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Analysis on Price Competition of Cold Chain Logistics Enterprises of Aquatic Products in Fujian Province*

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***Abstract*—At present, the cold chain logistics industry of aquatic products in Fujian Province is developing slowly, and the market competition is fierce, and the vicious price competition among enterprises is frequent, resulting in the decline of enterprise profits, which seriously affects the healthy and stable development of the whole industry. This paper investigates the well-known cold chain logistics enterprises in Fujian Province, summarizes the competition situation of the whole province's cold chain logistics enterprises of aquatic products, studies the game process of price competition among cold chain logistics enterprises of aquatic products under complete information static game and Cartel alliance by using Bertrand Model in game theory, and finally puts forward some suggestions to break through the price competition predicament.**

Keywords—aquatic products; cold chain logistics enterprises; price competition; game theory; Fujian Province

I. INTRODUCTION

Under the support of Maritime Cooperation Project between China and ASEAN, EPCA (Framework Agreement for Economic Cooperation on the West Coast of the Straits) Industrial Cooperation Project, and a series of important government policies and measures, the development of fishery in Fujian Province has enjoyed sound momentum in recent years. According to the data released by Department of Oceans and Fisheries, the output of aquatic products in the province has increased year after year, and the growth trend is obvious especially after 2009. In 2017, the gross ocean production of Fujian Province reached RMB 920 billion, a year-on-year growth of 15%; the total output value of fishery economy reached RMB 287 billion, a year-on-year growth of 5%; the total output of aquatic products reached 8,020,800 tons, a year-on-year growth of 4.54%. The foreign exchange through aquatic product export in the whole province remained first in the country.

However, in 2017, the comprehensive cold chain circulation rate of fresh edible agricultural products in the province was nearly 27%, and the cold chain circulation rate of aquatic products was 65%, 30 percentage points higher than the national average. But compared with the cold chain circulation rate of garden stuff, meat, aquatic products that reaches more than 90% in America and other developed countries, the gap is still very obvious. As far as the current development of cold chain logistics in Fujian Province is concerned, there are few enterprises specializing in cold chain logistics of aquatic products. Many cold chain enterprises also operate other products concurrently, and most of them have small scale and single service. The undifferentiated service of cold chain logistics enterprises intensifies the industrial competition. In order to compete for market share, enterprises and individual operators vie in forcing down the price, resulting in a chaotic and disorderly vicious price competition in the market, which brings a great negative impact on the whole cold chain logistics market. Therefore, based on the game theory, this paper analyzes the reasons, advantages and disadvantages, game process and results of price competition among cold chain logistics enterprises of aquatic products in Fujian Province, and puts forward the method to solve price competition, which can offer experience and reference for future research of aquatic product cold chain logistics enterprises.

II. GAME THEORY METHOD

A. Basic Concept of Game Theory

Gaming theory studies the decision-making and relevant balancing problems when decision-making bodies react against each other. In the game, both parties adjust and improve their strategies based on the other party's strategies, so as to win in the competition. This paper adopts the theory

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and method in the non-cooperative game in analyzing the price competition of cold chain logistics enterprises of aquatic products in Fujian Province.

B. Nash Equilibrium and Bertrand Model

Nash equilibrium means that in the game $G = \{S_1, \cdots, S_n; u_1, \cdots u_n\}$, in a strategy combination $s^* = (s_1^*, \cdots, s_i^*, \cdots, s_n^*)$ consisting of one strategy from each participant, if the strategy of any participant is the optimal strategy for the combination $s_{-i}^* = (s_1^*, \cdots, s_{i-1}^*, s_{i+1}^* \cdots, s_n^*)$ of other participant's strategy, that is:

$$u_i(s_i^*, s_{i-1}^*) \geq u_i(s_i, s_{i-1}^*),\ \forall s_i \in S_i, \forall i$$

Formula (1-1)

Then $s^* = (s_1^*, \cdots, s_i^*, \cdots, s_n^*)$ is Nash equilibrium of G.

