Revenue Sharing Contract in Dual Channel Supply Chain in Case of Free Riding

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Abstract. After the Internet channel emerged, consumers can go to the traditional retailer store and accept sales services, and then buy the product from the Internet store. Thus a free riding problem occurs. This paper analyzed the optimal prices of dual channel for the entire supply chain and competing equilibriums of various dual channel structures when free riding problem exists. This paper also studied the application of coordination strategy of revenue sharing contract to various dual channel structures when free riding problem exists. The result shows that revenue sharing contract can fully coordinate the entire supply chain of decentralized dual channel, and can't fully coordinate the entire supply chain of horizontally integrated dual channel, the revenue sharing contract and a coordination policy of fixed price difference can fully coordinate the entire supply chain of partially integrated dual channel.

1 Introduction

With the rapid growth and exciting potential of Internet channel, more and more firms utilize both the traditional channel and Internet channel to sell their products. Many articles researched the price equilibrium or service equilibrium of dual channel of manufacturer's direct channel and retailer's traditional channel. Chiang et al. showed that the manufacturer's direct marketing can indirectly increase the flow of profits through the retail channel, help the manufacturer improve overall profitability by reducing the degree of inefficiency caused by double marginalization [1]. Yao et al. studied the Stackelberg game and Bertrand game between the manufacturer and the retailer when the manufacturer introduced a direct channel, the conclusion showed that the retailer will increase the selling effort and both the manufacturer and the retailer can gain more profits [2]. Yan et al. pointed out the retailer can use high quality of service weakening the competitiveness of manufacturer's direct channel and making the entire supply chain better [3].

The introduction of Internet channel makes parts of consumers turn to shopping on Internet and brings channel conflict. Webb et al. proposed twelve methods of softening the channel conflict [4]. Cattani et al. compared manufacturer's three

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pricing strategies (keep wholesale price unchanged, keep retail price unchanged, select wholesale price and retail price that optimize profits for the manufacturer) for dual channel which are used to diminish the channel conflict. He found that the third strategy is preferred by both the manufacturer and the retailer [5]. Xiao considered the strategy of letting the retailer finish the manufacturer's direct channel's orders and found that the strategy is attributable to both the manufacturer and the retailer under certain conditions [6]. Theoretically, channel coordination can make the retailer gain more profits and eliminate the channel conflict effectively [7]. When there is only one traditional channel, many coordination mechanisms such as revenue sharing contract, quantity discount contract, buy back contract and so on are designed to eliminate double marginalization [8,9]. Some scholars researched the application of coordination strategy used in single traditional channel to dual channel. Boyaci found that the buy back contract can't fully coordinate the entire supply chain in dual channel [10]. Xie and Cai et al. found that the quantity discount contract can fully coordinate the entire supply chain in dual channel of manufacturer's direct channel and retailer's traditional channel [11, 12].

The introduction of Internet channel also brings the free riding problem. Many consumers firstly accept the retail services such as explaining the product in detail, touch and feel the real product in the traditional store, and then buy the product through the Internet store after making purchase decision. Such behavior is called free riding. The free riding problem occurs if the presales activities can be conducted separately from the actual sale of the product. Free riding always hurt the retailer which provides the service [13]. Xin studied the impact of free riding on retailer's pricing strategy in single traditional channel [14]. Wu studied the impact of free riding problem on the retailer who provides the costly service under the circumstance of dual channel where the searching cost of consumers is decreased [15]. Because of the difficulty of providing the services provided by the traditional retailer for the Internet retailer and the lower price for Internet channel, the free riding behavior becomes a popular phenomenon in dual channel. Baal et al. found that 20% of the consumers are free riders [16]. Carlton et al. showed that the manufacturer is apt to set a higher or equal price in Internet channel to weaken the free riding problem [17].

In summary, the research on the price equilibrium or coordination strategy in dual channel when free riding problem exists is rare. On the other hand, existing researches mostly concentrate on the dual channel structure of manufacturer's direct channel and retailer's traditional channel. However, among the top 10 U.S. Internet retail sites in 2008, only two were manufacturer's direct channels, whereas five were owned by traditional retailers, and the rest were pure Internet retailers [18]. The existing studies are lack of analysis of these diverse channel structure possibilities. This paper studied the pricing strategy for the optimization of the entire supply chain in dual channel and pricing equilibriums of three different dual channel structures in case of free riding when the supply chain members make decision separately. This paper also studied whether the coordination strategy of revenue sharing contract can fully coordinate the entire supply chain of various dual channel structures when free riding problem exists.

