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# Research on Supply Chain Alliance Strategy Based on Product and Service Competition

Hongyuan Li[1,2*], Zhen Chen[1,2] and Die Hu[3]
[1]School of Business, Lingnan Normal University, Guangdong, Zhanjiang 524048, P.R. China
[2]South China Sea Silk Road Collaborative Innovation Center, Lingnan Normal University, Guangdong, Zhanjiang 524048, P.R. China
[3]School of Economics and Commerce, South China University of Technology, Guangdong, Guangzhou 510006, P.R. China
[*]Corresponding author

*Abstract*—**This article introduces the product competition intensity factor for three levels of two competitive supply chains and builds a supply chain competing model based on product and service competition. On this basis, it studies the decision making of centralized and partial alliance strategies. And the impacts of competition intensity on decision-making and supply chain efficiency of the two alliance strategies are analyzed. Finally, the dominances of the two alliance strategies under the change of competition intensity are discussed. The results from the analysis show that the optimal market wholesale price and quality of service are affected by its own product cost and the competitor's product cost. Enterprise with cost advantage which uses the partial alliance strategy is in a dominant position compared to the competitor in overall profit. When the competition intensity is small, the centralized decision model brings the supply chain more on the profit than the partial alliance model, otherwise the opposite. When retailer's rate of return is set too high, it will lead to a decline in the supply chain's profit.**

***Keywords-supply chain; product competition; alliance; decision making; model strategy***

## I. INTRODUCTION

The age of product homogeneity comes with the rapid growth of industries. For example, many brands of toothpaste with whitening function are present in the market. As a result, competition has become increasingly fierce among homogeneous products in a saturated market. Hence, facing this change in the market, what decisions can member enterprises of supply chains implement to ensure their maximum profit?

Research topics on supply chain competitive decisions about substitutability products have been the focus of many scholars. Boyaci and Gallego (2004) model customer service competition by using game-theoretical concepts for two competing supply chains, and by assuming that the business environment forces supply chains to charge similar prices and to compete strictly based on customer service. The study analyzes the competition between the two competing supply chains and reports that coordinated supply chain is better than uncoordinated supply chain. Prakas and Shanker (2008) discuss the competitive advantage and organization performance that can be obtained from service quality differentiation. Considering a two-stage supply-chain distribution system where two vendors compete to sell differentiated products through a common retailer in the market, Sinha and Sarmah (2010) analyze synthetically the coordination issues of the two-stage supply chains under three different contexts that include price competition without channel coordination, price competition with channel coordination, and global coordination. Xu and Sun (2011) investigate supply chain competition by examining the relationship between shelf-display and retail price in three settings, namely, two decentralized supply chains, two centralized supply chains, and one decentralized vs. one centralized supply chain. Xia (2011) studies the competition between two coexisting suppliers with different inventory cost structures and offers one type of the two substitutable products to a retailer in a two-echelon supply chain. Rajagopalan and Xia (2012) establish a competition model in which a supplier provides several homogeneous products for two retailers, and then analyze the influence of multi-product sales on the profit of the retailer and the supply chain when consumers are sensitive about price, brands, and search cost. Zhao et al. (2012) analyze the pricing problem of substitutable products by using game theory, when the manufacturing cost, and characterize customer demand for each product as fuzzy variables. Two competitive manufacturers produce substitutable products, which are sold by one common retailer to the consumers. Chen et al. (2012) propose a supply chain competition model composed of two manufacturers selling substitutable products to the same retailer, with one of the two manufacturers selling products to consumers directly through an Internet channel. The study analyzes the competition and cooperation relationship between the members in the supply chains, and presents the dominant equilibrium decisions. Yao (2013) models price and customer service competition in shipping and analyzes comparatively the optimal decisions and optimal profit under centralized, decentralized, and partially centralized decision-making structures. The studies above assume that the products in the two competing supply chains can substitute each other completely, such that the substitution degree of the products is not considered. However, in practice, differences always exist between the homogeneous products, such as the taste of Coca-Cola and Pepsi-Cola. In the eyes of different consumers, the difference degrees of the homogeneous products will be different.

Several studies indicate that product substitutability competition can influence the coordination of a supply chain and the competition between supply chains (Xiao et al., 2007; Tang and Yin, 2007; Hsie and Wu, 2009; and Edirisinghe et al., 2011). Therefore, product substitutability competition should be considered when we study the decision-making problem of competing supply chains about substitutable products. Several studies introduce competition intensity and influence degree in substitutable products to their research. Xie et al. (2011) include competition intensity of quality into two competing supply chains, which is composed of one supplier and one manufacturer, to analyze comparatively the competitions under centralized and decentralized decision-making structures. Shamir (2012) sets the product substitutability, and then discusses the decisions of the members in a two-echelon supply chain with one manufacturer selling a homogeneous product to n price-setting competing retailers based on the sharing information of retailers with each other and retailers only sharing information with its manufacturer. Wu et al. (2009) investigate the equilibrium behavior of two competing supply chains in the presence of demand uncertainty, and consider joint pricing and quantity decisions as well as competition under three possible supply chain strategies: Vertical Integration (VI), Manufacturer's Stackelberg (MS), and Bargaining on the Wholesale Price over a single or infinite number of periods. They analyze the influence of buy-back contract for a supply chain on retail price, order quantity, and wholesale price under a duopoly competition environment (Wu, 2013). However, most literature considers the price or quality competitive factor solely.

