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The Upgrading of Fishery Industrial Structure and Its Influencing Factors: Evidence from China

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Abstract: Aquatic products have made an increasingly important contribution to ensuring food security and nutrition. The huge and dynamic aquatic product consumption market in China has created a new consumption pattern, and the transformation and upgrading of the aquatic industry is essential. Using system generalized method of moments (GMM) and fishery industry data from 2003 to 2019 in 31 provinces and regions, this paper constructs the upgrading index of fishery industrial structure and finds that: (1) In general, the upgrading level of China's fishery industrial structure is on the rise, but it is still in its infancy. (2) The upgrading level of the fishery industrial structure in coastal areas is greater than that of inland areas. (3) The level of economic development and the labor productivity of primary fishery industry are the key influencing factors of China's fishery industrial upgrading. (4) By comparing the heterogeneity of the impact of various factors on the upgrading of fishery industrial structure in coastal and inland areas, the impact is mainly in coastal areas. To promote the upgrading of China's fishery industrial structure, this paper puts forward some suggestions.

Keywords: China; fishery; the industrial upgrading; influencing factors; system GMM

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1. Introduction

With the rapid development of economics, the requirement of food quality has been greatly enhanced. Aquatic products are an important source of high-quality protein. In recent years, consumers' demand for aquatic products has been increasing. Since 1961, the global consumption of aquatic products (excluding algae) has increased at an average annual rate of 3.0%, almost twice the average annual growth rate of the world population. At present, the per capital annual consumption of aquatic products has reached 20.2 kg, more than twice that of the 1960s [1]. It is estimated that this consumption will increase by 15% to 21.4 kg per capita by 2030 [2]. China is a super consumer of aquatic products. From 1981 to 2019, the per capita consumption of aquatic products of Chinese households increased from 2.49 kg/person/year to 13.9 kg/person/year, with an average annual growth rate of 4.56% [3]. According to the estimation of the Freshwater Fisheries Research Center of the Chinese Academy of Fishery Sciences, the actual per capita consumption of aquatic products in China in 2019 was 29.35 kg [4].

Driven by change of consumption concept and demand growth of aquatic products, global fishery output has reached a high record, and aquatic products have made an increasingly important contribution to ensuring food security and nutrition. According to the 2022 edition of The State of World Fisheries and Aquaculture, the total fisheries and aquaculture output in 2019 rose to the highest level in history, reaching 177 million tons, more than 79% higher than the average level in the 1990s [5]. The output of aquatic products in China also increased at an annual rate of about 32%, from 4.65 million tons in 1978 to 64.50 million tons in 2019. The proportion of Chinese aquatic products in the total output of world aquatic products also increased from 6.36% in 1978 to 36.44% in 2019 (Figure 1).

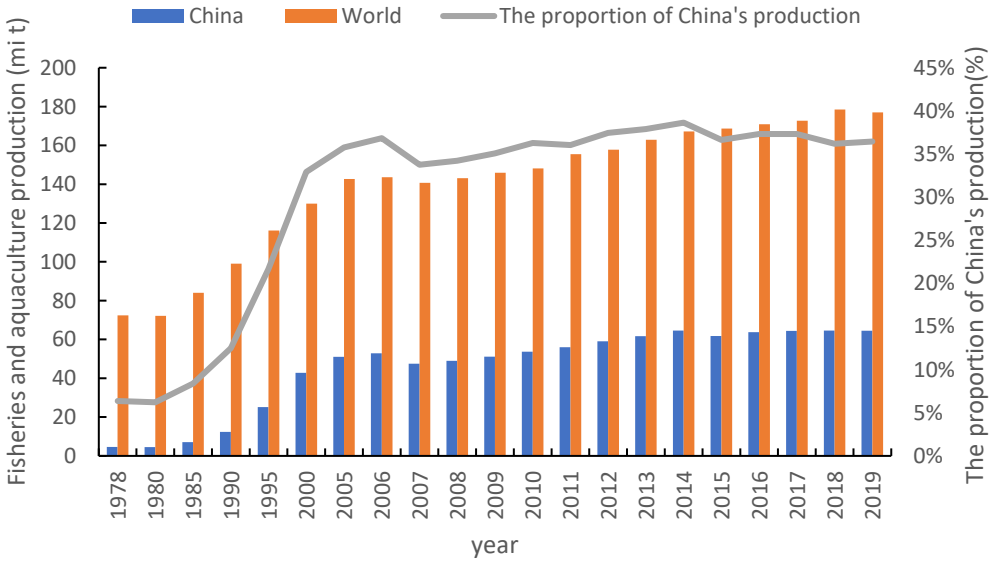

Figure 1. The trend of total fishery aquatic products in China and the world since 1978. Data Source: China Fisheries Statistical Yearbook (1979–2020) [6] and The State of World Fisheries and Aquaculture (2002, 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020) [7].

