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Industry-finance integration activities is beneficial to the improvement of business performance of fishery companies—Based on DEA-CCR Model and DEA-Malmquist Model

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Abstract

Fisheries are an essential component of the national economy. The evaluation of fishery enterprises' business performance helps reveal the fishery industry's operating efficiency and serve the fishery economy's sustainable and high-quality development. This study used the data of fishery companies with industry-finance integration on the stock market from 2012-2021 and conducted a comparative study on the business performance of fishery companies with industry-finance integration on the stock market based on the DEA-CCR model and DEA- Malmquist index method. Two main results were revealed (i) the integration of industry and finance was an effective means to improve business performance, and the financial gains from the integration of industry and finance by listed fishery companies improve the overall efficiency and total factor productivity (TFP) of enterprises. (ii) The average TFP of listed fishery companies in China is declining, and technological decline is the main reason for the decline in TFP.

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Introduction

In recent years, China's fishery economy has continued to develop rapidly under the strategic layout of a "Strong Ocean State." The total market supply of aquatic products is sufficient, playing an essential role in ensuring national food security and promoting fishermen's income, becoming an indispensable engine in China's economic development (Zhan et al.,2016; Guan et al., 2019). However, the fishery economy also suffers from sloppy production methods, backward production equipment, and stagnant technological development, which seriously restrict the modernization of the fishery economy. In 2013, the State Council of the People's Republic of China issued "Several Opinions on Promoting the Sustainable and Healthy Development of Marine Fisheries." It held a national television and telephone conference on the construction of a modern fishery, pointing out that the construction of a modern fishery is given a prominent position so that it will be at the forefront of agricultural modernization and efforts to build a modern fishery country. In 2016, the Ministry of Agriculture and Rural Affairs, PRC issued the "thirteenth five-year plan for the development of national fisheries" the notice pointed out that "firmly establish the five development concepts, accelerate the modernization of fisheries." In the No. 1 Document of the Central Government in 2021, it was again emphasized that "we should comprehensively promote the rural revitalization and accelerate the pace of development of modernization of agriculture and rural areas." As an essential part of China's agricultural and rural modernization, fisheries modernization is the process of transformation and development from traditional experience-based fisheries to modern science-based fisheries. Therefore, it is of great theoretical and practical significance to construct a scientific and reasonable fishery performance evaluation system, evaluate the development level and stage of China's fishery industry, identify key obstacle factors in the development process, and propose targeted countermeasure suggestions. As representatives of industry productivity, listed fishery enterprises are more sensitive to market economic fluctuations and are the direct targets of industrial policies. The study of the business performance of listed fishery enterprises can reflect the current development of the fishery industry and help analyze the development trend of the fishery economy.

The integration of industry and finance, as a new form of industrial organization, refers to the capital integration between the industrial economy and the financial industry through cross-shareholding or holding and other forms of equity participation, which brings about the combination of both sides in the capital, talent, and management (Lin Yuan, 2010). With the development of trade globalization, the integration of industry and finance has become one of the essential ways for many large industrial groups to achieve economies of scale and internationalization strategies, which can bring a stable capital supply for the expansion of R&D and production, and realize the joint development of financial industry and real enterprises. Fishery companies that integrate industry and finance usually maintain a stable and close relationship with financial institutions in terms of capital supply and demand, equity, and personnel, to achieve mutual integration and co-growth. Nowadays, the rate of Chinese fishery companies entering the financial field is also increasing, and the mode of combining industry and finance is also showing a diversified trend. At the macro level, integrating industry and finance is an essential path for the fishery industry to modernize and have a substantial financing and competitive advantage. From the micro level and the internal capital allocation of fishery companies, the integration of industry and finance can optimize the company's capital structure, enrich the company's profit model, and bring convenience to its financing. However, the integration of industry and finance can also lead to new problems, such as the amplification of the operating risks of fishery companies and the exposure to high risks in the financial industry, so the business performance of fishery-listed companies with the integration of industry and finance has also attracted widespread attention.

It is of theoretical and practical significance to study fishery-listed companies with the integration of industry and finance. In terms of theoretical significance, on the one hand, most of the existing literature on the efficiency of fishery enterprises uses cross-sectional data or time series alone, lacking the comparison and analysis of differences between different enterprises in different periods. On the other hand, although scholars have studied the economic consequences of industry-finance integration, there is a paucity of studies on the economic consequences of industry-finance integration-type fishery companies. In this paper, based on the data of fishery-listed companies with industry-finance integration from 2012-2021, We used the DEA-CCR model and DEA-Malmquist index model to conduct an in-depth analysis and research on the business performance of fishery-listed companies. The results obtained can accumulate original materials for the research of fishery enterprises, enrich the theoretical research on the business performance of fishery enterprises and the economic consequences of the industry-finance integration to a certain extent, and promote and enrich the development of related disciplines. In terms of practical significance, this paper provides empirical evidence on the enhancing effect of the industry-finance integration on the operational efficiency of fishery enterprises by conducting a targeted study on the industry-finance integration of fishery companies, thus proving the importance of the practical significance of the industry-finance integration in further promoting the healthy development of China's fishery industry.

