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Has Finance Promoted High-Quality Development in China's Fishery Economy?—A Perspective on Formal and Informal Finance

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Abstract: The high-quality development of China's fishery economy serves as its core objective, with robust financial support playing a pivotal role. This study employs provincial panel data spanning 2005 to 2020 and utilizes the entropy method to evaluate the level of high-quality development in China's fishery economy across three dimensions: fundamental security, sustainability, and comprehensive efficiency. From the perspectives of formal and informal finance, it compares their support effects on different aspects of high-quality development in China's fishery economy, while also exploring the mechanisms underlying these effects by considering factors such as industrial uncertainty and economic scale. The findings indicate that, overall, the support provided by both formal and informal finance for high-quality development in the fishery economy is insufficient. Further analysis reveals a significant threshold effect of fishery economic scale, with turning points at 108.44 billion CNY and 232.98 billion CNY for formal and informal finance, respectively. For higher-level indicators, such as sustainability and comprehensive efficiency, formal and informal financial systems demonstrate complementary roles, depending on the scale of the regional fishery economy. Furthermore, industrial uncertainty serves as a significant mediating factor only for formal financial support, with the levels of sustainability and comprehensive efficiency most affected.

Keywords: fishery economy; high-quality development; financial support; formal finance; informal finance

Key Contribution: We believe that our research makes several important contributions. First, it provides a comprehensive analysis of the role of different financial systems in promoting the high-quality development of China's fishery economy. Second, it reveals the threshold effect of fishery economic scale and the complementary roles of formal and informal finance. Finally, it identifies industrial uncertainty as a mediating factor for formal financial support.

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1. Introduction

The fishery economy plays a vital role in ensuring national food security and improving the living standards of the population. In the new era, the core objective of China's fishery economy is to achieve high-quality development [1]. Since the Reform

and Opening-up, China's fishery economy has made significant strides. Key indicators, such as aquatic product output and total fishery economic output, have ranked first in the world for consecutive years. However, the industry still encounters the challenge of being "large but not strong", with a formidable task lying ahead in terms of upgrading and optimizing its structure [2]. Official data indicate that in 2023, China's total fishery output reached 71.16 million tons, with the gross output value of the fishery economy amounting to 3267 billion CNY. However, the industrial structure of the fishery remains suboptimal, with the primary industry accounting for the highest proportion, at 48.8%. Furthermore, the scale of the fishery population remains substantial, totaling 16.99 million individuals, with a per capita income of merely 25,777.21 CNY. After achieving significant quantitative growth, the next critical challenge for China's fishery economy lies in advancing qualitative development. Attaining higher-level objectives, such as sustainability and comprehensive efficiency, while ensuring steady enhancement of fundamental capabilities, requires robust financial support. However, due to the unique production processes and product characteristics of the fishery sector, stakeholders often face substantial practical difficulties in accessing adequate financing. This issue has garnered considerable attention in academic research.

In response to this context and guided by the practical demands of high-quality development in China's fishery economy, this study systematically constructs an evaluation framework and investigates the financial support mechanisms from the dual perspectives of formal and informal finance. The analysis contributes to the theoretical understanding of financial support in the fishery sector while offering valuable insights with substantial practical implications.

2. Literature Review

2.1. Relevant Theoretical Foundations

As a vital component of the national macroeconomic system, the relationship between finance and economic development has always been a significant research topic in the field of economics. Since the mid-20th century, economists, through long-term research on the economic growth of developing countries, have formed a body of representative theoretical achievements around concepts such as financial deepening, financial structure, and financial constraints. These studies posit that the deepening of financial markets and the optimization of financial structures can promote the effective allocation of capital, thereby enhancing firms' financing and innovation capabilities. A sound and well-functioning financial market system is a critical condition for fostering rapid economic and industrial development. In many late-developing economies, whether industries can secure sufficient financial support after their initial growth phase becomes a key determinant of their long-term development prospects [3–5]. The "New Structural Economics", born out of China's economic reform and development practices, introduces the concept of an "optimal financial structure", suggesting that the optimal financial structure, corresponding to different stages of economic development, varies. Whether the financial system can provide sufficient support for industrial development depends on whether its structure aligns with the current stage of economic development and the trend of industrial structural evolution [6–8].

Applying these theoretical perspectives to China's fishery economy suggests that during its extensive growth phase, a financial structure predominantly reliant on operators' capital accumulation, government policy support, and small-scale fundraising can support rapid development. However, as China's fishery economy enters the stage of diminishing returns to scale [9], the intensified demand for capital driven by economic transformation makes effective financial support a critical issue for the sector's high-quality development.

2.2. Key Issues in Financial Support for China's Fishery Economy

Globally, fishery development is highly uneven. Developing countries, including China, have not yet achieved the level of industrialization and specialization seen in developed countries' fisheries. Despite this, the critical role of financial support in exploring suitable fishery development paths has gained widespread attention. Research on the flexibility of small-scale fishery units in production and economic resilience, the role of blue finance in promoting marine ecological sustainability and fishery development, and the financing barriers faced by small- and medium-sized fishery enterprises has generated significant reference value [10–13].

Researchers generally recognize that the key issue lies in the inherent disadvantages of fisheries when seeking financial support, due to high production uncertainty, perishable products, long payback cycles, and small-scale operations [14–16]. As a late-developing industry, early research on financial support for Chinese fisheries primarily took a theoretical perspective, focusing on industry needs and policy support to explore feasible solutions to financing difficulties. Among these, the limited financial support from formal sources, such as banks and capital markets, has garnered the most attention. Researchers argue that a moderately relaxed policy environment could help to form a favorable financial support structure for fisheries [17] and that strengthening financial risk management is a crucial guarantee for rationally guiding the optimal allocation of fishery financial resources [18]. Structural inefficiencies, institutional shortcomings, and limited financial products in China's financial markets have been cited as major unfavorable factors hindering fisheries' access to financial support [19].