The huge and dynamic aquatic product consumption market has created an opportunity for the development of fishery industry, and at the same time there is a pressure for more diversified production and sustainable development in global fishery industry, as well as in China's. The transformation and upgrading of the aquatic industry are essential. How to give full play to the role of fisheries, satisfy consumers' advanced requirement for food security and nutrition and achieve the sustainable development of fishery without exceeding the scope of the ecosystem is an important issue that needs to be solved urgently in China at present. However, there are some problems in China's fishery industry, such as the uncoordinated development of fishery industrial structure [8], the low level of aquatic product processing technology [9], and the imperfect fishery circulation (and related services) [10]. These problems have seriously hindered the sustainable development of China's fisheries. In order to ensure that fisheries continue to play an important role in ensuring food security and meeting consumption diversity, it is imperative to upgrade the fishery industrial structure.

With the increasing urgency of upgrading the fishery industrial structure, scholars have investigated this issue from different perspectives. Yan and Ping (2012) [11] are from the perspective of change in consumer demand, Le and Liu (2017) [12] are from the perspectives of production, and Marco et al., (2021) [13] are from the perspective of fisheries management. Su (2009) [14] investigated the evolution of the internal industrial structure of the Chinese fishery industry. They also considered the characteristics of industrial structures and existing problems. Consequently, he put forward some countermeasures, such as consolidating the internal foundation, strengthening material support, arousing the initiative of the industry, reforming the business model, and optimizing the external environment. Zhou and Chen (2017) [15] analyzed the current situation of the fishery industrial structure upgrading in China and found that the fishery industrial structure has the problems of slow development of the secondary and tertiary fishery industries, insufficient investment in characteristic aquaculture, serious constraints on resources and environment, low degree of organization, and lagging scientific and technological innovation. Zhang et al., (2018) [16] analyzed the impact of fishery diversification and specialization on the upgrading of the fishery industry. Guo and Li (2018) [17] considered the effect of scientific and technological innovation on fishery development and industrial upgrading.

Suffice to say, the existing literatures are more focused on qualitative research of the upgrading of the fishery industrial structure [11–14]. In recent years, some scholars have

tried to use quantitative method to study the upgrading of the fishery industrial structure. For example, Xu and Zhang (2018) [18] used gray correlation analysis model to find the imbalance of the fishery industry structure; Bian (2019) [19] measured the upgrading of the fishery industrial structure in Zhejiang province by using the dynamic deviation share model; Zhang et al. (2018) [16], Guo and Li (2018) [17] utilized a multiple regression panel model and generalized method of moments (GMM) to study the impact of technological innovation on the upgrading of the fishery industrial structure.

From the foregoing, a lot of research has been conducted on the fishery industrial structure upgrading, but there are still some deficiencies. Most of them studied the impact on the upgrading of fishery industry from a certain perspective or several factors, and the research methods did not solve the possible endogenous problems. To fill these gaps, this paper constructed the upgrading index of fishery industrial structure and adopted the system GMM to analyze the impact of various factors on the upgrading of fishery industrial structure.

The rest of the paper is organized as follows: In Section 2, this paper constructs the model of fishery industrial structure upgrading index and the influencing factors of the fishery industrial structure upgrading, and introduces the data sources; Section 3 is the empirical analysis; Section 4 is the discussion; Section 5 is the conclusions.