Materials and Methods

There are many foreign studies on fisheries productivity, mainly using empirical research methods such as the DEA or SFA model. Diana Tingley et al. (2005) used SRF and DEA models to study several factors affecting the efficiency of fisheries production in the English Channel and compared the two approaches to conclude that they are internally consistent. Fabio A. Madau (2009) also used a DEA model to assess the economic efficiency of a small-scale fishery in the Mediterranean region and showed that the fleet in this region has a short-term and long-term excess production capacity while showing that with the current level of technology, fishermen can increase production by adding effectively fixed inputs. Eggert (2011) analyzed the TFP performance of fisheries in three countries, Iceland, Norway, and Sweden, over the period 1973-2003, expecting that the rapid diffusion of technological innovations in fishing would contribute to an increase in TFP. Still, the empirical results showed no significant increase in TFP among these three countries despite the widespread use of best-practice fishing technologies. Elhendy (2012) used the Malmquist index to study TFP changes in a traditional fishing fleet in the Arabian Gulf from 2001-2006. Based on the results, he suggested that improving fishing technology and fishermen's fishing skills should be prioritized.

Most studies on fisheries efficiency in China have used empirical analysis, and the main models, like those commonly used in foreign studies, are DEA and SFA models. For example, Zhang Tong (2006) used the Malmquist index analysis to measure and analyze the aquaculture capacity of 11 Chinese coastal provinces and cities from 2000 to 2005 and concluded that the pure technical efficiency of Chinese aquaculture is high. Still, the overall efficiency performance is low, mainly caused by the low scale efficiency. Ping Ying (2013) studied the fishery production efficiency of 31 regions in China in 2011 using a nonparametric DEA model. The results showed that most regions had sloppy production methods, low production efficiency, and excessive inputs of fishery production factors. Yu Shuhua (2013) measured TFP in 11 coastal provinces and cities using the Malmquist index analysis and empirically concluded that TFP in China's coastal fisheries has improved significantly in recent years. However, most provinces and regions are non-intensive in terms of technological progress, so the overall efficiency still needs further improvement. Xiao Shan et al. (2008) used the DEA method to evaluate the effectiveness of the fishery economy in 11 coastal provinces and cities and adjusted the non-DEA-effective provinces and cities to provide practical suggestions for the sustainable development of the fishery economy in the future. Using DEA, Xi Liqing et al. (2010) measured the economic efficiency of fisheries in 29 Chinese provinces and cities from 1999 to 2007, and the results showed that coastal regions and inland regions differed in their TFP growth patterns, with coastal regions focusing on technological progress and inland regions pursuing both technological progress and technical efficiency.

According to a study on industry-finance integration in China and foreign, Elyasiani and Jia (2010) concluded that the stability of firms' equity holdings in financial institutions is homogeneously associated with their business performance, that is to see, the more stable the firm's equity holdings, the better the business performance. Based on previous theoretical analysis, Steven and Maria (2009) established a comprehensive evaluation index system for the performance of industry-finance integration. The study shows that the implementation of the industry-finance integration has a significant positive impact on improving the TFP of the company, especially for the factor productivity of the core business. Tan Xiaofang et al. (2016) studied the current industry-finance integration combination of state-owned listed companies. They suggested that its effectiveness has been initially improved.

The profitability of the companies operating and financial assets after implementing the industry-finance integration has been improved. Industrial capital and financial capital have produced synergistic effects. Wang Aidong et al. (2017) studied the effect of implementing industry-finance integration in different industries using the super-efficiency DEA model. They found that the overall efficiency increased in each industry, but the degree of effectiveness was different. Sheng Anqi et al. (2018) analyzed the data of A-share manufacturing companies listed in 2015. They found that implementing industry-finance integration by building financial equity can effectively improve the market competitiveness of real enterprises. However, other parts of scholars believe that enterprises cannot effectively synergize industrial and financial capital after implementing the industry-finance integration, and the industry-finance integration is ineffective or even negative for enterprises. Li and Greenwood (2004) studied the impact of industry-finance integration on the overall performance of corporate groups from a strategic management perspective. Due to industry differences, the lack of proper synergy between firms and financial institutions has not allowed firms to improve their operational efficiency. Therefore, the initiative of industry-finance integration was considered ineffective. Huang Changfu and Xu Yaqin (2016) conducted an empirical investigation on the status of the industry-finance integration of Chinese manufacturing listed companies, analyzed the industry-finance integration of A-share manufacturing listed companies participating in non-listed financial institutions listed in Shanghai and Shenzhen from 2009 to 2013, and studied its relationship with the investment efficiency of enterprises and the market performance of enterprises. The results showed that the industry-finance integration effectively improved enterprises' investment efficiency and market performance but harmed the improvement of financial performance, which is especially obvious in non-state-owned enterprises.

In summary, abundant studies exist on the economic consequences of fishery industry efficiency and industry-finance integration outside China. Still, only some scholars have studied and evaluated the business performance of listed fishery enterprises with industry-finance integration. This study on the business performance of listed fishery companies with industry-finance integration can help us understand the impact of industry-finance integration on fishery companies and provide a reference for the efficient development of fishery companies.