2.3. The Financial Support System for China's Fishery Economy

In light of the unfavorable financing situation, researchers have identified the long-standing, relatively flexible, and pragmatic financial support paths as an important factor behind the sustained and rapid development of China's fishery economy. While there is considerable research on formal financial instruments, like fishery loans, capital markets, and insurance, the findings are inconsistent. For instance, some researchers found that fishery loans significantly promote marine fishery economic growth, but that the opposite is not true [20]. Others argue that the situation is more complex, with studies showing that overall financial development significantly boosts fishery per capita GDP and labor productivity, but that changes in the overall financial structure negatively affect these indicators. While the development of credit and insurance markets has significantly promoted the growth of fishery per capita GDP, the insurance market's contribution is relatively small; the development of credit and insurance markets does not significantly affect labor productivity. Conversely, stock market development shows a significant negative impact on both per capita GDP and labor productivity in the fishery economy [21]. Some researchers even found that financial development in China has not promoted the upgrading of the fishery industrial structure and may have had a suppressing effect, possibly due to the higher risk premiums associated with the primary sector of the fishery industry [22]. Su et al. (2021) discovered that, from a regional perspective, financial development only significantly impacts fishery economic growth in China's eastern marine economic zones, with little effect in non-coastal regions [23].

The inconsistency of formal finance in supporting fishery development has implications for other agricultural economic sectors as well. Researchers have begun to explore other financial factors contributing to the development of China's fishery economy, with widespread attention being drawn to informal finance. Lu and Yang (2008) proposed a financial path selection model in Chinese fisheries, in which informal finance serves self-employed entities, rural credit cooperatives support operational entities, commercial

banks cater to market-oriented entities, and policy finance assists support-oriented entities [24]. Various researchers have highlighted the relationship between informal finance and agricultural or overall economic development, such as the effect of informal finance on farmers' income growth. Li and Shan (2014) found that informal finance is efficient in promoting rural economic growth and has the potential to become an engine driving rural development, although regional disparities are evident [25]. With respect to the sector heterogeneity of the role of informal finance in agriculture, Wang et al. (2017) discovered that rural informal finance boosts crop planting but has a minimal influence on fishery, and likewise has little impact on forestry and animal husbandry [26]. Informal finance also plays a role in promoting agricultural scaling, with Chen and Zhang (2022) discovering that informal finance promotes overall agricultural growth through scaling [27] and that its effect on forestry is more pronounced than formal finance [28]. Informal finance also contributes to high-quality economic development, with Liu and Cao (2024) finding that informal finance fosters high-quality economic development by transforming growth modes, optimizing economic structure, and shifting growth drivers, with spillover effects across regions [29].

Moreover, most previous studies have employed single-dimension indicators, such as per capita income, total output, and innovation [30–32], when analyzing the impact of financial development on fisheries or other agricultural sectors. In the current context, where China's fishery economy emphasizes high-quality development, the representativeness and reference value of these studies are somewhat limited.

In conclusion, there are reasons to hypothesize that appropriate financial supply may positively impact multiple aspects of fishery economic development, with both formal and informal finance playing crucial roles. While existing research provides some support, it has limitations, including: (1) insufficient alignment between research designs and the current high-quality development goals of China's fishery economy, limiting the reference value; (2) the difficulty in generalizing conclusions based on single-indicator studies to the entire fishery economy, necessitating a scientific measurement of high-quality development levels based on overall goals; and (3) the unclear roles of formal and informal finance in supporting the high-quality development of fisheries, considering regional disparities in China. This paper investigates the primary objectives of high-quality fishery development using a scientific framework across three dimensions: fundamental security, sustainability, and comprehensive efficiency. It analyzes the effects of formal and informal financing on the high-quality development of China's fishery economy, explores underlying mechanisms, and provides policy recommendations to enhance financial support.

3. Methods and Data

3.1. Model Setting

3.1.1. Baseline Model

To investigate the impact of formal and informal finance on the high-quality development of China's fishery economy, this paper specifies the following baseline model, expressed in Equation (1), as follows:

$$Fishery_{it} = \alpha_0 + \alpha_1 Finance_{it} + \alpha_2 Control_{it} + \varepsilon_{it} \quad (1)$$

where i denotes the provincial administrative region and t denotes the year, *Fishery* represents the level of high-quality development of China's fishery economy, *Finance* refers to the level of development of different types of financial systems, *Control* is a vector of control variables, and ε is the error term.

3.1.2. Mediation Effect Model

Building on the baseline model, this paper draws on the mediation effect testing model proposed by Wen et al. (2004) [33] and constructs a recursive mediation model with the economic uncertainty of fisheries as the mediating variable. This approach aims to investigate the intrinsic mechanisms and differences of various types of financial support for the high-quality development of fisheries, detailed in Equations (2)–(4), as follows:

$$Fishery_{it} = \beta_0 + \beta_1 Finance_{it} + \beta_2 Control_{it} + \varepsilon_{it} \quad (2)$$

$$Risk_{it} = \delta_0 + \delta_1 Finance_{it} + \delta_2 Control_{it} + \varepsilon_{it} \quad (3)$$

$$Fishery_{it} = \gamma_0 + \gamma_1 Finance_{it} + \gamma_2 Risk_{it} + \gamma_3 Control_{it} + \varepsilon_{it} \quad (4)$$

where i denotes the provincial administrative region and t denotes the year, *Risk* is the mediating variable representing fishery economic uncertainty, *Fishery* denotes the level of high−quality development of China's fishery economy, *Finance* refers to the development level of various types of financial systems, *Control* represents a series of control variables, and ε is the error term.

3.1.3. Threshold Model

To examine the impact of economic scale, this study constructs a panel threshold model, drawing on the methodology from related research [34], illustrated in Equation (5), as follows:

$$\begin{aligned} Fishery_{it} = {} & \mu_0 + \mu_1 Finance_{it} \times I(DF \le \theta_1) + \mu_2 Finance_{it} \times I(\theta_2 < DF \le \theta_3) + \cdots + \\ & \mu_n Finance_{it} \times I(\theta_{n-1} < DF \le \theta_n) + \mu_{n+1} Finance_{it} \times I(DF > \theta_n) + \mu_{\varnothing} Control_{it} + \varepsilon_{it} \end{aligned} \quad (5)$$

where i denotes the region and t denotes the year, *DF* is the threshold variable which captures the scale of the fishery economy, θ is the threshold value to be estimated, $I(\cdot)$ is the indicator function, where $I = 1$ if the condition holds; otherwise, $I = 0$, μ represents the coefficients in different threshold regimes, capturing the impact of financial support on fishery development across those regimes.