2. Materials and Methods

2.1. Methods

2.1.1. Industrial Structure Upgrading Index

The indicator-based approach and model method [20] are commonly used in the existing research. The indicator-based approach identifies the upgrading level of industrial structure by building a single indicator or indicator system, in which the commonly used single indicator includes the structural value [21], industrial structure advance coefficient [22], and so on. The model method is used to estimate the level of industrial structure optimization and upgrading by using various econometric models and mathematical models. The Petty–Clark Theorem generalizes the upgrading of industrial structure as the evolution process of the increase in the proportion of the tertiary industry, the slow decline of the proportion of the secondary industry, and the relative decrease in the proportion of primary industry. Therefore, the upgrading of the fishery industrial structure can be seen as a gradual shift in the focus of industrial development from primary industry to secondary and tertiary fishery industries. In this paper, the single indicator method is selected to measure the upgrading of the fishery industrial structure. Thus, the upgrading index of the fishery industrial structure was constructed as follows:

$$STRU = \sum_{i=1}^{3} x_i \times i, i = 1,\ 2,\ 3 \tag{1}$$

Among them, x_i represents the proportion of the tertiary industry i to the total fishery production value, and $STRU$ is within the range of 1–3, which mainly reflects the upgrading level of the fishery industrial structure.

2.1.2. Influencing Factors of China's Fishery Industrial Structure Upgrading Model

To test the influencing factors of China's fishery industrial structure upgrading, a panel model was constructed.

Static panel model:

$$STRU_{it} = \pi X'_{it} + \alpha_i + \epsilon_{it} \tag{2}$$

Among them, i represents the province, t represents the time, and $STRU_{it}$ is the upgrading index of the fishery industrial structure of the i province in the t year, X'_{it} represents the important factors that affect the upgrading of fishery industrial structure, such as the level of economic development, fishery environment, etc., π measures the impact of various factors on the upgrading of China's fishery industrial structure, which is

the key factor of this paper, α_i represents the fixed effect of provinces, ϵ_{it} is the error term, and the standard deviation of all regression is aggregated at the provincial level.

Equation (2) is the benchmark estimation model used in this study. Without considering endogenous problems, the analysis methods of the ordinary least-squares (OLS) model and fixed effects are biased and inconsistent. To solve the possible endogenous problems, this paper constructs a dynamic panel model based on a static model for estimation.

Dynamic panel model: Due to the level of production technology, the adjustment of production costs, and the constraints of their own conditions, the upgrading of fishery industrial structure has a certain stickiness in the adjustment of fishery industrial structure in various regions. Introducing the lag term of the upgrading level of the industrial structure into the dynamic model (3) based on the static model (2) can better control the stickiness factor.

$$STRU_{it} = \beta STRU_{it-1} + \pi X'_{it} + \alpha_i + \epsilon_{it} \quad (3)$$

$$\Delta STRU_{it} = \beta \Delta STRU_{it-1} + \pi X'_{it} + \Delta\epsilon_{it} \quad (4)$$

The difference in model (3) can eliminate the difference in α_i, affecting inter-provincial resource endowment and the economic environment. At the same time, as the model after difference (4) correlates with the first-order differential lag term of the explained variable and the different terms of the error term, it is necessary to introduce instrument variables. However, in the random effect model, the difference in GMM estimation not only has the problem of weak instrument variables but also removes the influence of non-time-varying variables while eliminating provincial differences. Then, this paper proposes adding the horizontal Equation (3) as the constraint condition based on the differential GMM estimation Equation (4), that is, the system GMM model. In view of this, this study uses the system GMM to estimate.

This paper also conducted a series of robustness tests and heterogeneity tests. To this end, first, dividing the whole country into coastal areas and inland areas to test whether the impact of various factors on the level of industrial structure upgrading will change with the change in the region. Second, some samples from 2011 and later are selected from the overall samples to study the influence of various factors on the upgrading level of fishery industrial structure to test the robustness of the results of this paper.

2.2. Variable Selection

The upgrading of fishery industrial structure refers to the process of achieving coordinated development of various fishery industries and meeting the growing demand for aquatic products of the society through the adjustment of the fishery industrial structure. The factors influencing the upgrading of the fishery industrial structure cover a wide range. Considering the availability of data and the existing literature, this paper selected six factors that affect the upgrading of the fishery industrial structure, including economic development, foreign trade, the degree of marketization, the economy of fisheries, the upgrading level of regional industrial structure, and the labor productivity of primary fishery industry. The six factors were previously identified as the essential factors affecting the upgrading of the fishery industrial structure [16,23–27], consequently constructing an index system to measure the upgrading level of fishery industrial structure in 31 provinces and regions in China. There are 34 provinces, autonomous regions, and municipalities directly under the central government in China, of which Hong Kong, Macao, and Taiwan are not included in the sample due to the lack of data. The 31 provinces (autonomous regions, and municipalities directly under the central government) selected in this paper are Beijing, Tianjin, Shanghai, Chongqing, Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Hainan, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Inner Mongolia, Guangxi, Tibet, Ningxia, and Xinjiang. Further, this paper constructed a model to test the influencing factors of the fishery industrial structure upgrading.

