The Establishment of Supply Chain with Game Model of Competition and Cooperation

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Abstract—The relationship between competition and cooperation in supply chain enterprises is not only affected by the factors inside the chain, but also by the competition chain. We choose two-level supply chain in this article, and discuss the four competition and cooperation states of manufacturer and retailer under the same market structure with reference chain, that is, cooperation-cooperation, competition-competition, cooperation-competition, competition-cooperation to establish models and solve. The result of analysis shows that the supply chain utility of cooperation-competition is effective, designing and analyzing the operation mechanism of cooperation-competition model. When the market profit rate is high, the satisfaction proceeds value of manufacturers is small, the cooperation proceeds distribution mechanism of manufacturer and retailers is easily determined.

Index Terms—supply chain, competition and cooperation, game model

I. INTRODUCTION

In the theory of competition-cooperation cooperation and competition, the complete information means the information that the all players in the cooperation and competition can knows the other well. That is, the competitors in the market understand their rival competition strategy and know the utility of each player under different combination strategy. Complete information is the precondition of theory that efficient complete competition market requires. In a sense, it is the essential condition of economy-person in the economic theory. Whether complete competition or complete monopoly, they are a kind of theory presumption. If the complete competition focuses on how to optimize resources for market mechanism, complete monopoly focuses on the fact that some product is the only market supplier but it can not exclude the other different products competition. The oligopoly monopoly between complete competition and complete monopoly is a typical market style, such as the coco-cola and Pepsi in carbonated drinks market, YiLi and Mengniu in dairy product market, Lenovo, HP and Dell in lap computer market, China telecom and China Netcom in digital communication market, China mobile and China Netcom in mobile communication industry, and Suning and Guo Mei in domestic electricity industry. The subject that we discuss here is the cooperation-competition cooperation and competition analysis based on reference chain, which is set in the background of oligopoly monopoly market and is based on the precondition of different supply chain products with complete height replacement. Because the target subject of research is different two or more supply chains, there are lateral decision problems at the same time among the same degree of enterprises and vertical decision among chain enterprises. So this research will discuss and analyze with the help of the Cournot output competition model of classical competition and cooperation theory and Stackelberg output competition model.

In terms of motive and reason of competition and cooperation relationship established between enterprises, Luo (2007), Chiirgui M (2005), Das and Teng (2000) have studied. The competitive cooperation may decline the negative influence brought by some uncertain factors, such as cost, risk during market expansion and new product development, and its aim is expand proceeds, share resources, supplement advantages, promote enterprises competitiveness, and fight for market domination rights [1-3]. In terms of competition–cooperation, they usually functions at the same subject, that is, cooperation with competition; it also contains cooperation with part of subject and competition with part of subject [4-6]. These research results will be helpful to analyze the competition between supply chains and competition and cooperation among supply chain enterprises. The competition and cooperation relationship between supply chain enterprises is not the same and is often controlled by maturity of supply chain itself. The competitive relationship between enterprises is more than the cooperation relationship between enterprises. At the early period of supply chain, the competitive relationship between enterprises among supply chain exceed cooperation relationship but as the cooperation relationship develops further, the management operation of supply chain also become more and more mature and every enterprise shows the competitive relationship and cooperation relationship as well. And as they develop further, they will combine and integrate and show better cooperation and cooperation relationship.
II. PROBLEM DESCRIPTION

Market shares, that is, the sale amount of an enterprise proportion among the same kinds of products in market. Market share can reflect directly satisfaction degree of goods and service provided by enterprises to consumers and also can reflect the position of goods provided by enterprises in market. The higher the market share is, the stronger the enterprise operation and competitiveness is. Market share is often seen as an important parameter for enterprises to decide. When we discuss the competitiveness and cooperation relationship among enterprises, we can introduce this parameter into models to judge competitive advantage among supply chain enterprises.

For the convenience of research, put forward some relative research presumption and scope and describe some signs and parameters in models.

Presuming that the market structure for supply chain enterprises is complete information and oligopoly monopoly. Every enterprise among supply chain is individual and collective reason and collective reason is controlled by individual reason; There is a two-level supply chain structure consisting of one manufacturer and one retailer in each single chain. The manufacturer is the core enterprise and has preference right to determining price; The production and sale is balanced among each supply chain, that is, the supply amount of retailer equals purchase amount of manufacturer without interruption of stock; Only consider one demand recycle; market retail price should meet line relationship: \( P = a - bQ \). \( a \) is the highest price of product. \( b \) is the influential factor that output influences price, that is, output side-effect influence to price. \( a \geq 0, b \geq 0 \). Under the same market, each retail price is the same; When establishing models treat one single chain as research target and another single as reference chain and exist as a relative independent cooperation and competition players and they form a complete system. The replacement product cost is average cost (designing a constant); Every enterprise among supply chain is medium risk; Not consider the third part logistics and stock problems.