3.2. Variables

3.2.1. Dependent Variables

The Ministry of Agriculture's guidelines on the high-quality development of China's fishery economy (Notice on Implementing Fishery Development Support Policies to Promote the High-Quality Development of the Fishery Industry (https://www.gov.cn/zhengce/zhengceku/2021-07/05/content_5622531.htm, accessed on 23 September 2024)), encompasses three key aspects: Stable Fundamental Security, Strong Sustainability, and High Comprehensive Efficiency. Stable Fundamental Security refers to positive trends in fishery output, production value and growth, underscoring the sector's capacity to maintain a consistent supply of aquatic products while supporting employment. Strong Sustainability focuses on metrics, such as unit output, average resource consumption and technological intensity, reflecting the sector's potential for sustained long-term development and ecological compatibility. High Comprehensive Efficiency encompasses key dimensions, including industrial structure, economic contributions, and per capita income, providing an integrated assessment of the sector's overall economic performance and competitive strength. This study applies the entropy method to calculate the dependent variables based on these criteria.

The High-Quality Development Index (YT) measures the overall level of high-quality development in China's fishery economy, with higher values indicating a more advanced state of development. The Fundamental Security Index (YS) evaluates the overall scale

of the fishery economy and its capacity to ensure foundational security, where higher values signify stronger foundational stability. The Sustainability Index (YQ) reflects the sustainability of fishery development, with higher values indicating greater long-term development potential and environmental compatibility, serving as a key indicator for assessing the high-quality development of China's fishery economy. The Comprehensive Efficiency Index (YE) assesses the overall efficiency and economic benefits of fishery development, where higher values represent greater efficiency and economic gains, providing an additional advanced metric for evaluating the high-quality development of China's fishery economy.

3.2.2. Independent Variables

Formal Financial Development (XN): This refers to the allocation of capital through formal financial intermediaries, including state-owned banks, policy banks, joint-stock commercial banks, and financial markets. Consistent with prior research [35,36], the level of formal financial development is quantified using the ratio of total loan balances of financial institutions to regional GDP. A higher ratio signifies a more advanced level of formal financial development.

Informal Financial Development (XU): Informal financial development encompasses financial activities conducted outside formal regulatory frameworks, often operating at the margins of regulation. It serves as a complement to formal finance, particularly in mitigating capital shortages [37]. Following established methodologies [38,39], this study employs the ratio of microloan balances to regional GDP as a measure of informal financial development. A higher ratio reflects a higher degree of development in the informal financial sector.

3.2.3. Mediating Variable

Fishery Industry Uncertainty (DF): The inherent production processes and characteristics of the fishery sector result in a higher degree of uncertainty compared to other agricultural industries, particularly in financial contexts where investment risks are pronounced. The risk assessment criteria employed by financial institutions play a critical role in shaping their investment decisions [40,41]. Such uncertainty may limit access to formal financial support, whereas informal financial systems, with a higher tolerance for risk, may provide differentiated financial backing [42]. In this study, fishery industry uncertainty is quantified as the ratio of fishery product losses to total production, with higher values indicating greater levels of uncertainty.

3.2.4. Threshold Variable

Fishery Economic Scale (XM): The substantial regional disparities in fishery development conditions across China lead to significant variations in the economic scale of the fishery sector. In general, a larger economic scale is associated with higher levels of specialization, refinement, and standardization, which in turn enhance the region's ability to attract financial resources [29]. In this study, the fishery economic scale is measured by the total output value of the regional fishery economy.

3.2.5. Control Variables

This study incorporates several control variables based on prior research [43,44], including the following:

Regional Economic Development (LnGDP): represented by the natural logarithm of per capita GDP, reflecting the overall economic performance of a region; Natural Endowments (Lnwater): measured by per capita water resource availability, capturing the region's natural resource base; Industrial Structure Optimization (Ind3): quantified as the share

of the tertiary sector in total economic output, indicating the level of industrial structure optimization; Market Development (Urbr): proxied by the urbanization rate, serving as an indicator of market expansion and modernization; Infrastructure Development (Railp): represented by per capita railway mileage, reflecting the level of regional infrastructure development; and Human Capital Quality (Lnedu): measured by per capita fiscal expenditure on education, serving as a proxy for the quality of human capital.

3.3. Datas

Due to the impact of the COVID-19 pandemic, statistical data from 2021 onward are somewhat incomplete. Accordingly, this study primarily relies on statistical indicators from 2006 to 2020 for China's provincial administrative regions. To ensure data integrity and continuity, data from Hong Kong, Macau, Taiwan, Xizang, and Qinghai are excluded. Data sources include successive editions of the China Fisheries Statistical Yearbook, China Statistical Yearbook, China Financial Yearbook, and regional statistical yearbooks. Missing values were addressed through interpolation methods. To objectively assess high-quality development in China's fishery economy based on historical data and reduce potential biases from expert evaluations, this study employs the entropy method [31]. The resulting indicators are used as the dependent variable, with the indicator system presented in Table 1. Descriptive statistics for all study variables are provided in Table 2. Unit root tests confirm that all data have the property of stationarity; multicollinearity tests indicate that all VIF values are below 10, suggesting an absence of multicollinearity. These results meet the conditions required for model estimation.

Table 1. Evaluation indicator system for high-quality development of China's fishery economy.

