SUPPLY CHAIN QUALITY AND PRICE COORDINATION: COMPETITIVE RETAILERS WITH DIFFERENT MARKET SHARE

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ABSTRACT: This paper focuses on the supply chain contained two competing retailers with different market shares and a manufacture, employed game theory, examined the impact of different market shares on product quality level and supply chain profits while the two retailers' competition and cooperation. The conclusions show that if the market share gap between the two retailers are same in the competition and cooperation model, compare to the cooperation model, the price gap is larger as well as the retailers' profits gap and the demand gap are smaller in the competition model. The product quality and total profits are the highest of centralized decision model, and product quality and the overall profits are lowest while retailers cooperation. There is no effect on the product quality and the profits of the manufacturer while the market share gap increases.

KEY WORDS: supply chain, quality, market share gap, competitive, game theory.

1 INTRODUCTION

With the rapid development of modern business, the type and the function of product are becoming more diversified, consumer demand change frequency is also accelerating. Enterprise manager continuous improving internal operation efficiency, at the same time, they try to improve product quality from the angle to enhance the attractiveness of goods, so as to seek greater competitive advantage. Enterprise only provides higher quality level than the other competitors and the right price to customers, so as to retain and attract customers, which can be in an invincible position in the competition (Simchi et al., 2004) [1]. Therefore, the quality management theory and pricing theory have become the focus of management theory and business circles. Product quality problems have seriously affected the efficiency of supply chain, and quality competition of enterprises is gradually transformed for the quality competition between supply chains. Therefore, as the core enterprise of closed-loop supply chain, through the selection of effective strategies, coordinating the relationship between the core enterprise, optimizing the closed-loop supply chain, improving the recovery efficiency and quality level, to achieve a win-win is of important significance.

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In the fierce market competition environment, enterprise managers have realized that in order to obtain the competitive advantage only rely on it alone cannot satisfy and adapt to the new market environment. Since twentieth century, some operation management experts put forward the basic idea of supply chain management. Supply chain management is an integrated product, service and information from the end user and to increase customer and other stakeholder value of the original supplier key business process. Supply chain management has become a powerful weapon for enterprises to improve operation efficiency, reduce costs and improve competitiveness (Cachon, 2003) [2]. The most important idea in supply chain management is to improve the supply chain performance by forming a supply chain decision-making mechanism, which is gradually recognized by the industry and academia. In this paper, we analyze the quality and price equilibrium in the multi retailer competition environment in supply chain, study the supply chain coordination on the market and the impact on supply chain competitiveness. The research of this paper will help to understand the impact of supply chain coordination on the whole industry and the key factors to improve the competitiveness of enterprises.

From the perspective of supply chain, the problem of quality management has caused the attention of some scholars. Chao and Iravani et al. (2009) studied impact of products recall cost sharing on product quality improvement in a supply chain consisting of a supplier and a retailer [3]. Xie and Wang et al. (2011) considered quality improvement in a given segment of the market, shared by two supplier–manufacturer supply chains which offer a given product at the same price but compete on quality [4]. Xie and Yue et al. (2011) considered the risk-averse behaviour of the players about quality investment and price decision in three different supply chain strategies: Vertical Integration (VI), Manufacturer's Stackelberg (MS) and Supplier's Stackelberg (SS) [5]. Lee and Rhee et al.(2013) tested the two most widely examined coordination schemes, buybacks and revenue-sharing, and find that these two contracts have critical drawbacks in the presence of quality uncertainty[6]. Ma and Wang et al. (2013) investigated the issue of channel coordination for a two-stage supply chain with one retailer and one manufacturer, analyzed the equilibrium behaviors of a two-stage supply chain (SC) under different supply chain structures [7]. Peng and Ma et al. (2013) under the assumption that the quality of the products and sales effort effects on demand, using two stages game to study the problem of supply chain coordination [8]. Yoo (2014) investigated a joint decision problem of the return policy and product quality in a buyer–supplier supply chain [9]. Shi and Li (2014) analyzed the quality of the two governance mechanisms, and the impact of formal contract governance and relational governance on supply chain efficiency is compared [10]. El Ouardighi (2010, 2014) established the wholesale price contract and revenue sharing contract models under dynamic conditions of supply chain quality management by two stages game [11-12].

As can be seen from the above literatures, scholars assume that the competitive members have the same initial market share, or assume they have the same product retail price. When the retailers have different initial market share, how to decision the retail price and quality level of manufacturer and how to coordinate the supply chain, the related research in this field are very few. And this is exactly what this paper wants to carry on.

In this paper, we focus on the price and quality coordination while retailers possess different market share. First, we will analyse integrated decision model, retailer cooperation model and retailer competition model. Second, according to the results of the models, we will comparative analysis and simulate for the three models. At last, conclusions will be given.

