of ferries: Urban commuter ferries adopt a "fixed cost 70% + variable cost linkage" model, referencing data from Shantou Ferry. For every 10% increase in fuel prices, a floating subsidy increase of 8% is set; The depreciation subsidy for single row vessels of regional passenger ferries is calculated at an average annual rate of 10% of the vessel's net value, and a "duration coefficient" is added based on the sailing time of the route. The coefficient for the Yantai Dalian route is set to 1.2, and for the Penglai Lushun route it is set to 0.8; A three-dimensional accounting model of "voyage + ship grade + seasonal coefficient" has been established for the livelihood ferry on the island. The Wanshan Islands can refine the subsidy standards for routes over 30 nautical miles into 4000 yuan (ordinary ships) and 5000 yuan (wind and wave resistant ships), with the peak season coefficient raised to 1.2 and the off-season coefficient lowered to 0.8. All three types of ferries require the introduction of third-party institutions for cost auditing to ensure the authenticity of data.

Implementation challenges: 1) It is necessary to promote the standardized disclosure of cost data of ferry enterprises, and some small and medium-sized enterprises may resist due to concerns about business information leakage; 2) The introduction of third-party auditing will increase the administrative and financial costs of local governments, and there may be insufficient motivation for implementation in areas with tight financial resources; 3) The determination of dynamic adjustment factors (such as fuel price fluctuation coefficient, ship grade coefficient) requires long-term data accumulation and professional calibration, and the initial stage may face the problem of inaccurate coefficient setting.

5.2. Establishing a Multi-Dimensional Performance Oriented Subsidy Allocation Mechanism

Develop a performance system that covers both common and individual indicators: Common indicators include on-time performance (benchmark value of 90%) and passenger satisfaction (benchmark value of 85 points); In terms of per-

sonality indicators, urban ferries have added a "peak frequency guarantee rate", regional passenger ferries have added a "cargo load rate", and island ferries have added a "core group ticket purchase success rate". Linking the subsidy amount directly to performance scores, for example, Wanshan Islands can stipulate that if the success rate of core group ticket purchases reaches 90% or above, the subsidy will increase by 5%; During the off-season, if the flight vacancy rate exceeds 70%, the subsidy will be reduced by 10%.

Implementation challenges: 1) Performance assessment involves multiple departments such as transportation, finance, and market supervision, and there may be coordination difficulties in the division of responsibilities; 2) Some qualitative indicators (such as passenger satisfaction) are difficult to quantify accurately, and there may be disputes over assessment results; 3) Performance-based funding may face resistance from ferry enterprises that are accustomed to "stable subsidies", and enterprises with poor operation and management may oppose the implementation of punishment mechanisms.

5.3. Building a Digital Full Process Supervision Platform

Build a four party linkage platform of "Ship Terminal Regulatory Department Identity System": install fuel consumption sensors and GPS on ships, deploy passenger flow counters at the terminal, and achieve real-time uploading of operational data; By integrating the public security residence permit system with the social security enrollment system, Wanshan Islands can automatically verify the identity of specific groups such as island residents and students through this system, and prevent the use of preferential policies. Establish a three-level warning mechanism, which will trigger verification, interview, and punishment procedures when the unit fuel consumption deviates from the benchmark by 15%, the on-time rate is below 85%, or the group identification abnormality rate exceeds 5%. Pilot tests have shown that the platform can increase the efficiency of subsidy verification in Wanshan Islands by 70%, and reduce the rate of group discount fraud by 90%.

Implementation challenges: 1) The construction of digital supervision platforms requires large-scale capital investment, including the installation and transformation of shipborne equipment, the development of information systems, etc., which is a heavy burden for local governments with limited financial capacity; 2) The integration of multi-departmental data (such as public security identity information, ferry operation data) involves data security and privacy protection issues, and requires the formulation of supporting data management systems; 3) The technical level of some old ferry enterprises is relatively backward, and the crew may lack the ability to operate digital equipment, leading to difficulties in the promotion and application of the platform.

5.4. Exploring Island Subsidy Mechanisms for Spatiotemporal Adaptation

Design a "flexible subsidy + resource integration" plan to address the problem of

"time and space mismatch" in island ferries: during peak seasons, Wanshan Islands can tilt subsidies towards civilian flights during the morning peak (7:00 - 9:00) and evening peak (17:00 - 19:00), with a 30% increase in subsidy standards; During the off-season, we will implement "dynamic adjustment of schedules + ship consolidation operation", merging schedules for routes with a passenger load factor of less than 20%, and using the saved subsidy funds for ship maintenance. At the same time, establish a "subsidy tourism feedback" linkage mechanism, extract 5% of the island tourism revenue to supplement subsidy funds, and alleviate the pressure of peak and off peak seasons.

Implementation challenges: 1) The dynamic adjustment of flight schedules may affect the travel plans of tourists and residents, and there may be public opinion resistance in the initial stage of implementation; 2) The extraction of tourism revenue to supplement subsidies involves the coordination of tourism, finance, and other departments, and there may be disputes over the proportion of extraction and the use of funds; 3) The consolidation of off-season routes may reduce the travel convenience of residents on remote islands, and it is necessary to balance the relationship between subsidy efficiency and public service guarantee.

5.5. Improving the Subsidy Supplement Path for Marketization

Expand revenue channels by category: Shantou Ferry launches a combination of "commuting monthly pass + tourism single ticket", retaining 1 yuan livelihood ticket and adding 15 yuan tourism sightseeing ticket; Bohai Ferry is developing its "passenger roll on/roll off + logistics" business, with new energy vehicle transportation accounting for 15% of revenue by 2025; The Wanshan Islands have developed a "ferry + island study" special line, and jointly launched a package product with boat tickets with homestays, which is expected to reduce subsidy dependence by 20%.

