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Optimal selling strategy in dual-channel supply chains

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Abstract: This paper focuses on the rate of consumer's preference for direct channel and the sales cost of the retail channel. By assuming that the supply chain is centralized or decentralized, we construct the mathematical models and analyze the impacts of sales cost and the rate of consumer's preference on the decisions of manufacturer and retailer. Then we offer the optimal strategies for manufacturer and retailer when they are under different situations.

Keywords: Selling Strategy, Dual-Channel Supply Chains, Rate Of Consumer's Preference

1. Introduction

Nowadays, online channel has become a critical sales channel. Hence, manufacturers and retailers also transform the sales model to appeal to the different consumption habits of consumers, also to ensure a greater advantage in the market competition.

Many literatures in dual channel supply chain address the issue how manufacturers and retailers could benefit from their own advantages, mainly concentrated on the sales price and service levels. Chen et al.(2008) examine how to make the proper decisions of the direct online sales channel together with a retail channel based on the same sales price and the different service levels of dual channel. Dumrongsiri et al.(2008) study the dual channel supply chain which exists the service and price competition, and prove that when the lower marginal cost and higher wholesale price of the retailers or the lower effectiveness of the product for the consumers, all these will increase the profits of the direct sales channel. Base on the former research, Hua et al.(2008)

consider the influence of the delivery time on the price strategy and profits of both manufactures and retailers under coordination of dual channel supply chain which based on price and delivery time. Cai et al.(2009) study the channel choice and coordination of dual channel supply chain. They compare four different channels to illustrate the pros and cons of these channels. Chun et al. (2011) analyze optimal channel strategies of a manufacturer when it considers an online store as its new direct channel and discuss some strategic implications of channel strategies from the perspective of consumer heterogeneity and the retail services. Liu et al.(2010) study the dual-channel supply chain under information asymmetry. They design two kinds of contracts to coordinate the supply chain and derive the optimal production and the optimal price of dual channel. Chen and Bell(2012) bring customer returns into the dual channel supply chain, and study how a firm that faces customer returns can enhance profit by using different customer returns policies, full-refund and no-returns, as a device to segment its market into a dual-channel structure. Chen et al.(2012) examine a manufacturer's pricing strategies in a dual-channel supply chain. They show the conditions under which the manufacturer and the retailer both prefer a dual-channel supply chain, and examine the coordination schemes for a dual-channel supply chain and find that a manufacturer's contract with a wholesale price and a price for the direct channel can coordinate the dual-channel supply chain, benefiting the retailer but not the manufacturer. Huang et al.(2012) develop a two-period pricing and production decision model in a dual-channel supply chain with demand disruption.

Unlike other studies, in this paper, we start by deriving the optimal quantities for both channels by employing the customer's utility theory, and then analyze how the prices affect the manufacturer's decisions. Besides, since the sales cost of retail channel plays an important role in dual channel supply chain, we derive the optimal strategies when the sales cost is considered.

2. Model assumptions and Notations

Q is the size of potential market; θ is the rate of consumers' preference for direct channel, $\theta\epsilon[0,1]$; c is the manufacturer's production costs;Δc is the sales cost of retail channel; p_r and p_d are the sales prices of retail channel and direct channel, respectively, $p_r > p_d$; q_r and q_d are the demands in retail channel and direct channel, respectively.

According to the literature of Ferrer et al.(2010), here we assume that consumers are willing to pay the price U for retail channel, where $U\epsilon[0, Q]$ uniformly distributed in this domain. The customer with product valuation U would derive the utility $U_r = U - p_r$ from retail channel or $U_d = \theta U - p_d$ from direct channel. If $U_d \geq 0$, consumers choose to purchase products from direct channel; similarly, if $U_r \geq 0$, consumers choose to purchase products from retail channel. In this paper, we consider the competition exists between the dual-channel. So, if $U_d > U_r$, consumers choose to purchase products from the direct channel, on the contrary, if $U_d < U_r$, consumers choose to purchase products from the retail channel. Then, we can get the following Proposition:

Proposition 1. *If* $\theta \in \left[\frac{p_d}{p_r}, 1 - \frac{p_r - p_d}{Q}\right]$, *the prices are:*

$$p_r = Q - q_r - \theta q_d \tag{1}$$

$$p_d = \theta(Q - q_r - q_d) \tag{2}$$

If $\theta < \frac{p_d}{p_r}$, all products are sold through the retail channel and the price of retail channel is $p_r = Q - q_r$;

If $1 - \frac{p_r - p_d}{Q} \leq \theta \leq 1$, all products are sold through the direct channel and the price of direct channel is $p_d = \theta(U - q_d)$.

