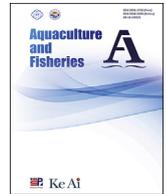




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Original research article

## Influence of industrial organizational structure on farming performance of large yellow croaker farmers

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### ABSTRACT

This paper determines the cost-benefit levels of yellow croaker farming households by comparing and analysing responses to questionnaires distributed to 405 households located in nine breeding regions of three counties (cities) in the Chinese provinces of Fujian and Zhejiang. A transcendental logarithmic stochastic frontier production function model is used to perform a quantitative analysis on the large yellow croaker production technique efficiency of different forms of industry organisation, with the farming household as the basic production unit. The findings indicate that the average production technology efficiency of the farming households is 84.33% and room for improvement remains; and there are significant differences between the production technique efficiency of farming households from different regions and under different forms of organisation. An analysis of the factors that affect farming household production technique efficiency found that capital input has a greater effect than labour input. Family participation and the number of individuals involved in the rearing of large yellow croakers, participation in technical training, and joining a closely-knit industry organisation all have a significant positive effect on increasing the production technique efficiency. These empirical results provide a basis and practical reference for optimising the development of the large yellow croaker farming industry, enhancing the degree of closeness of the organisations in the industry, and improving aquaculture performance.

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### 1. Introduction

The yellow croaker is the leading sea product of China. It is a valuable agricultural fish that is native to the southeastern coast of China and one of the most commonly reared marine fishes in the country. In terms of annual production, the yellow croaker consistently ranks in the top three among marine fishes, and its annual production exhibits an increasing trend (Fisheries Administration Bureau, 2011–2016). In 2016, the total production volume of yellow croaker in China reached 148,600 tonnes, accounting for 11.4% of the total production of marine fishes in China (Fisheries Administration Bureau, 2016). Chinese yellow croaker breeding is concentrated in villages along the coast of Zhejiang, Fujian, and Guangdong provinces. Most of the farms are owned by individuals, and these farms are typically family-run. There are four main types of organisation in the industry: farming household,

company, farming household + company, and cooperative. The business model of more than 90% of these organisations is that of a family-run or individually operated business (Gao et al., 2013). Farmers using this model are more enthusiastic in terms of production and operation. However, it is harder for these organisations to adapt to changes in supply and demand, which restricts industry development. The current focus of scholars is centred on how to organise individual farming households to form an effective link with the market and improve the economic efficiency of the agricultural-organisation system. Local and foreign researchers agree that supply-chain management is effective for addressing the conflict(s) between small-scale farming units and a large market while ensuring the safety of the supplied agricultural products (Hu, Fred, & Thomas, 2006; Huang & Zhang, 2008; Luanne & Timonhy, 2007). In agricultural supply-chain management, a key element is the organisation of the farming industry. Luo (2002) argues that organisation in the farming industry is a transaction coordination mechanism that makes farmers switch to professional management. Based on research results, Yin (2002) noted that, in the early 1990s, industrial organisation models with leading enterprises,

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intermediary organisations, or professional markets as their stalwarts, flourished in various parts of China, with desirable socio-economic outcomes. In other supply-chain studies, vertical coordination or industry organisation have also indicated that industry organisation substantially affects the quality-control behaviour of the farmers, their income, and their adoption of technology (Han & Wang, 2008). The useful findings of such studies provide a scientific basis for the formulation of agricultural and village policies in our country. However, research has failed to quantitatively consider the effect of industry organisation on variation in the production outcome of the farmers and the factors that underlie this outcome from the perspective of production technique efficiency.

We chose the yellow croaker (a representative species in China's mariculture) as our research object. Empirical analysis was used to study the efficiency of yellow croaker production techniques employed by the basic production unit of the family. This analysis was replicated for different forms of industry organisation based on data collected through field research at 405 yellow croaker farming households located in nine breeding regions in three counties (cities) in the provinces of Fujian and Zhejiang, China.

## 2. Model and data

### 2.1. Theoretical model

The stochastic frontier production function model developed by Aigner, Lovell, and Schmidt (1977) can simultaneously estimate the loss of technical efficiency and the stochastic production frontier function as well as analyse the factor(s) that cause a loss in technical efficiency under the premise of guaranteeing unbiased and effective estimation results. The theoretical model is as follows:

$$Y_i = f(X_i, \beta) \cdot \exp(V_i - U_i) \quad (1)$$

We get the logarithm to the left and right sides of the function:

$$\ln Y_i = \ln f(X_i, \beta) + V_i - U_i \quad (2)$$

In (2),  $Y_i$  represents the actual output of the  $i$ -th entity,  $X_i$  is the input vector of the  $i$ -th entity,  $\beta$  is an unknown parameter, the error term  $\varepsilon_i = V_i - U_i$  has a composite structure, and  $V_i$  and  $U_i$  are mutually independent.  $V_i$  represents non-controllable factors in the samples, such as natural disasters and the weather, and can be used to determine the measurement error and the effect of random interference with  $V_i \in N(0, \sigma_v^2)$ , while  $U_i$  is the production technique inefficiency part of the  $i$ -th sample unit (i.e., the separation between the output and the production possibility boundary).  $U_i \in (m_i, \sigma_u^2)$  is a non-negative random variable and  $U_i = 0$  indicates that the sample unit is at the production frontier.  $U_i > 0$  indicates that the output of the sample unit is below the production frontier (i.e., in a state of non-technical efficiency).