The descriptive signs are the follows:

\( M_i \): the manufacturer \( i \), \( i = 1, \cdots, n \);
\( R_i \): retailer \( i \), \( i = 1, \cdots, n \);
\( P \): market retail price;
\( P_{Mi} \): the price that manufacturer \( M_i \) transfers selling price to retailer \( R_i \);
\( q_{Bi} \): if the order amount retailer’s \( i \) offer to manufacturers \( i \) is the same with the supply amount retailer’s offer to the market, the production and selling is in balance.;
\( C_{Mi} \): product unit cost of manufacturer \( M_i \);
\( C_{Bi} \): the added cost of retailer \( R_i \) used for product selling;

\( \overline{C} \): average cost of reference chain;
\( \pi_{Mi} \): utility of manufacturer \( M_i \);
\( \pi_{Bi} \): utility of retailer \( R_i \);
\( \pi_{Si} \): the total utility of single chain \( i \);
\( \beta_i \): market share of retailer \( i \) in the supply chain \( S_i \);

- \( \beta_1 \): Under the optical condition of cooperation–cooperation model, the market share of supply chain \( S_i \);
- \( \beta_2 \): Under the optical condition of competition–cooperation model, the market share of supply chain \( S_i \);
- \( \beta_3 \): under the optical condition of cooperation–competition model, market share of supply chain \( S_i \);
- \( \beta_4 \): under the optical condition of competition–cooperation model, the market share of supply chain \( S_i \);

\( E \): under the optical condition, market demand price elasticity;

According to presuming condition, we understand that manufacturers are core enterprises and have preference price deciding right and the cooperation and competitiveness relationship between retailer and manufacturer: firstly, manufacturers decide product price and retailers determine their own order according to their own total cost and order amount equals the optical sale amount. The market structure of supply chain enterprises is complete information. The costs, utility function among supply chain enterprises are transparent to other enterprises. When enterprises among supply chain decide their own product amount and price, they will consider their own profit in favor of themselves and will consider the proceeds and decision of their partners.

So, the utility function of manufacturer \( M_i \) can be described as:

\[
\pi_{Mi} = (P_{Mi} - C_{Mi})q_{Bi}
\]

(1)

Utility function of retailer \( R_i \):

\[
\pi_{Bi} = (P - P_{Mi} - C_{Bi})q_{Bi}
\]

(2)

The total utility function of No. \( i \) single chain:

\[
\pi_{Si} = \pi_{Mi} + \pi_{Bi} = (P - C_{Mi} - C_{Bi})q_{Bi}
\]

(3)

III. MODEL ESTABLISHMENT AND RESOLUTION

The utility of every enterprise among supply chain depends on different strategy combination. The strategy choice is controlled by different reason sense. When establishing models, we should consider the influence on enterprises proceeds and competitive position under different combination and determine further the best strategy of competition and cooperation. Supply chain model with reference chain. See fig. 1.
A. Cooperation-cooperation cooperation and competition model and resolution

George Stigler, an American economist, points out when he studies industrial organization behavior that under the circumstances of that there is only single up reaches buyer (such as supplier or manufacturer) in industry chain and single down reaches buyer (such as manufacturer or distributor), whether as the up reaches seller or the down reaches buyer, they usually decide prices by optimizing their own profits, which makes the whole industry chain go through price increasing twice, that is, double price increasing. When the down buyers make purchase from up reaches sellers, they aim at optimizing their own profits without considering the order amount. So double –edge involves decision of enterprise order. Whether manufacturers or distributors, they have some certain market power, and if they lack price decision strategy, it will lead to final prices higher than the total utility level of manufacturers and distributors. Double-edge will result in channel conflict. So the competition and cooperation and competition model under complete information supply chain is based on such reality. We can discuss it through four cases. Firstly, complete cooperation model, secondly, completer competition model, thirdly, competition-cooperation model (cooperation-competition, cooperation-competition), lastly, comparison and analysis of four kinds of models are given.

