Cost-benefit Analysis on Higher-place Pond Culture of Penaeus Vannamei

—— A case of a farmer in Zhanjiang City of Guangdong Province

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Abstract: This paper is intended to perform cost-benefit, break-even and sensibility analysis of higher-place pond culture of Penaeus vannamei through a case study of a farmer in Zhanjiang City of Guangdong Province, using cost-benefit data about this farmer's higher-place pond culture of Penaeus vannamei collected from field survey. Major findings of this study include: (1) The variable costs, as a component of the cost structure, are prime costs that include feed cost, utilities, and manure & shrimp drug expenses, of which the feed cost is the largest contributor; fixed costs make up a smaller share of total costs, of which the fixed labor cost and depreciation of fixed assets are prime costs, and the former is the largest contributor. (2) The higher-place pond culture of Penaeus vannamei is robustly resistant to the risks associated with market price fluctuation and uncertainties and yields high economic benefits. (3) The net margin is most sensitive to price, followed by variable costs and fixed costs. Finally, relevant suggestions on how to help farmers (or aquaculture businesses) increase their economic benefits are proposed based on the above findings.

Key words: Penaeus vannamei; higher-place pond culture; cost-benefit analysis

Introduction

Penaeus vannamei is currently one of the commercial important shrimp specifies in the world. According to FAO statistics, Penaeus vannamei was cultured in 38 countries and districts throughout the world in 2015, with its total production reaching 3,879,800 tons. The major producer countries of Penaeus vannamei include China, India, Indonesia, Ecuador, Vietnam, Thailand, Mexico, Brazil and Malaysia which altogether produced 3,700,800 tons of Penaeus vannamei in 2015, accounting for 95.39% of the world's total production; among these 9 countries, China output 1,624,600 tons of Penaeus vannamei, representing 41.87% of the world's total production and coming first in the world.

Through nearly 30 years of development, China has evolved its aquaculture model of Penaeus vannamei from the single earth pond culture to varied aquaculture models. The aquaculture models now prevailing around China include earth pond, higher-place pond and industrial aquaculture[1]. Among them, higher-place pond culture is a culturing method where a pond is built on sands above the high-water line. The pond is typically in rectangular shape, with a unit area of 1 - 3 mu (1 mu = 666.7 m^2) for a water depth of 1.5 – 2.4 m and equipped with aerators[2]. In early 1990s, higher-place pond culture of shrimp was firstly introduced to Guangdong Province on a trial basis and later expanded swiftly across the southern coastal areas, promoting the rapid development of shrimp aquaculture in China[3]. In this paper, the cost and benefit of higher-place pond culture of Penaeus vannamei are analyzed and the problems that may exist in the farming course are investigated to increase the profit margin of Penaeus vannamei farming and propose relevant suggestions on how to help farmers (or aquaculture businesses) increase their economic benefits.

As early as 1987, foreign scholars J.A. WYBA et al. analyzed the operational costs of shrimp aquaculture farms in Hawaii and Texas aquaculture, asserting that shrimp seed, feed and labor costs are the prime costs that incur in the course of farming and operating profit is more sensitive to output increase (i.e. raising survival rate, market price, stocking density and growth rate) than to cost reduction (i.e. reducing PL, labor, taxation or feed costs) [4]. In 2006, Shaun M. Moss compared the production costs between pond culture and industrial recirculating aquaculture system (RAS) of shrimps and concluded that feed cost occupies the largest share of variable costs in both cultivation methods and survival rate is the most important factor that affects the total cost structure by contributing to 90.9% changes in total cost. After comparing the survival rate, average growth and efficiency of food conversion between the two cultivation methods, they contended that RAS is an economically feasible alternative to pond culture[5]. Later, a number of foreign scholars have studied the aquaculture cost and benefit. For example, both Graeme and Nyberga examined the cost and benefit of a single fingerling. Specifically, Graeme et al. analyzed the cost structure and net margin of Tilapia aquaculture, claiming that feed cost is the prime cost of Tilapia aquaculture and an aquaculture method backed by scientific management is beneficial to boosting economic benefits of aquaculture. [6] Nyberga et al. made an NPV (net present value) analysis on the aquaculture economic benefits of Atlantic salmon[7]. Honghua Shi et al. studied the farming cost and benefit of mixed aquatic products (three aquaculture models including single kelp, single scallop, kelp + scallop) and compared the economic benefits among these three aquaculture models using NPV and cost-profit ratio[8]. Mark J. Kaiser et al. analyzed the cost and benefit of aquaculture in the open ocean[9]. Domestic scholars such as Peng Gang[10], Yang Zhengyong[12], Yang Deli[13], Gao Ya[14], Zhang Shijun[15] and Lv Xiaoting[16] et al. also conducted a cost-benefit analysis on their respective selected aquatic products, all stating that feed cost is the prime cost of aquaculture and fingerling cost is another major cost of fish farming. To be specific, Peng Gang suggested that pond rental is another prime cost of farming in addition to feed and fingerling costs; Gao Ya found that labor cost is also a prime cost in addition to the above cost factors; Zhang Shijun performed a cost-benefit analysis of Hongdao clam culture and supported that labor cost is a prime cost factor of farming; Yang Deli analyzed the cost and benefit of turbot cultivation and demonstrated that operating profit is more flexible to unit price than to unit variable cost and fixed cost and that the prime costs of farming include feed cost, utilities and depreciation of unit fixed cost.