2 Model

Similar to Xiao and Guo et al. [6, 19], we assume a linear downward sloping demand function. The demand of traditional channel and Internet channel are given as below respectively:

$$d_r = a_r - bp_r - \theta(p_r - p_e), \tag{1}$$

$$d_e = a_e - bp_e + \theta(p_r - p_e). \tag{2}$$

Where $p_i, i \in \{r, e\}$ is the product's retail price in channel i ($i = r$ denotes the traditional channel, $i = e$ denotes the Internet channel). $a_i, i \in \{r, e\}$ is the market potential of channel i. b is the price elasticity factor. θ is the factor of demand change with respect to the price in the other channel. So the change of quantity from the traditional channel to Internet channel is $\theta(p_r - p_e)$. The changed quantity contains two parts. One is the quantity that consumers buying from Internet store directly, the other is the quantity related to free riding. We assume the free riding ratio is μ .That is to say the quantity bought from free riders is

$$d_f = \mu\theta(p_r - p_e). \tag{3}$$

Let $c_i, i \in \{r, e\}$ denote the retail cost for each customer who visits the store in channel i. Similar to Xin (2007), we assume that the traditional retailer will incur selling cost to serve a customer who may or may not purchase a product. For the quantity of d_f, both the retailers in each channel should pay the corresponding costs. There are two reasons for having such an assumption. One is that traditional retailer must expand time and effort to help customers identify the product that best fits their needs irrespective of whether they buy the product. The other is that traditional retailer gives up its opportunity to make another sale by serving the wrong customers (free riders).

In order to utilize the above model, we assume $a_r > a_e$, $c_r > c_e$ and $a_r - a_e + (2\theta + b)(c_r - c_e) - 2\mu\theta c_r > 0$. $a_r > a_e$ means that the traditional channel has a larger market potential. $c_r > c_e$ means that the traditional retailer should pay a higher unit cost. $a_r - a_e + (2\theta + b)(c_r - c_e) - 2\mu\theta c_r > 0$ means $p_r > p_e$ when the entire supply chain realize the maximization of profits and also ensures the existence of free riding problem under various dual channel structures. We also have the assumption of $a_i > bc_i, i \in \{r, e\}$, which can guarantee that prices exceed marginal costs and quantities are nonnegative.

Similar to Yoo et al. [18], we considered four dual channel arrangements. They are vertically integrated dual channel (VID), partially integrated dual channel (PID), decentralized dual channel (DD) and horizontally integrated dual channel

(HID). The corresponding channel structures are shown in figure 1. The real line in the figure means the two parts belong to one entity. The broken line in the figure means the two parts belong to two entities. In vertically integrated dual channel (e.g., Dell), the manufacturer called vertically integrated manufacturer (vim) owns both the Internet channel and the traditional channel. In partially integrated dual channel (e.g., Lenovo and Haier), the manufacturer called partially integrated manufacturer (pim) owns Internet channel. It competes with the traditional retailer (tr) in the market. In decentralized dual channel (e.g., Amazon.com), the manufacturer (m) doesn't owns any channel, and the traditional retailer (tr) and Internet retailer (er) compete with each other in the market. In horizontally integrated dual channel (e.g., Wal-mart), the retailer called horizontally integrated retailer (hir) owns both the Internet channel and the traditional channel.