In 1883, Bertrand proposed Bertrand oligopolistic model. In the model, each manufacturer chooses the price as the strategy space, and under the given price chosen by all the manufacturers, manufacturer can produce enough products to meet all the market demand. The model has three basic assumptions: undifferentiated products, unconstrained production capacity and static game with complete information. The Bertrand Model is the basis for studying enterprise price competition [1].

III. Analysis on Price Competition of Cold Chain Logistics Enterprises of Aquatic Products in Fujian Province

A. Competition Situation of Cold Chain Logistics Enterprises of Aquatic Products in Fujian Province

1) Competition mode is dominated by price competition: The cold chain logistics industry of aquatic products in Fujian Province is in its infancy, with imperfect industry standards and operational specifications, and relatively backward enterprises' technical level, facilities and equipment and management capabilities. Its services that can be provided are single, especially in the traditional logistics such as transport and storage. The strong homogeneity of services fundamentally determines that the competition mode of cold chain logistics enterprises will be dominated by price. At present, in the cold chain logistics market of aquatic products, the cold chain logistics services with added value such as inventory management, logistics cost control, whole-process cold chain logistics and logistics scheme design are quite scarce, while the traditional road transportation and warehousing services oversupply, resulting in fierce price competition. Moreover, people have insufficient understanding of the cold chain and have not realized the importance of the cold chain to ensure product quality and safety. As a result, producers, wholesalers, and retailers are looking for the lowest-priced cold chain logistics providers, so that cold chain logistics enterprises have to compete on price to contend for customers.

2) Diverse and chaotic competitive subjects: At present, the competitive subjects of cold chain logistics market in Fujian Province include aquatic product processing enterprises or wholesalers with self-run cold chain logistics, third-party cold chain logistics enterprises, and many individual transport operators lacking cold chain knowledge. These individual transport operators usually purchase a small and medium-sized refrigerator truck, specializing in the LTL transport of aquatic products in the province. In the aquatic product market, there are many individual transport operators waiting for goods. Because of limited daily supply and scattered distribution destinations, many individual transport operators spend a morning collecting goods suitable for their own transport. Therefore, the individual transport operators have to lower the price to reduce the empty load rate and the loss, which intensifies the competition degree of the market. In the case of limited cold chain logistics market, the influx of many competitive subjects will not only lead to excessive competition in the cold chain logistics market in certain areas or regions, but also bring difficulties in standardizing and managing the cold chain logistics market, resulting in disorderly competition in the cold chain logistics market.

3) Relatively narrow competitive fields: There are three reasons why the competition content fields of cold chain logistics enterprises of aquatic products in Fujian Province are limited to refrigerated transport and storage. First, cold chain logistics enterprises of aquatic products can only provide basic transport and storage services due to their backward software and hardware. They do not have the ability to provide integrated cold chain logistics services and whole-process cold chain logistics services. The expansion to value-added service sector requires a large investment and a greater risk-taking. Self-operated cold chain logistics enterprises and individual transport operators with limited capital and technology will not easily make a try. Second, at present, most of the aquatic products are sold directly after rough processing. In addition to the necessary refrigerated transportation and storage, enterprises have less demand for high-end cold chain logistics services. Third, people's understanding of cold chain logistics is generally insufficient, and they are not aware of the hazards of cold chain breakage, as a result, cold chain logistics enterprises lack motivation in equipment input, technology improvement and service innovation [2].

B. Price Competition Based on Game Theory

1) Analysis of static game with complete information based Bertrand Model

a) Establishment of basic model of market game: In the cold chain logistics market of aquatic products in Fujian Province, enterprises provide kinds of service products. If

the enterprise chooses the price, customers' demand for enterprise product is [3]:

$$q_i(p_i,\ p_j) = a_i - b_i p_i + \sum_j d_{ij} p_j - \sum_j d_{ji} p_i$$

Formula (4-1)

In the formula, $1 \le i \le n,\ \ 1 \le j \le n,\ \ a_i, b_i > 0,\ \ 0 \le d_{ij} \le 1,\ \ 0 \le d_{ji} \le 1,$ j refers to other enterprises except i, and ai refers to consumers' demand for the product, and bi refers to consumers' sensitivity to price, and dij refers to the product substitution coefficient of enterprise i to enterprise j, by the same token, dji refers to the product substitution coefficient of enterprise j to enterprise i.