Model Construction

Among the methods of measuring operating efficiency, there are "parametric methods" represented by SFA (Stochastic Frontier Analysis) and "non-parametric methods" represented by DEA (Data Envelopment Analysis), depending on whether the model can construct a " production frontier " or not. Parametric methods generally mean that the estimator designs the production function according to the theory, uses statistical methods to estimate the parameters in the functional equation, and calculates the efficiency value. The non-parametric method means that the specific form of the production frontier cannot be known in advance and only the efficiency value needs to be calculated. In this study, we apply DEA to measure the operating efficiency of fishery-listed companies with industry-finance integration.

DEA-CCR model

The CCR model is the earliest and most widely used modeling method in DEA, which can analyze the efficiency of a company's operation with multiple inputs and outputs and is not affected by the input and output data units. The CCR model divides several companies into DMU (Decision Making Units), each consisting of input and output vectors. The input and output DMU are combined into a matrix to represent all the data in all DMU. The DEA validity of each DMU is determined by whether it falls on the practical production frontier.

Therefore, this paper adopts the CCR model to analyze fishery-listed companies' comprehensive efficiency with industry-finance integration statistically. Its basic principles and expressions are:

Suppose there are n comparable DMU, and each $DMU_j(j=1,2,\ldots,\mathrm{n})$ has the same type of m inputs (representing the DMU's consumption of the resource) x_j and s outputs (representing the "effectiveness" of the resource when it is consumed) y_j . Namely, $X_j=(x_{1j},x_{2j},\ldots,x_{mj})^T$; $Y_j=(y_{1j},y_{2j},\ldots,y_{sj})^T$, $j=1,2,\ldots,\mathrm{n}$; The weight vectors corresponding to m inputs and s outputs are denoted as v and u. $V=(v_1,v_2,\ldots,\mathrm{v}_m)^T$; $U=(u_1,u_2,\ldots,\mathrm{u}_s)^T$. So, the efficiency calculation of $DMU_{j0}\,(j_0=1,2,\ldots,\mathrm{n})$ can be translated into the following planning problem:

$$\begin{cases} \max h_0 = \dfrac{\sum_{r=1}^{s} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}} \\ s.t. \dfrac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \\ u_r \geq 0, v_i \geq 0; r=1,2,\ldots,\mathrm{s}; \mathrm{i}=1,2,\ldots,\mathrm{m} \end{cases} \tag{1}$$

By C^2-transforming and introducing non-Archimedean infinitesimal $(\varepsilon=10^{-6})$, the duality programming of Eq. (1) is:

$$\begin{cases} \min[\theta - \varepsilon(\hat{e}^T s_i^- + e^T s_r^+)] \\ s.t.\sum_{j=1}^{n}\lambda_j x_{ij} + s_i^- = \theta x_{ij_0} \\ \sum_{j=1}^{n}\lambda_j y_{rj} - s_r^+ = y_{rj_0} \\ \lambda_j \geq 0; s_i^- \geq 0; s_r^+ \geq 0; \theta \in R \\ \mathrm{j} = 1,2,...,\mathrm{n};\ \mathrm{i} = 1, 2, ..., \mathrm{m};\ \mathrm{r} = 1, 2, ..., \mathrm{s} \end{cases} \tag{2}$$

$\hat{e} = (1,1,...,1)^T \in E^m; e = (1,1,...,1)^T \in E^s$; s_i^- , s_i^+ is a slack variable; θ represents the effective value of the DMU, and reflects the minimum value that can be achieved by reducing all inputs in the same proportion while maintaining no reduction in output. Let the optimal solution of the model be λ_j^*, s_i^{-*}, s_r^{+*}, θ^*, then there is the conclusion : ① The DMU_{j_0} is said to be DEA(CCR) effective if $\theta^* = 1$ and $s_r^{+*} = s_i^{-*} = 0$. ② The DMU_{j_0} is said to be DEA(CCR) weak effective if $\theta^* = 1$ and $s_i^{-*} \neq 0$ or $s_r^{+*} \neq 0$. ③ The DMU_{j_0} is said to be DEA(CCR) noneffective if $\theta^* < 1$. In the case of ② and ③, it means that there are too many inputs or not enough outputs. Let $\hat{x}_{ij_0} = \theta^* x_{ij_0} - s_i^{-*}$, $\hat{y}_{rj_0} = y_{rj_0} + s_r^{+*}$, Then $(\hat{x}_{ij_0}, \hat{y}_{rj_0})$ is the projection of DMU_{j_0} on the effective frontier surface, i.e., it is DEA effective concerning the original n DMUs.

DEA-Malmquist Index Model

The Malmquist index model is a method proposed by the Swedish scholar Malmquist in 1953 to analyze the trend of dynamic efficiency changes. On this basis, Shephard (1970) proposed the "distance function," which was later applied to productivity analysis by Caves et al. (1982) to form the theoretical model of the DEA-Malmquist productivity index method. Fare (1989) and Grosskopf (1993) turn the Malmquist index from a theoretical model into an empirical approach built on Caves. The model can decompose the change in TFP into technical efficiency change, which reflects the change in the production frontier, and technological change, which captures the impact of technological and institutional factors on the production frontier. This study also adopts the Malmquist index model to analyze the dynamics of TFP of fishery-listed companies with industry-finance integration.