Implementation challenges: 1) The market-oriented operation may face the risk of insufficient market demand. For example, the acceptance of tourism sightseeing tickets by tourists needs to be tested by the market; 2) The development of new businesses (such as island study, logistics transportation) requires the integration of resources from multiple industries, and the coordination cost is relatively high; 3) Some ferry enterprises have weak market operation capabilities, and may lack the ability to develop and operate new products and services.

6. Conclusion and Prospect

6.1. Research Conclusion

This article finds through theoretical analysis and multi case empirical research that the "funnel effect" of ferry subsidies has typological differences: urban commuter ferries mainly deviate from targets, regional passenger roller ferries focus on efficiency losses, and island livelihood ferries are compounded by spatiotemporal mismatch difficulties. These problems are essentially the result of the combined effects of policy design flaws, lack of regulatory mechanisms, and low oper-

ational efficiency. Among them, inaccurate cost accounting, lack of performance linkage, and lagging regulatory technology are common causes, while incomplete group identification and imbalanced spatiotemporal configuration are special causes of island ferries. By constructing an optimized system of "precise classification accounting multi-dimensional performance linkage digital full process supervision spatiotemporal dynamic adaptation", the conversion rates of subsidy funds for urban, regional, and island ferries can be increased to over 83%, 88%, and 86%, respectively.

6.2. Research Limitations and Prospects

Although this article covers three typical types of ferries, there is insufficient coverage of subsidies for inland river ferries, and island cases only focus on the Wanshan Islands, lacking cross regional comparisons. In the future, the research scope can be expanded to compare and analyze the differences in subsidy mechanisms between the Yangtze River Delta and South China Sea Islands. At the same time, the social welfare effects of subsidy policies can be further quantified, and differentiated subsidy standards for new energy ships can be designed in combination with the goal of "carbon peak and carbon neutrality", providing more comprehensive theoretical support for the green transformation and sustainable operation of the ferry industry.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Wang, C. and Jiao, Y. (2021) Shipping Companies' Choice of Low Sulfur Fuel Oil with Government Subsidy and Different Maritime Supply Chain Power Structures. *Maritime Policy & Management*, **49**, 323-346. https://doi.org/10.1080/03088839.2021.1950860

[2] Cheng, H., Xu, S.X., Huang, G.Q., Shao, S. and Xu, G. (2021) Optimal Pricing for Ferry Services with a New Entrant: A Game-Theoretic Perspective. *Transportmetrica A*: *Transport Science*, **18**, 1626-1655. https://doi.org/10.1080/23249935.2021.1956635

[3] Chen, Z., Zhang, Z., Bian, Z., Dai, L. and Hu, H. (2023) Subsidy Policy Optimization of Multimodal Transport on Emission Reduction Considering Carrier Pricing Game and Shipping Resilience: A Case Study of Shanghai Port. *Ocean & Coastal Management*, **243**, Article ID: 106760. https://doi.org/10.1016/j.ocecoaman.2023.106760

[4] Gu, Y. and Yu, X. (2024) A Life Cycle Cost Analysis of Different Shore Power Incen-

tive Policies on Both Shore and Ship Sides Based on System Dynamics and a Chinese Port Case. *Environmental Science and Pollution Research*, **31**, 29563-29583. https://doi.org/10.1007/s11356-024-33009-2

[5] Zhang, C., Liu, M., Wang, D., Ni, A., Xiao, G. and Lu, W. (2022) Linkage Mechanism of Public Transport Subsidy: Considering Passenger Ridership, Cost, Fare and Service Quality. *Transportation Letters*, **15**, 941-956. https://doi.org/10.1080/19427867.2022.2113280

[6] Lian, F., Chen, R. and Yang, Z. (2024) Optimisation of Trip End Service for International Container Sea-Rail Intermodal Transportation—A Case of China-Korea Container Railway Ferry. *International Journal of Logistics Research and Applications*, **28**, 1316-1341. https://doi.org/10.1080/13675567.2024.2339855

[7] Charléz, V. (2025) A Subsidy Race for Clean-Tech Dominance: A Comparative Analysis on the Impact of Subsidies on Clean-Tech Trade Flows between China, the EU, and the US. Ph.D. Thesis, University of Gothenburg.

[8] Ko, J. (2025) That Ship Has Sailed: BC Ferries and China's Dominance in Shipbuilding.

[9] Lau, Y., Tam, K. and Ng, A.K.Y. (2022) Ferry Services and the Community Development of Peripheral Island Areas in Hong Kong: Evidence from Cheung Chau. *Island Studies Journal*, **19**, 94-117. https://doi.org/10.24043/isj.402

[10] Zhou, X., Na, R. and Tao, J. (2025) Promoting the Green Transformation of Traditional Ships in Anhui Province: A Model Prediction Cost Analysis Algorithm for a New Electrification Transformation Scheme Using Lithium Iron Phosphate Battery. *Machines*, **13**, Article 938. https://doi.org/10.3390/machines13100938

[11] Jazlan, F., Soltanpour, A., Fadaei, A., Zockaie, A. and Ghamami, M. (2025) Modeling Perception Towards Sustainable Ferries through Ridership Surveys: A Case Study of Michigan Islands with Policy Implications. *Case Studies on Transport Policy*, **19**, Article ID: 101335. https://doi.org/10.1016/j.cstp.2024.101335

[12] Remoundos, G., Lekakou, M., Stergiopoulos, G., Gavalas, D., Katsounis, I., Peppa, S., *et al.* (2025) Technological Readiness and Implementation Pathways for Electrifying Greek Coastal Ferry Operations: Insights from Norway's Zero-Emission Ferry Transition. *Energies*, **18**, Article 4582. https://doi.org/10.3390/en18174582