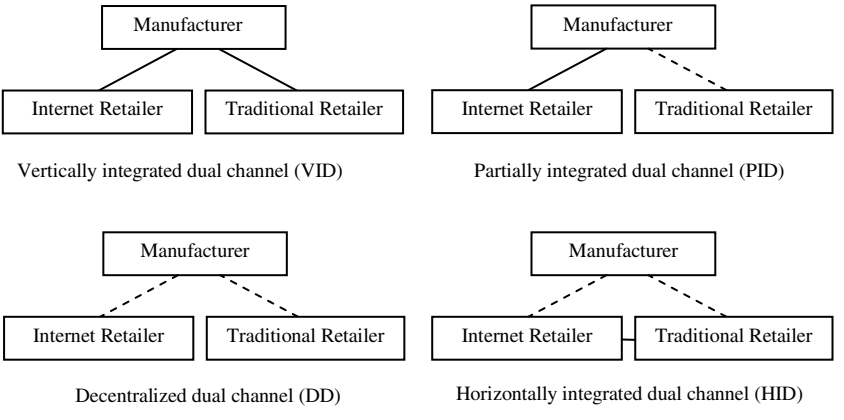

Fig. 1 Four Dual Channel Structures

Without coordination, the players optimize their own profits sequentially rather than maximize the entire supply chain profits globally. Similar to numerous previous studies, we assume the following: (1) The manufacturer, as the Stackelberg leader, sets the wholesale price to maximize its own profits with the foresight of the independent retailers' optimal responses; (2) As a Stackelberg follower, the independent retailer sets its retail price to maximize its own profits conditional on the wholesale price. The price competition between two independent retailers is assumed to be Bertrand–Nash; (3) If dual channel members are vertically or horizontally integrated, their pricing decisions are coordinated to maximize the joint profits. When the supply chain utilizes coordinated strategy of revenue sharing contract, the retailer shares ρ $(0 < \rho < 1)$ of its revenue with the manufacturer. The value of ρ generally reflects the negotiation power between the manufacturer and the retailer and is usually determined in a negotiation process which is not a focus of this paper.

3 Model Analysis

3.1 Vertically Integrated Dual Channel

The profits of the vertically integrated manufacturer is $\pi_{vim}^{VID} = (p_r - c_r)d_r + (p_e - c_e)d_e - c_r d_f$. The vertically integrated manufacturer decides p_r and p_e to maximize its profits. We can know that π_{vim}^{VID} is jointly concave with respect to p_r and p_e. Letting the differentials of π_{vim}^{VID} on p_r and p_e both be zero, we can get

$$p_r = \frac{\theta a_e + \theta a_r + b a_r + 2\theta b c_r + b^2 c_r - \mu\theta b c_r}{2b(b + 2\theta)}, \tag{4}$$

$$p_e = \frac{\theta a_e + \theta a_r + b a_e + 2\theta b c_e + b^2 c_e + \mu\theta b c_r}{2b(b + 2\theta)}. \tag{5}$$

The profits of the entire supply chain are π_{vim}^{VID} in every dual channel structure. It is to say that the entire supply chain will realize the maximization of profits if p_r and p_e satisfied equation (4) and equation (5) respectively. So we have the following result.

Result 1. The retail prices of traditional channel and Internet channel are equation (4) and equation (5) respectively in vertically integrated dual channel, and the entire supply chain realizes the maximization of profits.

3.2 Partially Integrated Dual Channel

Without coordination, the profits of the partially integrated manufacturer and the traditional retailer are $\pi_{pim}^{PID} = w_{tr} d_r + (p_e - c_e)d_e$ and $\pi_{tr}^{PID} = (p_r - w_{tr})d_r - -(d_r + d_f)c_r$. Where w_{tr} is the wholesale price for the traditional retailer. The sequence of the game is that the partially integrated manufacturer sets w_{tr} first and then the partially integrated manufacturer and the traditional retailer set p_r and p_e respectively at the same time. We can know that π_{pim}^{PID} is concave with respect to p_e and π_{tr}^{PID} is concave with respect to p_r. In accordance with backward induction, letting the differential of π_{pim}^{PID} on p_e and the differential of π_{tr}^{PID} on p_r both be zero, we obtain

$$p_r = \frac{\begin{array}{c} 4\theta b w_{tr} - 2\mu\theta^2 c_r + b\theta c_e + 2b^2 c_r + 4\theta b c_r + 2b a_r + \\ 2b^2 w_{tr} - 2\mu\theta b c_r + 2\theta a_r + 3\theta^2 w_{tr} + 2\theta^2 c_r + \theta^2 c_e + \theta a_e \end{array}}{(3\theta^2 + 4b^2 + 8b\theta)}, \tag{6}$$

$$p_e = \frac{\begin{array}{c}\theta a_r + 3w_{tr}\theta^2 + \theta c_r b + \theta^2 c_r + 3\theta b w_{tr} + 2c_e b^2 - \\ \mu c_r \theta^2 + 2ba_e + 2\theta^2 c_e + 2\theta a_e + 4b\theta c_e\end{array}}{3\theta^2 + 4b^2 + 8b\theta}. \quad (7)$$