Using the time t period technology T_t as a reference, the Malmquist index based on the output perspective can be expressed as:

$$M_0^t(x_{t+1}, y_{t+1}, x_t, y_t) = d_0^t(x_{t+1}, y_{t+1}) / d_0^t(x_t, y_t) \tag{3}$$

Similarly, using the time t+1 period technology T_{t+1} as a reference, the Malmquist index based on the output perspective can be expressed as:

$$M_0^{t+1}(x_{t+1}, y_{t+1}, x_t, y_t) = d_0^{t+1}(x_{t+1}, y_{t+1}) / d_0^{t+1}(x_t, y_t) \tag{4}$$

To avoid the differences caused by the arbitrary choice of periods, Caves et al. take the geometric mean of both as the Malmquist index measuring the productivity change from period t to period t+1, following the construction method of Fisher's ideal index.

The Malmquist production index based on total factor technology level in period t is:

$$M_0^{t\ t+1}(x_{t+1},\ y_{t+1},\ x_t,\ y_t)\ =\sqrt{\frac{d_0^t(x_{t+1},\ y_{t+1})}{d_0^t(x_t,\ y_t)}}\times\sqrt{\frac{d_0^{t+1}(x_{t+1},\ y_{t+1})}{d_0^{t+1}(x_t,\ y_t)}} \tag{5}$$

where $(x_{t+1},\ y_{t+1})$ and $(x_t,\ y_t)$ denote the input and output vectors for periods t+1 and t, respectively; d_0^t and d_0^{t+1} denote the distance functions for periods t and t+1, respectively, with technology T_t in period t as the reference.

The Malmquist index obtained according to the above treatment has good properties, and it can be decomposed into the composite technical efficiency change index (TEC) and the technical progress change index (TPC) under the assumption of constant returns to scale, which is decomposed as follows.

$$M_0^{t\ t+1}(x_{t+1},\ y_{t+1},\ x_t,\ y_t)=\frac{d_0^{t+1}\left(x_{t+1},\ y_{t+1}\right)}{d_0^t\left(x_t,\ y_t\right)}\times\sqrt{\frac{d_0^t\left(x_{t+1},\ y_{t+1}\right)}{d_0^{t+1}\left(x_{t+1},\ y_{t+1}\right)}\times\frac{d_0^t\left(x_t,\ y_t\right)}{d_0^{t+1}\left(x_t,\ y_t\right)}} \tag{6}$$

$$TEC=\frac{d_0^{t+1}\left(x_{t+1},\ y_{t+1}\right)}{d_0^t\left(x_t,\ y_t\right)} \tag{7}$$

$$TCP=\sqrt{\frac{d_0^t\left(x_{t+1},\ y_{t+1}\right)}{d_0^{t+1}\left(x_{t+1},\ y_{t+1}\right)}\times\frac{d_0^t\left(x_t,\ y_t\right)}{d_0^{t+1}\left(x_t,\ y_t\right)}} \tag{8}$$

Where TEC can be further decomposed into pure technical efficiency change (PTEC) and scale efficiency change (SEC).

Specifically, the judgment rules of the Malmquist index method are as follows: (1) If the Malmquist index is greater than 1, it indicates that the production unit has achieved productivity improvement from period t to t+1; if the Malmquist index is equal to 1, it means that the productivity of the DMU has not changed; and if the Malmquist index is less than 1, it means that the DMU has experienced a productivity decline. (2) TEC > 1, which means that the relative technical efficiency of DMU has improved from period t to t+1; if TEC = 1, it means that the technical efficiency of DMU has not changed; TEC < 1 means that the technical efficiency of DMU has decreased. (3) TPC > 1 indicates that the DMU has achieved technological progress from period t to t+1, i.e., the production frontier has been improved; if TPC = 1, it means that the technology of the DMU has not changed from period t to t+1; TPC <1 indicates that the DMU has suffered a technological decline.

Data Pre-Processing

The DEA model requires that the data on the sample must be positive values. At the same time, the original data has negative and zero values, so the panel data must be preprocessed before the model calculation is performed. This paper standardizes the raw data to ensure that the data are positive. Suppose i represents a particular indicator of an enterprise, and $i_{\max}$ and $i_{\min}$ represent the maximum and minimum values of the sample data of this indicator, respectively. Then, the standardization formula of the panel data is:

$$I=0.1+0.9\times\frac{i-i_{min}}{i_{max}-i_{min}} \tag{9}$$

Data sources

To study the business performance of fishery-listed companies with industry-finance integration. Referring to the practice of available literature, this study takes whether a company holds foreign long-term equity investment as the basis of whether it has carried out an industry-finance integration. Finally, continuous financial data from 2012-2021 of seven Chinese fishery companies listed in Shanghai and Shenzhen were selected as the study samples. All data was obtained from the Wind database and CSMAR database. Details of all companies are shown in **Table 1**.