Economic Development (Eco): Peneder (2003) [23] believed that the level of economic development can promote the changes of industrial structure. Generally, the more developed the economy of a region, the higher the income and living standards of people. The more people that demand high-quality protein, including aquatic products, the higher the demand for high value-added aquatic products. Driven by this demand, the fishery industry will also carry out corresponding structural adjustments and promote the upgrading of the industrial structure. Here, the level of economic development is represented by the per capita GDP of a region.

Foreign Trade (Tra): International trade enables China's fishery industry to carry out international cooperation, exchange capital, technology and intelligence, learn advanced fishery technology, and innovate equipment. Introducing advanced breeding, fishing, production, and processing technologies for fishery development, which is conductive to the upgrading of fishery industrial structure. Jiang et al., (2020) [24] believed that the higher the share of import and export trade in a region, the more frequent the foreign exchange in the region, and the frequent foreign exchange can promote the upgrading of the fishery industrial structure. Here, the foreign trade is reflected in the proportion of the total import and export of aquatic products in the total output value of the fishery.

Degree of Marketization (Mar): Kuznets and Murphy (1966) [25] believed that a high level of marketization means that the factors of production continue to flow from the low-efficient production sector to the high-efficient production sector, and the improvement of the efficiency of resource allocation can have an impact on the division of labor, reorganization, agglomeration, and production specialization of the fishery industry, promote the specialization and further development of the fishery industry, improve the operating mechanism of the fishery market, and further promote the upgrading of the fishery industrial structure. Here, the marketization index calculated by Fan et al., (2018) [26] was used to express the marketization level of a region.

Fishery Economy (Fis): The more developed a region's fishery economy is, the more attention the government and enterprises will pay to the development of its fishery industry. The upgrading of industry is an inevitable requirement to realize high-quality development of fisheries [16]. Therefore, the more prepared a region's fishery economy is and the higher its fishery foundation is, the higher its industrial upgrading level may be. Here, the fishery basis of a region is represented by the proportion of the total fishery output value of regional GDP.

Regional industrial upgrading level (Upg): Fishery, as a part of the primary, secondary, and tertiary industries with a large caliber, the higher the level of industrial upgrading in a region, the higher the level of its industrial structure upgrading [16].

Labor productivity of primary fishery industry (Eff): Drucker and Feser (2012) [27] believed that the change in labor productivity in different industries reflects the change in industrial structure to a certain extent, and the industrial structure will be concentrated in industries with higher labor productivity. As the production efficiency of the secondary and tertiary fishery industries are not available, this paper uses the production efficiency of the primary industry. Here, the high production efficiency of the fishery primary industry means that more resources are concentrated in the fishery primary industry, and the proportion of output value of the fishery primary industry will increase accordingly, which reduces the upgrading level of the fishery industrial structure to a certain extent. Therefore, the improvement of the primary industry's production efficiency hurts the upgrading of the industry.

2.3. Data Sources

The data of this study mainly come from two sources: (1) China Fisheries Statistical Yearbook from 2004 to 2020. The China Fishery Statistical Yearbook [6] is currently the most comprehensive data source of China's fishery production, covering data on fishery economic accounting, production input and output, aquatic product processing, and trading of the country (covering 31 provinces, autonomous regions, and municipalities

directly under the central government); after data processing, continuous panel data of 31 provinces and cities for 17 years was obtained; (2) China marketization index [26], which uses the same indicator system to continuously measure the marketization process of each region, providing a stable observation framework reflecting the marketization reform so that the marketization process of each province, autonomous region, and municipality can be comprehensively compared from different aspects.