Therefore, this article considers two aspects of product and service competition to build a supply chain competition model based on product and service competition. On this basis, the decision makings of centralized and partial alliance strategies are studied. And the impacts of competition intensity on decision making and supply chain efficiency of the two alliance strategies are analyzed. Finally, the advantages of the two alliance strategies under the change of competition intensity are discussed.

## II. MODEL DESCRIPTION AND SYMBOLS

### A. *Model Description and Hypotheses*

The system structure of two supply chains with three levels composed of two manufacturers (*M1*, *M2*), two distributors (*D1*, *D2*) and one common retailer (*R*). Each manufacturer, distributor, and retailer in the supply chain may make a centralized or partial strategy. For ease of understanding, the symbols involved in this the text are described below, seeing Table 1.

This paper places a supply chain competing model in Figure 1, in which two manufacturers sell homogeneous products (i.e. product 1 and product 2) to the same retailer. Each supply chain comprise of one manufacturer, one distributor, and the same retailer. In the two supply chains, the manufacturers provide products to the distributors at the wholesale price of $w_i$, and the distributors provide the products to the retailer at the wholesale price of $s_i$. Subsequently, the retailer offer the products to consumers at a price of $p_i$, and finally, the distributors provide services to the customers at quality of service level $e_i$.

TABLE I. MODEL SYMBOLS IN THE MODEL

| Symbols | Meaning |
|---|---|
| $\alpha$ | Basic market size, the fixed value |
| $c_i$ | Unit production cost of product *i* |
| $w_i$ | Unit first whole sale price of product *i* |
| $s_i$ | Unit secondary wholesale price of product *i* |
| $p_i$ | Unit price of product *i* |
| $e_i$ | The quality of service is provided by the distributor *i* |
| $\theta$ | Competition intensity |
| $\beta$ | The sensitivity of the consumer to the price of the product |
| $\lambda$ | Consumer sensitivity to product services |
| $\gamma$ | Cost factor of service quality provided by the distributor *i* |
| $\pi_c$ | A whole profit of the two supply chain |
| $\pi_{sci}$ | Supply chain profit of product *i* |
| $i$ | $i \in \{1,2\}$, 1 for product 1, 2 for product 2 |

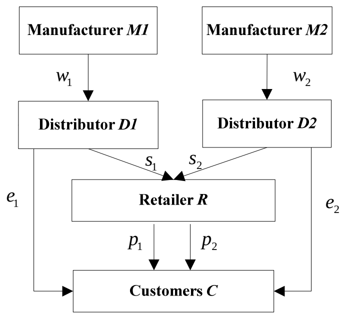


FIGURE I. COMPETITIVE PATTERN OF THE TWO SUPPLY CHAINS

In order to facilitate the study, the paper makes the following key assumptions and explanations:

(1) The manufacturers' production capacity is large enough to meet the retailer's ordering demand, and there is no product shortage or unsatisfactory.

(2) Manufacturers, distributors and retailer are perfectly rational brokers, and their attitude towards risk is neutral.

(3) The market demand function is a linear function, which only affects the actual demand of the market by the product price and quality of service level.

(4) According to the economic point of view, supply chain enterprises in the market competition pursue profit maximization, the companies can make decisions based on the alliance agreement.

(5) This article uses the hypothesis about service cost from Yao (2013). The hypothesis thinks that the service cost of the distributor is a quadratic function about $e$, namely, $C(e_i) = \frac{\gamma}{2} e_i^2$, where $\gamma$ is the influence coefficient of the quality of service to cost. We hypothesize that the quality of service only relates to the enterprise who sells the product, and we do not discriminate the influence coefficient according to different products.

(6) In view of the real social situation and in order to ensure the effectiveness of the study, the parameters must meet $p_i \geq s_i \geq w_i \geq c_i \geq 0$ and the competition intensity must meet $0 < \theta < 1$.

*B. Product Demand Analysis*

In the demand function, it is assumed that the price, the quality of service and the competition intensity affect the market demand of the product. This article extends the linear function from traditional linear relationship between demand and price in Western Economics to the relationship between demand and logistics service, and considers the substitute degree between the products of the two supply chains. Referring to the demand function from Gang et al. (2011), Choi Sc. (1996), and Yao & Liu (2005), and combined with the research content, the market demand function can be determined as follows:

$$D_i(p_i, p_j, e_i, e_j) = \alpha - \beta(p_i - \theta p_j) + \lambda\left(e_i - e_j\right) \quad i = 1,2;\ j = 3-i \tag{1}$$

In Equation (1), $D_i$ is the market demand for the product $i$. Since the product $i$ and the product $j$ are competitive products and it is determined that the two products are competing in the same market, it can be assumed that market demand function of $j$ is similar to product $i$.