Table 1 Basic situation of fishery-listed companies with industry-finance integration

Company name	*Abbreviations*	*Stkcd*	*Year-to-market*	*Business scope*
CNFC OVERSEAS FISHERIES CO., LTD	COFC	000798	1998	Argentine squid, Peruvian squid, swordfish and tuna and bycatch species and other pelagic fisheries fishing; aquatic products trade, ship repair, fishing vessels and fishing equipment and fishing supplies import and export
ZONECO GROUP CO., LTD	ZONECO	002069	2006	The main industries are seafood, seawater breeding and marine food, and the related multi-industries are cold chain logistics, marine leisure and fishery equipment.
BAIYANG AQUATIC GROUP, INC	BAIYANG	002696	2012	Aquatic feed and aquaculture, tilapia and other aquatic products deep processing industry
ZHANJIANG GUOLIAN AQUATIC PRODUCTS CO., LTD.	GUOLIAN	300094	2010	Introduction, research and development, breeding and sales of aquatic seeds, aquatic feeds and aquatic products
SHANGHAI KAICHUANG MARINE INTERNATIONAL CO., LTD	KAICHUANG	600097	1997	Tuna, cod and other offshore fishing, aquaculture of marine and freshwater products, fishing boats, fishery machinery, marine equipment and accessories, rope nets and related products
SUZHOU TAIHU ELECTRIC ADVANCED MATERIAL CO., LTD	TAIHU	600257	2000	Silver carp, Chinese soft-shelled turtle and other freshwater aquaculture fishing, aquatic products seed breeding, lake water environment management
SHANDONG HOMEY AQUATIC DEVELOPMENT CO., LTD	HOMEY	600467	2004	Ecological seawater nursery and breeding, sea cucumber and abalone breeding and deep processing, marine biological medicine and health care

Among the seven listed fishery companies selected for this study, KAICHUANG is the earliest listed fishery company, and the last listed company is BAIYANG. The regions where the listed fishery companies are located are primarily concentrated in the east of China. In contrast, TAIHU is located in the central region, and its operation and operation space are cross-sea. From the overall number, the number of listed companies in China's marine fishery industry is relatively small, and there are not many large-scale enterprises. At the same time, the operation mode of each listed fishery company is relatively single, primarily concentric diversification with highly related industries, carrying out offshore fishing and simple aquatic products breeding and primary processing, as well as fishing vessel trading. Only a relatively small number of companies have expanded the company business, such as HOMEY's medical care and ZONECO's recreational fishing.

Index selection

output indicator

This paper uses the leading business profit margin and return on equity to measure the company's output under certain input conditions in a certain period. The primary business profit margin mainly measures the profitability of the company’s main business, avoids the deviation of profit estimation due to income instability, and reflects the integration of industry and finance on the company's main business. The return on net assets is used as the output index of the listed fishery companies, which mainly considers the benefits of long-term equity investment to the company's equity owners and also makes up for the lack of financial benefits in the primary business profit rate.

<u>input indicator</u>

(1) Size of the company. The size of a company mainly includes the company's fixed assets investment, working capital investment, and other capital investment associated with production and operation activities. Whether a company uses input capital for production and whether it develops and utilizes it appropriately is an essential factor in our evaluation of its operating efficiency. The theory of scale economy suggests that a company's pursuit of expansion of scale can bring the company economies of scale by reducing the operating costs within the company. As an indicator reflecting the company's size, total company assets can fully reflect the company's overall investment in each asset while also considering the impact of economies of scale on the company's operating efficiency. In this paper, total company assets are used as an evaluation index of company size and logarithmically processed to ensure the reasonableness of asset size comparison among different companies.

(2) Company's operating capacity. The company's operational capability index mainly reflects the company's utilization of various assets, and the operational efficiency of assets is directly related to the company's cost savings and profit creation. In this paper, the total asset turnover ratio is chosen to consider the overall utilization of the company's input capital, and the current asset turnover ratio is used to reflect the efficiency of the enterprise's liquid assets to consider the overall operating capacity of the company from the above two aspects.

(3) Company's riskiness indicators. The company's riskiness indicators reflect the company's capital structure, solvency, and liquidity of assets. To a certain extent, a company's debt can increase its profitability, but excessive debt can bring financial risks and reduce corporate earnings. The gearing ratio is used to measure the ability of a company to use funds supplied by creditors to engage in risky business activities, so this indicator is used to evaluate the riskiness of a company. For the liquidity of corporate funds and the impact of the ability to repay debts on the business risk, the current ratio and quick ratio are selected to measure this paper.

In summary, the definitions of output and input indicators and the corresponding detailed formulas of the listed enterprises with industry-finance integration are shown in **Table 2**.