Substituting equation (6) and equation (7) into π_{pim}^{PID} and letting the differential of π_{pim}^{PID} on w_{tr} be zero, we obtain

$$w_{tr} = \frac{\begin{array}{c}25\theta^3 ba_e - 16\theta^4 bc_r - 8b^5 c_r + 9\theta^4 a_e + 32\mu\theta^2 b^3 c_r + 8\mu\theta b^4 c_r + 32\theta^3 ba_r - \\ 2\theta^4 bc_e + 48\theta^2 b^2 a_r - 56\theta^3 b^2 c_r - 72\theta^2 b^3 c_r + 32\theta b^3 a_r + 8\theta b^3 a_e + \\ 16\mu\theta^4 bc_r - \theta^3 b^2 c_e + 40\mu\theta^3 b^2 c_r + 24\theta^2 b^2 a_e + 8b^4 a_r + 9\theta^4 a_r - 40\theta b^4 c_r\end{array}}{2b(b+\theta)(b+2\theta)(8b^2+16\theta b+9\theta^2)}. \quad (8)$$

Substituting equation (8) into equation (6) and equation (7), we can get

$$p_r = \frac{\begin{array}{c}4b^5 c_r + 20\theta b^4 c_r + 4\theta b^4 c_e + 12b^4 a_r - 4\mu\theta b^4 c_r + 36\theta^2 b^3 c_r - 16\mu\theta^2 b^3 c_r + 16\theta^2 b^3 c_e \\ +48\theta b^3 a_r + 8\theta b^3 a_e - 20\mu\theta^3 b^2 c_r + 21\theta^3 b^2 c_e + 28\theta^3 b^2 c_r + 24\theta^2 b^2 a_e + 70\theta^2 b^2 a_r \\ -8\mu\theta^4 bc_r + 44\theta^3 ba_r + 25\theta^3 ba_e + 10\theta^4 bc_e + 8\theta^4 bc_r + 9\theta^4 a_r + 9\theta^4 a_e\end{array}}{2(b+\theta)(b+2\theta)(8b^2+16\theta b+9\theta^2)}, \quad (9)$$

$$p_e = \frac{\begin{array}{c}8b^4 c_e + 32\theta b^3 c_e - 2\theta b^3 c_r + 8b^3 a_e - 6\theta^2 b^2 c_r + 2\mu\theta^2 b^2 c_r + 43\theta^2 b^2 c_e + 24\theta b^2 c_e \\ +10\theta b^2 a_r + 22\theta^3 bc_e + 20\theta^2 ba_r + 4\mu\theta^3 bc_r + 25\theta^2 ba_e - 4\theta^3 bc_r + 9\theta^3 a_r + 9\theta^3 a_e\end{array}}{2b(b+2\theta)(8b^2+16\theta b+9\theta^2)}. \quad (10)$$

It is easy to see that equation (9) isn't equal to equation (4), equation (10) isn't equal to equation (5) either. In other words, it doesn't realize the optimized profits of the entire supply chain. So we have the following result.

Result 2. Without coordination, the wholesale price for the traditional retailer is equation (8) and the retail prices of traditional channel and Internet channel are equation (9) and equation (10) respectively in partially integrated dual channel.

When the supply chain utilizes revenue sharing contract, the profits of the partially integrated manufacturer and the traditional retailer are $\pi_{pim}^{PID} = w_{tr}d_r + (p_e - c_e)d_e + \rho p_r d_r$ and $\pi_{tr}^{PID} = ((1-\rho)p_r - w_{tr} - c_r)d_r - c_r d_f$. Similar to Cai [20], we introduce a fixed price difference scheme $p_r = p_e + \varepsilon$ and obtain the following theorem.

Theorem 1. The coordination strategy of

$$p_r = p_e + \frac{a_r - a_e + (2\theta + b)(c_r - c_e) - 2\mu\theta c_r}{2(b+2\theta)}, \quad (11)$$

and the revenue sharing contract with

$$w_{tr} = \frac{\begin{array}{c} 2\rho\theta^2 c_e - 2\rho\theta^2 c_r + \theta b c_r - \theta b c_e - 2\mu\theta^2 c_r - 5\rho\theta b c_r + \rho\theta b c_e + 2\rho\mu\theta^2 c_r - \\ \theta a_r + \theta a_e + 2\theta^2 c_r - 2\theta^2 c_e + \rho\theta a_r - \rho\theta a_e - 2\mu\theta b c_r - 2\rho b^2 c_r + 2\rho\mu\theta b c_r \end{array}}{2b(b+2\theta)}, \quad (12)$$

fully coordinates the supply chain with partially integrated dual channel.

