Research on the Fishery Industry Sustainability in Liaoning– Based on an Expanded C-D Production Function Model

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Abstract: This paper attempts to shed light on the effects of the production input factors utilized on the fishery industry sustainability focusing on both of their independent and synergetic impacts, taking the fishery industry in Liaoning province of China as an example. In the process, an extended C-D production function model is utilized in estimating the elasticity of each individual input factor and the rate of contribution to the total fishery output, following by conducting seemingly unrelated regression analysis for investigating the synergetic effects being attributable to the integrated input factors used in the fishery industry sustainability. The analysis reveals some interesting results with respect to appealing the government fishery policy and the strategic fishery business decision makings in Liaoning province and elsewhere in China and yet even cross over the world.

1. Introduction

In 2013, the Chinese President Xi Jingping solemnly promised to lift all the poor people out of the poverty by the end of 2020 for the whole country. In order to reach the goal, in 2018 the president called on that the country's fishery economy should embark on a green and quality-driven path of sustainable development[1]. There are six primary coastal cities in Liaoning province, including Dalian, Dandong, Jinzhou, Yingkou, Panjin, and Huludao, with their totality covering 68,000 square kilometers of the sea area. Historically, the province took the marine resources as its strategic resource for aquatic industry development. However, owing to the conducts of over-capacity uses of the marine resources and inadequate efforts exerted on sea water protection, in recent years the total natural fishery output in the province has been decreased considerably, arousing the acrid shortage of supply in the crude fishery products. The remained content of the paper is arranged as follows: Section 2 provides literature review which elaborates technical exposition of the Lowe index and summarizes related studies on effects of factor input on fishery output measured by input elasticity, total factors productivities and the characteristics of production functions in terms of returns to scales. Section 3 formulates the empirical model framework used for the analysis; section 4 addresses analytical procedure which involves the data treatment and discussing the model results, following by section 5 for the research conclusions and policy suggestions.

2. Literature review

A numerous study has documented the sustainable fishery development. One of the earliest works was done by Comitini and Huang who used a Cobb–Douglas model to characterize the production of 32 halibut fishing vessels in the North Pacific over a seven-year period[2]. Squires published a study measuring productivity in the Pacific Coast Trawl Fishery using an index number approach[3]. In dealing with the scarcity of marine resources, technological innovation must come into a play, which requires a considerable amount of research funding. Unfortunately, based on the assessment conducted by Li Yuangang, over the last 40 years of the China's reform and opening-up, no conspicuous effect has been achieved toward sustainable fishery development in China being attributable to scientific research[4]. The continuously declined fishery productivity in China has triggered some researchers to consider a possibility of using green island tourism to displace for the fishery industry and see the former as a silver lining for being deteriorated fishery industry[5].

In a nutshell, although a large body of literatures have documented factors which are able to make contribution to the fishery productivity, most of those empirical results are focused on the fishery output effects imposed by an isolated single input factor, such as R&D investment, a specific fishing technology, and a hoc government policy, etc. using simplistic modeling methods[6]. To fill out the gap, this study attempts to evaluate the total factor productivity for the fishery industry using a C-D production model approach, taking the six cities in Liaoning China as a study area. The model results are used to address the issues closely associated with the sustainable fishery development in Liaoning province of China. Certainly, the discoveries have potential to provide lessens and insights for fishery industry development elsewhere in China and even across the world.

3. Model framework

We can establish a C-D production function framework by focusing on the following five factors including natural resource, labor, capital, R&D, and institution. This model framework is presented in Eqn. (1):

$$\mathrm{Y} = \mathrm{AK}^{\alpha}\mathrm{L}^{\beta}\mathrm{R}^{\gamma}\mathrm{I}^{\delta} \tag{1}$$

where Y is the level of fishery output, A represents institution, ($\mathrm{A} = A_0\mathrm{e}^{\theta t}$) in which A_0 represents a base period，θ reflects the institution effect, t is a time variable; K stands for capital input, L is labor input; R represents natural resource used in fishery production; I stands for R&D investment; α、β、γ、δ represent the elasticity of fishery output with respect to each specific input factor of capital, labor, natural resource, and R&D, respectively.