2 MODEL DESCRIPTION

We consider a supply chain which contains a manufacture and two retailers who occupy different market share in our models. The manufacture sells the products which quality level is x with wholesale price w to the retailers, the retailers sell the products to the consumer with price p_1 and p_2 respectively. The two retailers have different market shares, we use $\alpha_1\phi$ and $\alpha_2\phi$ to express retailer 1 and retailer 2 market share, respectively, and $\alpha_1 + \alpha_2 = 1, \phi$ is the base market size.

According to Banker, Khosla et al. (1998)[13], the cost function for SC is given by

$$c(d,x) = (c + vx)d + \xi x^2 \quad (1)$$

Thus, the quality level selected by the manufacture affects total costs in two ways. First, investment in a quality improvement program increases fixed production costs δx^2, which is increasing and convex in the quality level x, and ξ is the fixed cost parameter. Second, the quality level also has an impact on the production cost per unit. Specifically, c denotes the variable production cost per unit not including the quality related costs. Given a quality level x selected by SC, the unit variable cost increases by vx, where $v > 0$. d denotes market demand.

Following Dixit et al. (1979) [14], we assume that the demand information is symmetrically known to SC members, and the demand function is linear in price and quality level. Thus, the demand function for retailer 1 is:

$$d_1(p_1,p_2,x) = \alpha_1\phi - \beta p_1 + \gamma p_2 + \mu x \quad (2)$$

Where $\beta(\mu)$ denotes the demand responsiveness to SC's own price (quality), γ means price competition coefficient, which reflects the degree of price competition among retailers. We suppose $\beta > \gamma$, which means the change in demand caused by the change of the price of product is higher than that of the competitor's product price. In the same way, we come to the retailer's 2 demand function.

$$d_2(p_1,p_2,x) = \alpha_2\phi - \beta p_2 + \gamma p_1 + \mu x \quad (3)$$

When the retail price p_i and cost c are equal excluding the quality related costs, the demand must be greater than 0, and the reality is in line with it, namely

$$\alpha_1\phi - \beta p_1 + \gamma p_2 + \alpha_2\phi - \beta p_2 + \gamma p_1 = \phi - 2c(\beta - \gamma) > 0.$$

The objective of each party is to maximize his (her) profit that can be expressed as below:

$$\pi_{R_1}(p_1) = (p_1 - w)d_1 \tag{4}$$

$$\pi_{R_2}(p_2) = (p_2 - w)d_2 \tag{5}$$

$$\pi_M(w, x) = (w - c - vx)(d_1 + d_2) - \xi x^2 \tag{6}$$

Where π_R, π_M and π_T denote the profit of the retailer, the manufacturer and the SC, respectively. We use superscripts T, H and J to denote integrated decision, retailer cooperative and retailer competition model, respectively. Superscript $*$ denotes the optimal.

We formulate the problem as a Stackelberg game model in which the manufacturer and the retailers form a leader–follower relationship.

3 PRICE AND QUALITY COORDINATION IN DIFFERENT MARKET SHARE

3.1 Integrated decision model

In this model, the manufacturer and the two retailers are considered as a whole, in order to achieve profit maximization, the SC should choose the optimal p_1, p_2 and x. From Eq.(4) and Eq. (6), the profit function for the SC as follow:

$$\max_{\{p_1,p_2,x\}} \pi_T = (p_1 - c - vx)(\alpha_1\phi - \beta p_1 + \gamma p_2 + \mu x) + (p_2 - c - vx)(\alpha_2\phi - \beta p_2 + \gamma p_1 + \mu x) - \xi x^2 \tag{7}$$

The first-order conditions characterizing equilibrium retail price and quality level are:

$$\frac{d\pi_T}{dp_1} = c\beta - c\gamma + x\mu + x\beta v - x\gamma v - 2\beta p_1 + 2\gamma p_2 + \phi\alpha_1 = 0 \tag{8}$$

$$\frac{d\pi_T}{dp_2} = c\beta - c\gamma + x\mu + x\beta v - x\gamma v + 2\gamma p_1 - 2\beta p_2 + \phi\alpha_2 = 0 \tag{9}$$

$$\frac{d\pi_T}{dx} = -2c\mu - 4x\mu v - 2x\xi + (\mu + (\beta - \gamma)v)p_1 + (\mu + \beta v - \gamma v)p_2 - v\phi = 0 \tag{10}$$

Note that the Hessian of π_T is negative definite for all values of p_1, p_2 and x if $((\mu - (\beta - \gamma)v)^2 - 2(\beta - \gamma)\xi) < 0$ (this condition also needs to be satisfied in the following). Solving Eq. (7)~ Eq.(9), we obtain the equilibrium p_1, p_2 and x:

$$p_1^{T*} = \frac{4cB(A - (\beta - \gamma)H) + A\phi(\alpha_1 - \alpha_2) + 2BH\phi}{4BA} \tag{11}$$

$$p_2^{T*} = \frac{4cB(A - (\beta - \gamma)H) + A\phi(\alpha_2 - \alpha_1) + 2BH\phi}{4BA} \tag{12}$$

$$x^{T*} = \frac{(\mu - (\beta - \gamma)v)(2c(\beta - \gamma) - \phi)}{2A} \tag{13}$$