In this paper, firstly, the cost and benefit of higher-place pond culture of Penaeus vannamei are analyzed using field survey data collected through a case study of a farmer in Zhanjiang City of Guangdong Province; and then the farming cost, benefit and break-even and as well as the sensibility of net margin to different factors are analyzed; finally, relevant suggestions on how to help farmers (or aquaculture businesses) increase their economic benefits are proposed based on the above findings.

1 Development of Penaeus Vannamei Farming in China

In 1988, Penaeus vannamei was introduced to China from America; in 1992, initial success was reported in parent shrimp artificial propagation; in 1994, a small batch of Penaeus vannamei seeds were harvested; in 1999, high-quality seed shrimps and propagation techniques were introduced from America. From then on, the cultivation technique was evolving progressively. The use of film mulching technology in 2001 contributed to an effective control of shrimp diseases and resulted in an increasing higher stocking density. Penaeus vannamei is characterized by strong adaptability to the aquaculture environment, short growth cycle, low nutritional requirement, strong resistance to diseases, easy artificial propagation and suitability to high-density rearing, making Penaeus vannamei culture developing rapidly in China. As can be seen in Figure 1-1, the production of Penaeus vannamei in China was on the increase year by year, climbing from 87,800 tons in 2001 to 1,672,200 tons in 2016, which was 19.04 times higher than 2001 and representing an AAGR (average annual growth rate) of 21.7%.

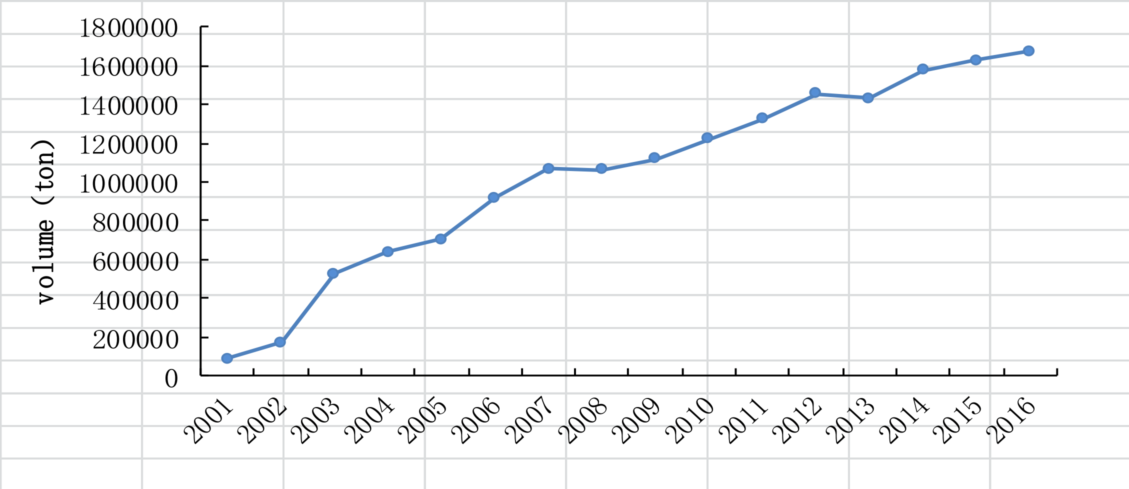

Figure 1-1 Changes of Penaeus vannamei production in China over time

*Source: FAO FishstatJ

China has secured the first place in Penaeus vannamei production across the world for long. Its production made up 31.34% of the world's total production in 2001, and the figure kept climbing year by year and coming up to 41.87% in 2015, as shown in Figure 1-2.