Each enterprise can set different sales prices so that the strategy space of each enterprise can be expressed as $S_i = (0, +\infty)$. Assuming that the fixed cost of enterprises is not taken into consideration (the cold chain logistics enterprise has already invested fixed costs in the early stage, and this part of cost is sunk cost, so it can be ignored in decision-making), the marginal cost of per unit output of each enterprise is c_i [4]. When the price of enterprise i is p_i, and the price of other enterprises is p_j, the profit function of the enterprise i can be expressed as:

$$\pi_i(p_i,\ p_j) = q_i(p_i,\ p_j)(p_i - c_i)$$

Formula (4-2)

$$= \left(a_i - b_i p_i + \sum_j d_{ij} p_j - \sum_j d_{ji} p_i\right)(p_i - c_i)$$

Formula (4-3)

The Nash equilibrium of the game should be to maximize the profit of each enterprise, and then:

$$\max \pi_i(p_i,\ p_j^*) = \max\left(a_i - b_i p_i + \sum_j d_{ij} p_j - \sum_j d_{ji} p_i\right)(p_i - c_i)$$

Formula (4-4)

It can be obtained:

$$p_i^* = \left[a_i + \sum_j d_{ij} p_j^* + \left(b_i + \sum_j d_{ji}\right)c_i\right] / 2\left(b_i + \sum_j d_{ji}\right)$$

Formula (4-5)

b) Price game between the two enterprises: In order to simplify the analysis, assuming that there are only two companies in the market and other parameters are temporarily uncertain, it can be obtained:

$$p_1^* = [a_1 + d_{12} p_2^* + (b_1 + d_{21})c_1] / 2(b_1 + d_{21})$$

Formula (4-6)

$$p_2^* = [a_2 + d_{21} p_1^* + (b_2 + d_{12})c_2] / 2(b_2 + d_{12})$$

Formula (4-7)

It can be obtained based on the two formulas:

$$p_1^* = \{2(b_2 + d_{12})[a_1 + (b_1 + d_{21})c_1] + d_{12}[a_2 + \\ /4(b_1 + d_{21})(b_2 + d_{12}) - d_{12}d_{21}$$

Formula (4-8)

$$p_2^* = \{2(b_1 + d_{21})[a_2 + (b_2 + d_{12})c_2] + d_{21}[a_1 + \\ /4(b_1 + d_{21})(b_2 + d_{12}) - d_{12}d_{21}$$

Formula (4-9)

$(p_1^*,\ p_2^*)$ is the only Nash equilibrium in the price game between the two enterprises. To better make comparison, let $a_i = 100,\ \ b_i = 1,\ \ d_i = 1,\ \ c_i = 10$, when $d_i = 1$ indicates that the service products provided by the two enterprises are completely substituted, the market equilibrium is obtained:

The product price of each enterprise is $p_1^* = p_2^* = p^* = 40$

The profit of each enterprise is $\pi_1^* = \pi_2^* = \pi^* = q^*(p^* - c_i) = 1800$.

Based on the Bertrand Model, we have established the basic price competition model of cold chain logistics enterprises of aquatic products in Fujian Province, by taking the two enterprises as an example, and we have assigned values to the parameters to obtain enterprise' product price and profit under the game model. However, in the above game, the result is whether the overall interests of the two enterprises reach the maximum; if not, whether similar price competition can be avoided. Therefore, we will explore the industry-wide profits in the form of Cartel alliance and compare them with the results in this section.

2) Analysis of cartel alliance based on game theory

a) Cartel alliance model: In September 1960, in order to overthrow western countries' exploitation of oil-producing countries in the Middle East, five countries including Iran and Saudi Arabia established Organization of Petroleum Exporting Countries. They raised price of oil through joint output restriction, thereby increasing the profits of member countries. This union was later called the Cartel alliance. Scholars define the Cartel alliance as "an organization that several enterprises producing high homogeneity products unite to control the price or output of products to achieve a monopoly"[5].