## III. COMPETITIVE SUPPLY CHAIN ALLIANCE MODEL

*A. Centralized Decision Model of Competitive Supply Chain*

First, we examine whether it is possible to maximize the profit of the two supply chains, with considering supply chain *SC1* and supply chain *SC2* as a whole.

In that way, taking the overall profit of the two supply chains as the objective function, we get

$$\begin{aligned}\max_{p_1\geq 0, e_1\geq 0,\ p_2\geq 0, e_2\geq 0} \pi_c &= \pi_{sc1} + \pi_{sc2} \\ &= (p_1 - c_1)\left[\alpha - \beta(p_1 - \theta p_2) + \lambda(e_1 - e_2)\right] \\ &\quad + (p_2 - c_2)\left[\alpha - \beta(p_2 - \theta p_1) + \lambda(e_2 - e_1)\right] - \frac{\gamma}{2}\left(e_1^2 + e_2^2\right)\end{aligned} \tag{2}$$

It is assumed that there is only $p_1$, $p_2$, $e_1$ and $e_2$ to make $\pi_c$ have the greatest value. And the partial derivatives of $\pi_c$ about $p_1$, $p_2$, $e_1$ and $e_2$ can be derived from Equation (2). Therefore, the following equation can be obtained.

$$\begin{cases}\dfrac{\partial \pi_c}{\partial p_1} = \alpha - 2\beta p_1 + 2\beta\theta p_2 + \lambda(e_1 - e_2) + \beta c_1 - \beta\theta c_2 \\ \dfrac{\partial \pi_c}{\partial e_1} = \lambda(p_1 - c_1 - p_2 + c_2) - \gamma e_1 \\ \dfrac{\partial \pi_c}{\partial p_2} = \alpha - 2\beta p_2 + 2\beta\theta p_1 + \lambda(e_2 - e_1) + \beta c_2 - \beta\theta c_1 \\ \dfrac{\partial \pi_c}{\partial e_2} = \lambda(p_2 - c_2 - p_1 + c_1) - \gamma e_2\end{cases} \tag{3}$$

Making $\frac{\partial \pi_c}{\partial p_1} = 0$, $\frac{\partial \pi_c}{\partial e_1} = 0$, $\frac{\partial \pi_c}{\partial p_2} = 0$ and $\frac{\partial \pi_c}{\partial e_2} = 0$ in Equation (3), we get $e_1 = -e_2$. However $e_1$ and $e_2$ must meet $e_1 \geq 0,\ e_2 \geq 0$. So we can see that there is no equilibrium solution $p_1$, $p_2$, $e_1$ and $e_2$ for the two supply chains as a whole to achieve the most profitable.

Then, this article analyzes the existence of a balanced solution for each of the two chains as a whole itself.

In this model, members of the supply chain (i.e. manufacturer *M1*, distributor *D1* and retailer *R*) reach agreement on product 1 to make profit maximization as a whole by setting the optimal retail price and the optimal quality of service for product 1. That is the same to the members of supply chain of product 2.

Therefore, the overall profit objective function of supply chain of product 1 can be obtained:

$$\max_{p_1\geq 0, e_1\geq 0} \pi_{sc1} = (p_1 - c_1)\left[\alpha - \beta(p_1 - \theta p_2) + \lambda(e_1 - e_2)\right] - \frac{\gamma}{2}e_1^2 \tag{4}$$

And the overall profit objective function of supply chain of product 2 can be obtained:

$$\max_{p_2\geq 0, e_2\geq 0} \pi_{sc2} = (p_2 - c_2)\left[\alpha - \beta(p_2 - \theta p_1) + \lambda(e_2 - e_1)\right] - \frac{\gamma}{2}e_2^2 \tag{5}$$

The first-order partial derivative and second-order partial derivative can be obtained from above Equation (4). They are $\frac{\partial \pi_{sc1}}{\partial p_1} = \alpha - 2\beta p_1 + \beta\theta p_2 + \lambda(e_1 - e_2) + \beta c_1$ , $\frac{\partial^2 \pi_{sc1}}{\partial p_1^2} = -2\beta < 0$ , $\frac{\partial \pi_{sc1}}{\partial e_1} = \lambda(p_1 - c_1) - \gamma e_1$ and $\frac{\partial^2 \pi_{sc1}}{\partial e_1^2} = -\gamma < 0$.

It can be seen that the total profit $\pi_{sc1}$ of *SM1* is the strict concave function of retail price $p_1$ and quality of service $e_1$. Therefore, the objective function has a maximum value about the retail price $p_1$ and quality of service $e_1$ for product 1. Similarly, the objective function of the supply chain of product 2 has the maximum value of the retail price $p_2$ and effort level $e_2$ for product 2.