Indicator	Description	Attribute	IUV	Weight
The Fishery Fundamental Security Index (YS)	Total Fishery Economic Output (10,000 CNY)	+	0.1027	4.27%
	Aquatic Product Output (tons)	+	0.0721	3.00%
	Fishery Employment (people)	+	0.0626	2.60%
	Total Aquatic Products Used for Processing (tons)	+	0.1146	4.77%
	Fishery Value Added (10,000 CNY)	+	0.0902	3.75%
	Motorized Fishing Vessels (gross tonnage)	+	0.0563	2.34%
	Aquaculture Area (hectares)	+	0.0404	1.68%
	Released Fish Species (tons)	+	0.0634	2.63%
	Fishery Growth Rate (%)	+	0.0775	3.22%
The Fishery Sustainability Index (YQ)	Proportion of Fishery Circulation and Service Industry Output (%)	+	0.0957	3.98%
	Proportion of Fishery Industry and Construction Industry Output (%)	+	0.1119	4.65%
	Proportion of Aquaculture Output (%)	+	0.0757	3.15%
	Aquatic Product Output per Fishery Law Enforcement Vessel (tons/vessel)	+	0.0468	1.95%
	Aquaculture Output per Aquaculture Area (tons/hectare)	+	0.0899	3.74%
	Proportion of Intermediate Consumption in Fisheries (%)	−	0.025	1.04%
	Funding for Aquatic Technology Promotion Institutions per Fishery Population (10,000 CNY)	+	0.131	5.45%
	Proportion of Aquatic Product Losses (%)	−	0.0577	2.40%
	Per Capita Aquatic Product Output (tons)	+	0.0843	3.50%

Table 1. *Cont.*

Indicator	Description	Attribute	IUV	Weight
The Fishery Comprehensive Efficiency Index (YE)	Average Aquatic Product Processing Volume per Enterprise (tons)	+	0.0995	4.14%
	Per Capita Fishery Output Value (10,000 CNY)	+	0.1181	4.91%
	Per Capita Net Income of the Fishery Population (CNY)	+	0.1363	5.67%
	Aquatic Product Export Value (10,000 CNY)	+	0.1167	4.85%
	Composition of Fishery Value Added (%)	+	0.0818	3.40%
	Recreational Fishery Output (10,000 CNY)	+	0.121	5.03%
	Per Capita Aquatic Product Consumption in Rural Areas (kilograms)	+	0.153	6.36%
	Urban Residents' Net Income relative to Fishery Population Net Income	−	0.1321	5.49%
	Total Fishery Economic Output as a Percentage of Regional GDP (%)	+	0.0487	2.02%

Table 2. Descriptive statistics of all variables.

Variable	Observation	Min	Max	Mean	Std. Dev	Med
YT	435	3.318	60.486	16.63	13.206	10.812
YS	435	0.036	33.308	6.923	8.105	2.952
YQ	435	1.378	10.596	3.599	1.357	3.245
YE	435	0.156	22.061	5.045	4.715	3.064
XN	435	0.552	2.648	1.238	0.434	1.162
XU	435	0.256	7.525	1.296	1.017	1.025
DF	435	1.488	4147.588	624.329	936.483	166.598
XM	435	0.002	0.144	0.018	0.022	0.011
LnGDP	435	3.762	5.217	4.592	0.268	4.611
Lnwater	435	1.715	3.751	3.019	0.518	3.197
Ind3	435	0.286	0.839	0.448	0.099	0.427
Urbr	435	0.275	0.896	0.56	0.138	0.543
Railp	435	0.136	5.905	0.969	0.821	0.696
Lnedu	435	2.348	3.716	3.117	0.281	3.188

4. Results

4.1. Baseline Estimations

Using the baseline model, this study estimates the effects of formal and informal financial development on the overall and specific dimensions of high-quality development within China's fishery economy, accounting for fixed time and regional effects. The estimation results are shown in Table 3. Models (1) to (4) present the estimated effects of formal finance on the high-quality development, fundamental security, sustainability, and comprehensive efficiency levels of China's fishery economy. Models (5) to (8) show the estimated effects of informal finance on these same dimensions.

Table 3. Estimation effects of formal and informal finance on high-quality development of China's fishery economy.

	XN				XU			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
XN	−4.201 ***	−2.625 ***	0.043	−1.635 ***				
	(1.015)	(0.636)	(0.246)	(0.432)				
XU					−1.695 ***	−0.915 **	−0.086	−0.696 ***
					(0.651)	(0.383)	(0.078)	(0.250)
LnGDP	−12.70 ***	−8.606 ***	1.771 *	−5.903 ***	93.299 ***	63.751 ***	4.897 ***	24.745 ***
	(4.157)	(2.603)	(1.008)	(1.771)	(9.315)	(5.479)	(1.110)	(3.580)
Lnwater	−1.064	−0.876	0.261	−0.443	7.201 ***	4.088 ***	0.074	3.044 ***
	(1.137)	(0.712)	(0.276)	(0.484)	(1.443)	(0.849)	(0.172)	(0.555)
Ind3	−11.666 **	−3.717	−2.257 *	−5.708 **	4.482	4.562	2.324	−2.357
	(5.529)	(3.462)	(1.340)	(2.355)	(13.362)	(7.859)	(1.592)	(5.135)
Urbr	6.742	17.527 ***	−13.517 ***	2.799	−49.10 ***	−42.864 ***	−3.039 *	−3.274
	(7.927)	(4.964)	(1.921)	(3.376)	(15.954)	(9.384)	(1.901)	(6.132)
Railp	−1.717 **	−1.433 ***	0.474 ***	−0.752 ***	−4.047 ***	−2.413 ***	−0.140	−1.496 ***
	(0.647)	(0.405)	(0.157)	(0.276)	(0.790)	(0.465)	(0.094)	(0.304)
Lnedu	5.203	4.319 *	−1.369	2.265	−61.279 ***	−46.043 ***	−0.551	−14.762 ***
	(3.756)	(2.352)	(0.910)	(1.580)	(9.179)	(5.399)	(1.094)	(3.528)
Constant	69.825 ***	32.029 ***	6.860 *	29.974 ***	−208.781 ***	−127.053 ***	−16.761 ***	−66.208 ***
	(16.623)	(10.409)	(4.029)	(7.080)	(35.731)	(21.016)	(4.258)	(13.733)
YEAR	YES	YES	YES	YES	YES	YES	YES	YES
REGION	YES	YES	YES	YES	YES	YES	YES	YES
N	435	435	435	435	435	435	435	435
Adj R^2	0.973	0.973	0.847	0.963	0.948	0.959	0.827	0.948

Note: The standard errors in parentheses; ***, ** and * after numbers indicate that significance levels of 1%, 5%, and 10% passed the significance test.

