

Research on the Retailer-leading Supply Chain Markdown Money Contract

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Abstract: In the retailer-leading supply chain, wholesale price contract model and markdown money contract model were built, and decision-making behaviors of the members of supply chain were compared under the above two contracts. Research results showed that both wholesale price contract and markdown money contract could not coordinate the supply chain, and efficiency of wholesale price contract was superior to markdown money contract in the retailer-leading supply chain, retailer would choose wholesale price contract. Finally, theoretical conclusion was verified by numerical simulation.

Keywords: Wholesale price contract; Markdown money contract; Supply chain

1. Introduction

With the rapid development of the global economy, the market demand has transferred from seller market to buyer market, and the enterprises pay more and more attention to the demand characteristics and personalized demand of consumer. The connection between retailer and consumer is strong and direct, and the retailer could get more information about the market or the changes of consumer demand, the advantage of retailer had made its status change from subordinate position to leading and active position in the supply chain structure. So it is meaningful to study the retailer-leading supply chain.

More and more researchers devoted their research interests on the supply chain contract in recent years. Cachon (2003) detailed supply chain contract for the first time and discussed advantages and disadvantages about different contracts[1]. Tsay (2001) compared and analyzed wholesale price contract and markdown money contract in condition of stochastic market demand, his research obtained that markdown money contract could coordinate supply chain when wholesale price contract could not coordinate[2]. Hou and Zhou (2006) discussed markdown money contract in condition of three-stage supply chain and expanded markdown money contract model[3]. Hua and Li (2008) discussed how stochastic market demand affected advantages of retailer and analyzed coordination problem between supplier and retailer[4]. This paper first discussed the wholesale price contract and the markdown money contract in retailer-leading supply chain, then the comparison of these two contracts were conducted.

2. Description of Problem and Illustration of Symbol

The research object of this paper is a simple two-stage supply chain, market demand is stochastic and decision-making behaviors of supplier and retailer are analyzed using the rules of Stackelberg Game. In the supply chain structure, the leader is retailer and the follower is supplier, and wholesale price announced by supplier is affected by the largest potential market order announced by retailer[4], above relationship can be expressed as $Q = Q_0 - bw$, b donates the sensitivity of retailer's order to supplier's wholesale price and is a constant, Q_0 is the largest potential market order announced by retailer. Because retailer is the leader, the sequence of game is ruled that retailer announces firstly largest potential market order according to market information and then supplier decides his wholesale price according to largest potential market order, finally, retailer decides his optimal order quantity according to wholesale price. At the end of sales period, price which supplier compensates retailer for left goods is expressed as r , residual value for left goods is expressed v , selling price is p , production cost is c , market demand is expressed as x , probability density function for x is expressed as $f(x)$, and demand distribution function for x is expressed as $F(x)$, expected sales and expected quantity of left goods is defined as

$$S(Q) = E \min(x, Q) = Q - \int_0^Q F(x) dx$$

$$I(Q) = Q - S(Q) = \int_0^Q F(x) dx$$

In this research, the information is assumed to be completely symmetrical, and supplier and retailer are risk

neutral and completely rational, which means that both supplier and retailer will pursue their maximum profits.

3. Establishing and Analyzing Model

3.1. Centralized decision-making mode

Members of supply chain achieve the real coordination under centralized decision-making mode, and supply chain obtains the maximum expected profit, so whether other contracts achieve the supply chain coordination or not is based on centralized decision-making mode. The parameter expression of centralized decision-making mode is first given, and the expected profit function of supply chain is expressed as

$$\Pi_r = pS(Q) + vI(Q) - cQ \quad (1)$$

Equation(1) is a concave function about Q , equation (1) does first-order derivative about Q and is equal to 0, then optimal order quantity of centralized decision-making mode is expressed as

$$F(Q^*) = (p - c) / (p - v) \quad (2)$$

3.2. Wholesale price contract mode

Expected profit functions of supplier and retailer in condition of wholesale price contract are expressed respectively as

$$\Pi_m = (w - c)Q \quad (3)$$

$$\Pi_r = pS(Q) + vI(Q) - wQ \quad (4)$$

Π_m = expected profit function of supplier, Π_r = expected profit function of retailer. In condition of wholesale price contract, wholesale price of supplier is firstly confirmed according to largest potential market order announced by retailer, equation (3) does first-order derivative and second-order derivative about w .

$$\frac{\partial \Pi_m}{\partial w} = Q_0 - 2bw + cb, \quad \frac{\partial^2 \Pi_m}{\partial w^2} = -2b < 0$$

Π_m is a concave function about w , so optimal wholesale price is expressed as

$$w^{\#} = c + (Q_0 - bw^{\#}) / b = c + Q_0 / b \quad (5)$$

After wholesale price is calculated, retailer begins to decide optimal order quantity. w in (4) can be replaced by (5), then (4) does first-order derivative and second-order derivative about Q_0 .

$$\frac{\partial \Pi_r}{\partial Q_0} = \frac{p - (p - v)F(Q) - c}{2} - \frac{Q}{b}$$

$$\frac{\partial^2 \Pi_r}{\partial Q_0^2} = -\frac{p - v}{4} f(Q) - \frac{1}{2b} < 0$$

Π_r is a concave function about Q_0 , so optimal order quantity is expressed as

$$F(Q^{\#}) = \frac{p - c}{p - v} - \frac{2Q^{\#}}{(p - v)b} \quad (6)$$

In summary, equation (5) and (6) express optimal wholesale price and optimal order quantity respectively, Q in (3) is $Q^{\#}$ in (6), and $Q^{\#} < Q^*$ can be obtained after comparing and analyzing (2) and (6), which means that wholesale price contract could not coordinate the supply chain.

