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Model of Long-term Stable Partners in Cigarette Industry Based on Game Analysis

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Abstract. At present, China's cigarette industry enterprises are developing rapidly, and have made positive contributions to the sustainable development of China's economy. However, in recent years, in the face of the impact of the COVID-19 epidemic and the complex and severe changes in the economic situation at home and abroad, the internal and external business environment of the cigarette industry has been challenged unprecedentedly, and the cigarette industry enterprises in China have experienced problems such as slowing down the growth of production and sales, rising inventory and shrinking consumer demand, which have made the industry as a whole. In the inter-provincial regions of the country, the cigarette planned quantity is closely related to the regional economy, which makes the major cigarette industrial enterprises compete and game with each other because of the cigarette planned quantity, and hinders the sustainable development of the big cigarette brands. In this paper, the complete information Cournot game model and Stackelberg game model are constructed among the strong and weak enterprises in the industry. Through the game calculation data, the current trend of cooperation among cigarette industrial enterprises is objectively judged. Through the analysis of the game model, the best partners and strategic partners of industrial enterprises are found, so as to stabilize the scale of cooperative production. Promote the development of key cigarette brands. The study found that from the two game models, it is found that most cigarette enterprises are in an unstable state of cooperation, and the construction of strategic cooperative relationship between enterprises can promote the stability of cooperation, meet the needs of strong cigarette industrial enterprises to find stable strategic partners, and promote the common development of cigarette industrial enterprises.

Keywords: Cigarette planned quantity; Complete information Cournot model; Stackelberg game model; Strategic partners.

1. Research Background

While systematically planning the cooperative relationship, cigarette industrial enterprises should ensure the continuous consolidation and improvement of their core competence on the one hand, and complement each other with the partners on the other hand. Through the analysis of two kinds of Cournot game models in the cigarette industry, a game model is constructed between the strong enterprises and the weak enterprises, so as to obtain the common interests and ways of realization that the cigarette industrial enterprises need in the cooperative production, as well as the development trend of the cooperative production of the cigarette industrial enterprises.

At present, in the scale of cooperative production plan of China's cigarette industry, Zhejiang Zhongyan accounts for about 1.5 million boxes, Yunnan and Jiangsu each account for about 1 million boxes, and Shanghai Tobacco, Hunan Zhongyan, Hubei Zhongyan and Guangdong Zhongyan account for about 1 million boxes. More than 90% of the cooperation of Yunnan Zhongyan is concentrated in its holding enterprises. For such strong cigarette industrial enterprises as Zhejiang Zhongyan, our main competitor is Jiangsu Zhongyan, while Jiangsu Zhongyan is similar to Zhejiang Zhongyan, with a cooperative production capacity of about 1 million boxes,

which is also a serious planned vacancy enterprise. How to improve our export brand structure and profit as soon as possible, understand the real situation of cooperative import disadvantaged enterprises, and judge the trend. How to plan company's future cigarette production plan and formulate long-term and short-term goals for the planned production. How to accurately identify the core demands of each input party and strive for a win-win situation for both sides without affecting the core interests of the company is of vital importance.

2. Analysis theory of Cournot game model with complete information

2.1 Applicability analysis of Cournot model with complete information

The Cournot model of complete information means that two companies are supposed to produce the same products at the same time and understand the market demand, so they must jointly decide the production quantity. It is assumed to simulate the game between two enterprises to strive for the cigarette surplus plan. Taking Zhejiang Zhongyan, a strong enterprise, as an example, the enterprise cooperates with 10 disadvantaged enterprises, including Sichuan Zhongyan, Guizhou Zhongyan, Shaanxi Zhongyan, Jiangxi Zhongyan, Guangxi Zhongyan, Chongqing Zhongyan, Zhongyan Industry, Anhui Zhongyan, Hebei Zhongyan and Henan Zhongyan. The relationship between the two enterprises is equal, and the two enterprises produce the same specification of cigarettes. And the two enterprises know the market demand and the cost of the cigarette of the specification, and the two enterprises know the cigarette planned quantity of the other side, and make the output decision at the same time. Therefore, through the construction of complete information Cournot model, the game of cooperative production planning quantity is carried out.