Substituting Eq.(11) ~ Eq.(13) into Eq.(7), we obtain:

$$p_1^{T*} - p_2^{T*} = \frac{\phi(\alpha_1 - \alpha_2)}{2B} \tag{14}$$

$$d_1^{T*} = \frac{4cC(A - CH) + (3A - 2CH)\phi\alpha_1 + (A - 2CH)\phi\alpha_2}{4A} \tag{15}$$

$$d_2^{T*} = \frac{4cC(A - CH) + (A - 2CH)\phi\alpha_1 + (3A - 2CH)\phi\alpha_2}{4A} \tag{16}$$

$$d_1^{T*} - d_2^{T*} = -\frac{1}{2}\phi(\alpha_1 - \alpha_2) \tag{17}$$

$$\pi_T^{T*} = \frac{(\mu + Cv)^2\phi^2(\alpha_1 - \alpha_2)^2 - 4\beta\xi\phi^2(\alpha_1^2 + \alpha_2^2) + 8cBC\xi(\phi - Cc) + 8\phi^2\alpha_1\alpha_2\gamma\xi}{8BA} \tag{18}$$

Where:
$A = (\mu - Cv)^2 - 2C\xi$, $B = \beta + \gamma$, $C = \beta - \gamma$, $H = -\mu v + Cv^2 - \xi$, and $A < 0, C > 0$.

3.2 Retailer cooperation model

In this model, the manufacturer sell products to the two retailers at the same wholesale price, while retailers are cooperative. The competition between the manufacture and retailers takes place in the following sequence in time:

(i) The manufacturer choose the optimal x and w to maximum his profits.

(ii) The retailer sell the products to the consumer and together choose the optimal p_1 and p_2 to maximum their profits.

From Eq. (4) and Eq. (6), the profit function for the SC as follows:

$$\pi_M^H = (w - c - vx)(\alpha_1\phi - \beta p_1 + \gamma p_2 + \mu x + \alpha_2\phi - \beta p_2 + \gamma p_1 + \mu x) - \xi x^2 \tag{19}$$

$$\pi_R^H = (p_1 - w)(\alpha_1\phi - \beta p_1 + \gamma p_2 + \mu x) + (p_2 - w)(\alpha_2\phi - \beta p_2 + \gamma p_1 + \mu x) \tag{20}$$

The manufacturer takes the retailers' reaction into consideration when choosing its strategy. The retailers' reaction function for a given w and x can be derived from the first-order derivative of π_H^R in Eq. (20):

$$\frac{d\pi_R^H}{dp_1} = w\beta - w\gamma + x\mu - 2\beta p_1 + 2\gamma p_2 + \phi\alpha_1 = 0 \tag{21}$$

$$\frac{d\pi_R^H}{dp_2} = w\beta - w\gamma + x\mu + 2\gamma p_1 - 2\beta p_2 + \phi\alpha_2 = 0 \tag{22}$$

Note that π_R^H gets maximum value definite for all values of p_1 and p_2 if $4(\beta^2 - \gamma^2)$>0. Solving Eq. (21) and Eq. (22), we obtain the equilibrium price:

$$p_1^H = \frac{(\beta + \gamma)(w\beta - w\gamma + x\mu) + \beta\phi\alpha_1 + \gamma\phi\alpha_2}{2(\beta^2 - \gamma^2)} \tag{23}$$

$$p_2^H = \frac{(\beta + \gamma)(w\beta - w\gamma + x\mu) + \gamma\phi\alpha_1 + \beta\phi\alpha_2}{2(\beta^2 - \gamma^2)} \tag{24}$$

Substituting Eq. (23) and Eq. (24) into Eq. (19), the first-order conditions characterizing equilibrium w and x are:

$$\frac{d\pi_M^H}{dx} = -c\mu + w\mu + w\beta v - w\gamma v - 2x\mu v - 2x\xi - \frac{1}{2}v\phi\alpha_1 - \frac{1}{2}v\phi\alpha_2 = 0 \tag{25}$$

$$\frac{d\pi_M^H}{dw} = c\beta - 2w\beta - c\gamma + 2w\gamma + x\mu + x\beta v - x\gamma v + \frac{\phi\alpha_1}{2} + \frac{\phi\alpha_2}{2} = 0 \tag{26}$$