Now, let us take logarithm for both sides on Eqn. (1), so that Eqn. (2) can be derived below. Obviously, Eqn. (2) is a linear panel regression model which can be used for the parameter estimations:

$$\mathrm{LnY}_{\mathrm{it}} = \mathrm{LnA} + \alpha\mathrm{LnK}_{\mathrm{it}} + \beta\mathrm{LnL}_{\mathrm{it}} + \gamma\mathrm{LnR}_{\mathrm{it}} + \delta\mathrm{LnI}_{\mathrm{it}} + \varepsilon_{\mathrm{it}} \tag{2}$$

where i stands for a cross-section block; t expresses year; LnA、α、β、γ、δ are coefficients to be estimated, and ε is a random error.

Let $\mathrm{Y}_0, \mathrm{A}_0, \mathrm{K}_0, \mathrm{L}_0, \mathrm{R}_0, \mathrm{I}_0$ be the effect of various fishery production input factors in the base period, respectively. Then, based on Eqn. (1), we can derive a more accurate model framework to be used in estimating the fishery productivity growth such as Eqn. (3):

$$y = \frac{a(K^{\alpha}L^{\beta}R^{\gamma}I^{\delta})}{{K_0}^{\alpha_0}{L_0}^{\beta_0}{R_0}^{\gamma_0}{I_0}^{\delta_0}} + \frac{K^{\alpha}L^{\beta}R^{\gamma}I^{\delta}}{{K_0}^{\alpha_0}{L_0}^{\beta_0}{R_0}^{\gamma_0}{I_0}^{\delta_0}} - 1 \tag{3}$$

where y is the rate of fishery production growth. Consideration of the Chinese marine fishery production remains at a lower productivity phase in terms of input use efficiency, it is reasonable to assume that the elasticity of production inputs maintains at constant over the analysis period, thus the estimated coefficients of $\alpha, \beta, \gamma,$ and δ are constant, respectively, and at the same time they are satisfied with the condition of: $\alpha = \alpha_0, \beta = \beta_0, \gamma = \gamma_0, \delta = \delta_0$. Therefore, our finally used fishery growth model becomes Eq. (4):

$$y = a + a(\alpha k + \beta l + \gamma r + \delta i) + \alpha k + \beta l + \gamma r + \delta i \tag{4}$$

Dividing both sides of Eqn. (4) by y, which results in Eqn. (5):

$$a/y + a/y \cdot (\alpha k + \beta l + \gamma r + \delta i) + \alpha k/y + \beta l/y + \gamma r/y + \delta i/y = 1 \tag{5}$$

where a/y represents the rate of fishery productive growth to be attributable to the government policy or institution; $a/y \cdot (\alpha k + \beta l + \gamma r + \delta i)$ expresses the synergy effect for the four types of production input factors, i.e., capital, labor, natural resource, and R&D on the fishery productivity, annually. Thus, the total fishery input factor productivity, namely the aggregate growth of the marine fishery productivity is attributed to the sum of each individual factor over the entire analytical periods. As such, they are expressed as of $\alpha k/y, \beta l/y, \gamma r/y, \delta i/y$, respectively.

4. Data treatment and model results

we gathered the data "Labor fishery productivity (Y), Capital input (K), Fishery labor input (L), Fishery resource (R), Level of science and technology (S)" from 1997 to 2017 . The first step is to conduct a stabilization test for the cross-section panel data using the co-integration and covariance tests in order to minimize the risk of the potential spurious regression, making sure the effectiveness of the model estimation results. The Second step is to correct autocorrelation and hetero variance for the data gathered from different coastal cities. In the process, the generalized least squares method is used for estimating the contribution of each individual factor to the average growth rate of the fishery output.The SPSS20.0 software is used in estimating the elasticity for each individual input factor with respect to the growth rate of the total fishery output. Again the input factors being considered include capital outlay, labor input, fishery resource, and science & technology. Based on the Eqn. (5), the elasticity of growth rates of the total fishery output with respect to the different input factors are computed and the results are presented in Table 1.