3. Results

3.1. Descriptive Statistics

Table 1 describes the statistics of some key variables. In the samples of this paper, from 2003 to 2019, for the labor productivity of primary fishery industry, the maximum value is 1.15 million yuan per person, the minimum value is 0, indicating that the production efficiency of the primary fishery industry among regions is very different; the mean is 0.13 million yuan per person, indicating that the production efficiency of the primary industry is still in a low level. For the economic development, the maximum value is 0.16 million yuan per person, the minimum value is 3700 yuan per person, indicating that the economic development among regions is very different; the mean is 0.13 million yuan per person, indicating that there are pronounced differences within and between regions for the economic development; the average value of the economic development is far less than the maximum value, which indicates that the economy of most provinces is underdeveloped. For the degree of marketization, the maximum value is 10, the minimum value is 0.01, and the mean is 5.95, indicating that the degree of marketization for provinces in China is fairly evenly distributed. As for the upgrading level of industrial structure in a province, the maximum value is 2.83, which is close to the maximum value 3 of the industrial structure upgrading level, and the average value is 2.28, which shows that the upgrading of China's industrial structure is at a high level. For the foreign trade and fishery economy, their minimum values are zero, and their average values are far lower than the maximum values, which indicates that the foreign trade and fishery economy are still at a low level for most provinces in China.

Table 1. Influencing factors of the upgrading level of fishery industrial structure.

Influence Factor	Symbol	Description	Mean	Minimum	Maximum
Labor productivity of primary fishery industry	Eff	Total output value of primary fishery industry/number of fishermen engaged in primary fishery industry (ten thousand yuan/person)	13.42	0.00	114.86
Economic development	Eco	Regional per capita GDP (ten thousand yuan/person)	3.84	0.37	16.42
Degree of marketization	Mar	The marketization index calculated by Fan [26]	5.95	0.01	10.00
Upgrading level of industry	Upg	Upgrading level of industry in the region	2.28	0.15	2.83
Foreign trade	Tra	Total import and export value of aquatic products/total output value of fishery	0.14	0.00	3.34
Fishery economy	Fis	Total fishery output value/regional GDP	0.03	0.00	0.18

3.2. Measurement of the Upgrading Level of Fishery Industrial Structure

The upgrading trend of China's fishery industrial structure from 2003 to 2019 is shown in Figure 2. In general, the upgrading level of China's fishery industrial structure is on the rise. From 2003 to 2010, China's fishery industrial structure continued to upgrade. The industrial structure upgrading index rose from 1.63 in 2003 to 1.72 in 2010. Owing to the financial crisis of 2008, the fishery industrial structure upgrading index declined temporarily. In response to the adverse impact, the Chinese government promptly applied a policy of supporting and benefiting the fishery industry (Policy of supporting a fishery and benefiting fishery: the state's policy support for fishery development mainly includes the state's financial allocation for fishery development, fishery subsidies, helping fishermen to change jobs, protection of fishery resources and construction of fishery safety production). Therefore, the industrial structure upgrading index rose rapidly in 2009. Noticeably, there was a steady growth period between 2011 and 2019 which was caused by the application of the aforementioned policy. By 2019, the upgrading index of China's fishery industrial structure reached 1.9.

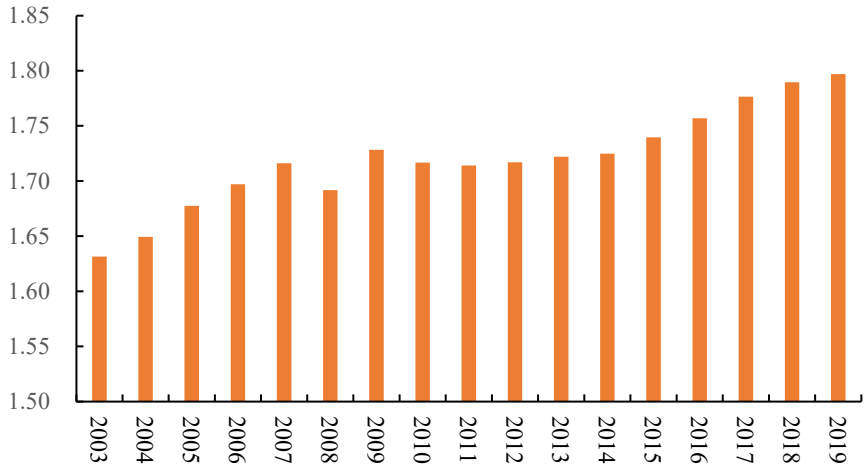

Figure 2. Upgrading level of China's fishery industrial structure from 2003 to 2019.