Note that π_M^H gets maximum value definite for all values of w and x if $-(\mu+(\beta-\gamma)v)^2+4(\beta-\gamma)(\mu v+\xi)>0$. From Eq. (25) and Eq. (26), we find that the manufacturing's optimal wholesale price and quality level are:

$$x^{H*}=\frac{(\mu-Cv)(2cC-\phi)}{2(A-2C\xi)} \quad (27)$$

$$w^{H*}=\frac{2c(A-C(H+\xi))+(H-\xi)\phi}{2(A-2C\xi)} \quad (28)$$

Substituting x^{H*} and w^{H*} into Eq.(23) and Eq.(24), we obtain:

$$p_1^{H*}=\frac{4cB(A-CH)+(A+2BH-2(3\beta+\gamma)\xi)\phi\alpha_1-(A-2BH+2(\beta+3\gamma)\xi)\phi\alpha_2}{4B(A-2C\xi)} \quad (29)$$

$$p_2^{H*}=\frac{4cB(A-CH)-(A-2BH+2(\beta+3\gamma)\xi)\phi\alpha_1+(A+2BH-2(3\beta+\gamma)\xi)\phi\alpha_2}{4B(A-2C\xi)} \quad (30)$$

Then we can obtain the demand and profits from Eq. (19) and Eq. (20):

$$d_1^{H*}=\frac{4cB(-A+BH)+(3A-2B(H+\xi))\phi\alpha_1+(A-2B(H-\xi))\phi\alpha_2}{4(A-2C\xi)} \quad (31)$$

$$d_2^{H*}=\frac{4cB(-A+BH)+(A-2B(H-\xi))\phi\alpha_1+(3A-2B(H+\xi))\phi\alpha_2}{4(A-2C\xi)} \quad (32)$$

$$\pi_{R_1}^{H*}=\frac{(4cC^2\xi+(A-4C\xi)\phi\alpha_1-A\phi\alpha_2)(4cBC\xi+(A-4\beta\xi)\phi\alpha_1+(A+4\gamma\xi)\phi\alpha_2)}{(16B(A-2C\xi))^2} \quad (33)$$

$$\pi_{R_2}^{H*}=\frac{(4cC^2\xi+(A-4C\xi)\phi\alpha_2-A\phi\alpha_1)(4cBC\xi+(A-4\beta\xi)\phi\alpha_2+(A+4\gamma\xi)\phi\alpha_1)}{(16B(A-2C\xi))^2} \quad (34)$$

$$\pi_M^{H*}=\frac{\xi(\phi-2cC)^2}{-4(A-2C\xi)} \quad (35)$$

Conclusion 1: For cooperative retailers, when their market share gap is $\Delta\alpha$, then the price difference is $\frac{\phi}{2(\beta+\gamma)}\Delta\alpha$, the demand difference is $\frac{\phi}{2}\Delta\alpha$, the profits difference is $\frac{\beta\xi\phi(\phi-2cC)}{2(\beta+\gamma)(2C\xi-A)}\Delta\alpha$.

Proof: from Eq. (29) ~Eq. (34), we can obtain $p_1^{H*}-p_2^{H*}=\frac{\phi\Delta\alpha}{2B}$, $d_1^{H*}-d_2^{H*}=\frac{1}{2}\phi\Delta\alpha$ and $\pi_{R_1}^{H*}-\pi_{R_2}^{H*}=\frac{\beta\xi\phi\Delta\alpha(\phi-2cC)}{2B(2C\xi-A)}$, where $\Delta\alpha=\alpha_1-\alpha_2$.

3.3 Retailer competition model

In this model, the manufacturer sell products to the two competitive retailers at the same wholesale price. The competition between the manufacture and retailers takes place in the following sequence in time:

(i) The manufacturer choose the optimal x and w to maximum his profits.

(ii) The retailer sell the products to the consumer and choose the optimal p_1 and p_2 to maximum each profits respectively.

From Eq. (4) and Eq. (6), the profit function for the SC as follows:

$$\pi_M^J=(w-c-vx)(\alpha_1\phi-\beta p_1+\gamma p_2+\mu x+\alpha_2\phi-\beta p_2+\gamma p_1+\mu x)-\xi x^2 \quad (36)$$

$$\pi_{R_1}^J=(p_1-w)(\alpha_1\phi-\beta p_1+\gamma p_2+\mu x) \quad (37)$$

$$\pi_{R_2}^J=(p_2-w)(\alpha_2\phi-\beta p_2+\gamma p_1+\mu x) \quad (38)$$

The manufacturer takes the retailers' reaction into consideration when choosing its strategy. The retailers' reaction function for a given w and x can be derived from the first-order derivative of π_H^J in Eq. (37) and Eq. (38):

$$\frac{d\pi_R^J}{dp_1}=w\beta+x\mu-2\beta p_1+\gamma p_2+\phi\alpha_1=0 \quad (39)$$

$$\frac{d\pi_R^J}{dp_2}=w\beta+x\mu+\gamma p_1-2\beta p_2+\phi\alpha_2=0 \quad (40)$$