All proofs in this paper can be offered if being requested.

3. The Centralized Model

For centralized model, we consider the manufacturer owns direct channel and retail channel, so we can get the centralized model with profit maximization:

$$\max_{q_r, q_d} \quad (p_r - c - \Delta c)q_r + (p_d - c)q_d \tag{3}$$

$$s.t. \quad q_r \geq 0, q_d \geq 0$$

Substituting (1) and (2) into (3) , we get:

$$\left(q_r^{z*}, q_d^{z*}\right) = \begin{cases} \left(\frac{Q - c - \Delta c}{2}, 0\right), & \Delta c \leq \frac{c}{\theta} - c \\ \left(\frac{Q(1-\theta) - \Delta c}{2(1-\theta)}, \frac{c\theta - c + \Delta c\theta}{2\theta(1-\theta)}\right), & \frac{c}{\theta} - c < \Delta c < Q(1-\theta) \\ \left(0, \frac{\theta Q - c}{2\theta}\right), & \Delta c \geq Q(1-\theta) \end{cases} \tag{4}$$

From the results, we can find that if the sales cost of the retail channel is less than $\frac{c}{\theta} - c$, the product is not sold by direct channel and manufacturer sells the product through the single retail channel; if $\frac{c}{\theta} - c < \Delta c < Q(1-\theta)$, manufacturer sells the product through direct channel and retail channel, and sales quantities at the retail channel and direct channel both are decreasing in θ. However $\left|\frac{\partial q_r^{z^*}}{\partial \theta}\right| < \left|\frac{\partial q_d^{z^*}}{\partial \theta}\right|$, this indicate θ has a greater impact on $q_d^{z^*}$ than on $q_r^{z^*}$; if $\Delta c \geq Q(1-\theta)$, because of the high sales cost of the retail channel, the product is not sold by retail channel and manufacturer sells the product through the single direct channel.

The optimal solutions to prices (p_r, p_r), sales quantities at the two channels $(q_r^{z^*}, q_d^{z^*})$, profits of the retail channel $\left(\prod_r^{z^*}\right)$ and the direct channel $\left(\prod_r^{z^*}\right)$ for a centralized model are summarized below in Table 1:

Table 1: Optimal strategies under centralized model

	$\Delta c \leq \frac{c}{\theta} - c$	$\frac{c}{\theta} - c < \Delta c < Q(1-\theta)$	$\Delta c \geq Q(1-\theta)$
$q_r^{z^*}$	$\frac{Q-c-\Delta c}{2}$	$\frac{Q(1-\theta)-\Delta c}{2(1-\theta)}$	0
$q_d^{z^*}$	0	$\frac{c\theta - c + \Delta c\theta}{2\theta(1-\theta)}$	$\frac{\theta Q - c}{2\theta}$
$q = q_r^{z^*} + q_d^{z^*}$	$\frac{Q-c-\Delta c}{2}$	$\frac{\theta Q - c}{2\theta}$	$\frac{\theta Q - c}{2\theta}$
p_r	$\frac{Q+c+\Delta c}{2}$	$\frac{Q}{2} + \frac{c+\Delta c}{2}$	0
p_d	0	$\frac{\theta Q + c}{2}$	$\frac{\theta Q + c}{2\theta}$
$\Pi_r^{z^*}$	$\left(\frac{Q-c-\Delta c}{2}\right)^2$	$\frac{(Q-c-\Delta c)(Q-Q\theta-\Delta c)}{4(1-\theta)}$	0
$\Pi_d^{z^*}$	0	$\frac{(c\theta - c + \theta\Delta c)(Q\theta - c)}{4\theta(1-\theta)}$	$\frac{(Q\theta - c)(Q\theta + c - 2c\theta)}{4\theta^2}$

Proposition 2. If $\frac{c}{\theta} - c < \Delta c < Q(1-\theta)$, manufacturer sells the product through direct channel and retail channel, and the optimal prices are:
$p_r = \frac{Q+c+\Delta c}{2}$ and $p_d = \frac{\theta Q + c}{2}$.

From Proposition 2, we can easily know that the price of retail channel is greater than the price of the direct channel. This is consistent with our hypothesis.

4. The Decentralized Model

4.1. Retailer's Problem

The retailer's best response to the rate of consumer's preference for direct channel θ, wholesale price w, and direct channel quantities q_d. So making retailer's profit maximization model:

$$\max_{q_r} \quad (p_r - w - \Delta c) q_r \tag{5}$$
$$s.t. \quad p_r = Q - q_r - \theta q_d$$

We obtain:

$$q_r^* = \frac{1}{2}(Q - w - \Delta c - \theta q_d) \tag{6}$$

From (6), we can get the following Proposition.