Table 2 Breakdown of input-output indicators of listed enterprises in the industry-financed fishery

Indicators			*Details*
Output Indicators	Profit margin from main business	Y1	Profit from main business / Revenue from main business ×100%
	Return on Assets	Y2	Total EBIT/average total assets ×100%
Input Indicators	Size	X1	In (Total assets)
	Total assets turnover ratio	X2	Operating income/total assets ×100%
	Current asset turnover ratio	X3	Operating income/average occupancy of current assets ×100%
	asset-liability ratio	X4	Total liabilities at end of period/total assets at end of period ×100%
	Current Ratio	X5	Current assets/current liabilities ×100%
	Quick Ratio	X6	Quick assets/current liabilities ×100%

Results

Static analysis of the DEA-CCR model

The CCR model in DEA can evaluate DMU's overall efficiency, i.e., technology and scale's combined efficiency. In this paper, DEAP 2.1 is used to plan and solve for the business performance of listed fishery companies and the mean values of the combined efficiency of seven listed fishery companies in the two operating cases of considering financial returns and not considering financial returns from 2012 to 2021 are obtained based on two different output indicators of central business profit margin and return on net assets, respectively, the two types of efficiency means are made as **Figure 1**. The line graph shown in **Figure 1** is used for comparative analysis.

Figure 1 shows that when financial gains are not considered, only three companies, namely, COFC, TAIHU, and HOMEY, have reached DEA effective with a combined efficiency of 1. When financial gains are considered, all six companies except GUOLIAN Fisheries achieve DEA validity, and the comprehensive efficiency of Guolian Fisheries also increases from 0.517 to 0.78. This indicates that the Integration of industry and finance by companies is conducive to improving comprehensive efficiency.

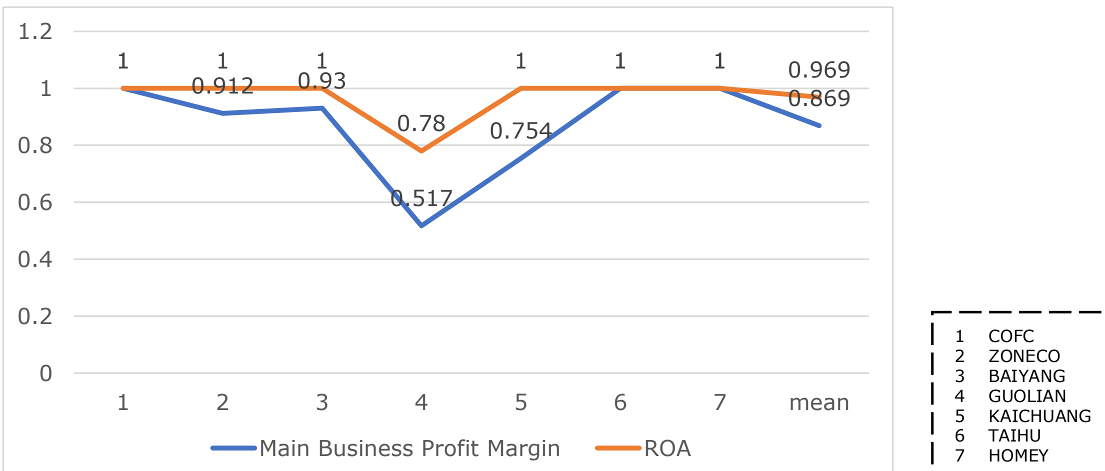

Figure 1 Comparison of average technical efficiency of fishery-listed companies

Dynamic analysis of DEA- Malmquist index

This paper uses DEAP 2.1 software to calculate the year-to-year changes of the Malmquist productivity index of seven fishery-listed companies with industry-finance integration from 2012 to 2021, the details of indicators are shown in **Table 2**. The experimental results are shown in **Table 3** and **Table 4**. means the performance level shows an increasing trend compared with the beginning of the year, and less than 1 means the performance level has decreased; the rate of TEC, the rate of PTEC, and the rate of SEC represent the influence of institutional improvement, capital allocation and SEC on the performance level. Such indexes more significant than 1 means the decomposition index has improved the performance level of the enterprise in the current year, and vice versa means the performance has decreased in the year.

Overall, As can be seen from **Figure 2**, the TFP of listed fishery companies shows a decreasing trend during 2012-2021, with an average decrease of 2.5% when financial gains are not considered and 0.9% when financial gains are considered. Thus, it seems that the Integration of industry and finance by listed fishery companies helps to improve their own TFP. From the decomposition of all factors, the technological decline is the main reason for the decrease in the mean value of TFP, regardless of whether the Integration of industry and finance is considered or not. As seen from **Table 3**, except for ZONECO and HOMEY, the rest of the enterprises' technology is declining. Technological progress is an important engine to guide the transformation of Chinese fisheries from traditional to modern industries. Therefore, maintaining technological progress is a sure way to promote Chinese fisheries' long and efficient development.