By making $\frac{\partial \pi_{sc1}}{\partial p_1} = 0$, $\frac{\partial \pi_{sc1}}{\partial e_1} = 0$, $\frac{\partial \pi_{sc2}}{\partial p_2} = 0$, $\frac{\partial \pi_{sc2}}{\partial e_2} = 0$, we can get

$$\begin{cases}\dfrac{\partial \pi_{sc1}}{\partial p_1} = \alpha - 2\beta p_1 + \beta\theta p_2 + \lambda(e_1 - e_2) + \beta c_1 = 0 \\ \dfrac{\partial \pi_{sc1}}{\partial e_1} = \lambda(p_1 - c_1) - \gamma e_1 = 0 \\ \dfrac{\partial \pi_{sc2}}{\partial p_2} = \alpha - 2\beta p_2 + \beta\theta p_1 + \lambda(e_2 - e_1) + \beta c_2 = 0 \\ \dfrac{\partial \pi_{sc2}}{\partial e_2} = \lambda(p_2 - c_2) - \gamma e_2 = 0\end{cases} \tag{6}$$

By parallel deriving the four expressions in Equation (6), we can get

$$\begin{cases} p_1^* = \dfrac{2\alpha+\beta(c_1+c_2)}{2\beta(2-\theta)} - \dfrac{(\beta\gamma-2\lambda^2)(c_1-c_2)}{2\beta\theta\gamma+4\beta\gamma-2\lambda^2} \\ p_2^* = \dfrac{2\alpha+\beta(c_1+c_2)}{2\beta(2-\theta)} + \dfrac{(\beta\gamma-2\lambda^2)(c_1-c_2)}{2\beta\theta\gamma+4\beta\gamma-2\lambda^2} \\ e_1^* = \dfrac{\lambda}{\gamma}\left[\dfrac{2\alpha+\beta(c_1+c_2)}{2\beta(2-\theta)} - \dfrac{(\beta\gamma-2\lambda^2)(c_1-c_2)}{2\beta\theta\gamma+4\beta\gamma-2\lambda^2}\right] - \dfrac{\lambda c_1}{\gamma} \\ e_2^* = \dfrac{\lambda}{\gamma}\left[\dfrac{2\alpha+\beta(c_1+c_2)}{2\beta(2-\theta)} + \dfrac{(\beta\gamma-2\lambda^2)(c_1-c_2)}{2\beta\theta\gamma+4\beta\gamma-2\lambda^2}\right] - \dfrac{\lambda c_2}{\gamma} \end{cases} \tag{7}$$

From Equation (7), in centralized decision model (i.e. the manufacturer *M1*, the distributor *D1* and the retailer *R* constitute the supply chain *SC1* and the manufacturer *M2*, the distributor *D2* and the retailer *R* constitute the supply chain *SC2*), the optimal market wholesale price and quality of service are affected by their own product cost and the competitor's product cost. However, because of the symmetric information in the stackelberg game of a centralized decision model, the two supply chains' members can share their product cost information each other. Therefore, in the centralized decision-making model, the competitiveness of the two supply chain is not obvious.

### B. Partial Alliance Model of Competitive Supply Chain

The partial alliance model is a deformation of the centralized decision model. It is a partial centralized decision model which is oriented by the concept of centralized decision model. Therefore, the difference with the centralized decision-making model is that there are only manufacturer and distributor involving in the alliance. The manufacturer *M1* cooperates with the distributor *D1* on the product 1. And they specify the secondary wholesale price and the optimal quality of service of product 1 according to the maximization of their profit as a whole. And it is the same to manufacturer *M1* and distributor *D1*. Finally, the retailer *R* determines the optimal retail price for the product based on the above decision and the rate of return for each product.

The rate of return determined by retailer is marked as $\tau$. Therefore, we get $p_1 = \tau s_1$, And the objective function on the partial supply chain of product 1 can be expressed as:

$$\max_{s_1\ge 0, e_1\ge 0} \pi_{md1} = (s_1-c_1)\left[\alpha - \beta\tau(s_1-\theta s_2) + \lambda(e_1-e_2)\right] - \frac{\gamma}{2}e_1^2 \tag{8}$$

Similarly, the objective function on the partial supply chain of product 2 can be expressed as:

$$\max_{s_2\ge 0, e_2\ge 0} \pi_{md2} = (s_2-c_2)\left[\alpha - \beta\tau(s_2-\theta s_1) + \lambda(e_2-e_1)\right] - \frac{\gamma}{2}e_2^2 \tag{9}$$

According to Equation (8), the first-order partial derivative and second-order partial derivative of $\pi_{md1}$ about the secondary wholesale price $s_1$ and quality of service $e_1$.can be obtained. They are $\dfrac{\partial \pi_{md1}}{\partial s_1} = \alpha - 2\beta\tau s_1 + \beta\theta\tau s_2 + \lambda(e_1-e_2) + \beta\tau c_1$, $\dfrac{\partial^2 \pi_{md1}}{\partial s_1^2} = -2\beta < 0$, $\dfrac{\partial \pi_{md1}}{\partial e_1} = \lambda(s_1-c_1) - \gamma e_1$ and $\dfrac{\partial^2 \pi_{md1}}{\partial e_1^2} = -\gamma < 0$.