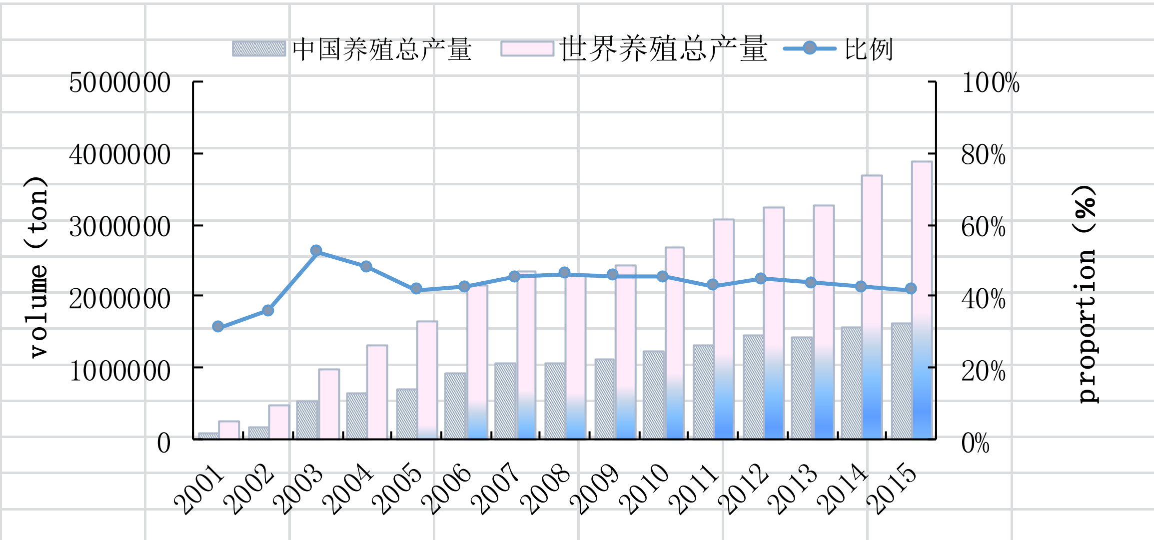

Figure 1-2 Comparison of China's and the world's productions of Penaeus vannamei in 2001-2015

*Source: FAO FishstatJ

Penaeus vannamei is becoming the shrimp species with the highest production in China. According to the data reported in the *China Statistics Yearbook on Fishery 2017*, Penaeus vannamei production accounted for 20.31% and 50.61% of total shrimp production in 2001 and 2016, respectively. The shrimp species currently cultured in China include Penaeus vannamei, Penaeus monodon, Penaeus chinensis, Penaeus japonicus, Macrobrachium rosenbergii, freshwater shrimp, Procambarus clarkii, etc. Among them, Penaeus vannamei has the highest yield, with its production accounting for 50.61% of total shrimp production in 2016. Penaeus vannamei is cultured in 28 provinces (cities and autonomous regions) across China, mainly distributing in eastern coastal areas including Guangdong, Guangxi, Jiangsu and Fujian Provinces. Guangdong Province produced 615,400 tons of Penaeus vannamei in 2016, ranking first in China and taking up 36.8% of China's total Penaeus vannamei production; Guangxi Province produced 211,000 tons of Penaeus vannamei, ranking second in China and occupying 12.62% of China's total Penaeus vannamei production; and the two provinces added up to 49.42% of China's total Penaeus vannamei production.

2 Cost-benefit Analysis on a Farmer's Higher-place Pond Culture of Penaeus Vannamei in Zhanjiang City of Guangdong Province

This paper includes a case study of a farmer in Zhanjiang City of Guangdong Province to support the cost-benefit analysis on the higher-place pond culture of Penaeus vannamei. The data about this farmer's Penaeus vannamei culture in 2017 were collected by the Industrial Economic Team of the National Shrimp and Crab Industrial Technology System through two field surveys conducted in September 2017 and January 2018 respectively. This farmer recruited professional personnel with years of aquaculture experience to manage the farm using sophisticated aquaculture management techniques. He contracted 53 mu lands to build 11 aquaculture ponds with a unit area of 3-4 mu, totaling 38 mu. With 6 permanent workers, this farm reared and produced Penaeus Vannamei for two seasons each year.

2.1 Cost Analysis

In view of this farmer's actual aquaculture conditions, the aquaculture costs are divided into fixed costs and variable costs, of which, variable costs include shrimp seed, feed, manure & shrimp drug costs, utilities and other expenses (including pick up charge, intermediary fee, feed shipping cost, daily expenses, etc.). Fixed costs include land rental, fixed labor cost, equipment maintenance cost and depreciation of fixed assets. The costs reported here are all average costs per mu.