Table 3 Firm means of Malmquist index and its decomposition results

Output Indicators	*Main Business Profit Margin*					*ROA*				
Companies	*TEC*	*TCP*	*PTEC*	*SEC*	*TFP*	*TEC*	*TCP*	*PTEC*	*SEC*	*TFP*
COFC	0.971	0.909	1.000	0.971	0.883	1.000	0.969	1.000	1.000	0.969
ZONECO	1.010	1.013	1.000	1.010	1.023	1.000	1.061	1.000	1.000	1.061
BAIYANG	0.977	0.962	0.973	1.004	0.941	0.991	0.990	0.999	0.992	0.981
GUOLIAN	1.068	0.965	1.063	1.005	1.031	1.021	0.997	1.012	1.009	1.018
KAICHUANG	1.032	0.963	1.000	1.032	0.994	1.000	0.945	1.000	1.000	0.945
TAIHU	1.000	0.959	1.000	1.000	0.959	0.990	0.952	0.990	1.000	0.942
HOMEY	1.000	1.002	1.000	1.000	1.002	1.000	1.025	1.000	1.000	1.025
mean	1.008	0.967	1.005	1.003	0.975	1.000	0.990	1.000	1.000	0.991

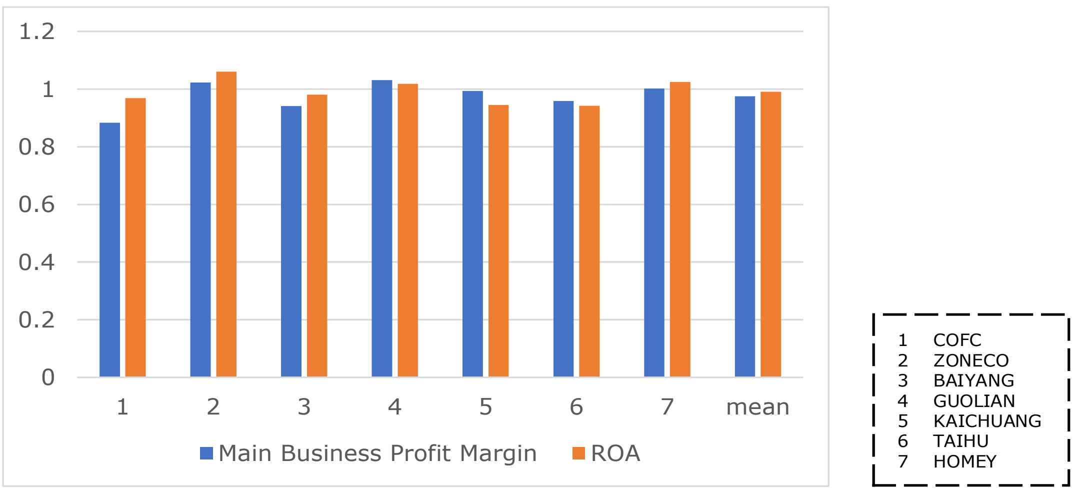

Figure 2 Comparison of TFP of listed fishery companies

The annual average TFP and its decomposition results of the listed companies in the industry-financing fishery are shown in **Table 4** and **Figure 3**. From the average annual TFP, it can be seen that the TFP of Chinese listed fishery companies shows a decreasing trend, and the rate of decrease of TFP considering financial returns is 0.9%, significantly lower than the rate of decrease of TFP without considering financial returns, which is 2.5%. It can be seen that the implementation of the industry-finance integration has improved the overall TFP of fishery companies. When financial gains are not considered, only 2013-2014, 2016-2017, and 2020-2021 are in a state of growth, with 2020-2021 showing the most growth with a growth rate of 10.5%; When financial gains are considered, the four years 2012-2013, 2015-2016, 2017-2018, and 2019-2020 all show growth, with 2019-2020 having the highest growth rate of 40.4%. The growth in the two periods, 2020-2021 and 2019-2020 is mainly due to the increase in technical efficiency, especially scale efficiency, which shows that the scale effect can lead to efficiency growth.

Table 4 Annual mean values of Malmquist index and its decomposition results for listed companies in the industry-financed fishery industry

Output Indicators	*Main Business Profit Margin*					*ROA*				
year	*TEC*	*TCP*	*PTEC*	*SEC*	*TFP*	*TEC*	*TCP*	*PTEC*	*SEC*	*TFP*
2012-2013	1.139	0.791	1.068	1.066	0.901	0.999	1.068	1.008	0.991	1.067
2013-2014	0.950	1.106	0.946	1.004	1.051	0.950	0.955	0.942	1.009	0.908
2014-2015	1.014	0.961	1.026	0.988	0.974	1.056	0.909	1.052	1.004	0.960
2015-2016	0.991	0.993	1.010	0.981	0.984	0.997	1.065	1.019	0.979	1.063
2016-2017	0.987	1.070	1.000	0.987	1.056	0.964	0.980	1.003	0.961	0.944
2017-2018	1.049	0.899	1.000	1.049	0.943	1.041	0.986	1.000	1.041	1.027
2018-2019	1.013	0.956	1.013	1.001	0.969	0.752	0.957	0.965	0.779	0.719
2019-2020	0.789	1.043	0.954	0.828	0.823	1.297	1.083	1.000	1.297	1.404
2020-2021	1.194	0.926	1.034	1.155	1.105	1.025	0.928	1.017	1.008	0.951
Mean	1.008	0.967	1.005	1.003	0.975	1.000	0.990	1.000	1.000	0.991