Considering different regions, the upgrading level of the fishery industrial structure in coastal areas is greater than that of inland areas (Figure 3) (According to the definition of coastal areas in China's Marine Statistical Yearbook, it refers to the areas with coastlines (mainland coastline and island coastline), which are divided into coastal provinces, autonomous regions, and municipalities directly under the central government according to administrative regions. At present, China has nine coastal provinces, one autonomous region and two municipalities directly under the central government, namely Tianjin, Hebei, Liaoning, Shandong, Jiangsu, Zhejiang, Shanghai, Fujian, Guangdong, Guangxi, and Hainan. The rest of the provinces (cities and autonomous regions) are inland areas). This can be attributed to coastal provinces in China having a high upgrading level of the fishery industrial structure because they harbor the necessary conditions, such as high economic levels, prosperous foreign trade, rich fishery resources, and a long history of fishery development. The development of the fishery industry in inland provinces was crippled by a variety of factors that include little natural water resources suitable for fishery development and little experience of fishery development.

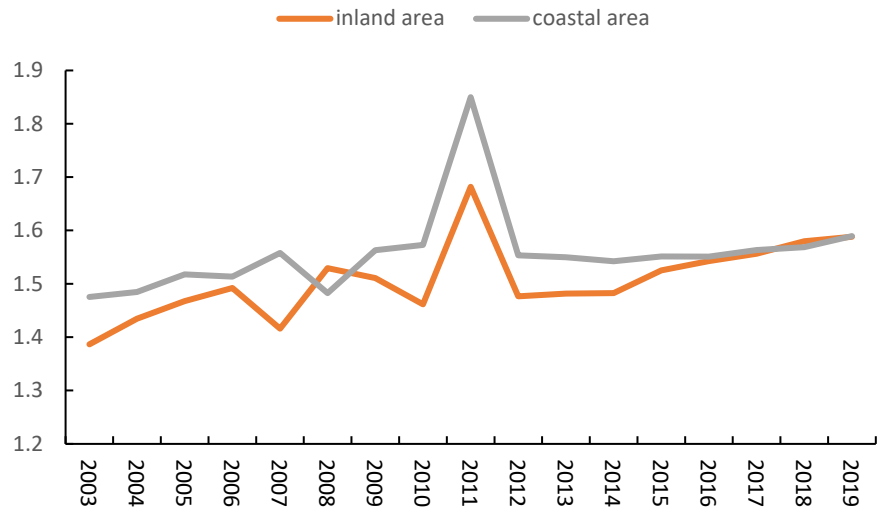

Figure 3. Upgrading level of fishery industrial structure from 2003 to 2019.

Specifically, the overall development trend of the upgrading level of the fishery industrial structure in inland areas was relatively stable from 2003 to 2019. The upgrading level of the fishery industrial structure in inland areas is generally within the range of 1.3–1.6 [8,9].

The upgrading level of fishery industrial structure in coastal areas shows an upward trend from 2003 to 2019, and the upgrading level is between 1 and 1.9, with the peak of each province concentrated in 2011. This is because 2011 was the beginning year of fishery development in the "Twelfth Five Year Plan". All provinces responded positively to the "Twelfth Five Year Plan" with all provincial fishery departments changing the mode of fishery development to align with the plan, starting fishery modernization constructions, and actively executing the "Twelfth Five Year Plan." Resultingly, the upgrading level of fishery industrial structure was significantly improved. In addition, since 2012, the fishery industry structural adjustment plan for coastal provinces has been more in line with reality. As a result, the fishery industrial structure upgrading level of each province shows a stable trend.

3.3. The Influencing Factors of the Fishery Industrial Structure Upgrading

Using a panel regression model, this paper empirically tested the impact of various factors on the upgrading of China's fishery industrial structure (Table 2). Column (1) is a pooled OLS model, column (2) adds a fixed effect, column (3) is the feasibility generalized least square model, and column (4) is the system GMM. Column (4) is the final model selected in this study. It is preliminarily concluded that the level of economic development and foreign exchanges have a positive impact on the upgrading of fishery industrial structure, and the improvement of the primary industrial production efficiency hurts the upgrading of the fishery industrial structure.

