Models of Pricing and Coordination in Dual-channel Supply Chain with Business Reputation

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Abstract

In order to meet the needs of different customer, manufacturer opened online direct channel based on retail channel. In the case of co-existence of dual-channel distribution, a model is built to analyze pricing competitions between one manufacturer and one retailer under the manufacturer providing business reputation to the retailer in a dual-channel supply chain. By designing business reputation, we make retailer participate in the competition more actively in dual-channel supply chain, improved the system order quantity. Furthermore the equilibrium pricing strategies were given by the Stackelberg game theory. The final illustrated the validity of the model by a numerical example.

Keywords: supply chain management, dual-channel distribution, Stackelberg game

1. Introduction

As the increasingly maturity of Internet shopping platform and people's lifestyle changes, the rapid growth of the number of businesses that use the Internet is a prevalent phenomenon. And more and more consumers are shopping through the Internet. It can be demonstrated from the data that in China up to June 2009, the size of on-line shopping user group had grown to 878.8 million, and the entire turnover had reached 3.6 thousand billion RMB with a year-on-year growth of 22.9%. The sales volume in France is up to 24.7 billion euros, with a growth of 33% and so on. Based on this background, increasing manufacturers are opening on-line direct sales channel, sell the goods to the consumer via online direct sales and retail stores (hereinafter referred to as dual-channel). Compared to traditional retail channel, dual-channel coexistence can reach potential markets which traditional retail channel can not reach, but at the same time, the dual-channel structure also makes the manufacture and the retailer forming transverse competition. Based on the situation, we designed a business reputation (or deferred payment) to make the retailer participate in the competition more actively, and we investigated the pricing policies and coordination condition in dual-channel supply chain, consisting of one manufacturer and one retailer, and drew qualitative insights based on a numerical analysis.

Currently, study on dual-channel supply chain is becoming a research hot spot in supply chain arena. Researchers pay attention to the problem using different models from a different perspective, [5-7] from the view of the impact and role of direct sales channel, and [8] from the models' separability and optimality considers the relation and existence conditions of equilibrium policies,[9] from

the industry characteristics consider the optimized ordering strategy and cooperative conditions. In the paper [10], the retail channel and direct channel are compared. In the paper [11], [12-14] pricing and contracts coordination in dual-channel supply chain have been studied respectively.

Literatures above mostly researched on pricing coordination issue under promotional efforts of retailers or different brand loyalty in dual-channel supply chain. Research on manufacturer providing business reputation (allow retailer to delay payment) in dual-channel supply chain is still very rare. Paper [15] researched the revenue-sharing contract based on the business reputation in the traditional retail channel. There is no consideration to the dual-channel supply chain coordination.

2. Dual-channel Supply Chain Coordination Model Based on the Business Reputation

In the supply chain consisting of one supplier and one retailer, manufacturer provides retailer with business reputation, that is, the manufacture allows the retailer delay in payment. By reducing the cost of retailer funds attracts retailer to increase orders, furthermore, expand sales and avoids the retailers out of competition when direct channel exists. This is equivalent to the manufacturer provides interest-free loan to the retailer. The retailer can use these funds to obtain the appropriate return on investment. If expands sales, the manufacturer's profit will also increase. However, the funds of the manufacturer will be occupied by the retailer. Manufacturer will increase the opportunity cost correspondingly. The longer the credit period, the greater the attractiveness to retailer, manufacturer increases the cost more. We assume the product is short-life cycle. The production capacity of the manufacturer is large enough.

Similar to the paper [11], we follow the price-sensitive demand function in dual-channel supply chain. d_e , d_t respectively donate direct channel and traditional retail channel demand

$$d_e = (a_e - bp_e) + v(p_t - p_e) \quad (1)$$

$$d_t = (a_t - bp_t) + v(p_e - p_t) \quad (2)$$

Where a_i denotes the demand of market benchmarks in channel i ,($i = e$ denotes the direct channel, $i = t$ denotes the traditional channel） , p_t denotes the retail price, p_e denotes the direct price, b denotes price elasticity of demand ($b > 0$), v denotes the degree of proliferation, which describes diffusion degree caused by the price differences of channels.

In the dual-channel supply chain, the profits of manufacturer and retailer are

$$\pi_m = (p_e - c)d_e + (w - c - ci_m t)d_t \quad (3)$$

$$\pi_r = (p_t - w + p_t i_r t)d_t \quad (4)$$

If the supply chain is a system which the manufacturer is the leader, and the retailer is the follower, then the manufacturer and the retailer construct a Stackelberg game model. Given the manufacturer's decision variable (w, p_e) , retailer develops appropriate decision (p_t, d_t) . So the equilibrium solutions are followings.