Complete cooperation dynamic cooperation and competition cooperation and competition model describes that supply chain member first should be collective reason, that is, the whole interest of supply chain is considered first, that is, manufacturers determine product price $P_{M1}$, and retailers decide order amount $q_{R1}$, which are aimed at optimizing the whole interest and they belong to typical supply chain management and operation model under intensive control. So we can overcome double edge phenomenon.

We can optimize the total of No. $i$ single chain with function and obtain differential coefficient of sale amount through equation (3) and make differential coefficient function zero. That is,

$$\frac{\partial \pi_i}{\partial q_{ri}} = \frac{\partial P}{\partial Q} q_{ri} + P - C_{M_i} - C_{R_i} = 0 \quad (4)$$

Calculate and obtain through equation (4) :

$$\frac{\partial \pi_i}{\partial q_{ri}} = \frac{\partial P}{\partial Q} q_{ri} + P - C_{M_i} - C_{R_i} = \frac{\partial P}{\partial Q} q_{ri} - \frac{\beta_i}{E} \quad (5)$$

Here

$$E = -\frac{\partial Q}{\partial P} \quad (6) \quad \beta_i = \frac{q_{ri}}{Q} \quad (7)$$

Equation (6) , (7) shows respectively demand price elasticity market share of retailers for market supply amount under the optimized condition.

Calculate and obtain through equation (6) :

$$P = \frac{C_{M_i} + C_{R_i}}{1 - \frac{\beta_i}{E}} \quad (8)$$

If market price of goods meets the need of reverse demand function $P = a - bQ$ , so we obtain

$$\frac{\partial Q}{\partial P} = -\frac{1}{b} \quad (9)$$

Put equation (9) into equation (7) respectively and obtain :

$$E = -\frac{\partial Q}{\partial P} Q = -\left(\frac{1}{b}\right) \times \frac{P}{\frac{1}{b}(a-P)} = \frac{P}{a-P} \quad (9)$$

Put equation (9) into equation (7) , we can get the balanced price of the optimized sale amount of retailers at each supply chain terminal under complete cooperation market structure:

$$P_i^* = \frac{a \beta_i + (C_{M_i} + C_{R_i})}{1 + \beta_i} \quad (10)$$

Put equation (10) into function $P = a - bQ$ , we can obtain market balance demand and need amount under current market structure:

$$Q_i^* = \frac{a - (C_{M_i} + C_{R_i})}{b(1 + \beta_i)} \quad (11)$$

Put equation (9) into (11) , obtain the balance order amount of retailer $R_i$ :

$$q_{ri}^* = \frac{\beta_i}{b(1 + \beta_i)} \left[a - \left(C_{M_i} + C_{R_i}\right)\right] \quad (12)$$

Put equation (10), (12) into equation (3), obtain supply chain total utility in the model of cooperation - cooperation;

$$\pi_{S_i} = \left(P_i^* - C_{M_i} - C_{R_i}\right) q_{ri}^* = \frac{\beta_i^*}{b(1 + \beta_i)} \times [a - (C_{M_i} + C_{R_i})]^2$$

According to economic theory and the price of the same products under the control of oligopoly market, we can get the market balance price of reference chain from the equation (10) : $a(1 - \beta_i) + \overline{C}$ and meets the demands of

$$\frac{a \beta_i + (C_{M_i} + C_{R_i})}{1 + \beta_i} = \frac{a(1 - \beta_i) + \overline{C}}{1 + (1 - \beta_i)} \quad (13)$$

From the equation of (13) , get the balance share of retailers:

$$\beta_i^* = \frac{a + \overline{C} - 2(C_{M_i} + C_{R_i})}{2a - \overline{C} - (C_{M_i} + C_{R_i})} \quad (14)$$
B. Competition-competition cooperation and competition model and resolution

Competition cooperation and competition under complete information means that individual reason of each supply chain enterprises takes the position of domination and manufacturers and retailers aim at optimizing their own interests. This supply chain management and operation method belongs to decentralized control. Because each supply chain member put interest optimization into consideration first, double edge effect will arise and its cooperation and competition process: manufacturer $M_i$ sell product price $P_{Mi}$ to retailers and retailer $R_i$ choose their own optimized order amount according to the product transfer price $P_{Mi}$ supplied by manufacturer.