The estimation results presented in Table 4 indicate that both formal and informal financial development exert limited influence on enhancing the overall level of high-quality development in China's fishery economy, as well as on its secondary sub-indicators. Except for the statistically insignificant effect on sustainability, the estimated coefficients for both types of financial development that reach statistical significance are predominantly negative. This suggests that formal and informal financial development may, to some extent, hinder the process of high-quality development in China's fishery economy.

Table 4. Descriptive statistics of new independent variables.

Variable	Observation	Min	Max	Mean	Std. Dev	Med
P-XN	435	0.052	0.454	0.210	0.093	0.198
P-XU	435	0.011	0.199	0.060	0.032	0.054

Furthermore, in the regression model analyzing the impact of formal financial development on high-quality growth in the fishery sector, regional economic development, industrial structure optimization, and infrastructure development are found to have a significant negative correlation with high-quality development in fisheries. This indicates that advancements in overall regional economic performance may create competitive or crowding-out effects from other industries, thereby further limiting the fishery sector's access to formal financial support [45]. Given the generally constrained availability of

formal financial resources, such competitive dynamics may exacerbate the challenges faced by the fishery sector in securing adequate financial support.

In the regression model assessing the impact of informal finance on high-quality development in the fishery sector, regional economic development and natural endowments exhibit a significant positive correlation with high-quality fishery development. This finding reflects a pattern distinct from that observed with formal finance but aligns with trends reported in the existing literature. In contrast, infrastructure quality and per capita educational attainment show a significant negative correlation, likely driven by crowding-out and competitive effects. Notably, the positive relationship between regional economic development and the advancement of fishery economic and financial development has been corroborated by numerous prior studies, which contrasts with the findings of the initial regression results.

4.2. Robustness Test

4.2.1. Substituting the Independent Variables

To address potential issues of spurious significance resulting from the arbitrary selection of explanatory variables, and to mitigate endogeneity concerns between explanatory and dependent variables, this study adopts an approach commonly used in the literature by employing alternative proxy variables [46,47]. Specifically, the density of regional bank branches (measured as the number of bank branches per 10,000 people) and the density of microcredit institutions (measured as the number of microcredit institutions per 10,000 people) are utilized as proxies for formal and informal financial development, respectively. The model parameters are re-estimated using these alternative proxies. Descriptive statistics for the proxy variables are presented in Table 4; the re-estimation results are summarized in Table 5.

Table 5. Estimation results after replacing independent variables.

	XN		**XU**	
	(9)	**(10)**	**(11)**	**(12)**
YT	−10.133 (9. 837)	−11.002 * (10.135)	−7.687 (7.920)	−8.148 * (6.651)
YS	−6.334 (5.569)	−7.585 * (6.461)	−10.427 (10.553)	−11.558 * (9.441)
YQ	−0.722 (0.954)	0.694 * (0.373)	−6.097 (6.248)	−9.110 * (6.166)
YE	−14.548 ** (9.536)	−15.772 ** (10.285)	−17.476 ** (9.479)	−16.104 ** (10.546)
Controls	NO	YES	NO	YES
Constant	66.278 ** (40.235)	71.588 ** (47.226)	−36.454 ** (9.299)	−39.774 ** (12.049)
YEAR	YES	YES	YES	YES
REGION	YES	YES	YES	YES
N	435	435	435	435
Adj R^2	0.743	0.751	0.589	0.661

Note: The standard errors in parentheses; ** and * after numbers indicate that significance levels of 1%, 5%, and 10% passed the significance test.

In Table 5, Models (9) and (11) present estimation results without control variables, while Models (10) and (12) include control variables. From these results, it can be observed that, after replacing the original independent variables with alternative proxy variables, the new model estimates exhibit a high degree of consistency with the original results. The effects of formal and informal finance on high-quality development in the fishery economy remain minimal, with most estimated coefficients either significantly negative or statistically insignificant. Only formal finance shows a positive effect on sustainability at the 10% significance level.

4.2.2. Changing the Estimation Method of the Dependent Variables

To mitigate potential measurement errors that may arise from using a single method to assess high-quality development in the fishery economy, this study remeasures it using the entropy–TOPSIS method applied to the original data. The newly derived series of high-quality fishery development indices (R-YT/R-YS/R-YQ/R-YE) are introduced as dependent variables in the original model for re-estimation. Descriptive statistics for the recalculated indicators are presented in Table 6; the model estimation results after replacing the dependent variables are presented in Table 7.

Table 6. Descriptive statistics of new dependent variables.

Variable	Observation	Min	Max	Mean	Std. Dev	Med
R-YT	435	3.721	62.347	18.455	14.375	12.132
R-YS	435	0.054	37.318	8.319	9.191	4.256
R-YQ	435	2.558	13.422	5.731	1.474	4.85
R-YE	435	0.656	25.18	7.114	5.365	3.717

Table 7. Estimation results after replacing dependent variables.

	XN		XU	
	(13)	(14)	(15)	(16)
R-YT	−5.533 *** (1.205)	−5.745 *** (1.315)	−1.221 * (0.831)	−1.147 ** (0.752)
R-YS	−1.332 ** (0.718)	−2.168 *** (0.915)	−1.356 * (0.974)	−1.117 ** (0.745)
R-YQ	−0.102 (0.257)	−0.148 * (0.116)	−0.154 ** (0.077)	−0.214 ** (0.088)
R-YE	−0.997 *** (0.413)	−0.889 ** (0.438)	−0.512 ** (0.279)	−0.731 ** (0.330)
Controls	NO	YES	NO	YES
Constant	9.885 *** (2.577)	12.891 *** (5.155)	−3.136 *** (0.819)	6.647 *** (4.866)
YEAR	YES	YES	YES	YES
REGION	YES	YES	YES	YES
N	435	435	435	435
Adj R^2	0.832	0.903	0.785	0.876

Note: The standard errors in parentheses; ***, ** and * after numbers indicate that significance levels of 1%, 5%, and 10% passed the significance test.