Solving Eq. (39) and Eq. (40), we obtain the equilibrium p_1 and p_2:

$$p_1^J=\frac{(2\beta+\gamma)(w\beta+x\mu)+2\beta\phi\alpha_1+\gamma\phi\alpha_2}{4\beta^2-\gamma^2} \quad (41)$$

$$p_2^J=\frac{(2\beta+\gamma)(w\beta+x\mu)+\gamma\phi\alpha_1+2\beta\phi\alpha_2}{4\beta^2-\gamma^2} \quad (42)$$

Substituting Eq. (41) and Eq. (42) into Eq. (36), the first-order conditions characterizing equilibrium w and x are:

$$\frac{d\pi_M^J}{dx}=-\frac{2c\beta\mu-2w\beta\mu-2w\beta^2v+2w\beta\gamma v+4x\beta\mu v+4x\beta\xi-2x\gamma\xi+\beta v\phi\alpha_1+\beta v\phi\alpha_2}{2\beta-\gamma}=0 \quad (43)$$

$$\frac{d\pi_M^J}{dw}=\frac{\beta(2(c\beta-2w\beta-c\gamma+2w\gamma+x\mu+x\beta v-x\gamma v)+\phi\alpha_1+\phi\alpha_2)}{2\beta-\gamma}=0 \quad (44)$$

Note that π_M^H gets maximum value definite for all values of w and x $if\ -\beta(\mu+(\beta-\gamma)v)^2+(-\beta+\gamma)(2\gamma\xi-4\beta(\mu v+\xi))=2(\beta-\gamma)^2\xi-\beta A>0$. From Eq. (43) and Eq. (44), we find the manufacture's optimal wholesale price and quality level are:

$$x^{J*}=\frac{\beta(\mu-Cv)(2cC-\phi)}{2(\beta A-2C^2\xi)} \quad (45)$$

$$w^{J*}=\frac{2c(-C(H\beta+C\xi)+\beta A)+(\beta H-C\xi)\phi}{2(\beta A-2C^2\xi)} \quad (46)$$

Substituting x^{J*} and w^{J*} into Eq. (45) and Eq. (46), we obtain:

$$p_1^{J*}=\frac{-2c\beta(2\beta+\gamma)(CH-A)+\beta(A+(2\beta+\gamma)H-6C\xi)\phi\alpha_1-(\beta A-\beta(2\beta+\gamma)H+2C(\beta+2\gamma)\xi)\phi\alpha_2}{2(2\beta+\gamma)(\beta A-2C^2\xi))} \quad (47)$$

$$p_2^{J*}=\frac{-2c\beta(2\beta+\gamma)(CH-A)+\beta(A+(2\beta+\gamma)H-6C\xi)\phi\alpha_2-(\beta A-\beta(2\beta+\gamma)H+2C(\beta+2\gamma)\xi)\phi\alpha_1}{2(2\beta+\gamma)(\beta A-2C^2\xi))} \quad (48)$$

Then we can obtain the demand and profits from Eq. (47) and Eq. (48):

$$d_1^{J*}=\frac{\beta(2cC(\beta+2\gamma)(A-CH)+((3\beta+\gamma)A-C(2\beta+\gamma)H-2C^2\xi)\phi\alpha_1+(\beta A-C(2\beta+\gamma)H+2C^2\xi)\phi\alpha_2)}{2(2\beta+\gamma)(\beta A-2C^2\xi)} \quad (49)$$

$$d_2^{J*}=\frac{\beta(2cC(\beta+2\gamma)(A-CH)+((3\beta+\gamma)A-C(2\beta+\gamma)H-2C^2\xi)\phi\alpha_2+(\beta A-C(2\beta+\gamma)H+2C^2\xi)\phi\alpha_1)}{2(2\beta+\gamma)(\beta A-2C^2\xi)}$$

$$\pi_{R_1}^{J*} = \frac{\beta(2cC^2(2\beta+\gamma)\xi+(\beta A+C(\gamma-4\beta)\xi)\phi\alpha_1-(\beta A+3C\gamma\xi)\phi\alpha_2)^2}{4(2\beta+\gamma)^2(\beta A-2C^2\xi)^2} \quad (50)$$

$$\pi_{R_2}^{J*} = \frac{\beta(2cC^2(2\beta+\gamma)\xi+(\beta A+C(\gamma-4\beta)\xi)\phi\alpha_2-(\beta A+3C\gamma\xi)\phi\alpha_1)^2}{4(2\beta+\gamma)^2(\beta A-2C^2\xi)^2} \quad (51)$$

$$\pi_M^{J*} = \frac{\beta\xi(\phi-2cC)^2}{4(2C^2\xi-\beta A)} \quad (52)$$

(53)