3.3. Markdown money contract mode

At the end of sales period, price which supplier compensates retailer for left goods in condition of markdown money contract is expressed as r , so expected profit functions of supplier and retailer are expressed respectively as

$$\Pi_m^{\wedge} = (w - c)Q - rI(Q) \quad (7)$$

$$\Pi_r^{\wedge} = pS(Q) + (v + r)I(Q) - wQ \quad (8)$$

Π_m^{\wedge} = expected profit function of supplier, Π_r^{\wedge} = expected profit function of retailer. In condition of markdown money contract, the sequence of game of markdown money contract is same as wholesale price contract, so wholesale price of supplier is firstly confirmed, equation (7) does first-order derivative and second-order derivative about w .

$$\frac{\partial \Pi_m^{\wedge}}{\partial w} = Q_0 - 2bw + bc + r b F(Q)$$

$$\frac{\partial^2 \Pi_m^{\wedge}}{\partial w^2} = -2b - r b^2 f(Q) < 0$$

Π_m^{\wedge} is a concave function about w , so optimal wholesale price in condition of markdown money contract is expressed as

$$w^{\wedge} = c + rF(Q) + Q / b \quad (9)$$

After wholesale price is calculated, retailer begins to decide optimal order quantity. w in (7) can be replaced by (9), then (7) does first-order derivative and second-order derivative about Q_0 .

$$\frac{\partial \Pi_r^{\wedge}}{\partial Q_0} = p - c - rQf(Q) - (p - v)F(Q) - 2Q / b$$

$$\frac{\partial^2 \Pi_r^{\wedge}}{\partial Q_0^2} = -(p + r - v)f(Q) - rQf'(Q) - 2 / b < 0$$

Π_r^{\wedge} is a concave function about Q_0 , so optimal order quantity is expressed as

$$F(Q^{\wedge}) = \frac{p - c}{p - v} - \frac{r f(Q^{\wedge}) Q^{\wedge} + 2Q^{\wedge} / b}{p - v} \quad (10)$$

In summary, equation (9) and (10) express respectively optimal wholesale price and optimal order quantity, Q in (9) is $Q^{\#}$ in (10), and $Q^{\wedge} < Q^*$ can be obtained after

comparing and analyzing (2) and (10), which means that markdown money contract could not coordinate the supply chain. $Q^{\wedge} < Q^{\#}$ can be easily obtained after comparing and analyzing (6) and (10), which means that optimal order quantity of markdown money contract is less than that of wholesale price contract, and then it can also be known that total expected profit of markdown money contract is less than that of wholesale price contract, so in the retailer-leading supply chain, efficiency of wholesale price contract is superior to markdown money contract, although both wholesale price contract and markdown money contract could not coordinate the supply chain, retailer would choose wholesale price contract as his basic supply chain contract.

4. Numerical Simulation

Assuming required parameters is given,
 $p = 8, c = 3, v = 1, r = 2, b = 20, x$ is subordinated to uniform distribution which has section $[0, 200]$, so $f(x)$ is $1/200, F(x)$ is $x/200$.

4.1. Centralized decision-making mode

$Q^* = 142.857$ can be obtained according to (2) in condition of centralized decision-making mode, so total expected profit of supply chain is 357.143.

4.2. Wholesale price contract mode

$w^{\#} = 4.852$ can be obtained according to (5) and $Q^{\#} = 37.037$ can be obtained according to (6), so expected profit of supplier is 68.593, expected profit of retailer is 92.587, total expected profit of supply chain is 161.18.

4.3. Markdown money contract mode

$w^{\wedge} = 5.067$ can be obtained according to (9) and $Q^{\wedge} = 34.48$ can be obtained according to (10), so expected profit of supplier is 65.33, expected profit of retailer is 86.28, total expected profit of supply chain is 151.61.

In summary, both optimal order quantity of wholesale price contract and markdown money contract are less than that of centralized decision-making mode, which means that both wholesale price contract and markdown money contract could not coordinate the supply chain. It can be found that optimal order quantity of markdown money contract is less than that of wholesale price contract, which means that efficiency of wholesale price contract is superior to markdown money contract according to numerical conclusion, it can also found that both total expected profit of wholesale price contract and markdown money contract are less than that of centralized decision-making mode.

5. Conclusions

In the retailer-leading supply chain, both wholesale price contract and markdown money contract could not coordinate the supply chain, and analytic results show that if retailer selects a supply chain contract as his basic contract, retailer would choose wholesale price contract.

References

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