In Table 7, Models (13) and (15) present estimation results without control variables, while Models (14) and (16) include control variables. It can be observed that, after reintroducing the fisheries high-quality development index recalculated using the Entropy–TOPSIS method as the dependent variable, the overall trend in the estimation results remains largely consistent with the original model. The influence of formal and informal financial development on various dimensions of high-quality fishery development remains largely negative across the estimations.

In summary, the estimation results have passed the robustness tests conducted by substituting independent or dependent variables. The new estimation outcomes reveal a strong consistency with the initial findings, showing that both formal and informal finance exhibit limited support across various dimensions of high-quality development in China's fishery economy. This suggests that the preliminary findings of this study possess a degree of reliability, supporting further analysis of underlying mechanisms.

5. Further Analysis

The empirical findings above indicate that both formal and informal finance seem to play a negative role in promoting high-quality development in China's fishery economy. Given the strong financing demand associated with the development of the fisheries

industry, it is unlikely that China's fisheries could have achieved such rapid growth and maintained a leading global position without necessary financial support. Thus, it is challenging to draw highly credible conclusions based solely on these results. This study proposes two possible underlying mechanisms for these findings.

First, the impact of economic scale on the fishery economy's access to financial support should be considered. Numerous studies have shown that the relationship between financial development and industrial growth is nonlinear [48–50]. The scale of an industry can influence the ease of obtaining financial support for enterprises by affecting factors such as credit ratings, repayment capacity, and risk resilience. In the specific context of the fishery economy, the expansion of economic scale enables relevant enterprises to secure a greater share of production factors and market resources, thereby enhancing their capacity to manage, bear, and mitigate risks. This increased scale makes banks and other financial institutions more willing to extend loans and other forms of financial support to these enterprises. Furthermore, economies of scale can reduce production and sales costs, thereby boosting profitability, strengthening cash flows, and lowering financing costs. The regional disparities within China's fishery economy are substantial, with variations in the scale of fishery economies across regions leading to qualitative differences in their economic structures. This diversity is expected to be reflected in the distinct characteristics of financial support within each region. These observations suggest that economic scale may introduce nonlinear characteristics in the impact of financial support on the high-quality development of the fishery economy.

Second, the impact of fisheries-related economic uncertainty on access to financial support should be considered. High uncertainty is a key characteristic of fisheries that has been noted by many researchers [51–53] and significantly affects their ability to secure financial support. Affected by factors, such as the natural environment, climate, resource availability and production methods, the fishery economy is characterized by high uncertainty, which typically increases investor caution in providing financial support to fishery enterprises, thereby raising their associated financing costs. Additionally, due to this inherent uncertainty, fishery enterprises often face challenges in providing adequate collateral or guarantees, which may limit financial institutions' lending willingness and the volume of funds provided. Based on these observations, it can be inferred that China's regional disparities in fishery economies, coupled with the varying capacities of formal and informal finance to accommodate industry uncertainty, may lead each to play distinct roles in promoting high-quality development within the fishery economy.

Based on the above analysis, this section focuses on exploring the mechanisms behind financial support for high-quality fishery development in China, primarily by examining the threshold effect of economic scale and the mediating effect of industry uncertainty.

5.1. Threshold Effect of Economic Scale

Traditionally, discussions of heterogeneity have often divided regions based on China's economic geography, conducting analyses through comparisons of the eastern, central, and western regions [54]. In the context of China's fishery economy, however, traditional regional classifications may not fully apply. For example, several provinces in central and western regions, such as Hubei and Hunan, demonstrate higher levels of fishery economic development than certain eastern provinces. Therefore, a classification based on the scale of the fishery economy is more appropriate. This study adopts the approach of Zhang and Weng (2015) [55], applying a panel threshold model with fishery economic scale as the threshold variable used to examine the underlying impact mechanisms.

Before modeling the threshold effect, this study applies the F-test, with 300 rounds of Bootstrap resampling, to examine the threshold nature of the economic scale of fisheries. The test results are presented in Table 8.

Table 8. Threshold effect test of the economic scale of fisheries.

Threshold Number	F	P	10% CV	5% CV	1% CV
1	52.27	0.010 ***	32.430	38.532	52.267
2	34.86	0.127	55.80	97.015	151.613
3	123.76	0.023 **	60.878	77.969	132.639

Note: *** and ** after numbers indicate that significance levels of 1% and 5% passed the significance test.

Based on the test results in Table 8, it can be observed that the F-statistics for both the single threshold and the triple threshold of the economic scale of fisheries exceed the critical values at the 0.01 and 0.05 significance levels, respectively. This indicates a triple-threshold effect of the economic scale of fisheries on the impact of financial support for high-quality fishery development, with threshold values of 108.34 billion CNY, 232.98 billion CNY and 340.68 billion CNY. Therefore, a threshold regression model was constructed; the estimation results are presented in Tables 9 and 10.

Table 9. Threshold effect of economic scale on formal finance.

	(17) YT	(18) YS	(19) YQ	(20) YE
DF $\leq$ 1083.4	−1.397 ** (0.638)	−1.355 *** (0.383)	0.356 (0.248)	−0.411 (0.280)
1083.4 < DF $\leq$ 2329.8	2.903 *** (0.721)	1.306 *** (0.432)	0.326 (0.280)	1.262 *** (0.316)
2329.8 < DF $\leq$ 3406.8	7.306 *** (0.774)	4.006 *** (0.465)	0.653 * (0.301)	3.036 *** (0.339)
DF > 3406.8	11.310 *** (0.943)	5.989 *** (0.566)	0.819 ** (0.366)	5.324 *** (0.413)
Controls	YES	YES	YES	YES
Constant	−15.074 ** (5.950)	1.160 (3.573)	−10.348 *** (2.312)	−6.951 *** (2.606)
N	435	435	435	435
Adj R^2	0.796	0.755	0.339	0.768

Note: The standard errors in parentheses; ***, ** and * after numbers indicate that significance levels of 1%, 5%, and 10% passed the significance test.

Table 10. Threshold effect of economic scale on informal finance.

