Analysis on the Growth Drivers of Mariculture in Liaoning Province

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Abstract. Mariculture is of great significance to the fishery economic development in coastal areas. Liaoning province is an important area of coastal fishery eco-nomic development in China. In this paper, the data from 2013-2020 are used to analyze the seawater output and production factor input in Liaoning Province, and then the production function model is constructed. The research results show that the regression result of C-D production function is not ideal, the re-gression coefficient of labor input is negative and the regression coefficient is not significant. Further analysis shows that the mariculture industry in Liaoning province is in the transition period of production mode, during which it is dif-ficult to explain the relationship between the input and output of production factors by constructing the C-D production function model. As the mariculture area continues to decline and the continuous decline of traditional fishermen, the strong capital investment can promote the increase of mariculture output per unit area and attract the inflow of fishery practitioners. Mariculture has shifted from labor intensive to capital intensive production.

Keywords: Mariculture, Marine economy, Cobb Douglas production function.

1 Introduction

Mariculture is an important part of aquaculture in coastal areas and is of great significance to fishery economic development in coastal areas. Many scholars have studied the growth factors of fishery economy based on the C-D production function model [1-5]. Yue (2019) analyzed the factors of the growth of fishery economy in Fujian province from the relevant input factors of capital input, labor input, breeding area and the number of fishing boats, and found that the capital input and labor input contributed the largest contribution rate to the growth of fishery economy in Fujian province [6]. Chen (2010) analyzed and compared the contribution rate of each input factor and found that the contribution rate of each factor was successively labor force, capital input and breeding area, which proved the labor-intensive industrial characteristics of freshwater fishery in Hubei Province [7]. Liang (2010) pointed out that the growth of fishery economy in Hebei province is mainly driven by investment, and the offset effect of labor input and water surface resource development leads to low benefit [8]. Huang (2020) analyzed the calculation of total factor productivity and influencing factors of mariculture in Zhoushan city [9]. Li (2023) calculated the contribution rate of fixed capital, labor and sea area based on the C-D production function, found that sea elements investment not only has important contribution to mariculture growth, and the pull of capital and labor

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factors is strong [10]. Studies on the growth factors of mariculture in Liaoning province were not reported.

Liaoning province is an important province in the development of Marine fisheries. As the most northern coastal province in China, it has faced the problem of reducing investment and labor force in recent years. In this paper, the C-D production function model of mariculture of Liaoning province is constructed, and the relationship between mariculture output and factor input is analyzed, which provides reference for the related research of Marine fishery development in Liaoning Province.

2 Model and Data

2.1 Model

To simulate the relationship between mariculture output and production factor input based on Cobb Douglas production function model. The model mathematical expressions are shown in Equation (1).

$$Y = AK^{\alpha}L^{\beta}S^{\gamma} \tag{1}$$

Y is the annual output value of mariculture, *A* is the technical level, represents the input of science and technology, *K* is the capital input, *L* is the labor input, and *S* is the area of aquaculture. And α, β, γ is the undetermined coefficient, which corresponds to the elasticity coefficient of the input and output of each production factor respectively.

Take the logarithm on both sides of formula (1) to obtain Equation (2):

$$\ln Y = \ln A + \alpha \ln K + \beta \ln L + \gamma \ln S \tag{2}$$

2.2 Variables and Data sources

Explained variable. *Y* selects the output value of mariculture, and the data are from China Fishery Statistical Yearbook.

Explanatory variable. Capital input *K* includes fixed asset input, fuel and ice costs, feed and seedling costs, employee costs, etc. The data are from operating fishery expenditure and depreciation of fishery fixed assets in China Fishery Statistical Yearbook.

Labor input *L* uses data from Marine fishery practitioners, and the data are from China Fishery Statistical Yearbook. Fishery practitioners include professional fishery practitioners, part-time fishery practitioners and temporary fishery practitioners. Traditional fishermen involved in farming are already included in the fishery practitioners.

Mariculture area *S* refers to the sea area of natural mariculture aquatic products, including offshore aquaculture, tidal flat aquaculture and other aquaculture. Factory farming and deep-water cages are not included in the mariculture area. Data are from the China Fisheries Statistical Yearbook.

Time series data for the years 2013 – 2020 were selected based on the availability of the data.

3 Results

3.1 Stability test and cointegration test results

Stability test and cointegration test results (see Table 1) show that ln *Y* and ln *L* are not stable, but stable after the first order difference. If the test model of ln *S* takes (0,0,0), and the test model of ln *L* takes (C,T,1), then both themselves are stationary sequence at the 10% significance level. Although they are unstable sequences after selecting other test models, according to the AIC value, it is judged to be close to the stationary sequence.

Table 1. ADF test results.