Table 2. Influencing factors of fishery industrial structure upgrading.

Variable	(1)	(2)	(3)	(4)
	OLS	**FE**	**FGLS**	**GMM**
Eff	−0.100 *** (0.014)	−0.095 * (0.054)	−0.055 *** (0.006)	−0.190 *** (0.068)
Eco	0.129 *** (0.023)	0.124 * (0.071)	0.046 * (0.024)	0.200 *** (0.074)
Mar	−0.05 (0.057)	−0.057 (0.074)	0.014 (0.011)	0.129 (0.100)
Upg	0.063 (0.062)	0.155 (0.166)	0.117 * (0.070)	−0.083 (0.078)
Tra	0.010 ** (0.005)	0.008 (0.008)	0.004 ** (0.002)	0.038 * (0.023)
Fis	0.025 ** (0.013)	0.011 (0.050)	0.072 *** (0.009)	−0.130 ** (0.060)
L.Stru				0.030 (0.092)
Constant	0.691 *** (0.131)	0.550 * (0.294)	0.890 *** (0.105)	
F/AR (1)	57.470	1.180	5994.170	0.051
R2/AR (2)	0.280	0.123		0.582
Hansen				0.533

Note: *, **, and *** are significant at 10%, 5%, and 1%, respectively; L.Stru represents the lag term of Stru; AR (1) and AR (2) represent the *p* values of the first-order and second-order sequence correlation of the difference residual term, respectively; Hansen is the kilogram variable transition recognition test.

The level of economic development and foreign trade have a positive impact on the upgrading of the fishery industry, which are in line with the expectation. The more developed the economy is, the higher the living standard of the people in the region will be, and the demand for fish products will be more diversified and high-end. Therefore, the level of the industrial structure upgrading will be improved. The more frequent foreign exchanges, the more favorable the acceptance of new knowledge and learning advanced fishery production mode, which is conductive to the upgrading of fishery industrial structure; the higher the labor productivity of primary fishery industry, the more resources will be mobilized to the fishery primary industry, which will increase the ratio of the output value of the fishery primary industry in the total output value of the fishery, and reduce the upgrading level of the fishery industrial structure. The level of the labor productivity of primary fishery industry has a negative impact on the upgrading of the fishery industry, which are in line with the expectation. The high labor productivity of primary fishery industry means that more resources are concentrated in the fishery primary industry, and the proportion of output value of the fishery primary industry will increase accordingly, which reduces the upgrading level of the fishery industrial structure to a certain extent.

To further verify the robustness and heterogeneity of the above results, this paper divided China into two regions according to the division of coastal and inland regions and examined the impact of various factors on the upgrading of the fishery industrial structure. In addition, sub-samples obtained after 2010 were selected for further testing (Table 3). By comparing the heterogeneity of the impact of various factors on the upgrading of fishery industrial structure in coastal and inland areas, this study found that the impact of the level of economic development and the labor productivity of primary fishery industry on the upgrading of fishery industry is mainly in coastal areas. In inland areas, the above factors do not have a significant impact, and the results of column (3) show that the level of economic development has a positive impact on the upgrading of the fishery industrial

structure, and the improvement of the labor productivity of primary fishery industry hurts the upgrading of the fishery industrial structure, which is the same as the results of Table 2, verifying the robustness of the above method/results.

Table 3. Robustness and heterogeneity test.

Variable	(1)	(2)	(3)
	Coastal Area	Inland Area	After 2010
Eff	−0.221 ***	−0.084	−0.247 ***
	(0.078)	(0.060)	(0.076)
Eco	0.176 *	0.101	0.261 ***
	(0.098)	(0.062)	(0.067)
Mar	0.376	0.102	0.147
	(0.274)	(0.235)	(0.089)
Upg	0.052 ***	0.425	−0.067
	(0.016)	(0.826)	(0.060)
Tra	−0.045	0.012	0.024
	(0.029)	(0.013)	(0.025)
Fis	0.032	0.013	−0.119 **
	(0.109)	(0.051)	(0.054)
L.Stru	0.076	0.191	0.006
	(0.137)	(0.253)	(0.090)
F/AR (1)	0.047	0.079	0.011
R2/AR (2)	0.473	0.179	0.670
Hansen	0.108	0.275	0.875

Note: *, **, and *** are significant at 10%, 5%, and 1%, respectively; L.Stru represents the lag term of Stru; AR (1) and AR (2) represent the *p* values of the first-order and second-order sequence correlation of the difference residual term, respectively; Hansen is the kilogram variable transition recognition test.