This kind of cooperation and competition belongs to Stackelberg game, which consists of two stages, and we can solve with reverse induction. During the second stage, solve the optimized order amount $q_{Ri}$ chosen by retailers and the process is: obtain differential coefficient of order amount through equation (2) and make its function zero.

$$\frac{\partial \pi_{Ri}}{\partial q_{Ri}} = \frac{\partial P}{\partial Q} q_{Ri} + P - P_{Mi} - C_{Ri} = 0$$  (15)

Obtain through equation (15):

$$P_i^* = \frac{a\beta_2^* + (P_{Mi} + C_{Ri})}{1 + \beta_2^*}$$  (16)

$\beta_2^*$ is market share of retailer $R_i$ under complete competition condition, the product optimization condition is different from complete competition and retailer sale cost $C_{Mi} + C_{Ri}$ under complete cooperation model has become $P_{Mi} + C_{Ri}$ under complete competition model. The average cost of reference chain supplier under the same market structure remains.

In terms of economic market theory, balance market share is determined by cost structure relationship of each enterprise. The market share is in inverse proportion with enterprise cost. That is, the higher the cost, the lower the share is determined by cost structure relationship of each enterprise.

Put equation (16) to obtain function and can obtain the optimized same amount in the market:

$$Q = \frac{a - (P_{Mi} + C_{Ri})}{b(1 + \beta_2^*)}$$  (17)

Put equation $\beta_2^* = \frac{q_{Ri}}{Q}$ into (17), can obtain the best order amount of retailer:

$$q_{Ri}^* = \frac{[a - (P_{Mi} + C_{Ri})] \times \beta_2^*}{b(1 + \beta_2^*)}$$  (18)

Put the equation (18) into (2) equation to obtain the balance profit of retailer $R_i$ under market structure:

$$\pi_{Ri} = (P_{Mi} - C_{Ri}) q_{Ri}^*$$  (19)

$$= \left(\frac{a\beta_2^* + (P_{Mi} + C_{Ri})}{1 + \beta_2^*} - P_{Mi} - C_{Ri}\right) \times \frac{[a - (P_{Mi} + C_{Ri})] \times \beta_2^*}{b(1 + \beta_2^*)}$$

$$= \frac{\beta_2^*}{b(1 + \beta_2^*)} \times [a - (P_{Mi} + C_{Ri})]$$

Put equation (18) into (1), can obtain the balance profit of manufacturer $M_i$:

$$\pi_{Mi} = (P_{Mi} - C_{Mi}) \times \frac{[a - (P_{Mi} + C_{Ri})] \times \beta_2^*}{b(1 + \beta_2^*)}$$

(20)

Same as the equation (15), we can obtain the market share of retailer $R_i$ at the end of supply chain under market structure:

$$\beta_2^* = \frac{a + C - 2(P_{Mi} + C_{Ri})}{2a - C - (P_{Mi} + C_{Ri})}$$  (21)

Presuming that if the average cost $C$ of reference supply chain enterprises under the same market structure remains, we can obtain through the equation (14) and (21):

$$\beta_2 = \frac{(P_{Mi} - C_{Mi})}{2(1 - \beta_2)} - 3\beta_2 \left[\frac{a - P_{Mi} - C_{Mi}}{P_{Mi} - C_{Mi}}\right]$$  (22)

At the first stage, manufacturer decides balance transfer price $P^*_{Mi}$.

Put equation (22) into (20) to obtain utility function of manufacturer about transfer price:

$$\pi_{Mi} = \left(\frac{P_{Mi} - C_{Mi}}{2(1 - \beta_2)} - 3\beta_2 \left[\frac{a - P_{Mi} - C_{Mi}}{P_{Mi} - C_{Mi}}\right]\right) \frac{3\beta_2^*}{3b(1 + \beta_2^*)}$$

(23)

Through $\frac{\partial \pi_{Mi}}{\partial P_{Mi}} = 0$ obtain product balance transfer price of manufacturer $M_i$:

$$P_{Mi}^* = \left(\frac{3\beta_2}{4(1 + \beta_2)} - \frac{a - C_{Mi} - C_{Ri}}{4b(1 + \beta_2)}\right)$$  (24)

Put equation (22) and (24) into (1)、(17), we can obtain the balance profit of manufacturer $M_i$ and balance total quantity of market:

$$\pi_{Mi2} = \frac{3\beta_2}{8(1 + \beta_2)} \times (a - C_{Mi} - C_{Ri})^2$$

$$Q^*_2 = \frac{4\beta_2}{4b(1 + \beta_2)} \times (a - C_{Mi} - C_{Ri})$$

(25)