Proof. Given equation (11) and equation (12), the optimal p_r for the partially integrated manufacturer is equation (4) and the optimal p_e for the traditional retailer is equation (5). That is to say the equilibrium prices are same to the optimal prices for the entire supply chain.

3.3 Decentralized Dual Channel

Without coordination, the profits of the manufacturer, the traditional retailer and the Internet retailer are $\pi_m^{DD} = w_{tr} d_r + w_{er} d_e$, $\pi_{tr}^{DD} = (p_r - w_{tr} - c_r) d_r - c_r d_f$ and $\pi_{er}^{DD} = (p_e - w_{er} - c_e) d_e$. Where w_{tr} and w_{er} are the wholesale prices for the traditional retailer and the Internet retailer respectively. The sequence of the game is that the manufacturer sets w_{tr} and w_{er} first and then the traditional retailer and the Internet retailer set p_r and p_e respectively at the same time. We can know that π_{tr}^{DD} is concave with respect to p_r and π_{er}^{DD} is concave with respect to p_e. In accordance with backward induction, letting the differential of π_{er}^{DD} on p_e and the differential of π_{tr}^{DD} on p_r both be zero, we obtain

$$p_r = \frac{\begin{array}{c} 4\theta b w_{tr} + \theta b c_e - 2\mu\theta^2 c_r + 2b^2 c_r + \theta b w_{er} + 4\theta b c_r + 2b^2 w_{tr} + 2ba_r \\ -2\mu\theta b c_r + 2\theta a_r + \theta a_e + 2\theta^2 c_r + 2\theta^2 w_{tr} + \theta^2 c_e + \theta^2 w_{er} \end{array}}{3\theta^2 + 8\theta b + 4b^2}, \quad (13)$$

$$p_e = \frac{\begin{array}{c} \theta a_r + 2\theta a_e + \theta b c_r + \theta^2 c_r + \theta b w_{tr} + \theta^2 w_{tr} - \mu\theta^2 c_r + 2b^2 w_{er} + \\ 4\theta b w_{er} + 2ba_e + 4\theta b c_e + 2\theta^2 c_e + 2\theta^2 w_{er} + 2b^2 c_e \end{array}}{3\theta^2 + 8\theta b + 4b^2}. \quad (14)$$

Substituting equation (13) and equation (14) into π_m^{DD} and letting the differentials of π_m^{DD} on w_{tr} and w_{er} both be zero, we obtain

$$w_{tr} = \frac{b^2 a_r - b^3 c_r - 3\theta b^2 c_r + \theta^2 a_e + \theta^2 a_r + \theta b a_e - 2\theta^2 b c_r + 2\theta b a_r + 2\mu\theta^2 b c_r + \mu\theta b^2 c_r}{2b(b+\theta)(b+2\theta)}, \quad (15)$$

$$w_{er} = \frac{b a_e + \theta a_r + \theta a_e - b^2 c_e - 2\theta b c_e}{2b(b+2\theta)}. \quad (16)$$

Substituting equation (15) and equation (16) into equation (13) and equation (14), we can get

$$p_r = \frac{\begin{array}{c}2b^4c_r + 8\theta b^3c_r + \theta b^3c_e + 6b^3a_r - 2\mu\theta b^3c_r - 6\mu\theta^2b^2c_r + 10\theta^2b^2c_r + 3\theta^2a_e + 3\theta^3a_r + \\ 3\theta^2b^2c_e + 15\theta^2ba_r + 10\theta^2ba_e + 4\theta^3bc_r - 4\mu\theta^3bc_r + 2\theta^3bc_e + 18\theta b^2a_r + 5\theta b^2a_e\end{array}}{2b(b+2\theta)(2b+\theta)(2b+3\theta)}, \quad (17)$$

$$p_e = \frac{\begin{array}{c}2b^4c_e + \theta b^3c_r + 8\theta b^3c_e + 6b^3a_e - \mu\theta^2b^2c_r + 18\theta b^2a_e + 3\theta^2b^2c_r + 5\theta b^2a_r + \\ 10\theta^2b^2c_e + 10\theta^2ba_r + 15\theta^2ba_e + 2\theta^3bc_r - 2\mu\theta^3bc_r + 4\theta^3bc_e + 3\theta^3a_r + 3\theta^3a_e\end{array}}{2b(b+2\theta)(2b+\theta)(2b+3\theta)}. \quad (18)$$

It is easy to see that equation (17) isn't equal to equation (4), equation (18) isn't equal to equation (5) either. In other words, it doesn't realize the optimized profits of the entire supply chain. So we have the following result.