The aquaculture costs are analyzed using field survey data, with the results summarized in Table 2-1. This farmer's average annual aquaculture cost in 2017 was RMB 35,625.37 per mu. The variable costs, as prime costs, accounted for 86.17% of total costs. Among all the variable costs, the feed cost is the largest contributor, reaching RMB 16,196.95/mu on average yearly and making up 45.46% of total costs, followed by manure & shrimp drug costs and utilities, reaching RMB 5,963.82/mu and RMB 4,060.64/mu and making up 16.74% and 11.40% of total costs, respectively. Fixed costs take up a smaller share of total costs, being 13.83%. Among all the fixed costs, the fixed labor cost is the largest contributor, reaching RMB 2,935.596/mu on average yearly and accounting for 8.24% of total costs, followed by depreciation of fixed assets, reaching

RMB 1,574.55/mu and making up 4.42% of total costs.

Table 2-1 Cost structure for higher-place pond culture of Penaeus vannamei in 2017

	Item	Amount (yuan/mu)	Percentage to total costs (%)
Variable costs	Shrimp seed	2868.54	8.05%
	Feed	16196.95	45.46%
	Manure and shrimp drug	5963.82	16.74%
	Utilities	4060.64	11.40%
	Other expenses	1607.51	4.51%
	Subtotal	30697.46	86.17%
Fixed costs	Land rental	328.95	0.92%
	Fixed labor cost	2935.59	8.24%
	Equipment maintenance	88.82	0.25%
	Depreciation of fixed assets	1574.55	4.42%
	Subtotal	4927.91	13.83%
	Total	35625.37	100.00%

*Source: data calculated based on field survey data.

2.2 Benefit Analysis

Aquaculture benefits are measured by total income, net margin, cost-profit ratio and return on sales. Net margin is a direct metric of aquaculture benefits. Costs-profit ratio is a measure of aquaculture profit level. Return on sales is a measure of the farmer's (or aquaculture business's) income level and reflects the business's profitability.

Table 2-2 illustrates the benefits generated from higher-place pond culture of Penaeus vannamei. As shown in the table, the total income of higher-place pond culture of Penaeus vannamei was RMB 84,740.29/mu in 2017, higher than the total cost RMB 35,625.37/mu and producing net margin of RMB 49,114.92/mu, suggesting that higher-place pond culture of Penaeus vannamei did yield high economic benefits. Meanwhile, the cost-profit ratio was 137.87% and the return on sales 57.96%, indicating that the farmer made profits at low costs, controlled operational costs and expenses reasonably and realized high return on sales and profitability.

Table 2-2 Benefit structure for higher-place pond culture of Penaeus vannamei in 2017

Total cost (yuan/mu)	Total income (yuan/mu)	Net margin (yuan/mu)	Cost-profit ratio (%)	Return on sales (%)
35625.37	84740.29	49114.92	137.87%	57.96%

2.3 Uncertainty Analysis

2.3.1 Break-even Analysis

Break-even analysis is performed to reflect the equilibrium relationship between aquaculture cost and benefit as well as a producer's adaptability to model change and resistance to risks.

Table 2-3 summarizes the results of break-even analysis on higher-place pond culture of Penaeus vannamei. As can be seen in the table, the break-even volume of Penaeus vannamei was 146,860 g/mu in 2017, much lower than the actual capacity 1,559,975 g/mu; the ratio of BEP to present capacity utilization was 9.42%, the actual sales price was 0.05354 yuan/g, 0.03116 yuan/g higher than the break-even price (i.e. 0.02238 yuan/g), suggesting that higher-place pond culture of Penaeus vannamei is robustly resistant to the risks associated with market price fluctuation and uncertainties in normal production years.

Table 2-3 Break-even analysis on higher-place pond culture of Penaeus vannamei in 2017

Break-even volume (g/mu)	Actual capacity (g/mu)	Ratio of BEP to present capacity utilization (%)	Break-even price (yuan/g)	Actual sales price (yuan/g)	Gap between actual sales price and break-even price (yuan/g)
293.72	3119.53	9.42%	11.19	26.77	15.58

2.3.2 Sensibility Analysis

This section provides an analysis of net margin's sensibility to various uncertainties. The sensibility coefficient of net margin to an uncertainty is calculated by the uncertainty's variable proportion divided by the resultant net margin's proportion of change. The higher the absolute value of sensibility coefficient is, the greater resultant changes of net margin will be under the same variable proportion, assuming that other conditions remain unchanged.