2.2 Principle of the Cournot model with complete information

The Cournot oligopoly model is a very important industrial organization model, which is the basis of analyzing the competitive strategy of enterprises and other issues. With two companies making the same kind of product, they compete in the market for production, that is, they provide each other with their own production, so as to obtain the greatest benefit. Respectively using the yieldq_1、q_2To represent, and will $Q = q_1 + q_2$As the total supply of the market product, where the price of the product is the inverse demand function of the market.$P(Q) = a - (q_1 + q_2)$Decide that the cost of firm I is$C_i(q_i) = c_i q_i, (i = 1,2)$, the profit function is$\pi_i(q_i, q_j) = P(Q)q_i - ci(q_i), i, j =$ 1,2 To get the Nash equilibrium, First, find the response function of company I. $R_i\,(q_j)$, and determine its yield q_j, and find the q_j Such that its maximum value is $max\pi_i(q_i, q_j) = [a - (q_i + q_j)]q_i - c_i q_i$, Derived: $\frac{\partial \pi_i}{\partial q_i} = a - q_j - c_i - 2q_i = 0$, The response function is: $R_i\,(q_j) = q_i = (a - q_j - c_i)/2$, The response function of firm J can be obtained similarly to the output of firm I.$R_j(q_i) = q_j = (a - q_i - c_j)/2$A Nash equilibrium is where two reaction curves intersect, and the result is:$q_1 = (a + c_2 - 2c_1)/3$, $q_2 = (a + c_1 - 2c_2)/3$, When the marginal cost of two firms

is$c_1 = c_2 = c$When, therefore

The equilibrium yield is $q_c = q_1 = q_2 = (a - c)/3$, The equilibrium price is $p_c = p_1 = p_2 = (a + 2c)/3$, The monopoly output is $q_m = (a - c)/2$, The monopoly price is $p_m = (a + c)/2$。

3. Use the complete information Cournot model to solve the competition and cooperation game relationship of cigarette industrial enterprises.

Under the assumption that the strong enterprise 1 is Zhejiang Zhongyan and the weak enterprise 2 is Guangxi Zhongyan, the two enterprises belong to the equal cooperative relationship. By constructing the complete information Cournot game relationship, the game calculation of the cooperative production plan quantity is carried out, and the equilibrium output (cooperative production quantity) and monopoly output are obtained.

In the oligopoly production game between Zhejiang Zhongyan and Guangxi Zhongyan, when the two enterprises cooperate in the demand function of production, $P = a - QA$ marginal cost C with no fixed cost is established. The complete information Cournot game model of two enterprises is shown.

The demand function of the cooperative production capacity of the two enterprises is obtained with the data of 2021: $p_1 = p_2 = 21546.4, Q_{21} = 132200$，$p_2 = a - Q_{21}$, solution:$a = 153746.4$, so the market demand function is $P = 153746.4 - Q$; C is the marginal cost,$c = 5564.7$ (Minimum cost of cigarettes per carton of output structure). According to the hypothesis, the Nash equilibrium yield (Cournot yield) is obtained by using the reaction function method as follows:$q_1 = q_2 = (a - c)/3 = (153746.4 - 5564.7)/3 = 49393.9, Q = 49393.9 \times 2 = 98787.8$。 At this point, the equilibrium price of the two firms is:$p_1 = p_2 = (a + 2c)/3 =$ （$153746.4 + 2 \times 5564.7$）$/3 = 54958.6, P = 54958.6/2 = 27479.3$ Monopoly output: $q_m = (a - c)/2 = 74090.9$，$Q_m = q_m \times 2 = 148181.8$ Monopoly price:: $p_m = (a + c)/2 = 79655.5$，$p_m = 79655.5/2 = 39827.8$ By analogy, that predict values of the complete information Cournot model for the strong enterprise and their partners in the cigarette industry are obtained as follows:

As can be seen from the above table, according to the cooperative production of strong export enterprises in the industry from 2021 to 2022, combined with the prediction results of the complete information Cournot model, the cooperative production of Zhejiang Zhongyan is currently in the stage of monopoly (saturation) output decline without falling below the equilibrium output. At present, the cooperative production of Hunan tobacco is in the stage of monopoly (saturation) production decline and does not fall below the equilibrium production, the cooperative production of Yunnan tobacco is in the stage of monopoly (saturation) production decline and does not fall below the equilibrium production, and the cooperative production of Shanghai tobacco is in the stage of monopoly (saturation) production decline and does not fall below the equilibrium production. At present, the cooperative production of Hubei Zhongyan is in the stage of falling below the equilibrium output, while the cooperative production of Jiangsu Zhongyan is in the stage of not reaching the monopoly (saturation) output. Therefore, it can be concluded from the above that the cooperative production in Zhejiang, Hunan, Yunnan and Shanghai is basically in a saturated state, which is not conducive to stabilizing the cooperative relationship with enterprises in the future; the cooperative production in Jiangsu still has room to rise, and the cooperative relationship can still

be stabilized in the future; Hubei Zhongyan has fallen below the equilibrium output and is on the verge of withdrawing from cooperation.

4. Analysis of Stackelberg Game Model

4.1 Applicability analysis of Stackelberg model

The Stackelberg model assumes that two companies, one a strong leader and the other a relatively weak follower, produce the same product together, with one firm in a dominant position and the other a follower. Manufacturers will make decisions according to their own production level in order to maximize profits.

It is assumed to simulate the game between two enterprises to strive for the cigarette surplus plan. The absolute strong export enterprises are Zhejiang Zhongyan, Jiangsu Zhongyan, Shanghai Tobacco, Hunan Zhongyan, etc. The absolute weak import enterprises are Chongqing Zhongyan, Shaanxi Zhongyan, Anhui Zhongyan, Hebei Zhongyan, and the strategic cooperative relationship between enterprises is one-to-one correspondence. Taking Zhejiang Zhongyan as an example, the enterprise signed a strategic cooperation agreement with Chongqing Zhongyan. Due to the slow development of the private brand of the absolutely weak industrial enterprise, Chongqing Zhongyan, as an absolutely weak import cooperative enterprise, follows the planned quantity under the guidance of the absolutely strong enterprise, and there is an output dependence relationship between the two sides. In a sense, it is a stable strategic partner. Similarly, Jiangsu Zhongyan and Shaanxi Zhongyan, Shanghai Tobacco and Anhui Zhongyan, Hunan Zhongyan and Hebei Zhongyan all constitute strategic cooperative relations. Therefore, through the construction of Stackelberg model to study the game relationship between the two sides.

4.2 Principles of the Stackelberg Model

Stackelberg made a dynamic analysis of the Cournot model and gave a model of duopoly. The time sequence of the model is as follows: firm 1 chooses output. q_1 Or more; Yeah q_1 After the observation, the output q_2 A selection was made; Company i $(i = 1、2)$ The profit function of is: $\pi_i(q_i, q_j) = p(Q)q_i - ci(q_i), i, j = 1,2$ On this basis, $Q = q_1 + q_2$ It is the whole supply in the market. p （Q） Is a function of price, and $ci(q_i)$ It's an enterprise $i(i = 1,2)$ And C is a convex function. The Stackelberg model is $s_1 = \{q_1 | q_1 \in [0, \infty)\}, s_2 = \{q_2 | q_2 = q_2(q_1)\}$ A dynamic game theory model is proposed, in which the Nash equilibrium can be solved by the inverse derivative, and the phase variable is represented by t. $t = 2$ When firm 2 observes firm 1's output q_1 Select the output when $q_2 = q_2(q_1)$ Make the profit function $\pi_2\ (q_1, q_2)$ Maximization, that is, solving a fixed output maximization problem: $\max \pi_2(q_1, q_2) = P(q_1 + q_2)q_2 - c_2(q_2)$

Because $\pi_2(q_1, q_2)$ About q_2 Is a convex function given by $\frac{\partial \pi_2(q_1, q_2)}{\partial q_2} = 0$ Yes, there is $P(q_1 + q_2) + P'(q_1 + q_2)q_2 - c_2'(q_2) = 0$ Thus, the response function of the enterprise 2 to the enterprise 1 can be obtained $q_2 = q_2(q_1)$。 $t = 1$ The response function of firm 1 to firm 2 I $q_2 = q_2(q_1)$ To maximize its own payoff function, that is, to solve the maximization problem: $\max \pi_1(q_1, q_2(q_1)) - p(q_1 + q_2(q_1))q_1 - c_1(q_1)$ Yeah q_1 Derivation, $P(q_1 + q_2(q_1)) + q_1(P'(q_1 + q_2(q_1))(1 + q_2'(q_1)) - c_1'(q_1) = 0$, therefore $P(Q) = a - (q_1 + q_2), ci(q_i) =$