Proposition 3. The retailer's best response order is increasing in Q, decreasing in θ, w and q_d, respectively.

4.2. Manufacturer's Problem

We use Stackelberg game to analyze the manufacturer's optimal decision-making when the manufacturer is dominant. From the above response of retailer, we can derive the manufacturer's decisions. The manufacturer's profit maximization model is:

$$\max_{q_d, w} \quad (w - c) q_r^* + (p_d - c) q_d \tag{7}$$
$$s.t. \quad p_d = \theta(Q - q_r - q_d), \; p_d \geq w$$

We employ the Lagrangian methods to solve it as shown following:

$$\max_{q_d, w} \quad (w - c) q_r^* + (p_d - c) q_d + \lambda (p_d - w)$$

And the optimal solutions are:

$$\begin{cases} q_d^* = \dfrac{\theta(c + Q\theta) + 2\Delta c\theta - 2c}{2\theta(2-\theta)} \\ w^* = \dfrac{c + Q\theta}{2} \end{cases} \tag{8}$$

From (8), we know that w is increasing in θ, Q and c, respectively; q_d^* is increasing in θ, Q and Δc, respectively, but decreasing in c. Hence, the cost leadership strategy is feasible in this case.

We can get the optimal quantities of manufacturer and retailer as follows:

$$\begin{cases} q_r^* = \dfrac{Q(1-\theta)-\Delta c}{2-\theta} \\ q_d^* = \dfrac{c\theta+Q\theta^2+2\Delta c\theta-2c}{2\theta(2-\theta)} \end{cases} \tag{9}$$

From (9), we can get following Proposition:

Proposition 4. *(I)* $q_d^* \geq q_d^{z^*}$*; (II) If* $\frac{c}{\theta}-c<\Delta c<Q(1-\theta)$, $q_r^{z^*} > q_r^*$.

Proposition 5. *(I) If* $\Delta c<Q(1-\theta)$, $p_r > w^* + \Delta c$ and $p_d = w^*$*; (II) If* $\Delta c \geq Q(1-\theta)$, the retail channel will be closed.

Proposition 5 shows that $p_d = w^*$, the manufacturer has two options: First, all of its product wholesale to retailer; second, continue to conduct direct sale. But by analyzing, we can get the manufacturer's maximum profits in first case and second case are $\frac{(Q-c-\Delta c)^2}{8}$ and $\frac{(Q\theta-c)^2}{4\theta}$, respectively. Since $\frac{(Q\theta-c)^2}{4\theta} - \frac{(Q-c-\Delta c)^2}{8} > 0$. We know that manufacturer will continue to use the direct channel.

Proposition 6. If $\Delta c > \frac{c}{\theta} - c$, the manufacturer's optimal production for the centralized model equals to decentralized model; if $\Delta c \leq \frac{c}{\theta} - c$, the manufacturer's optimal production for the centralized mode is greater than the optimal production for the decentralized model.

Proposition7. Under decentralized model, the equilibrium price of retail channel is greater than the price of direct channel. The equilibrium prices are $p_d = \frac{\theta Q+c}{2}$ and $p_r = \frac{c(2-\theta)+2\Delta c(1-\theta)+Q(2-\theta^2)}{2(2-\theta)}$.

Let $\prod_r^*$ and $\prod_d^*$ be the profits of retail channel and direct channel under decentralized model, then we can summarize the optimal strategies under decentralized model in Table 2.

Table 2: Optimal strategies under decentralized model

	$\Delta c < Q(1-\theta)$	$\Delta c \geq Q(1-\theta)$
q_r^*	$\frac{Q(1-\theta)-\Delta c}{2-\theta}$	0
q_d^*	$\frac{c\theta + Q\theta^2 + 2\Delta c\theta - 2c}{2\theta(2-\theta)}$	$\frac{\theta Q - c}{2\theta}$
$q = q_r^* + q_d^*$	$\frac{\theta Q - c}{2\theta}$	$\frac{\theta Q - c}{2\theta}$
p_r	$\frac{c(2-\theta)+2\Delta c(1-\theta)+Q(2-\theta^2)}{2(2-\theta)}$	0
p_d	$\frac{\theta Q + c}{2}$	$\frac{\theta Q + c}{2\theta}$
Π_r^*	$\frac{[Q(1-\theta)-\Delta c]^2}{(2-\theta)^2}$	$\frac{(Q\theta - c)(Q\theta + c - 2c\theta)}{4\theta^2}$
Π_d^*	$\frac{(Q\theta - c)^2}{4\theta}$	0

Comparing Table 2 with Table 1, we know that if $\Delta c < Q(1-\theta)$, profit of retail channel under centralized model is more than decentralized mode; if $\Delta c \geq Q(1-\theta)$, the retailer's profit is zero for the centralized model and decentralized model; if $\Delta c \leq \frac{c}{\theta} - c$, profit of direct channel for the centralized model is lower than the decentralized model; if $\Delta c \geq Q(1-\theta)$, the direct sale profit for the centralized model is equal to the decentralized mode; if $\frac{c}{\theta} - c < \Delta c < Q(1-\theta)$, profit of direct channel for centralized model lower than the decentralized model.