(26)

With the same theory, we can get the balance product output of the salesman $R_i$:

$$\eta_{Ri}^* = \frac{\beta_2^*}{2b(1 + \beta_2^*)} \times (a - C_{Mi} - C_{Ri})$$

(27)

Balance market share:

$$\beta_2^* = \frac{2\beta_2}{4 - \beta_2}$$

(28)

Balance price:
Balance profit:
\[
\pi_{\text{opt}} = \frac{\beta^3_3}{4b(1+\beta_3)} (a-C_{m0}-C_{r0})^2
\]  
(30)  
The total utility of supply chain under the complete competition model:
\[
\pi_{\text{opt}} = \pi_{\text{M0}} + \pi_{\text{R1}} = \frac{5\beta^3_3}{8b(1+\beta_3)} (a-C_{m0}-C_{r0})^2
\]  
(31)  

C. Cooperation-Competition cooperation and competition model and resolution

Competition and cooperation dynamic cooperation and competition model is based on manufacturer and retailer, for whom at least one of them is collective reason when making reason. That is, obtain the optimization of interest of collective cooperation among chain and quit optimization of one’s own interest. Other cooperation partners can pay no attention to their partner’s interest temporarily for the optimization of collective cooperation amount chain when competing with some enterprises among the same level of supply chain and pursue optimization of them. First consider cooperation-competition model. The detailed cooperation and competition process: manufacturer \( M \) put optimization of interest of themselves and the total interest of retailer into consideration firstly while deciding transfer price \( P_{Mr} \) of product, that is \( \max \pi_{S1} \); retailers decide their own optimized order amount \( q_{R1} \) according to product transfer price \( P_{Mr} \), and the decision of retailers is aiming at optimizing own interest.

This model belongs to Stackelberg cooperation and competition. We can discuss this cooperation and competition process through two stages. The second stage is true of complete competition model. So the optimized decision and result for retailers can refer to that of complete competition. That is,  

Optimal market retail price:
\[
P = \frac{a\beta_3 + (P_m + C_{m0})}{1+\beta_3}
\]  
(32)  

Optimal order quantity:
\[
q_m = \frac{[a-(P_m + C_{m0})]x\beta_3}{b(1+\beta_3)}
\]  
(33)  

Market share:
\[
\beta_3 = \frac{(P_m-C_{m0})(2-\beta_3)-3\beta_3(a-P_m-C_{m0})}{(P_m-C_{m0})(1+\beta_3)-3(a-C_{m0}-C_{r0})}
\]  
(34)  

Retailer utility:
\[
\pi_{R1} = \frac{\beta^3_3}{b(1+\beta_3)} [a-(P_m + C_{m0})]
\]  
(35)  

Manufacturer utility:
\[
\pi_{M0} = \frac{\beta^3_3}{b(1+\beta_3)} [a-(P_m + C_{m0})][P_m-C_{m0}]
\]  
(36)  

The supply chain total utility:
\[
\pi_{\text{opt}} = \pi_{M0} + \pi_{R1} = \frac{\beta^3_3}{4b(1+\beta_3)} [(a-P_m-C_{m0})[\beta_3(a-P_m-C_{m0})+(W-C_{m0})(1+\beta_3)]]
\]  
(37)  

Put (34) into (37) and get:
\[
\pi_{\text{opt}} = \frac{1}{4b(1+\beta_3)} [(P_m-C_{m0})(2-\beta_3)-3\beta_3(a-P_m-C_{m0})]
\]  
(38)  

In the first stage of cooperation and competition, manufacturers determine balance and transmit price \( P_{Mr} \). Through equation (37), we obtain the differential coefficient about \( P_{Mr} \), and make function zero that is:
\[
\frac{\partial \pi_{S1}}{\partial P_{Mr}} = 0
\]

obtain:
\[
P_{Mr} = \frac{3\beta_3(a-C_{m0}-C_{r0})}{4(1+\beta_3)}
\]  
(39)  

The balance decision and corresponding balance result of manufacturer and retailer under cooperation-competition dynamic model is the follows: put \( P_{Mr} \) into equation (34), obtain the balance market share of retailer \( R_1 \):
\[
\beta_3 = \frac{6\beta_3}{4+\beta_3}
\]  
(40)  