Conclusion 2: For competitive retailers, when their market share gap is $\Delta\alpha$, then the price difference is $\frac{\phi}{2\beta+\gamma}\Delta\alpha$, the demand difference is $\frac{\beta\phi}{2\beta+\gamma}\Delta\alpha$, the profits difference is $\frac{\beta C\xi\phi(\phi-2cC)}{(2\beta+\gamma)(2C^2\xi-\beta A)}\Delta\alpha$。

Proof: From Eq. (47) ~ Eq. (52), we can obtain $p_1^{J*} - p_2^{J*} = \frac{\phi\Delta\alpha}{2\beta+\gamma}$ $d_1^{J*} - d_2^{J*} = \frac{\beta\phi\Delta\alpha}{2\beta+\gamma}$ and $\pi_{R_1}^{J*} - \pi_{R_2}^{J*} = \frac{\beta C\xi\phi\Delta\alpha(\phi-2cC)}{(2\beta+\gamma)(2C^2\xi-\beta A)}$, where $\Delta\alpha = \alpha_1 - \alpha_2$.

Conclusion 3: If the market share gap between the two retailers are $\Delta\alpha(>0)$ in the competition and cooperation model, compare to the cooperation model, the price gap is larger and the retailers' profits gap and the demand gap are smaller in the competition model.

Proof: from conclusion 1 and conclusion 2, we can obtain $\frac{p_{R_1}^{J*}-p_{R_2}^{J*}}{p_{R_1}^{H*}-p_{R_2}^{H*}} = \frac{2\beta+2\gamma}{2\beta+\gamma} > 1$,

$\frac{\pi_{R_1}^{J*}-\pi_{R_2}^{J*}}{\pi_{R_1}^{H*}-\pi_{R_2}^{H*}} = \frac{2\beta+\gamma}{2(\beta+\gamma)}\frac{2C^2\xi-\beta A}{2C^2\xi-(\beta-\gamma)A} < 1$, $\frac{d_{R_1}^{J*}-d_{R_2}^{J*}}{d_{R_1}^{H*}-d_{R_2}^{H*}} = \frac{2\beta}{2\beta+\gamma} < 1$.

4 COMPARATIVE ANALYSIS

4.1 Quality analysis

Conclusion 4: $x^{T*} > x^{J*} > x^{H*}$; $\frac{dx^{i*}}{d\mu} > 0$, $\frac{dx^{i*}}{d\beta} < 0$, $\frac{dx^{i*}}{d\gamma} > 0$, where $i = T, J, H$.

Proof: From the above suppose conditions, we can know that that $\phi - 2cC > 0$, $\mu - Cv > 0$, $\beta A - 2C^2\xi < 0$ $A - 2C\xi < 0$ and $A < 0$, so we can obtain $x^{T*} - x^{J*} = \frac{C^2(\mu-Cv)\xi(\phi-2cC)}{A(\beta A-2C^2\xi)} > 0$, $x^{J*} - x^{H*} = \frac{C\gamma(\mu-Cv)\xi(\phi-2cC)}{(A-2C\xi)(\beta A-2C^2\xi)} > 0$. $\frac{dx^{T*}}{d\mu} = \frac{(A+4C\xi)(\phi-2cC)}{2A^2} > 0$, $\frac{dx^{T*}}{d\beta} = -\frac{-2c(\mu A+2C(\mu+Cv)\xi)+(vA+2(\mu+Cv)\xi)\phi}{2A^2} < 0$, $\frac{dx^{T*}}{d\gamma} = \frac{-2c(\mu A+2C(\mu+Cv)\xi)+(vA+2(\mu+Cv)\xi)\phi}{2A^2} > 0$. Adopt the same way, we can easily get $\frac{dx^{J*}}{d\mu} > 0$, $\frac{dx^{J*}}{d\beta} < 0$, $\frac{dx^{J*}}{d\gamma} > 0$, $\frac{dx^{H*}}{d\mu} > 0$, $\frac{dx^{H*}}{d\beta} < 0$, $\frac{dx^{H*}}{d\gamma} > 0$. The Simulation as shown in Figure 1.

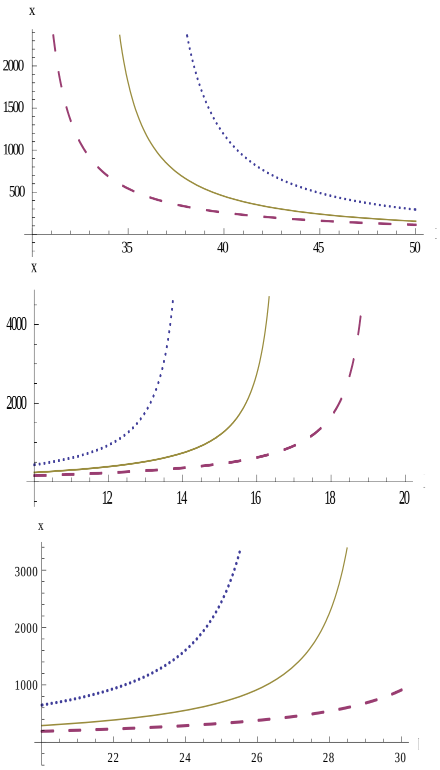

Fig. 1 Product quality level change trend chart ($\phi = 10000, \beta = 41, \gamma = 22, c = 20, v = 0.1, \lambda = 10, \mu = 12, \xi = 4, \alpha_1 = 0.7, \alpha_2 = 0.3$).