It can be seen that the total profit $\pi_{md1}$ is the strict concave function of the secondary wholesale price $s_1$ and quality of service $e_1$. Therefore, the objective function has a maximum value of the retail price $s_1$ and quality of service $e_1$ for product 1. Similarly, the objective function of the supply chain of product 2 has the maximum value of the secondary wholesale price $s_2$ and quality of service $e_2$ for product 2.

By making $\dfrac{\partial \pi_{md1}}{\partial s_1} = 0$, $\dfrac{\partial \pi_{md1}}{\partial e_1} = 0$, $\dfrac{\partial \pi_{md2}}{\partial s_2} = 0$, $\dfrac{\partial \pi_{md2}}{\partial e_2} = 0$, we can get

$$\begin{cases} \dfrac{\partial \pi_{md1}}{\partial s_1} = \alpha - 2\beta\tau s_1 + \beta\tau\theta s_2 + \lambda(e_1-e_2) + \beta\tau c_1 = 0 \\ \dfrac{\partial \pi_{md1}}{\partial e_1} = \lambda(s_1-c_1) - \gamma e_1 = 0 \\ \dfrac{\partial \pi_{md2}}{\partial s_2} = \alpha - 2\beta\tau s_2 + \beta\tau\theta s_1 + \lambda(e_2-e_1) + \beta\tau c_2 = 0 \\ \dfrac{\partial \pi_{md2}}{\partial e_2} = \lambda(s_2-c_2) - \gamma e_2 = 0 \end{cases} \tag{10}$$

By parallel deriving the four expressions in Equation (10), we can get

$$\begin{cases} s_1^* = \dfrac{2\alpha+\beta\tau(c_1+c_2)}{2\beta\tau(2-\theta)} - \dfrac{(\beta\tau\gamma-2\lambda^2)(c_1-c_2)}{2\beta\tau\theta\gamma+4\beta\tau\gamma-2\lambda^2} \\ s_2^* = \dfrac{2\alpha+\beta\tau(c_1+c_2)}{2\beta\tau(2-\theta)} + \dfrac{(\beta\tau\gamma-2\lambda^2)(c_1-c_2)}{2\beta\tau\theta\gamma+4\beta\tau\gamma-2\lambda^2} \\ e_1^* = \dfrac{\lambda}{\gamma}\left[\dfrac{2\alpha+\beta\tau(c_1+c_2)}{2\beta\tau(2-\theta)} - \dfrac{(\beta\tau\gamma-2\lambda^2)(c_1-c_2)}{2\beta\tau\theta\gamma+4\beta\tau\gamma-2\lambda^2}\right] - \dfrac{\lambda c_1}{\gamma} \\ e_2^* = \dfrac{\lambda}{\gamma}\left[\dfrac{2\alpha+\beta\tau(c_1+c_2)}{2\beta\tau(2-\theta)} + \dfrac{(\beta\tau\gamma-2\lambda^2)(c_1-c_2)}{2\beta\tau\theta\gamma+4\beta\tau\gamma-2\lambda^2}\right] - \dfrac{\lambda c_2}{\gamma} \end{cases} \tag{11}$$

From Equation (11), in the partial alliance model, the optimal secondary wholesale price and the optimal quality of service are affected by their own product cost and the competitor's product cost. Being similar to the case of a centralized decision model, due to symmetric information on both chains in the stackelberg game, the members of the two supply chain can get the cost information each other. It caused a lot of competition and influence for the secondary wholesale price and the quality of service.

## IV. ANALYSIS OF MODEL RESULTS

### A. Impact of Competition Intensity on the Centralized Decision Making

Without loss of generality, this article sets the basic parameters to be $\beta$=3, $\lambda$=2, $c_1$=500, $c_2$=520, $\gamma = 50$. In addition, the competition intensity is taken 0.1 for its step in the range $0 < \theta < 1$. Then, we observe the changes of the optimal retail price, quality of service and the profit of supply chain when the competition intensity changes. The results are shown in Table 2.

TABLE II. CHANGES OF THE DECISIONS WHEN THE COMPETITION INTENSITY CHANGES (UNIT: YUAN)

| $\theta$ | $p_1$ | $p_2$ | $e_1$ | $e_2$ | $SC_1$ | $SC_2$ |
|---|---|---|---|---|---|---|
| 0 | 843 | 834 | 13.72 | 12.5414 | 329150 | 308300 |
| 0.1 | 887 | 878 | 15.48 | 14.3156 | 421530 | 398910 |
| 0.2 | 936 | 927 | 17.43 | 16.285 | 537660 | 513140 |
| 0.3 | 990 | 982 | 19.62 | 18.4844 | 684280 | 657670 |
| 0.4 | 1052 | 1044 | 22.08 | 20.9571 | 870440 | 841530 |
| 0.5 | 1122 | 1114 | 24.86 | 23.758 | 1108600 | 1077100 |
| 0.6 | 120 | 1194 | 28.05 | 26.9576 | 1416200 | 1381800 |
| 0.7 | 1293 | 1286 | 31.73 | 30.6481 | 1817900 | 1780200 |
| 0.8 | 1401 | 1394 | 36.03 | 34.9524 | 2350100 | 2308500 |
| 0.9 | 1528 | 1521 | 41.10 | 40.0379 | 3067200 | 3021100 |
| 1 | 1680 | 1674 | 47.19 | 46.139 | 4053700 | 4002400 |

According to the data in Table 2, the changes of the optimal quality of service level and retail price of the products 1 and 2 with the competition intensity are shown in Figure 1 and Figure 2.