Balance profit of manufacturer \( M \):
\[
\pi_{M0} = \frac{9\beta^3_3(a-C_{m0}-C_{r0})^2}{8b(1+\beta_3)}
\]  
(41)  

Balance product quantity supplied by the market:
\[
Q_3 = \frac{(a-C_{m0}-C_{r0})(4+\beta_3)}{4b(1+\beta_3)}
\]  
(42)  

Balance order quantity of retailer \( R_1 \):
\[
q_{R1} = \frac{3\beta_3(a-C_{m0}-C_{r0})}{2b(1+\beta_3)}
\]  
(43)  

Balance profit of retailer \( R_1 \):
\[
\pi_{R1} = \frac{(a-C_{m0}-C_{r0})^2}{4b(1+\beta_3)}
\]  
(44)  

Retail price of balance market:
\[
P_3 = \frac{(C_{m0}+C_{r0})(4+\beta_3)+3a\beta_3}{4(1+\beta_3)}
\]  
(45)  

Under the mode of cooperation –competition cooperation and competition, the total profit of supply chain:
\[
\pi_{\text{opt}} = \pi_{M0} + \pi_{R1} = \frac{9\beta_3(a-C_{m0}-C_{r0})^2}{8b(1+\beta_3)}
\]  
(46)  

D. Completion-Cooperation model and resolution

The description of competition-cooperation model under complete information is that manufacturer \( M \) among two-level supply chain enterprises first aim at
optimizing interest while choosing transfer price $P_{Mi}$, while retailer $R_i$ aim at optimizing the total supply chain utility when retailer $M$ choose transfer price $P_{Mi}$.

The solution still adopts reverse induction method. At the second stage, the retailer $R_i$ make the decision of order amount $q_{Ri}^*$ with optimization of supply chain.

Through equation (3), we know that $\pi_{Mi} = \pi_{Mi} + \pi_{Ri} = (P - C_{Mi} - C_{Ri})q_{Ri}$, and combine equation (11), (13), (15), we can obtain the optimized retail price $P_{Ri}^*$ of retailer $R_i$, optimized order amount $q_{Ri}^*$ and the optimized market share $\beta_{Mi}^*$ that is,

$$P_{Ri}^* = \frac{a\beta_i + (C_{Mi} + C_{Ri})}{1 + \beta_i}$$ (47)

$$q_{Ri}^* = \frac{\beta_i}{b(1 + \beta_i)} \left[ a - (C_{Mi} + C_{Ri}) \right]$$ (48)

$$\beta_i = \frac{a + C - 2(C_{Mi} + C_{Ri})}{2a - C - (C_{Mi} + C_{Ri})}$$ (49)

We can put equation (48) and (49) into (1) and obtain:

$$\pi_{Mi} = \beta_i^* (P_{Mi} - C_{Mi}) \left( a - C_{Mi} - C_{Ri} \right)$$ (50)

At the first stage, manufacturer $M_i$ aim at optimizing their own utility $\pi_{Mi}$ while deciding transfer price $P_{Mi}$. We can obtain differential coefficient to equation (50) and make its function zero, that is, $\frac{\partial \pi_{Mi}}{\partial P_{Mi}} = 0$. Can obtain the balance price of manufacturer $M_i$:

$$P_{Mi4} = C_{Mi} + \frac{\beta_i}{1 + \beta_i} \left( a - C_{Mi} - C_{Ri} \right)$$ (51)

Further resolve:

$$\pi_{Mi} = \frac{\beta_i^* (a - C_{Mi} - C_{Ri})^2}{b(1 + \beta_i)}$$ (52)

$$\pi_{Ri4} = \frac{\beta_i^* (a - C_{Mi} - C_{Ri})^2}{b(1 + \beta_i)}$$ (53)

$$\pi_{Mi} = \pi_{Mi4} + \pi_{Ri4} = \frac{\beta_i^* (a - C_{Mi} - C_{Ri})^2}{b(1 + \beta_i)}$$ (54)

E. comparison and analysis of four models

Compare in terms of balance decision variation and result of manufacturer and retailer, We can compare the following results:

$$\beta_{i1} > \beta_{i2}, q_{Ri1} > q_{Ri2}, Q_i > Q_i, P_i > P_i, \pi_{Mi1} > \pi_{Mi2}$$

$$\beta_{i1} < \beta_{i2}, q_{Ri1} < q_{Ri2}, Q_i < Q_i, P_i < P_i, \pi_{Mi1} < \pi_{Mi2}$$