4.2 Profits analysis

Conclusion 5: $\pi_M^{H*} < \pi_M^{J*}$; $\frac{d\pi_M^{H*}}{d\mu} > 0$,$\frac{d\pi_M^{H*}}{d\beta} < 0$, $\frac{d\pi_M^{H*}}{d\gamma} > 0$; $\frac{d\pi_M^{J*}}{d\mu} > 0$, $\frac{d\pi_M^{J*}}{d\beta} < 0$, $\frac{d\pi_M^{J*}}{d\gamma} > 0$.

Proof: According to the proof of conclusion 4, we can get $\pi_M^{H*} - \pi_M^{J*} = -\frac{C\gamma\xi^2(\phi-2cC)^2}{2(A-2C\xi)(\beta A-2C^2\xi)} < 0$; $\frac{d\pi_M^{H*}}{d\mu} = \frac{(\mu-Cv)\xi(\phi-2cC)^2}{2(A-2C\xi)^2} > 0$, $\frac{d\pi_M^{H*}}{d\beta} = -\frac{\xi(\phi-2cC)((\xi-H)\phi-2c(A-C(H+\xi))}{2(A-2C\xi)^2} < 0$, $\frac{d\pi_M^{H*}}{d\gamma} = \frac{\xi(\phi-2cC)((\xi-H)\phi-2c(A-C(H+\xi))}{2(A-2C\xi)^2} > 0$. Also, we can easily obtain $\frac{d\pi_M^{J*}}{d\mu} > 0$,$\frac{d\pi_M^{J*}}{d\beta} < 0$,$\frac{d\pi_M^{J*}}{d\gamma} > 0$. The simulation is shown in figure 2.

Conclusion 6: If $\alpha_1 \geq \alpha_2$, then $\pi_{R_1}^{H*} \geq \pi_{R_2}^{H*}$, $\pi_{R_1}^{J*} \geq \pi_{R_2}^{J*}$; if $\alpha_1 < \alpha_2$, $\pi_{R_1}^{H*} < \pi_{R_2}^{H*}$, $\pi_{R_1}^{J*} < \pi_{R_2}^{J*}$.

Proof: Because $\pi_{R_1}^{H*} - \pi_{R_2}^{H*} = \frac{\beta\xi\phi(\alpha_1-\alpha_2)(\phi-2cC)}{-2B(A-2C\xi)}$, $\pi_{R_1}^{J*} - \pi_{R_2}^{J*} = \frac{\beta(\beta-\gamma)\xi\phi(\alpha_1-\alpha_2)(\phi-2cC)}{-(2\beta+\gamma)(\beta A-2C^2\xi)}$, according to the assumptions, we can obtain if $\alpha_1 \geq \alpha_2$, then $\pi_{R_1}^{H*} \geq \pi_{R_2}^{H*}$, $\pi_{R_1}^{J*} \geq \pi_{R_2}^{J*}$; if $\alpha_1 < \alpha_2$, $\pi_{R_1}^{H*} < \pi_{R_2}^{H*}$, $\pi_{R_1}^{J*} < \pi_{R_2}^{J*}$ therefore conclusion 6 is established. The simulation as shown in figure 3.

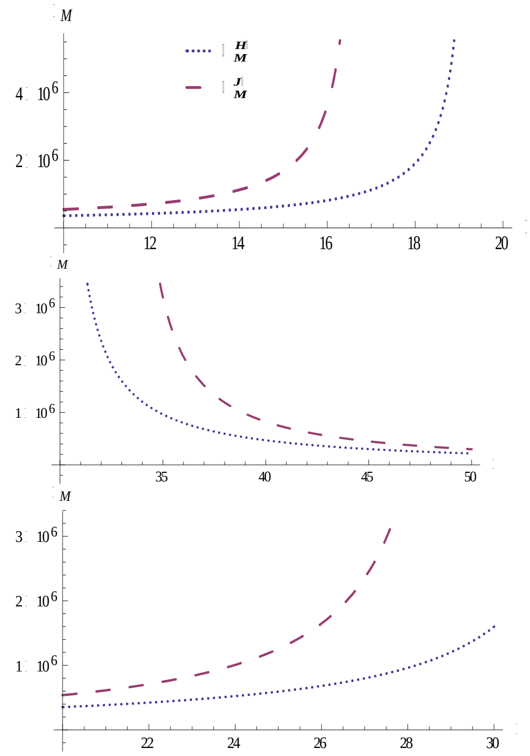

Fig. 2 Manufacture profits change trend chart ($\phi = 10000, \beta = 41, \gamma = 22, c = 20, v = 0.1, \lambda = 10, \mu = 12,$ $\xi = 4, \alpha_1 = 0.7, \alpha_2 = 0.3$).