$ciq_i, (i = 1,2)$ From formula (7), the response function of enterprise 2 to enterprise 1 is $q_2(q_1) = (a - q_1 - c_2) / 2$ It follows from (8) that $q_1 = (a - 2c_1 + c_2) / 2$ So Stackelberg's subgame Nash equilibrium is:$q_1^s = (a - 2c_1 + c_2) / 2$， $q_2^s = (a - 3c_2 + 2c_1) / 4$Therefore, when$c_1 = c_2 = c$The two equilibrium results are$q_1^s = (a - c) / 2$， $q_2^s = (a - c) / 4$。

5. Use Stackelberg model to solve the competition and cooperation game relationship of cigarette industrial enterprises.

Assuming that the strong enterprise 2 is Zhejiang Zhongyan and the weak enterprise 1 is Chongqing Zhongyan, the two enterprises belong to the strategic cooperative relationship. By constructing the Stackelberg game relationship (as shown in Figure 4-1), the game calculation of the planned amount of cooperative production is carried out, and the equilibrium output (cooperative production) is obtained.

In the Stackelberg output game of oligarchs between Zhejiang Zhongyan and Chongqing Zhongyan, Zhejiang Zhongyan has an absolute leading position in output. When the demand function of cooperative output $P = a - Q$ There is no fixed charge, the marginal charge C. The two-firm Stackelberg game model is shown in.

Obtain the demand function of the cooperative production of two enterprises with the data of 2021: put forward the output $Q = 120000, P = 17182.3$, solution: $a = 137182.28$, so the market demand function is $P = 137182.28 - Q$; C is the marginal cost, $C = 5564.7$ (The cost of a single carton of cigarettes with the lowest output structure), according to the assumption, the Nash equilibrium result of Stackelberg's sub-game is: $q_1^s = (a - c) / 2 = (137182.28 - 5564.7)/2 = 65808.8$, $q_2^s = (a - c) / 4 = (137182.28 - 5564.7)/4 = 32904.4$, $Q^s = 65808.8 + 32904.4 = 98713.2$

By analogy, the Stackelberg model predicted value of absolute strong industrial enterprises and strategic partners in the cigarette industry is obtained:It can be seen from Table 4-1 that Zhejiang Zhongyan and Chongqing Zhongyan belong to a strategic cooperative relationship, in which the increase of the equilibrium output of Stackelberg model and Cournot equilibrium output is 11000 boxes. Similarly, in the strategic cooperative relationship between Jiangsu Zhongyan and Shaanxi Zhongyan, the equilibrium output of Stackelberg model and Cournot equilibrium output is 20000 boxes. In the strategic cooperative relationship between Shanghai Tobacco and Anhui Zhongyan, the equilibrium yield of Stackelberg model and Cournot equilibrium yield were 19,800 boxes, and in the strategic cooperative relationship between Hunan Zhongyan and Hebei Zhongyan, the equilibrium yield of Stackelberg model and Cournot equilibrium yield were 16,600 boxes. Therefore, it is more beneficial to build strategic cooperative relations between cigarette industrial enterprises to promote more stable cooperative relations between the two sides.

6. Conclusion

In This paper, we use the complete information Cournot model and Stackelberg model of game theory to construct the long-term stable partner model of cigarette industry, and comprehensively analyze the demand characteristics of price, output, profit and so on between strong and weak cigarette industrial enterprises on the residual planned quantity game. At the same time, the equilibrium output, monopoly output of cooperative production and the follow-up output of weak enterprises are calculated through the game surplus plan of export enterprises relative to weak enterprises, which provides a basis for strong enterprises to find stable partners and deal with the balance between cigarette plan and regional economy, so as to promote the development of key industrial enterprises and cigarette brands. It is a major problem to be solved urgently in China's cigarette industry.

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