Table 2-4 shows the sensibility coefficients of net margin generated from higher-place pond culture of Penaeus vannamei to various influence factors. By analyzing the absolute values of net margin's sensibility coefficients, we can find that the net margin's sensibility coefficient to price was the highest (i.e. 1.72) in 2017, suggesting that net margin is more sensitive to price than to variable and fixed costs. Meanwhile, the angle between the line and the horizontal axis as shown in Fig. 2-1 Net Margin Sensibility Analysis for Higher-place Pond Culture of Penaeus Vannamei also reveals that the net margin is most sensitive to price, followed by variable costs and fixed costs. The above analysis suggests that reduction of variable costs is an easier way to raise the net margin of higher-place culture of Penaeus vannamei and improve profitability.

Table 2-4 Net margin sensibility coefficients for higher-place pond culture of Penaeus vannamei in 2017

	coefficients
Fixed costs	-0.10
Variable costs	-0.63
Price	1.72

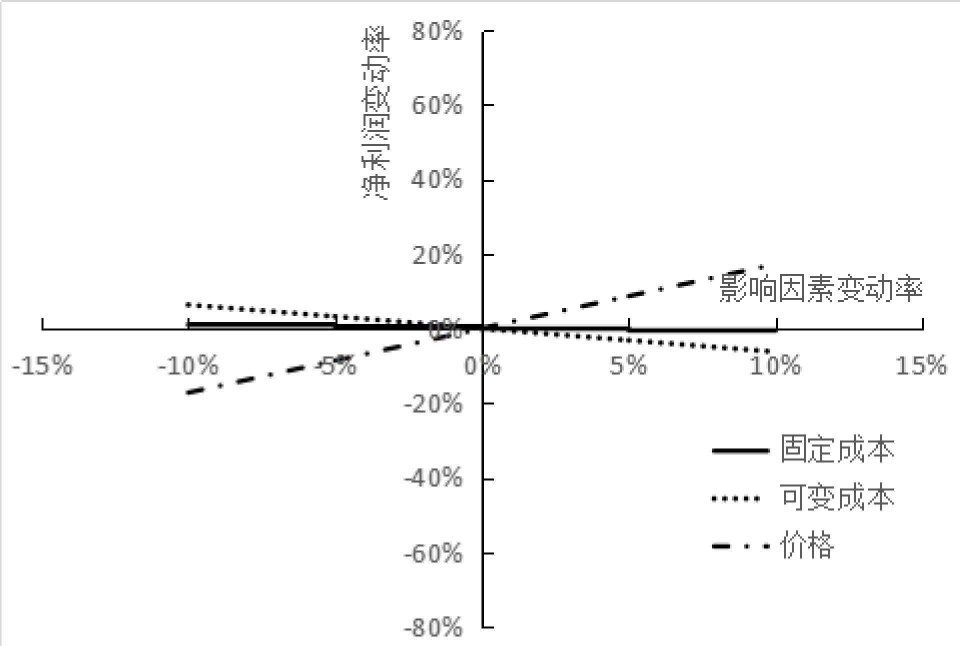

Fig. 2-1 Net margin sensibility analysis for higher-place pond culture of Penaeus vannamei in 2017

3 Conclusions and Recommendations

In this paper, the cost and benefit of higher-place pond culture of Penaeus vannamei are analyzed using field survey data collected through a case study of a farmer in Zhanjiang City of Guangdong Province. Major findings of this study include: (1) The variable costs, as a component of the cost structure, are prime costs that include feed cost, utilities, and manure & shrimp drug expenses, of which the feed cost is the largest contributor; these three cost factors account for about 74% of total costs. Fixed costs make up a smaller share of total costs, of which the fixed labor cost and depreciation of fixed assets are prime costs, and the former is the largest contributor. (2) The higher-place pond culture of Penaeus vannamei is robustly resistant to the risks associated with market price fluctuation and uncertainties and yields high economic benefits. (3) The net margin is most sensitive to price, followed by variable costs and fixed costs.

To sum up, the following recommendations are proposed to help farmers (or aquaculture businesses) increase their economic benefits: the competent authority of the industry and relevant enterprises should intensify their efforts in scientific R&D of shrimp feeds and diseases and technology promotion, cut down the production cost of feeds, produce high-quality feeds and improve diseases prevention and control technologies. Farmers should take an active part in aquaculture technique training to improve their aquaculture management expertise, select high-quality shrimp feeds, drugs and aquaculture machines supplied by noted enterprises for higher efficiency of feeds and aquaculture machines, and improve their knowledge on shrimp disease prevention and control to mitigate undesired aquaculture costs and risks. Realization of higher aquaculture benefits depend on the joint efforts of the competent authority of the industry, relevant enterprises and farmers (or aquaculture businesses).

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