From table 1, it can be seen that the product quality and total profits are the highest of centralized decision model, and product quality and the overall profits are lowest while retailers cooperation. There is no effect on the product quality and the profits of the manufacturer while Δα increases, but with Δα increases the total profit of supply chain increases. if the market share gap between the two retailers are Δα(>0) in the competition and cooperation model, compare to the cooperation model, the price gap is larger as well as the retailers' profits gap and the demand gap are smaller in the competition model.

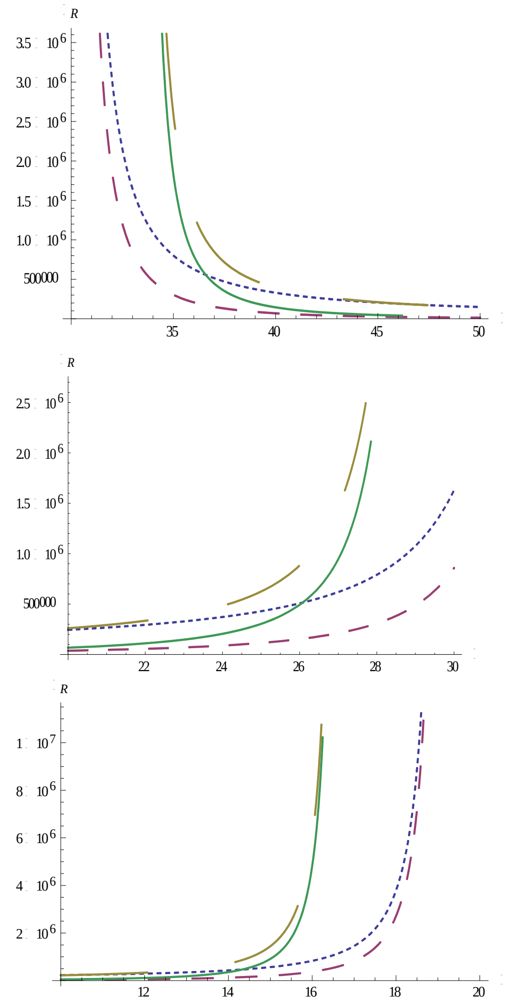

Fig. 3 Retailers profits change trend chart ($\phi = 10000, \beta = 41, \gamma = 22, c = 20, v = 0.1, \lambda = 10, \mu = 12,$ $\xi = 4, \alpha_1 = 0.7, \alpha_2 = 0.3$).

Table 1. Effect of $\Delta\alpha$ on quality and profits ($\phi = 10000, \beta = 41, \gamma = 22, c = 20, v = 0.1, \lambda = 10, \mu = 12, \xi = 4, \alpha_1 \geq \alpha_2$)

	x^T	π_T^T	x^J	π_M^J	π_{R1}^J	π_{R2}^J	π_T^J	x^H	π_M^H	π_{R1}^H	π_{R2}^H	π_T^H
$\Delta\alpha = 0$	933	1707890	387	708945	207331	207331	1123610	231	422682	159037	159037	740756
$\Delta\alpha = 0.2$	933	1715830	387	708945	267191	155053	1131190	231	422682	222546	103464	748693
$\Delta\alpha = 0.4$	933	1739640	387	708945	334632	110357	1153930	231	422682	293992	55828	772502
$\Delta\alpha = 0.6$	933	1779320	387	708945	409654	73241	1191840	231	422682	373374	16128	812185
$\Delta\alpha = 0.8$	933	1834880	387	708945	492257	43707	1244910	231	422682	460693	-15635	867740

5 SUMMARY

This paper focuses on a supply chain contained two competing retailers with different market shares and a manufacturers, examined the impact of different market shares on product quality level and supply chain profits while the two retailers' competition and cooperation. The conclusions show that: from the market share point of view, if the market share gap between the two retailers are $\Delta\alpha(>0)$ in the competition and cooperation model, compare to the cooperation model, the price gap is larger as well as the retailers' profits gap and the demand gap are smaller in the competition model. The product quality and total profits are the highest of centralized decision model, and product quality and the overall profits are lowest while retailers cooperation. There is no effect on the product quality and the profits of the manufacturer while $\Delta\alpha$ increases, but with $\Delta\alpha$ increases the total profit of supply chain increases. The supply chain models established in this paper are relatively simple, the researchers can establish the supply chain network model with multiple manufacturers and retailers, and can get a more general situation of supply chain competitive equilibrium solution, and can also analyse the impact of supply chain coordination on the supply chain system and the impact of the entire market.

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