Variables	Test model	ADF	1%	5%	Stability
ln *Y*	(0,0,0)	-0.2678	-2.9372	-2.0062	no
Δ ln *Y*	(0,0,0)	-2.7895	-3.0074	-2.0211	yes**
ln *K*	(0,0,0)	1.0251	-2.9372	-2.0062	no
Δ ln *K*	(0,0,0)	-2.4406	-3.0074	-2.0211	yes**
ln *L*	(C,T,0)	-1.3310	-6.2920	-4.4504	no
Δ ln *L*	(C,T,1)	-118.7157	-8.2355	-5.3383	yes***
ln *S*	(C,T,1)	-1.7739	-7.0063	-4.7731	no
Δ ln *S*	(C,T,1)	-21.0522	-8.2355	-5.3383	yes***

, * Represents stationary at 5% and 1% significance levels, respectively

Since the data is only eight years, the Johansen co-integration test cannot yield the results, so the Engle-Granger test can only be used to determine whether the co-integration relationship exists between the variables.

3.2 Regression results

The regression results of the model in Table 2 are not ideal, mainly in three aspects. First of all, the result of the judgment coefficient is 0.6987, and the fitting degree is not very good, especially the corrected determinable coefficient is only 0.4727. Secondly, the regression coefficient has a negative value. The regression coefficient of labor input is negative, although there are negative results in relevant studies, some are interpreted as negative correlation. Some scholars have delayed the capital investment, and the regression coefficient of the capital investment after correction is positive. It should be emphasized that the negative regression coefficient does not conform to the basic assumptions of the production function model. And there is no reasonable explanation for the delay of labor input. Thirdly, capital invest-ment and labor investment are not significant. Try to use only ln K and ln L as independent variables for regression, and the fitting effect is not ideal.

The regression results of the model are not ideal, which means that the input of production factors of the samples in each period is difficult to directly explain the output of mariculture. The relationship between input and output of mariculture factors needs to be further discussed.

In 2016, the area of mariculture fell precipitously, but the output of mariculture increased instead of decreasing, and the output per unit area increased by 28.7% compared with the previous year. The labor input has decreased by about 1/3 compared with the previous year, but the capital input has increased by 1.7 times compared with the previous year. The labor input per unit area has decreased by about 1/5 compared with the previous year, and the capital input per unit area is 2-3 times of the previous year. The capital-labor ratio remained at 0.02 in the three years from 2013 to 2015. But in 2016, K/L was 0.07. Compared with labor input, capital investment has multiplied. Therefore, it can be said that the production mode of mariculture changed in 2016.

Table 2. Regression results.

Variables	Regression Coefficient	SE	t-Stat	P-Value
ln K	0.1351	0.1071	1.2607	0.2759
ln L	-0.1403	0.1397	-1.0038	0.3722
ln S	0.9144*	0.3971	2.3023	0.0827
Constant	7.4534	4.3355	1.7191	0.1607
$\boldsymbol{R^2}$		0.6987		
$\boldsymbol{\bar{R}^2}$		0.4727		
DW		2.0250		

*Indicates that the variable is significant at 10% significance level

Although the output growth brought by the doubling of capital input, the growth rate of output per unit area is far lower than that of capital input. In 2017, the marginal output of capital investment decreased. In 2017, the capital input per unit area further increased, while the labor input per unit area increased slightly, the output per unit area decreased. In 2018, the labor input increased significantly, the labor input per unit area increased by 49% compared with the previous year, the capital input per unit area increased by 16% compared with the previous year, and the output per unit area continued to decrease. The factor structure has begun to change from 0.7 to 0.6. In 2019, with the capital input per unit area basically unchanged, the labor input further increased, the capital-labor ratio decreased to 0.5, and the output per unit area increased significantly. Therefore, since 2017, the production mode of mariculture has entered an obvious period of structural adjustment.

In 2020, the capital investment per unit area has doubled again. Under the condition that the labor input is basically the same as the previous period, the capital-labor ratio reaches 0.11. After the period of structural adjustment, the increase of output per unit area brought by the doubling of the capital-labor ratio can be said to be a sign of transformation. Under the trend of continuous reduction of mariculture area and the number of traditional fishermen, the output per unit area increased by increasing capital investment in 2016. The subsequent structural adjustment period also successfully attracted more labor inflows. Driven by capital investment in 2020, the output per unit area reached a new high, which is equivalent to entering a new stage compared with 2016, and also confirmed the structural transformation of mariculture production mode.

To sum up, it is difficult to explain the relationship between input and output of production factors by constructing a C-D production function model using sample data from the transformation period of mariculture.

4 Conclusion

This paper uses the data from 2013-2020 to build the production function model of mariculture in Liaoning Province. It is found that the goodness of fit of the regres-sion results is not ideal, and there are problems with negative regression coefficient of labor input and insignificant regression coefficient. Further analysis found that the mariculture industry in Liaoning Province was in the transition period of pro-duction mode during this period, so it was difficult to explain the relationship be-tween input and output of production factors by constructing a C-D production function model. With the continuous decline of mariculture area and the continuous decrease of traditional fishermen, the doubling of capital investment can increase the output of mariculture per unit area and attract the inflow of fishery practitioners. Seawater aquaculture has shifted from labor-intensive production to capi-tal-intensive production.

Whether the growth of mariculture can continue after the transformation is still a problem that needs further attention. The increase in output growth rate driven by the doubling of capital investment in 2020 has shown a decline in marginal output compared with 2016. Whether the cost increase brought by the transformation will affect the export of mariculture products, and whether the export change will affect the further growth of mariculture industry is a direction worthy of attention in the follow-up study.

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