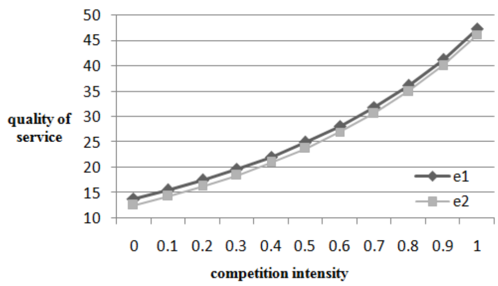


FIGURE II. THE RELATIONSHIP BETWEEN THE QUALITY OF SERVICE AND THE COMPETITION INTENSITY UNDER THE CENTRALIZED DECISION MODEL

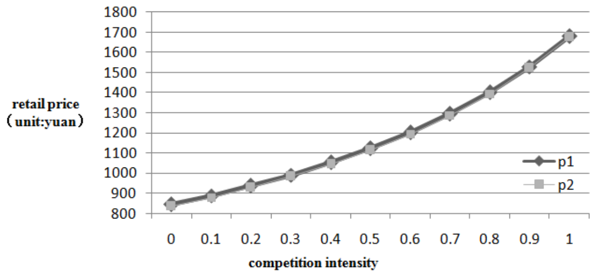


FIGURE III. THE RELATIONSHIP BETWEEN THE RETAIL PRICE AND THE COMPETITION INTENSITY UNDER THE CENTRALIZED DECISION MODEL

From Figure 2 and Figure 3, we find that there is a positive correlation between service quality and competition intensity under centralized decision model, and there is a positive correlation between retail price and competition intensity. It shows that when the competition intensity of product 1 and product 2 increases, their optimal retail pricing will also increase. In addition, the study also found that the gap between the quality of service of product 1 and the quality of service of product 2 is significant in the centralized decision model. However the gap of the two retail prices is not obvious. It shows that in the process of competition, enterprises pay more attention to retail prices than the quality of service. In the premise of maximizing profit, when they set retail prices, they often fully reference to the opponent's situation to avoid too much difference.

### *B. Impact of Competition Intensity on Partial Alliance Decision Model*

The other parameters' values are the basic settings in Section 3.1. We assume that the rate of return for retailer is $\tau$=1.2. According to Section 2.2, in the alliance decision model, we analyze the relationship between the competition intensity and the decision makings and the profit of each member in supply chain. Therefore, table 3 can be obtained as below.

TABLE III. CHANGES OF THE DECISION WHEN THE COMPETITION INTENSITY CHANGES IN PARTIAL ALLIANCE MODEL (UNIT: YUAN)

| $\theta$ | $s_1$ | $s_2$ | $e_1$ | $e_2$ | $MD_1$ | $MD_2$ | $p_1$ | $p_2$ | $R$ |
|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 746 | 736 | 9.84 | 8.65 | 198510 | 181070 | 895 | 884 | 246610 |
| 0.10 | 785 | 776 | 11.39 | 10.22 | 269100 | 249620 | 942 | 931 | 303410 |
| 0.20 | 828 | 819 | 13.11 | 11.96 | 360200 | 338540 | 993 | 982 | 371660 |
| 0.30 | 876 | 868 | 15.04 | 13.91 | 477790 | 453800 | 1051 | 1041 | 454340 |
| 0.40 | 930 | 922 | 17.22 | 16.09 | 630020 | 603470 | 1116 | 1107 | 555430 |
| 0.50 | 992 | 984 | 19.68 | 18.57 | 828070 | 798700 | 1190 | 1181 | 680340 |
| 0.60 | 1062 | 1055 | 22.50 | 21.40 | 1087600 | 1055100 | 1275 | 1266 | 836550 |
| 0.70 | 1144 | 1137 | 25.75 | 24.66 | 1431200 | 1395100 | 1373 | 1364 | 1034600 |
| 0.80 | 1239 | 1232 | 29.55 | 28.47 | 1891600 | 1851400 | 1486 | 1478 | 1289800 |
| 0.90 | 1351 | 1344 | 34.03 | 32.97 | 2518600 | 2473700 | 1621 | 1613 | 1625000 |
| 1.00 | 1485 | 1479 | 39.42 | 38.36 | 3389500 | 3338900 | 1782 | 1775 | 2075100 |

According to the data in Table 3, the changes of the optimal quality of service level and retail price of the products 1 and 2 with the competition intensity increasing are shown in Figure 4 and Figure 5.