	(21) YT	(22) YS	(23) YQ	(24) YE
DF $\leq$ 1083.4	−0.05 (0.187)	0.124 (0.091)	−0.146 (0.095)	−0.027 (0.108)
1083.4 < DF $\leq$ 2329.8	−0.954 * (0.540)	−0.755 *** (0.264)	0.598 ** (0.276)	−0.786 ** (0.314)
2329.8 < DF $\leq$ 3406.8	1.319 ** (0.635)	1.056 *** (0.310)	0.199 (0.324)	0.073 (0.369)
DF > 3406.8	7.302 *** (1.060)	4.416 *** (0.517)	−0.431 (0.541)	3.588 *** (0.615)
Controls	YES	YES	YES	YES
Constant	−53.812 *** (7.986)	−9.559 ** (3.896)	−32.274 *** (4.076)	−13.268 *** (4.635)
N	435	435	435	435
Adj R^2	0.695	0.566	0.435	0.603

Note: The standard errors in parentheses; ***, ** and * after numbers indicate that significance levels of 1%, 5%, and 10% passed the significance test.

5.1.1. Threshold Effect to Formal Finance

The estimation results for the threshold effect model of economic scale in the support of formal finance for the high-quality development of China's fishery economy are shown in Table 9. Models (17) to (20), respectively, present the threshold effect estimates of

formal finance on high-quality development, fundamental security, sustainability, and comprehensive efficiency in China's fishery economy.

According to the estimation results, in regions where the economic scale is below 108.34 billion CNY, the overall effect of formal finance on high-quality fishery development is negative. However, in regions where the economic scale exceeds 108.34 billion CNY, the overall effect not only becomes positive but also exhibits a significant increase in magnitude as the economic scale rises. This trend is similarly observed across the individual indicators, with 108.34 billion CNY serving as the tipping point between negative and positive effects. For sustainability support, however, the economic scale of fisheries needs to exceed 232.98 billion CNY before the effect turns positive. Thus, 108.34 billion CNY serves as an important indicator for effectively leveraging formal financial support in high-quality fishery development across China's regions. When the economic scale of a province's fisheries surpasses this threshold, the impact of formal finance on high-quality fishery development undergoes a qualitative shift and continues to strengthen.

5.1.2. Threshold Effect to Informal Finance

The estimation results for the threshold effect model of economic scale in the support of informal finance for high-quality development of China's fishery economy are shown in Table 10. Models (21) to (24), respectively, present the threshold effect estimates of informal finance on high-quality development, fundamental security, sustainability and comprehensive efficiency in China's fishery economy.

The results indicate that informal finance also exhibits a significant threshold effect in supporting high-quality development in China's fishery economy and its required economic scale for regional fisheries is higher compared to formal finance which contrasts with the commonly perceived role and characteristics of informal finance [56]. For overall high-quality fishery development and fundamental security levels, informal finance only begins to provide substantial support when the economic scale of the fisheries reaches 232.98 billion CNY; this support effect becomes increasingly pronounced as the scale rises. For the sustainability of fisheries, informal finance exerts a positive effect, primarily in regions where the economic scale is between 108.34 billion and 232.98 billion CNY, which complements the role of formal finance, the main influence of which occurs in regions where the economic output of fisheries exceeds 232.98 billion CNY. The highest economic scale requirement for informal finance is observed in supporting comprehensive efficiency, where a positive effect only becomes significant when the output exceeds 340.68 billion CNY.

5.2. The Mediating Effect of Industrial Uncertainty

We continued our analysis of the mediating role of uncertainty in the fisheries industry. First, following the mediation effect testing steps proposed by Wen et al. (2004) [33], we conducted a mediation effect test for uncertainty in the fisheries industry. The results revealed that it only plays a significant mediating role between formal finance and the high-quality development of the fishery economy. Specifically, the direction and strength of this effect vary across different sub-indicators of high-quality fishery development. Detailed testing results are presented in Table 11.

Table 11. Mediation effect test of uncertainty in the fisheries industry.

Path	*c*	*a*	*b*	*a* × *b*	Boot SE	z	*95% BootCI*	*c′*	Type
XN => XM => YT	−7.255 ***	−0.013 ***	146.973 ***	−1.968	0.018	−108.634	−0.104~−0.033	−5.286 **	partial
XN => XM => YS	−6.319 ***	−0.013 ***	80.864 ***	−1.083	0.017	−63.986	−0.095~−0.029	−5.236 ***	partial
XN => XM => YQ	0.388	−0.013 ***	14.174 ***	−0.19	0.019	−10.041	−0.105~−0.031	0.578 **	masking
XN => XM => YE	−1.35	−0.013 ***	51.963 ***	−0.696	0.02	−35.683	−0.107~−0.030	−0.655	full

Note: *** and ** after numbers indicate that significance levels of 1%, 5%, and 10% passed the significance test.

In Table 11, *c* represents the regression coefficient in the formal finance model without the inclusion of mediating variables, indicating the total effect; *a* denotes the regression coefficient of formal finance on uncertainty in the fisheries industry; while *b* indicates the regression coefficient of uncertainty in the fisheries industry on the level of high-quality fishery development. The product $a \times b$ represents the mediating effect. The *95% BootCI* denotes the 95% confidence interval calculated through Bootstrap sampling; if the interval does not include 0, it indicates significance. *c'* represents the regression coefficient of formal finance on the level of high-quality fishery development when the mediating variable is included, indicating the direct effect. It can be concluded that industrial uncertainty plays a partial mediating role in the overall support of formal finance for the high-quality development of fisheries. Specifically, it acts as a partial mediator in supporting the foundational security of fisheries, an attenuating factor in fostering sustainability, and a full mediator in enhancing the comprehensive efficiency level within the fishery economy.

The estimation results of the mediating effect model are presented in Table 12. From this, it is evident that industrial uncertainty significantly diminishes the support of formal finance for the development level of the fisheries industry across various dimensions. The mediating effects on the overall level of high-quality fishery development, foundational security level, sustainability level, and comprehensive efficiency level are 26.336%, 16.636%, 47.49% and 100%, respectively. Notably, for the two higher-order indicators of sustainability and comprehensive efficiency, which are particularly critical for the high-quality development of the fishery economy in China at this stage, the mediating effect of industrial uncertainty is especially vital, representing an urgent issue that needs to be addressed in the pursuit of high-quality development in China's fishery economy.