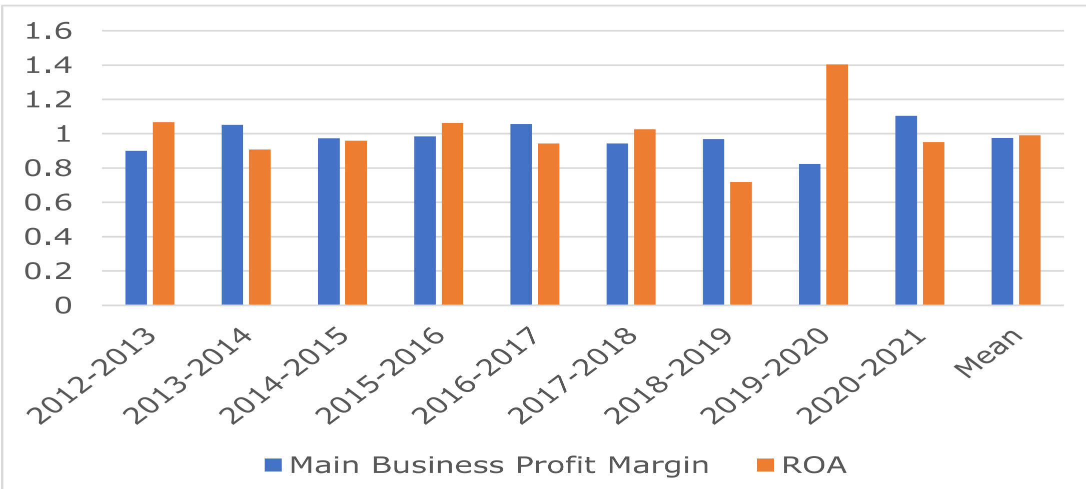

Figure 3 Comparison of annual average TFP

Discussion

Main Conclusions

(1) During 2012-2021, only 3 firms that did not consider financial gains achieved DEA validity, while 6 firms achieved DEA validity after considering financial gains. The implementation of the integration of industry and finance increases the performance of companies.

(2) The annual average TFP of listed fishery companies and the average TFP of each company in 2012-2021 are decreasing, and technological decline is the main reason. TFP considering financial gains is higher than TFP without considering financial gains. Over the years and in companies with rising TFP, rising PTEC is the main reason driving the rise in TFP.

Recommendations

Through the analysis of the business performance of fishery-listed companies with industry-finance integration, we propose the following recommendations.

(1) Strengthen the efforts of scientific and technological innovation and promotion and application, and improve the level of technological progress. From the results of the dynamic analysis of the DEA-Malmquist index, the main reason for the decline of TFP is the technological decline. Since the 1960s and 1970s, China's innovation in basic research of offshore fishing vessels and nets, high-performance materials of fishing gear, and fishing

auxiliary technology have stagnated, resulting in the equipment and technology related to vessels and nets seriously lagging behind the developed countries in fisheries. Therefore, it is necessary to increase fishery science and technology innovation, improve the mechanism of scientific and technological personnel guarantee, and accelerate technology diffusion and industrial integration. Fishery production departments should not only accelerate the development of technology and transformation of results within the fishery industry in the direction of high, precise, and deep research but also gradually improve the fishery industry technology system and transformation system, accelerate the progress of fishery technology and improve the efficiency of fishery technology.

(2) Strengthen the linkage between industry and finance, increase capital investment, expand enterprises' scale, and improve enterprise resource utilization to promote the growth of enterprise business performance. In the operation process of fishery-listed companies with industry-finance integration, it is also necessary to strictly prevent financial risks while using financial enterprises to bring benefits to improve the operational efficiency and risk prevention level of the company faster and more steadily.

Implications for foreign listed fishery companies

From international experience, there are still problems of low business performance and sustainable development of fisheries in foreign-listed fishery companies. After analysis, We propose the following suggestions.

(1) Strengthen the integration of industry and finance in fisheries. Although the fishery industry is relatively developed in some developed countries, it is still in a rough and single-product development stage, and the transformation of the fishery is a long way to go. With the reduction of marine resources and the limited space for fishery survival and development, it is imperative to transform the fishery's development mode, promote the fishery's supply-side structural reform and achieve sustainable development. The integrated development of the fishery industry is an important measure to extend the fishery industry chain, enhance the fishery's value chain, and expand the fishery's income chain. This paper proposes to extend the path of fishery industry integration development in four aspects, such as enhancing the added value of aquatic processing, developing fishery e-commerce, cultivating new fishery businesses, and increasing financial support to realize the income increase of fishermen, the beauty of fishing villages and the prosperity of fishing areas, to improve the business performance and promote the sustainable development of fishery.

(2) Modern technology is continuously applied to fisheries. Despite the differences in natural conditions and socio-economic conditions among countries, they all have in common the reliance on a strong foundation of industrial modernization to develop fisheries. By refining the focus on equipping the fishing industry with industrial equipment and focusing on the development of fishing machinery, we will improve labor productivity and thus improve the business performance of the fishing industry.

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