5. Numerical Example

We use the following numbers as the base values of the parameters: Q=800, c=200, $\theta \epsilon (0.6,1)$, $\Delta c = 80$. Then we can get the joint effect of the rate of consumer's preference for direct channel and the sales cost of the retail channel on selling strategy, which is described as Figure 1.

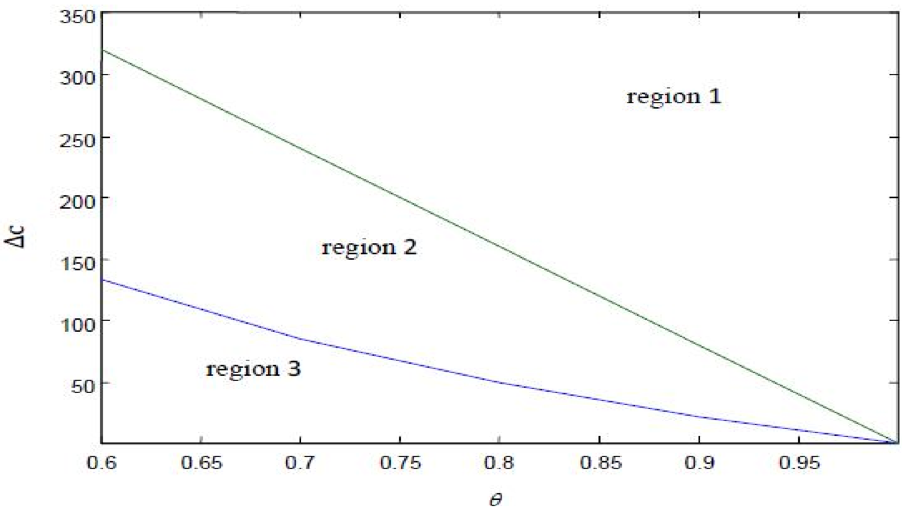

Fig. 1: The joint impact of consumer preference and sales cost on selling strategy

5.1. Centralized Model Analysis

Figure 1 shows that: (I) If $(\theta, \Delta c)$ is in region 1, the product is not sold by the retail channel, manufacturer sells the product only through the direct channel; if $(\theta, \Delta c)$ is in region 2, manufacturer sells the product through the direct channel and the retail channel simultaneously; if $(\theta, \Delta c)$ is in the region 3, the product is not sold by the direct channel, manufacturer sells the product only through the retail channel. (II) For a given θ, if the sales cost of retail channel above a certain value, the retail channel will be pushed out of the market by direct channel; if the sales cost of the retail channel below a certain value, the direct channel will be pushed out of the market by retail channel; otherwise, retail channel and direct channel will coexist. (3) If the sales cost of the retail channel more than 320, the product is not sold by retail channel, manufacturer sells the product only through the direct channel; if the sales cost of the retail channel between 0 and 320, with a certain sales cost, the direct channel will exist only when θ is higher than a certain level; also, with a certain θ, the retail channel will exist only when sales cost is below a certain level.

5.2. Decentralized Model Analysis

If $(\theta, \Delta c)$ is in region 1, the product is not sold by retail channel, the manufacturer sells the product through the single direct channel; if $(\theta, \Delta c)$ is in region 2 or region 3, the manufacturer sells the product through direct channel and the retailer sells the product through retail channel. This is different with the centralized model because the impact of Q is greater than the impact of Δc.

6. Conclusions

In this paper, we analyze optimal strategies of the centralized model and decentralized model respectively. We find the condition of the existence of direct channel and retail channel, and prove that the sales cost of the retail channel and consumer's preference rate for direct channel strongly influence the manufacturer's and retailer's decisions and profits. Our numerical shows that if the sales cost of retail channel above a certain value, the retail channel will be pushed out of the market by direct channel; if the sales cost of the retail channel below a certain value, the direct channel will be pushed out of the market by retail channel.

In this paper, just one retailer has been discussed. In the future work, we will take more retailers into account.

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