Table 12. Threshold effect of economic scale on informal finance.

	(21) YT	(22) YS	(23) YQ	(24) YE
XM	146.973 *** (−5.362)	80.864 *** (−4.839)	14.174 *** (−4.455)	51.963 *** (−5.208)
XN	−5.286 ** (−2.550)	−5.236 *** (−4.142)	0.578 ** (−2.401)	−0.655 (−0.867)
Controls	YES	YES	YES	YES
Effect size	26.366%	16.636%	47.49%	100%
N	435	435	435	435

Note: The standard errors in parentheses; *** and ** after numbers indicate that significance levels of 1%, 5%, and 10% passed the significance test.

6. Discussion

6.1. Support of Formal Finance for High-Quality Development in China's Fishery Economy

Overall, the support of formal finance for the high-quality development of China's fishery economy is less than satisfactory, as evidenced by negative estimated coefficients. This phenomenon can largely be attributed to significant regional disparities within China's fishery economy, which can be partially explained by the threshold effect of the economic scale of the fisheries. When the total output value of regional fisheries' economics is below 108.34 billion CNY, the support effect of formal finance on the overall level of high-quality fishery development is negative. Conversely, once the total output value exceeds 108.34 billion CNY, the support effect becomes positive and intensifies rapidly, with further increases in the scale of fisheries' economics. Given that only eight of the 29 provincial-level administrative regions selected for this study had a total fisheries' economic output exceeding 100 billion CNY in 2020, effective support from formal finance for high-quality fishery development is not easily achievable in most regions of China. Furthermore, industrial uncertainty plays a crucial role, especially regarding the higher-order indicators of sustainability and comprehensive efficiency, where its mediating effect

is particularly pronounced. This provides valuable insights into the importance of financial support for high-quality fishery development. Since the scale of fisheries' economics is often constrained by natural endowments, focusing on industrial uncertainty is especially pertinent, as it typically signifies higher risk in the financial market, which can be a decisive factor for risk-averse investors in their investment decisions. Grassroots fishery organizations have accumulated a wealth of risk management strategies [14]. Adapting and refining these strategies based on the current development characteristics and needs of the fishery economy would be significant in mitigating risks within the industry.

6.2. Support of Informal Finance for High-Quality Development in China's Fishery Economy

The support effect of informal finance for the overall level of high-quality fishery development is similarly unsatisfactory. By introducing the scale of the fisheries' economics as a threshold variable, this study finds that informal finance requires a higher economic scale to support high-quality development. Specifically, the estimated coefficients only become positive when the total economic output of fisheries reaches at least 232.98 billion CNY, indicating that only a few provincial regions meet this condition. In supporting high-quality development within China's fishery economy, informal finance demonstrates a distinct preference for wealthier regions, diverging from the general consensus in existing studies in the literature. Many studies suggest that informal finance, as a crucial supplement to formal finance, plays an essential role in promoting industrial growth, especially during the early stages of regional economic development [29]. However, this complementary role does not appear to hold in the context of China's fishery economy. On the other hand, the insignificant mediating effect of industrial uncertainty on the relationship between informal finance and high-quality fishery development suggests a higher tolerance for risks induced by industrial uncertainty. Considering the implications for high-quality development, this characteristic of informal finance provides a referential framework for promoting industrial upgrading and structural optimization in more advanced fishery regions, while also offering strategies to support more balanced growth in less developed fishery areas.

6.3. Complementary Effects of Formal and Informal Finance

One of the most insightful findings of this study is the complementary effect observed between formal and informal finance in supporting higher-level indicators of high-quality development in the fishery economy, contingent upon economic scale. On the one hand, neither formal nor informal finance show a significant effect in supporting the fundamental security level, indicating that following prolonged rapid expansion, China's fishery economy is facing increasing difficulty in securing effective financial support through extensive growth models, rendering this approach largely unsustainable. On the other hand, in the threshold model based on economic scale, formal and informal finance exhibit a clear "complementary" effect in supporting sustainability. Specifically, informal finance demonstrates a more substantial impact in regions where fishery economic output ranges from 108.34 billion to 232.98 billion CNY, while formal finance shows a stronger support effect in regions with fishery economic output exceeding 232.98 billion CNY. This insight provides a valuable framework for different regions to explore tailored pathways toward high-quality fishery development. Furthermore, considering the markedly different sensitivities of formal and informal finance to the uncertainties within the fishery industry, this complementary relationship offers deeper explanatory value. Given the diverse segments within the fishery industry chain, entities within different chain links can form an objective understanding of their unique risk characteristics, thereby enabling them to devise more targeted financing strategies.

7. Conclusions

This paper constructs an evaluation system for the high-quality development level of China's fishery economy based on three indicators: fundamental security level, sustainability level, and comprehensive efficiency level. It examines the supportive effects of formal finance and informal finance on both the overall high-quality development of China's fishery economy and its various dimensions. Building on this, the study further analyzes the intrinsic mechanisms of financial support for high-quality fishery development by establishing a panel threshold regression model based on fishery economic scale and a mediating effect model based on fishery industry uncertainty. The conclusions drawn from the research findings provide valuable insights for both managers and operators.

The multilayered findings presented in this study offer valuable insights for exploring regionally tailored financial support strategies for the fishery economy in a country, like China, where fishery development is highly uneven across regions. Recognizing the critical roles of industry uncertainty and economic scale is essential for advancing China's fishery economy towards genuine, high-quality development. Given the sensitivity of formal finance to industry uncertainty, establishing a robust risk-sharing mechanism, and creating a standardized production supervision system for aquatic products are of significant practical importance. Considering the complementarity between formal and informal finance, the distinct types of financial products represented in the underlying financial markets, and the varied financial needs of different fishery operators, developing a differentiated multi-level financial support system will serve as a strong guarantee for the high-quality development of China's fishery economy. Achieving this objective requires the establishment of a comprehensive financial service and cooperation network that includes financial institutions, fishery enterprises, government agencies, and other relevant organizations. This network will facilitate the efficient circulation of information among enterprises, financial institutions, and policymakers, thereby enabling the introduction of practical and targeted financial products and services.

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