To better make comparison, it is still assumed that there are only two cold chain logistics enterprises of aquatic products in the market. These two enterprises form a Cartel alliance and stipulate that the monopoly price is p. At this point, the function of market's overall demand for cold chain logistics can be expressed as:

$$Q = \sum_{i=1}^{2} q_i = \sum_{i=1}^{2}\left(a_i - b_i p + \sum_j d_{ij}\, p - \sum_j d_{ji}\, p\right) = \sum_{i=1}^{2}(a_i - b_i p)$$

Formula (4-10)

At this point, all the substitutions of the product are completely cancelled out, that is, the product is not replaced.

The total profit of the industry is:

$$\pi(Q) = \sum_{i=1}^{2}(a_i - b_i p)(p - c_i)$$

Formula (4-11)

Work out the partial derivative of the above function, and make it equal to 0, the following can be obtained:

$$a_i - 2b_i p + b_i c_i = 0$$ Formula (4-12)

The result is:

$$p = (a_i + b_i c_i)/2b_i$$ Formula (4-13)

The obtained monopoly price is brought into the total profit function to obtain the total profit as:

$$\pi(Q) = \sum_{i=1}^{2}(a_i - b_i c_i)^2/4b_i$$

Formula (4-14)

Similarly, let $a_i = 100$, $b_i = 1$, $d_i = 1$, $c_i = 10$, it can be calculated:

The price of monopoly products is $p = 55$..

The profit of each enterprise is $\pi_i = 2025 > 1800$.

Obviously, Bertrand equilibrium profit is less than the Cartel alliance profit. It can be seen that when enterprises form a cartel alliance, the price of the product is raised and the profits of each enterprise will also increase. In turn, it can be explained that Bertrand price competition will make enterprises fall into the prisoner's dilemma and reduce the profits of the whole industry.

b) Stability analysis of alliance: Through the above comparative analysis, we can see that the profit of the Cartel alliance enterprises is higher than the profit obtained through Bertrand price competition. Then, to explore whether enterprises can get out of the prisoner's dilemma through alliance, the author will analyze the stability of the Cartel alliance.

It is assumed that the enterprise 1 complies with the agreement and sets the product price as monopoly price:

$$p_1 = p = (a_1 + b_1 c_1)/2b_1$$

Formula (4-15)

And the enterprise 2 violates the agreement and secretly reduces the price by β, namely:

$$p_2 = (a_2 + b_2 c_2)/2b_2 - \beta$$
$$(0 < \beta < (a_2 + b_2 c_2)/2b_2 - \beta)$$

Formula (4-16)

At this time, the profits of enterprise 1 and enterprise 2 are:

$$\pi_1 = (a_1 + b_1 c_1)(a_1 - b_1 p_1 + d_{12} p_2 - d_{21} p_1)/2b_i$$

Formula (4-17)

$$\pi_2 = [(a_2 + b_2 c_2)/2b_2 - \beta\,](a_2 - b_2 p_2 + d_{21} p_1 - d_{12} p_2)$$

Formula (4-18)

Let $a_i = 100$, $b_i = 1$, $d_i = 1$, $c_i = 10$, $\beta = 10$, it can be obtained:

$$\pi_1 = 1925 < 2025$$ Formula (4-19)

$$\pi_2 = 2925 > 2025$$ Formula (4-20)

It can be seen that the enterprise 2 violates the agreement and reduces the price, so that its profits become 2925, which is greater than the 2025 obtained by the alliance, so the enterprise 2 has sufficient motives to violate the agreement. But this will have an adverse impact on enterprise 1 and reduce the profit of the enterprise 1 from 2025 to 1925. Similarly, when the enterprise 2 complies with the agreement but the enterprise 1 violates the agreement and reduces the price, the profit of the enterprise 1 will also become 2925. Therefore, both sides of the game will choose to violate the agreement and reduce the price, thus bringing extra profits to themselves. At this time, this game returns to the Bertrand price competition model. It can be seen that although the formation of Cartel alliance can improve the profit of game participants, since the participants are all individual rationalists and seek to maximize their own interests, the Cartel alliance is unstable [5].