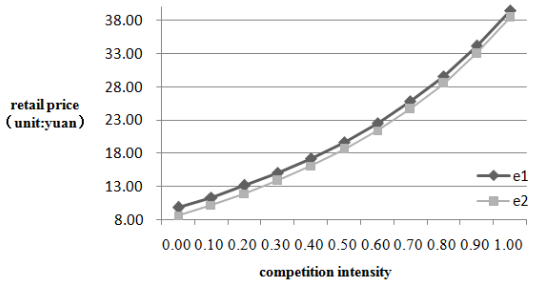


FIGURE IV. THE RELATIONSHIP BETWEEN QUALITY OF SERVICE AND THE COMPETITION INTENSITY UNDER THE PARTIAL ALLIANCE MODEL

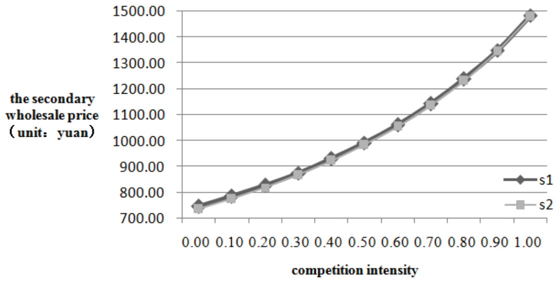


FIGURE V. THE RELATIONSHIP BETWEEN THE SECONDARY WHOLESALE PRICE AND THE COMPETITION INTENSITY UNDER THE PARTIAL ALLIANCE MODEL

On the whole, the change of decision makings under partial alliance model is similar to that under the centralized decision model. Both of the optimal secondary wholesale price and the service quality of products 1 and 2 will increase with the competition intensity. They are proportional. It is found that the secondary wholesale price of the supply chain with cost advantage is higher than its competitors with cost disadvantage. It shows that the enterprise with cost disadvantage still choose low-price sales strategy to demise greater value to its downstream member. In addition, in the partial alliance model, with the increase of competition intensity, the gap between the secondary wholesale price of product 1 and that of product 2 is getting smaller gradually.

In addition, from the data analysis, the profit of the supply chain members is shown in Figure 6 below under the partial alliance model.

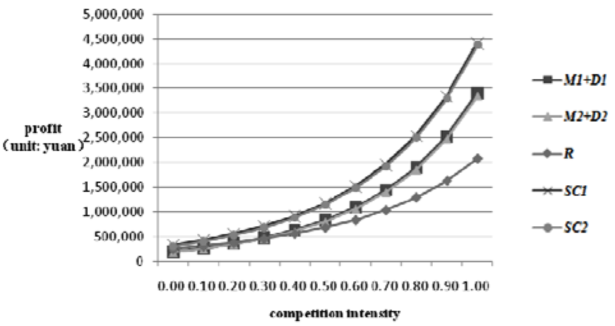


FIGURE VI. THE PROFITS OF THE SUPPLY CHAIN MEMBERS UNDER THE PARTIAL ALLIANCE MODEL

With the increase of product competition intensity, the profit of members in the two supply chain will increase. The overall profit of the supply chain alliance with cost advantage is in a dominant position than its competitor. In addition, under the partial alliance model, the increase speed of the profit of the enterprises which take part in the alliance is quicker than the retailer who doesn't take part in the alliance. It can be seen that the alliance can bring greater benefits and competitiveness to enterprises.

## C. *Comparative Analysis of the Two Alliance Strategies*

According to the data in sections 3.1 and 3.2, the changes of the retail prices and the quality of service of the two alliance strategies can be analyzed comparatively with the change of the competition intensity. As product 2 and product 1 are similar, we do not analyze the situation of product 2. Here, the situation of product 1 will be described in Figure 7.

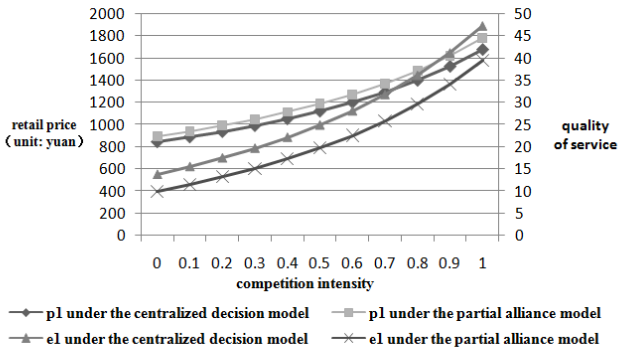


FIGURE VII. THE COMPARISON OF THE RETAIL PRICE AND QUALITY OF SERVICE OF THE TWO ALLIANCE STRATEGIES

From Figure 6, it can be seen that the retail price of the product under the centralized decision model is lower than that under the partial alliance model, and the quality of service under the centralized decision model is higher than that under the partial alliance model. It shows that the retail price and service level under the centralized decision model have more advantages than that under the partial alliance model to provide customers with low-price and high-quality products.