4. Discussion

This paper constructed the upgrading index of fishery industrial structure and adopted the system GMM to analyze the impact of various factors on the upgrading of fishery industrial structure. Estimates from the upgrading index of fishery industrial structure show that although the upgrading level of China's fishery industrial structure is on the rise, China's fishery industrial structure upgrading is still in its infancy; this suggests that there is still much room for improvement in the upgrading of China's fishery industrial structure. System GMM estimation shows that the level of economic development and foreign exchanges have a positive impact on the upgrading of fishery industrial structure, and the improvement of the labor productivity of primary fishery industry hurts the upgrading of the fishery industrial structure. These results are robust to sub-samples.

This work has several improvements compared to previous literature on the upgrading of the fishery industrial structure and its influencing factors. Most of them studied the impact on the upgrading of fishery industry from a certain perspective or several factors. For example, Zhang et al. [16] studied the impact of fishery specialization and diversification on the fishery industrial structure upgrading. Yu and Zhao [28] studied the impact of financial development on the upgrading of fishery industrial structure. What is more, some research methods did not solve the possible endogenous problems [18,28]. To fill these gaps, this paper constructed the upgrading index of fishery industrial structure and adopted the system GMM to analyze the impact of various factors on the upgrading of fishery industrial structure.

Two areas are beyond the scope of this paper but should be explored in future research. First, there are multiple influencing factor of the upgrading of fishery industrial structure, including technological innovation, local government attitude, experience of fisheries

management, etc. Due to the limitation of data availability, these factors were not included in the model. Second, system GMM may be reasonable for this paper, the estimation method is not perfect one because more samples are needed. The provincial panel data in this paper determines the limited number of samples. Future studies should use more microscopic data, like household level data or county level data, to quantify the influencing factors of the upgrading of fishery industrial structure.

5. Conclusions

This paper studies the upgrading of China's fishery industrial structure and draws the following conclusions. First, the upgrading level of fishery industrial structure is continuously rising, but the primary industry is still dominant, and China's fishery industrial structure upgrading is still in its infancy. Second, the level of economic development has a significant positive impact on the upgrading of the fishery industrial structure, and the labor productivity of primary fishery industry has a significant negative impact on the upgrading of the fishery industrial structure. Third, by comparing the heterogeneity of the impact of various factors on the upgrading of fishery industrial structure in coastal and inland areas, the impact of the level of economic development and the labor productivity of primary fishery industry on the upgrading of fishery industry is mainly in coastal areas.

To promote the upgrading of the fishery industry, the following suggestions are put forward:

Improve the productivity of secondary or tertiary fishery industries. Accelerate the pace of technological, management, and institutional innovation in the secondary and tertiary industries of fisheries, so as to improve their efficiency. The production efficiency improvement will attract more resources to these industries and promote the development of the secondary and tertiary fisheries industry.

Promote the development of aquatic products deep-processing industry, aquatic products circulation industry and recreational fishing. First, promote the development of aquatic products processing industry in the direction of deep-processing and higher added value; Second, build aquatic products logistics centers with key fishing ports as the main body to integrate trading, warehousing, distribution, and transportation, so as to promote the development of aquatic products circulation industry; Third, improve the infrastructure of service industry and vigorously develop leisure fishery.

Improve the marketization level and make full use of the healthy market mechanism to upgrade the fishery industrial structure. Build a fully competitive healthy market mechanism and severely crack down on the vicious competition among enterprises for fishery resources; Give full play to the role of market mechanism to reasonably allocate resources and make healthy market competition mechanism the main driving force for the upgrading of fishery industrial structure.

Strengthen international and regional cooperation. Reduce investment barriers, improve the ability of fishery to use foreign funds and learn foreign advanced technology and production technology, and constantly improve the development level of fishery industry. Cooperate with foreign countries in many fields, such as fishery resources, upstream and downstream of the industrial chain, and product structure.

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