The results show that under complete cooperation model, the total performance of supply chain compared with complete competition is efficient. This is because the former, manufacturer and retailer among supply chain are aiming at optimizing the total performance of supply chain. So complete cooperation model under complete information can realize intensive decision of supply chain enterprises to increase market share of retailers and improve the total utility of supply chain. For the fourth competition and cooperation model, the balance effect is the same with that of balance model. Presuming that manufacturer is core industry and it comply with the whole operation model principle under supply chain intensive management model. Compared with complete cooperation model, for cooperation-competition model, supply chain performance is improved. Under complete cooperation model, manufacturer can obtain nothing to improve the competitiveness of supply chain and strengthen market power. Manufacturer can devote at the price of their own profit under cooperation and competition model, that is,

$$\pi_{Mi1} = \left( -9\beta_i^* (a - C_{Mi} - C_{Ri})^2 / b(1 + \beta_i) \right) < 0$$

to support retailer to compete in market. When retailers have cost advantage, they can expand market share. At the same time, the total performance of supply chain will be improved further.

at the same time, the reference chain of lateral competition under the same market structure will react to the situation and will change supply chain structure and lower average cost $C$ and increase market amount and lower sale price. Also they will sue the other supply chain enterprises with corresponding laws of selling with lower price to fight against abnormal competition action to make supply chain cooperation and competition develop into a new competition structure situation. Under the current market structure condition, through the four models analysis of cooperation-cooperation, competition-competition, cooperation-competition, competition-cooperation. We should consider how to balance profit of enterprises among each supply chain while assuring the whole performance and this is the base of supply chain stable cooperation for long period. So the key problem is that, under cooperation-cooperation model, proceeds between retailers and manufacturers are distributed. Can the competition-cooperation, cooperation-competition model be realized? If they can be realized, what about the realization way and assuring mechanism? We will discuss further in section 4.

IV. ANALYSIS OF SUPPLY CHAIN COOPERATION PROCEEDS DISTRIBUTION MECHANISM

According to the above discussion, we will discuss further in terms of supply chain cooperation proceeds distribution to analyze further connotation of cooperation-competition strategy among supply chain. Presuming that manufacturer $M_i$ satisfaction proceeds is $\theta$ under cooperation-cooperation model, so the proceeds of retailer $R_i$ is

$$\pi_{Mi} - \theta = \left( \beta_i^* \left[ a - (C_{Mi} + C_{Ri}) \right] \right) / \left( b(1 + \beta_i^*) \right) - \theta$$

It is not easy to obtain the sole Nash balance proceeds matrix contains, that is, competition-competition. The Nash balance is the best for players of cooperation-competition, which is different from the result we pursue.
So it proves that under complete competition market condition, there is low efficiency situation. If supply chain enterprises can not cooperate, they will result in predicament situation. If the cooperation and competition among supply chain enterprises belong to the single cooperation-competition, Nash balance is the result. But the cooperation among supply chain enterprises will long period, belonging to repetition cooperation-competition and will result in cooperation.

Through the above analysis, we know that under the four cooperation-competition model, the whole performance of supply chain conform with the following results:

\[ \pi_{S2}^* < \pi_{S1}^* = \pi_{S4}^* < \pi_{S3}^* \]

In terms of process and result, we can see that the decision of retailer \( R_i \) is crucial, and as for manufacturer how to choose, the total performance of supply chain is the same. But the decision of manufacturer \( M_i \) is different from the risk that retailer \( R_i \) choose cooperation strategy. When manufacturer \( M_i \) chooses cooperation strategy, the total performance of cooperation strategy at the first stage to \( t-1 \) stage. At the \( t \) stage, if one side chooses cooperation strategy, the other side will choose cooperation strategy, or they will choose competition strategy to revenge each other. We will introduce discount coefficient that discount proceeds at the first stage as that at the second stage.

\[ \delta = 1/(1 + \gamma), (0 \leq \delta \leq 1) \]

\( \gamma \) is market rate of interest limited by the first stage.