Result 3. Without coordination, the wholesale price for the traditional retailer and the Internet retailer are equation (15) and equation (16) respectively and the retail prices of traditional channel and Internet channel are equation (17) and equation (18) respectively in decentralized dual channel.

When the supply chain utilizes revenue sharing contract, the profits of the manufacturer, the traditional retailer and the Internet retailer are $\pi_m^{DD} = (w_{tr} + \rho p_r)d_r + (w_{er} + \rho p_e)d_e$, $\pi_{tr}^{DD} = ((1-\rho)p_r - w_{tr} - c_r)d_r - c_r d_f$ and $\pi_{er}^{DD} = ((1-\rho)p_e - w_{er} - c_e)d_e$. We obtain the following theorem.

Theorem 2. The revenue sharing contracts with

$$w_{tr} = \frac{\begin{array}{c}\rho\theta b^2c_e - 6\rho\theta b^2c_r - 2\rho b^3c_r + 2\rho\mu\theta b^2c_r - \rho\theta ba_e - \theta b^2c_e + \mu\theta^2bc_r - 2\theta^2bc_e + \\ 2\rho\theta^2bc_e + \theta ba_e + 3\rho\mu\theta^2bc_r - 4\rho\theta^2bc_r - \rho\theta^2a_r + \theta^2a_r - \rho\theta^2a_e + \theta^2a_e\end{array}}{2b(b+\theta)(b+2\theta)}, \quad (19)$$

$$w_{er} = \frac{\begin{array}{c}2\mu\theta b^2c_r - 2\rho b^3c_e - 66\rho\theta b^2c_e - \theta b^2c_r - 2\rho\mu\theta b^2c_r + \rho\theta b^2c_r + 3\mu\theta^2bc_r - \rho\theta^2a_e + \\ 2\rho\theta^2bc_r - 4\rho\theta^2bc_e - 2\theta^2bc_r - 3\rho\mu\theta^2bc_r - \rho\theta ba_r + \theta ba_r + \theta^2a_e - \rho\theta^2a_r + \theta^2a_r\end{array}}{2b(b+\theta)(b+2\theta)}. \quad (20)$$

fully coordinates the supply chain with decentralized dual channel.

Proof. Given equation (19) and equation (20), the solution of p_r and p_e for the traditional retailer and the Internet retailer in a Nash game are equation (4) and equation (5) respectively. That is to say the equilibrium prices are same to the optimal prices for the entire supply chain.

3.4 Horizontally Integrated Dual Channel

Without coordination, the profits of the manufacturer and the horizontally integrated retailer are $\pi_m^{HID} = w_{hir}(d_r + d_e)$ and $\pi_{hir}^{HID} = (p_r - w_{hir} - c_r)d_r - c_r d_f +$

$(p_e - w_{hir} - c_e)d_e$. Where w_{hir} is the wholesale price for the horizontally integrated retailer. The sequence of the game is that the manufacturer sets w_{hir} first and then the horizontally integrated retailer set p_r and p_e. We can know that π_{hir}^{HID} is jointly concave with respect to p_r and p_e. In accordance with backward induction, letting the differentials of π_{hir}^{HID} on p_r and p_e both be zero, we obtain

$$p_r = \frac{\theta a_e + 2\theta bw + b^2 c_r + 2\theta bc_r + ba_r + b^2 w - \mu\theta bc_r + \theta a_r}{2b(b+2\theta)}, \tag{21}$$

$$p_e = \frac{2\theta bw + b^2 c_e + 2\theta bc_e + ba_e + b^2 w + \mu\theta bc_r + \theta a_e + \theta a_r}{2b(b+2\theta)}. \tag{22}$$