In this case, the efficiency function can be expressed as follows:

$$m_i = \delta_0 + \sum_{j=1}^n \delta_j w_j + \varepsilon_{it} \quad (3)$$

In equation (3),  $w_j$  represents the  $j$ -th exogenous variable that determines the production technique efficiency of entities in the sample, with  $\delta_0$  and  $\delta_j$  as the parameters to be estimated. When  $\delta_j$  is positive, the exogenous variable  $w_j$  has a negative effect on production technique efficiency.  $\varepsilon_{it}$  is a random variable that is subjected to extreme distributions.

Since the error terms in equations (2) and (3) contain the unobservable variables of technical efficiency and random disturbance, the regression equation does not satisfy the classical assumptions of the least squares method. In addition, the ordinary

least squares (OLS) method cannot be used to estimate the parameters. Based on the maximum likelihood estimation, Battese and Corra (1977) used  $\sigma^2 = \sigma_v^2 + \sigma_u^2$  and  $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$  to replace the variance of the alternative error term and the technical efficiency, with  $\gamma \in N(0, 1)$ .

Therefore, the technical efficiency of the production and operation of the sample unit "i" can be estimated using equation (4).

$$TE_i = \exp(-U_i) = \frac{Y_i}{e^{f(x_i, \beta) + v_i}} = \frac{Y_i}{Y_i^*} \quad (4)$$

In (4),  $Y_i$  is the actual output of the sample under observation, and  $Y_i^*$  is the maximum output under the existing technology.

### 2.2. Establishment of the empirical model

Based on the previously mentioned approach, this paper adopts a more flexible form of the transcendental logarithm production function, which is based on the stochastic frontier production function model defined by Battese and Coelli (1995), to analyse the production technique efficiency of yellow croaker breeders under different types of industry organisation. The equation is as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln(AC)_i + \beta_2 \ln(AL)_i + 1/2\beta_3 \ln[(AC)_i]^2 + 1/2\beta_4 \ln[(AL)_i]^2 + \beta_5 \ln(AC)_i \ln(AL)_i + \beta_6 D + V_i - U_i \quad (5)$$

In the above formulation,  $Y_i$  is the production of large yellow croaker in unit area of the farmers;  $AC_i$  is the capital input per unit surface area of the  $i$ -th farmer and includes the construction and purchase of fixed assets, such as enclosures and boats, fry, feed, medicine, and other production data inputs;  $AL_i$  is the labor input of unit area of the  $i$  farmer, which includes the employee and family labor.  $D$  represents the regional dummy variables (take Fujian as a reference);  $V_i$  is the random error terms;  $U_i$  is the loss of technical efficiency;  $\beta_0 - \beta_6$  is the parameters to be estimated.

The farmer's technical efficiency is an endogenous variable that is affected by many exogenous factors. From a microscopic viewpoint, it is primarily affected by the family's endowment. The main variables used to explain the differences in efficiency among yellow croaker farmers are family traits, whether the farmer has received training in breeding techniques, farm scale, and type of industry organisation.

The settings of the yellow croaker farmer production technology efficiency factors model can be represented as follows:

$$m_i = \delta_0 + \delta_1 x_{1i} + \delta_2 x_{2i} + \delta_3 x_{3i} + \delta_4 x_{4i} + \delta_5 x_{5i} + \delta_6 x_{6i} + \delta_7 x_{7i} + \delta_8 x_{8i} + \delta_9 x_{9i} + \varepsilon_i \quad (6)$$

In equation (6),  $i$  represents the serial number of the farming household,  $x_1$  is the age of the head of the farming household,  $x_2$  is the household head's educational level,  $x_3$  is the farming household's experience,  $x_4$  is the number of members in the farming household,  $x_5$  is the fraction of the farming household's income that is derived from rearing yellow croakers,  $x_6$  is the surface area of the farming household's breeding enclosures,  $x_7$  is the surface area of the farming household's breeding enclosures in square metres,  $x_8$  is whether members of the farming household have undergone technical training,  $x_9$  is the type of industry organisation to which the household belongs, and  $\delta_0 - \delta_9$  are the parameters that affect the farming household production technique efficiency that must be estimated.

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