$$\begin{aligned} p_e^* &= a_t v(4 + 5i_r t)\phi + bcv(8 + 7i_r t)\phi \\ &+ a_t i_r^2 t^2 v\phi - (b + v)ci_m i_r t^2 v\phi \\ &+ (4a_e b + 4a_e v + 4b^2 c)(1 + i_r t)\phi \end{aligned} \quad (5)$$

$$
\begin{aligned}
w^* &= 4a_t b^2\ (1+i_r t)\mu + 4b^3 c(1+i_m t)\mu \\
&+ a_t v^2\ (4+3i_r t)\mu + 2\ b^2 cv(6+i_r t)\mu \\
&+ 2a_e i_r t v^2\ (b+1)\mu + 8a_t bv\mu + 8\ bcv^2\mu \\
&+ 4a_e v(b+v)\mu - ci_m i_r t^2 v^2\ (b+v)\mu
\end{aligned} \tag{6}
$$

$$
\begin{aligned}
p_t^* &= 3\ b^2 ctv(i_r + 2i_m)\varphi/(b+v) \\
&+ \left(6a_t b^2\ + 4a_t v^2\ + 12a_t bv\right)(1+i_r t)\varphi/(b+v) \\
&+ \left(4a_e v + 8\ bcv + 3a_e i_r tv - ci_m i_r t^2 v^2\ \right)\varphi \\
&+ bctv^2\ (4i_m + 5i_r)\varphi/(b+v) \\
&+ 2b^3 c(1+i_m t)\varphi/(b+v)
\end{aligned} \tag{7}
$$

$$
\begin{aligned}
d_t^* &= 2a_t b^2\ (1+i_r t)\varphi - \ bci_m tv(6b+4v)\varphi \\
&- 2b^3 c(1+i_m t)\varphi + \left(b^2 cv + 4a_t bv\text{-}4b^2\ cv\right)i_r t\varphi \\
&+ \left(a_e v^2\ + a_t v^2\ + a_e bv + 2bcv^2\ \right)i_r t\varphi
\end{aligned} \tag{8}
$$

Where

$$
\varphi = 1/\left(8b^2(1+i_r t) + 16bv(1+i_r t) - i_r{}^2 t^2 v^{22}\right)
$$

$$
\mu = \varphi(1+i_r t)/(b+v)
$$

From Equation (5-8), there are the equilibrium profits of manufacturer and retailer in decentralized decision-making π_m^*, π_r^*; and by $\pi_s^* = \pi_m^* + \pi_r^*$,we can get the equilibrium profit of the supply chain system π_s^* in decentralized decision-making.

If the supply chain is vertically integrates system, the total system profit is

$$
\pi = (p_e - c)d_e + (p_t + p_t i_r t - c - ci_m t)d_t \tag{9}
$$

From the first-order condition, we can see the optimal parameters in centralized decision-making system are followings.

$$
\begin{aligned}
p_{se}{}^* &= a_t v(2+3i_r t)\phi + bcv(4+3i_r t)\phi \\
&+ a_t i_r{}^2 t^2 v\phi - (b+v)ci_m i_r t^2 v\phi \\
&+ \left(2a_e v + 2a_e b + 2b^2 c\right)(1+i_r t)\phi
\end{aligned} \tag{10}
$$

$$
\begin{aligned}
p_{st}{}^* &= (2a_t b + 2a_t v)(1+i_r t)\phi \\
&+ \left(2b^2 c + 4bcv\right)(1+i_m t)\phi \\
&+ \left[a_e v(2+i_r t) + bci_r tv - ci_m i_r t^2 v^2\ \right]\phi
\end{aligned} \tag{11}
$$

Where

$$
\phi = 1/\left(4b^2(1+i_r t) + 8bv(1+i_r t) - i_r{}^2 t^2 v^{22}\right)
$$

Then the optimal profit of the supply chain system π^* is

$$
\begin{aligned}
\pi^* &= (i_m - i_r)v^2\phi\left[(a_e + a_t)ci_r t^2 - 2bc^2 i_m t^2\right] \\
&+ \left(4a_t bci_m t - a_e{}^2\right)(1+i_r t)v\phi \\
&+ a_t bci_r t(3-i_r t)v\phi - (a_t + a_t i_r t)^2\ v\phi \\
&+ b^2 c^2 i_m t^2 v(i_r - 3i_m)\phi - b^3 c^2\phi\left[(1+i_m t)^2 + i_r t\right] \\
&+ a_e bci_r tv(5+i_m t)\phi - a_t{}^2 b(1+i_r t)^2\ \phi \\
&+ 4(a_e + a_t)bcv\phi - a_e a_t i_r tv(3+i_r t)\phi \\
&+ 4b^2 c^2(1+i_m t)v\phi + \left(2b^2 c^2 i_r t + 2a_e a_t\right)v\phi \\
&+ \left(2a_t b^2 ci_m t + 2a_t b^2 c - a_e{}^2 b + 2a_e b^2 c\right)(1+i_r t)\phi
\end{aligned} \tag{12}
$$