When retailer \( R_i \) chooses cooperation strategy at the first stage, manufacturer \( M_i \) chooses competition strategy and the total proceeds are:

\[ \frac{\beta_i^m [a-(C_m+C_w)]}{b(1+\beta_i^m)} + \frac{3\beta_i^m [a-(C_m+C_w)]}{8b(1+\beta_i^m)} \delta + \frac{3\beta_i^m [a-(C_m+C_w)]}{8b(1+\beta_i^m)} \delta^2 + \ldots \]

\[ \frac{\beta_i^m [a-(C_m+C_w)]}{b(1+\beta_i^m)} + \frac{3\beta_i^m [a-(C_m+C_w)]}{8b(1+\beta_i^m)} \delta + \frac{3\beta_i^m [a-(C_m+C_w)]}{8b(1+\beta_i^m)} \delta^2 + \ldots \]

56)

When the retailers choose cooperation at the first stage, manufacturers obtain:

\[ \frac{\beta_i^m [a-(C_m+C_w)]}{b(1+\beta_i^m)} \]

Because of the non-cooperation of the manufacturer, the manufacturers will choose competition from the second stage to revenge. Then the manufacturer obtain without considering discount:

\[ \frac{3\beta_i^m [a-(C_m+C_w)]}{8b(1+\beta_i^m)} \]

If manufacturer choose cooperation strategy, then they will obtain:

\[ \theta + \theta \delta + \theta \delta^2 + \ldots = \frac{\theta}{1-\delta} \]

If manufacturer \( M_i \) always choose cooperation in the cooperation and competition, they must meet the demands of:

\[ \frac{\theta}{1-\delta} \geq \frac{\beta_i^m [a-(C_m+C_w)]}{b(1+\beta_i^m)} + \frac{3\beta_i^m [a-(C_m+C_w)]}{8b(1+\beta_i^m)} \delta \]  

(57)

That is, the total utility of cooperation always dominates in competition strategy.

If retailers always choose cooperation strategy in the cooperation and competition, they should meet the following demands of:

\[ \frac{\beta_i^m [a-(C_m+C_w)]}{b(1+\beta_i^m)} - \theta \geq \frac{3\beta_i^m [a-(C_m+C_w)]}{4b(1+\beta_i^m)} \]

(58)

That is, the total utility of cooperation strategy always dominates.

If the manufacturer \( S_i \) and retailer \( M_i \) in supply chain choose cooperation strategy in the long term repetition cooperation and competition, the feasible interval of satisfactory proceeds \( \theta \) of the manufacturers should meet the demand of:

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the total and retailer can work as an effective distribution mechanism of cooperation and competition model, let's result that manufacturer pursue. To seek operation enterprises as supply chain, this result is not the final result that manufacturer pursue. To seek operation mechanism to make manufacturer and retailer follow cooperation and competition strategy, then the balance results of cooperation and competition model will become a consistent prediction of them. Through equation (46), we know that

\[ \pi^*_{MC} = -\frac{9\beta_1(a-C_{M}-C_{R})}{8b(1+\beta_1)^2} \leq 0 \], for independent enterprises as supply chain, this result is not the final result that manufacturer pursue. To seek operation mechanism of cooperation and competition model, let's presuming that the final satisfaction performance of manufacturer under this model is \( \eta \), the total performance of retailer is \( \eta = \frac{9\beta_1(a-C_{M}-C_{R})}{8b(1+\beta_1)^2} \). And at the same time they should meet

\[ \eta \geq \theta \text{ and } \eta = \frac{9\beta_1(a-C_{M}-C_{R})}{8b(1+\beta_1)^2} \geq \frac{9\beta_1(a-C_{M}-C_{R})}{b(1+\beta_1)} - \theta \]

\[ \theta \leq \eta \leq \theta + \frac{9\beta_1(a-C_{M}-C_{R})}{8b(1+\beta_1)^2} \]

From competition and cooperation matrix, we know that the sole Nash balance is cooperation and competition strategy combination. \( \eta \) can work as an effective distribution mechanism of cooperation and competition for manufacturer \( M \) and retailer \( R \).

**V. CONCLUSION**

The relationship between competition and cooperation in supply chain enterprises is not only affected by the factors inside the chain, but also by the competition chain (reference chain). We choose two-level supply chain in this article, and discuss the four competition and cooperation states of manufacturer and retailer under the same market structure with reference chain, that is, cooperation-cooperation, competition-competition, cooperation-competition, competition-cooperation to establish models and solve. The result of analysis shows that the supply chain utility of cooperation-competition is effective, designing and analyzing the operation mechanism of cooperation-competition model. When the market profit rate is high, the satisfaction proceeds value of manufacturers is small, the cooperation proceeds distribution mechanism of manufacturer and retailers is easily determined.

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