IV. Conclusion

The fundamental reason for the collapse of Cartel alliance is that it is composed of independent economic subjects freely, and the relationship between members does not belong to superior and subordinate, and they don't have to obey one another. The only reason for them to unite is the interests, so such an organization is very unstable. Members will not hesitate to betray the agreement once a larger interest emerges [6]. Therefore, it can be said that the Cartel behavior itself provides incentives to break up the Cartel alliance. However, there is no such strong enterprise in the cold chain logistics market of aquatic products in Fujian Province, so the price alliance cannot be established, and enterprises still cannot get out of the prisoner's dilemma.

Aquatic product enterprises must break through price competition through the following method.

A. Product Differentiation

With the change of people's consumption concept, customers also raise a higher demand to the cold chain logistics service. The traditional and single cold chain logistics service will gradually fail to meet the needs of customers. Therefore, from the perspective of long-term development, enterprises must add new services and create service product differentiation. In fact, in addition to the two basic services of refrigerated transportation and storage, cold chain logistics enterprises of aquatic products can also consider providing customers with fully integrated cold chain services, inventory management, cold chain logistics program planning, logistics inquiry, cargo tracking and other new services. On the one hand, by adding new products, enterprises can distinguish their products from those of other enterprises, reduce the degree of product homogeneity, and avoid the threat of price competition; on the other hand, these services have high added value and can greatly increase corporate profits.

B. Union or Merger of Enterprises

Cold chain logistics enterprises of aquatic products can take the form of merger or acquisition to integrate numerous scattered small third-party cold chain logistics enterprises, individual transport operators and cold chain logistics enterprises taking self-operated aquatic products as main form to form several relatively large enterprises. This will not only improve the strength and competitiveness of enterprises and reduce competitors in the market, but also optimize the allocation of social resources.

Moreover, aquaculture enterprises, processing enterprises, cold chain logistics enterprises in different types, different industries and regions, and distributors and retailers at all levels can form an alliance to discuss and exchange technological innovations, market segmentation, industry standards, and collaboration. Meanwhile, they also can establish a logistics industry that provides integrated cold chain supply chain services from the source to the retail terminal. Enterprises share out the work and cooperate with one another, and the degree of competition can be reduced.

C. Cultivating the Cold Chain Logistics Leading Enterprises of Aquatic Products

Fujian provincial government should cultivate several cold chain logistics enterprises of aquatic products with strong comprehensive strength to reduce the negative impact of price competition on the development of the whole industry. The government can support some cold chain logistics enterprises of aquatic products with good foundation and great potential, and give these enterprises preferential policies in financing, taxation, land requisition and equipment renewal, so that they can develop first, and then boost the development of the cold chain logistics industry of aquatic products in Fujian Province. What's more, the government can introduce well-known cold chain logistics enterprises at home and abroad to advance the development of the cold chain logistics industry in Fujian Province.

D. Developing and Improving Industry Standards

On the one hand, due to the lack of industry standards and norms and low market entry barriers, a large number of small-scale cold chain logistics enterprises of aquatic products and individual transport operators that have no cold chain logistics qualification emerge, resulting in market chaos; on the other hand, the cold chain operation has no basis, and the enterprise lacks the supervision, and the problem of cold chain breakage cannot be solved, and the formulation of cold chain standards is extremely urgent. The Fujian provincial government should speed up the construction of the cold chain logistics standard system for aquatic products based on the relevant documents issued by the state and the actual situation of the cold chain logistics of aquatic products in the province and by referring to foreign standards. By formulating and improving industry standards, the government should standardize the operation specifications of cold chain logistics of aquatic products, carry out quality-safety certification, raise barriers to market entry, and then regulate the entire cold chain logistics industry of aquatic product.

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