TABLE IV. OVERALL PROFIT OF SUPPLY CHAIN FOR PRODUCT 1 UNDER THE TWO ALLLIANCE STRATEGIES

| $\theta$ | Centralized decision model $SC_1$ | Partial alliance model $SC_1$ |
|---|---|---|
| 0.00 | 329150 | 320396 |
| 0.10 | 421530 | 419220 |
| 0.20 | 537660 | 544280 |
| 0.30 | 684280 | 703025 |
| 0.40 | 870440 | 905604 |
| 0.50 | 1108600 | 1165905 |
| 0.60 | 1416200 | 1503287 |
| 0.70 | 1817900 | 1945657 |
| 0.80 | 2350100 | 2533317 |
| 0.90 | 3067200 | 3327580 |
| 1.00 | 4053700 | 4423065 |

Observing Table 4, it is found that when $\theta \leq 0.2$, the profit of $SC_1$ is higher under the centralized decision model than that under the partial alliance model. However, when $\theta > 0.2$, the profit of $SC_1$ is lower under the centralized decision model than that under the partial alliance model. It can be seen, when the competition intensity is small, the centralized decision can bring the supply chain greater profit. And when the competition intensity is large, the partial alliance strategy is more dominant.

In order to study the profit of supply chain in the two alliance strategies under the change of $\tau$, this paper assumes that the competition intensity is constant. Making $\theta$=0.3 and $\tau$ changes from 1 to 1.5. The overall profit of $SC_1$ is taken as the research object, so we can get Figure 8.

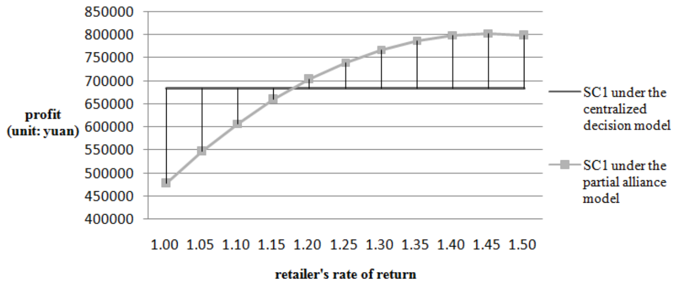


FIGURE VIII. THE COMPARISON OF THE PROFIT OF $SC_1$ UNDER THE TWO ALLIANCE STRATEGIES WITH THE CHANGE OF RETAILER'S RATE OF RETURN

From Figure 7, when retailer's rate of return $\tau$ changes from 1 to 1.5, the profit of $SC_1$ under the centralized decision model is more than that under the partial alliance model firstly, and then it is opposite. That means when $\tau$ is small, the centralized decision model is better than the partial alliance model. However, when $\tau$ is large, the centralized decision model is disadvantage. In addition, with the increase of retailer's rate of return, the profit of the supply chain increases firstly and then decreases under the partial alliance model. This indicates that when the retailer's rate of return is set too high, it will damage the interests of consumers, resulting in lower supply chain profit. As a result, retailers need to pay more attention to the setting of the rate of return.

## V. CONCLUSION

This article introduces the product competition intensity factor for two three levels competitive supply chains and builds a supply chain competing model based on product and service competition. On this basis, it studies the decision making of centralized and partial alliance strategies. And the impacts of competition intensity on decision making and supply chain efficiency of the two alliance strategies are analyzed. Finally, the advantages of the two alliance strategies under the change of competition intensity are discussed. The following management revelations are obtained.

*A.* The optimal wholesale price and quality of service are affected by their own product cost and its competitor's product cost. In addition, with the increase of competition intensity, retail prices, competitive strength and profit of the two supply chain will improve. The supply chain with cost advantages under the partial alliance model has been in a dominant position compared to its competitor. Therefore, when the enterprise determine the price and service level, they should consider their own cost, the cost of its competitor, product competition intensity.

*B.* The gap between the quality of service of product 1 and that of product 2 is significant in the centralized decision model. However the gap of the two retail prices is not obvious. This shows that in the process of competition, enterprise pays more attention to retail price than the quality of service. In the premise of maximizing profits, when they determine the retail price, they often fully reference to the opponent's situation to avoid too much difference. Therefore, enterprises should be aware of this problem and give more attention to the quality of service.

*C.* The retail price of a product under the centralized decision model is lower than that under the partial alliance model, and the quality of service under the centralized decision model is higher than that under the partial alliance model. When the competition intensity is small, the centralized decision can bring the supply chain greater profit. And when the competition intensity is large, the partial alliance strategy is more advantage. Therefore, enterprises should pay attention to both retail price and their own profit to avoid attending to one thing and losing another.

*D.* When the retailer's rate of return is set too high, it will damage the interest of consumers, resulting in lower supply chain profit. As a result, retailer needs to pay more attention to the setting of the rate of return.

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