Substituting equation (21) and equation (22) into π_m^{HID} and letting the differential of π_m^{HID} on w_{hir} be zero, we obtain

$$w_{hir} = \frac{a_r + a_e - bc_r - bc_e}{4b}. \tag{23}$$

Substituting equation (23) into equation (21) and equation (22), we can get

$$p_r = \frac{6\theta a_e - 2\theta bc_e + 6\theta bc_r + 6\theta a_r + 3b^2 c_r + 5ba_r - b^2 c_e + ba_e - 4\mu\theta bc_r}{8b(b+2\theta)}, \tag{24}$$

$$p_e = \frac{6\theta a_e - 2\theta bc_r + 6\theta bc_e + 6\theta a_r + 3b^2 c_e + 5ba_e - b^2 c_r + ba_r + 4\mu\theta bc_r}{8b(b+2\theta)}. \tag{25}$$

It is easy to see that equation (24) isn't equal to equation (4), equation (25) isn't equal to equation (5) either. In other words, it doesn't realize the optimal profits of the entire supply chain. So we have the following result.

Result 4. Without coordination, the wholesale price for the horizontally integrated retailer is equation (23) and the retail prices of traditional channel and Internet channel are equation (24) and equation (25) respectively in horizontally integrated dual channel.

When the supply chain utilizes revenue sharing contract, the profits of the manufacturer and the horizontally integrated retailer are $\pi_m^{HID} = w_{hir}(d_r + d_e) + \rho(p_r d_r + p_e d_e)$ and $\pi_{hir}^{HID} = (1-\rho)(p_r d_r + p_e d_e) - (d_r + d_e)w_{hir} - (d_r + d_f)c_r - c_e d_e$. We obtain the following theorem.

Theorem 3. The revenue sharing contracts can't fully coordinate the supply chain with horizontally integrated dual channel.

Proof. Given w_{hir}, the solution of p_r and p_e for the horizontally integrated retailer are

$$p_r = \frac{\theta a_r - \rho\theta a_r + \theta a_e - \rho\theta a_e - \rho b a_r + 2\theta b c_r + 2\theta b w_{hir} + b^2 w_{hir} + b a_r + b^2 c_r - \mu\theta b c_r}{2b(1-\rho)(b+2\theta)}, \quad (26)$$

$$p_e = \frac{2\theta b w_{hir} - \rho b a_e + \theta a_r - \rho\theta a_r + \theta a_e - \rho\theta a_e + \mu\theta b c_r + b a_e + b^2 w_{hir} + 2\theta b c_e + b^2 c_e}{2b(1-\rho)(b+2\theta)}. \quad (27)$$

Letting equation (26) equal to equation (4) and equation (27) equal to equation (5), we can get

$$w_{hir} = \frac{-\rho c_r (b + 2\theta - \mu\theta)}{b + 2\theta}, \quad (28)$$

$$w_{hir} = \frac{-\rho(2\theta c_e + \mu\theta c_r + b c_e)}{b + 2\theta}. \quad (29)$$

Equation (28) isn't equal to equation (29). That is to say there is no w_{hir} which can make the horizontally integrated retailer set the retail prices equal to the optimal prices for the entire supply chain.

4 Conclusion

When the Internet channel has a lower retail price, free riding becomes a popular phenomenon. In this paper we classified dual channel structures into four categories according to the entity which owns the Internet channel, and analyzed the optimal prices of dual channel for the entire supply chain and pricing equilibriums in various channel structures when the channel members decide separately. The result shows that the pricing equilibriums can't realize the maximal profits of the entire supply chain. Then we studied the application of revenue sharing contract to various channel structures and obtained the following results: The revenue sharing contract can be applied in partially integrated dual channel and decentralized dual channel and fully coordinate the entire supply chain; the revenue sharing contract can't fully coordinate the entire supply chain of horizontally integrated dual channel.

Our research has important managerial insight. We show that the revenue sharing contract has different performances in different dual channel structures. If the supply chain utilized coordination strategy of revenue sharing contract before the Internet channel being introduced, it can continue utilize the same coordination strategy in partially integrated dual channel or decentralized dual channel, but it will apply itself to find another coordination strategy in horizontally integrated dual channel. How to find such a coordination strategy should be researched further. There is another kind of free riding that the consumers search for information in Internet channel and then buy the product from traditional store in dual channel circumstance. How to coordinate the supply chain when such a free riding problem exists is another interesting research issue.

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