Table1–Elasticity for the input factors and their rates of contribution to the fishery output growth

Cities	Capital （K_i）		Laborer（L_i）		Resource（R_i）		S&T（S_i）		Instn（A）	Total factors
	Elast.	C.Rate	Elast.	C.Rate	Elast.	C.Rate	Elast.	C.Rate	C.Rate	C.Rate
Dalian	0.3305***	30.53	0.1207***	11.82	0.3423***	25.57	0.3235***	30.31	3.57	2.88
Dandong	0.2927**	32.85	0.1042*	8.55	0.3257***	36.28	0.2773***	25.60	3.39	3.03
Jinzhou	0.2633***	34.26	0.1221**	9.26	0.1956*	23.82	0.2477***	19.28	2.90	2.42
Yingkou	0.4129***	31.33	0.1189***	10.11	0.2455****	24.61	0.2613***	24.63	3.42	1.94
Panjin	0.3048**	26.60	0.1654***	14.42	0.2932***	26.77	0.2905***	23.55	2.65	2.69
Huludao	0.2194***	33.02	0.1470**	8.28	0.2541**	30.19	0.2633**	23.73	2.23	2.66
Average	0.32	31.48	0.13	10.41	0.25	27.83	0.28	24.51	3.18	2.75

The seemingly unrelated regression analysis (SURA) is utilized in testing the synergetic effects of the fishery input structure on the overall fishery output growth in Liaoning province. Under the condition where the correlations present among the estimated residual terms, then it is meaningful to carry out the SURA for investigating the potential synergetic effects of the integrated input factors on the total fishery product output. The specific merit of conducting the SURA here is to better serve the industrial policy makings because both the elasticity and the rates of contribution analyses accomplished above are only able to tell about the potential roles played by each input factor independently, i.e., in an isolated manner. Thus, it fails to reveal any information on whether there exist the synergetic effects of the inputs used together on the total fishery output. For example, according to Table 2, the SURA results show that the capital's marginal output happens to be negative in both Jinzhou and Huludao cities, suggesting that the ways of the capital uses in these two coastal cities somehow did not collaborate well with other input factors used in the fishery production process.

Table2–Seemingly unrelated regression analysis on the fishery output growth in Liaoning province, China

Var.	Dalian	Dandong	Jinzhou	Yingkou	Panjin	Huludao
LnA	35.615(0.00)	-13.936(0.01)	-24.433(0.00)	21.723(0.00)	-3.524(0.66)	-26.866(0.00)
K_i	0.010(0.64)§	0.032(0.00)	-0.034(0.01)	0.020(0.25)	0.003(0.92)	-0.031(0.00)
L_i	-3.093(0.00)	-0.749(0.06)	0.448(0.00)	-1.832(0.00)	2.399(0.01)	1.993(0.06)
R_i	1.801(0.01)	1.578(0.00)	1.039(0.00)	0.371(0.09)	1.347(0.01)	0.094(0.39)
S_i	2.412(0.00)	2.713(0.00)	0.027(0.00)	0.525(0.099)	0.246(0.72)	1.058(0.00)

Note：The number in the parenthesis expresses the level of significance.

5. Conclusions and policy implications

The analytical results lead us to the following conclusions. First, based on the magnitudes of the factor input elasticity, the capital input exhibits the highest elasticity among the five input factors being analyzed across the entire fishery production areas, following by science & technology, resources, and laborers. The input elasticity reflects the sensitivity of fishery output with respect to the usage of production input. Although the resource factor also shows a high sensitivity to the fishery output, it is difficult to change its usage due to its changeless nature. The lower rates of the total factors contribution to the fishery industry output clearly implies that the input factors used for fishery production sustainability in Liaoning province are not well coordinated among both the production organizational levels and cities' government levels as well. With regard to the lower fishery labor productivity or incompatible laborer input used with other non-labor input factors in fishery industry operation, it should be tackled by transferring fishery laborers from fishery production segment to the prior and posterior fishery product segments, i.e., shifting laborers from fishery production to fishery processing and marketing. Due to the unbalanced fishery resource endowments among the fishery production areas, especially a wide gap exists for the level of capacity and capability of technological innovation among the coastal cities, the future fishery industry growth in the whole province must uphold the integrated fishery industrial development strategy. In this regard, the provincial government must do a top-level design and assume the major responsibilities in coordinating various fishery operations among the coastal cities within the fishery industry and beyond.

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