3. The Condition of Nodes Coordination in Dual-channel Supply Chain under Business Reputation

In traditional environmental, supply chain coordination often avoid 'double marginalization' through adjusting the profits conflict between the upstream and downstream nodes enterprises. This paper coordinates the supply chain by adjusting pricing. As $\pi_s^* > \pi_m^* + \pi_r^*$, we can see that the total profit of the supply chain system in centralized decision-making is greater than that of in decentralized decision-making, therefore, making the optimal

profit under the decentralized decision-making equal to the optimal profit under the centralized decision-making, must meet the optimal pricing policy equal. That is $p_{se}^{*} = p_{e}^{*}$ and $p_{st}^{*} = p_{t}^{*}$. Simultaneous equations (5)、(10) and (7)、(11). When the condition

$$\begin{aligned}&\left(2b^2a_t + 4bva_t\right)\left(1+i_r t\right) + a_e\left(i_r t v^2 + b i_r t v\right)\\&-b^3c\left(1+i_m t\right) - b^2cv\left(4+6i_m t - i_r t\right)\\&+2bctv^2\left(i_r - 2i_m\right) + a_t i_r t v^2 = 0\end{aligned}$$

is satisfied, the pricing equation is true. That is the dual-channel system can achieve pricing coordination and avoid the 'double marginalization'.

4. Numerical Example

In this section our objective is to draw qualitative insights based on a numerical analysis of our model in a dual-channel supply chain, when business reputation exists. We illustrate our results with the help of a selected numerical example. The parameters are $b = 7$, $v = 2$, $c = 5$, $i_s = 10\%$, $i_r = 50\%$, $a_e = 400$, $a_t = 339$. When the credit cycle is different value in the interval $[1,12]$, we can obtain the relation graphs between credit cycle and other parameters.

Figure 1 and Figure 2 represent the effect of credit cycle on order quantity and equilibrium price, where the unit of credit cycle is month. As the credit cycle increases, both the direct price and wholesale price at equilibrium go up, and order quantity at equilibrium increase as well, but the retail price at equilibrium decreases.

Therefore, an increase in the retailer's credit cycle allows the retailer to decrease the retail price under the premise of expanding profit. At the same time, although the manufacture increases the wholesale price, the retailer still increases order quantity.

Another interesting observation from Figure 2 is that as the credit cycle increases, the wholesale price at equilibrium increases. Thus the wholesale price at equilibrium increasing leads to the direct channel sales volume reducing. So the manufacture's profit increases must root in the retailer order quantity increasing. That is the profit root in the retailer order quantity at equilibrium increases at a faster rate than the manufacturer loss in the direct price increases. Thus, it is indeed possible for the manufacturer to focus on increasing its credit cycle in order to be more profitable.

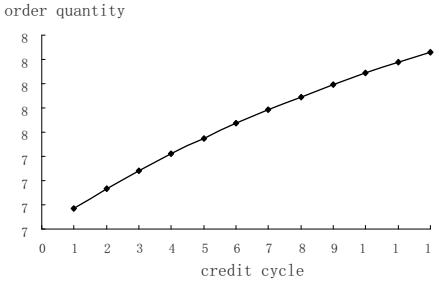

Fig. 1: The relation between credit cycle and order quantity.

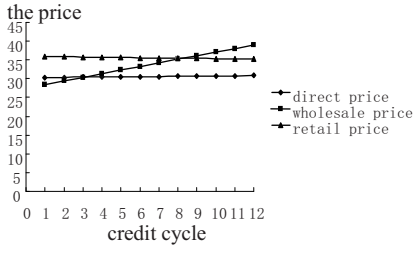

Fig. 2: The relation between credit cycle and sale price.

Figure 3 represents the relationship between wholesale price w and order quantity d_t. When the wholesale price changes in a certain range, the order quantity remains unchanged. For example, when

$w \in [27.2, 27.8]$, order quantity remains at 68.5 units. As the wholesale price increases, order quantity also increases until it reaches the point of maximum demand, after that no matter whether the wholesale price increases or decreases, order quantity is maintained at the same point of maximum demand.

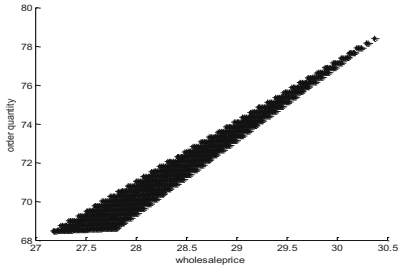

Fig. 3: The relation between wholesale price and order quantity.

5. Conclusions

Based on business reputation, we consider the optimal pricing strategies in dual-channel supply chain both in decentralized and centralized decision-making. Under the assumption of price-sensitive demand functions, we coordinate the supply chain by adjusting price. This work expands the study of traditional supply chain coordination based on business reputation. And our model differs from prior studies in the following areas: First of all, most of the studies about the business reputation or deferred payment have focused on traditional retail channel, but we consider the pricing policies of the supply chain in dual-channel environment. Another the research in dual-channel supply chain often gave a parameter (such as promotional efforts), instead, this paper establishes multiple parameters such as capital employed rate of manufacturer and return in investment rate of retailer, credit period and other parameters. It was closer to the actual analysis, coordinating the supply chain and ensure that the win-win situation of the channel members.

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