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Research on the Pricing Strategy of Manufacturer's Dual Channel under the Closed-loop Supply Chain

Liang Xiaohao
College of Economics and Management, China JiLiang University,
Hangzhou, China
E-mail:lxh464008424@qq.com

Huang Zuqing
College of Economics and Management, China JiLiang University,
Hangzhou, China
E-mail:hzq1210@163.com

Abstract—This article focuses on the product pricing of manufacturer's dual channel under the closed-loop supply chain, which consists a single manufacturer and retailer. In this paper, we assume that the manufacturer is the market leader, and it sales the products through online and offline channels in the same time. All supply chain member's products prices are determined by recycling level and re-manufacturing capacity. Furthermore, we have calculated the best pricing strategy of products under the leadership of manufacturer for the market.

Keywords-closed-loop supply chain; double channel; pricing strategy; Internet commerce; game theory

I. Introduction

With the rapid development of Internet and information technology, a large amount of manufactures and retailers begin to sale the products to consumers in the network directly. According to the latest data of Singles' Day. Alibaba retailer, a Chinese e-commerce, has achieved the total gross merchandise volume (GMV) to a stunning $17.8 billion in 2016 up almost one quarter compared with 2015. Therefore, the way of traditional selling has been broken, the dual channel supply chain is also formed.

II. Literature References

The research on dual channel supply chain theory can be divided into the following categories:

A. Research on dual channel structure and options of optimization policies.

Kumar et al.(2006)[1]studied the impact of channel requirements is determined by the pricing and the level of service provided by retailers. Kabadayi et al.(2008)[2]studied the problem whether to open direct channel and non-direct channel selection.

B. Research on the pricing strategy under dual-channel supply chain.

Tapiero et al.(2005)[3] took into account the acceptability of consumers to different channels, and analyzed the dynamic pricing problem under dual channel supply chain.

In recent years, scholars have extended this research into the closed-loop supply chain. Cao Xiaogang et al.(2015)[4]considered the pricing and coordination decision under the background of dual-channel closed-loop supply chain.

C. Research on the coordination of dual-channel supply chain.

Yue et al.(2005)[5]used the information to coordinate the profits of dual channel supply chain. Boyaci et al.(2005)[6]assumed the manufacturers and retailers have equal status,

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and analyzed the coordination problems under the dual channel supply chain.

Obviously, the above of three aspects of research are not under closed-loop supply chain. This paper will study the pricing strategy of the manufacturer dual channel under the closed-loop supply chain.

III. Model Assumptions and Notation

According to Savaskan et al.(2004)[7]The closed-loop supply chain with the highest efficiency is responsible for the recovery of the retailer. So we rely on this conclusion and use the following notation throughout the paper: c_n is the unit cost of manufacturing a new product, c_r is the unit cost of re-manufacturing a returned product into a new one, Δ denote the cost saving. w denote the unit wholesale price of a new product. p_e^m denote the unit direct selling price of manufacturer. p_r is the unit retail price of products. δ denote retailers' recycling efficiency. q_r denote the market demand under the traditional offline channel. q_e^m denote the market demand of the product online channel. γ is the recycled product's proportion. s denote un-remanufacturing residual parts. The primary goal of this paper is to understand the pricing strategy. Hence, we consider the following scenario and make the following model assumptions.

Assumption 1. Manufacturing new products by using a used products are less costly than manufacturing a new one. Returned products from the consumer to the retailer are less costly than returned product from the retailer to the manufacturer. In order to ensure manufacturers can make profits from recycling manufacturing process in the closed-loop supply chain, we assumed: $\Delta \geq B \geq b \geq 0$ ($\Delta = c_n - c_r$).

Assumption 2. The total cost of the retailer's recovery consists of fixed cost and variable cost , the expression: $C(\delta) = f(\delta) + b\delta(q_e^m + q_r)$, $f(\delta) = c_0\delta^2$ denote retailer’s fixed investment under the recycle products process. c_0 denote the scale parameter.

Assumption 3. Based on the assumptions of article [8].There is no difference between new product and re-manufactured product. Therefore, two products are identical in wholesale and retail prices.

Assumption 4. The market’s demand function is linear, the form of traditional retailers network offline sales channels and manufacturer direct sales channel to the corresponding demand function can be expressed:

$$q_r = \varphi - \frac{p_r - p_e^m}{1-\theta} \qquad q_e^m = \frac{\theta p_r - p_e^m}{\theta(1-\theta)}$$

θ denote the extent of consumer preference for network channels. φ denote potential market demand.

Assumption 5. Retailers recycle the waste products at unit price b .Manufacturers repurchase waste products from retailers for re-manufacturing, it’s unit price is B .

The market demand for products will be met by new products and re-manufactured goods.

IV. Pricing Strategy Model With Manufacturing Dual-Channel (Model MS)

A .Pricing strategy

The section presents only manufacture new products in two stages (Model M, Figure 1(a)), the closed-loop supply chain with the retailer collecting used products and manufacturer use the direct channel(Model MS, Figure 1(b)) ,we will show the figure below. Under closed-loop supply chain, manufacturers and retailers in the model MS are designed to maximize their own profits. In manufacturer dominant of Stacklberg game situations. Hence, the manufacturer and retailer optimizes:

$$\max_{w,p_e^m} \pi_m^{MS} = (w - c_n + \Delta\delta\gamma)q_r + (p_e^m - c_n + \Delta\delta\gamma)q_e^m - B\delta(q_r + q_e^m) + S[\delta(1-\gamma)(q_r + q_e^m)]$$

(1)

$$s.t. \max_{p,\delta} \pi_r^{MS} = (p_r - w)q_r + (B-b)[\delta(q_r + q_e^m)] - c_0\delta^2$$

(2)

When the manufacturer dominates market ,according to the backward induction method ,we can calculate the Hesse matrix 1:

$$\frac{\partial \pi_r^{MS}}{\partial {p_r}^2} = -\frac{2}{1-\theta} < 0$$

According to the Hesse matrix 1，we know that the objective function is jointly concave in and the retailer's first-order conditions characterize the unique best response, we could calculate the formula primarily:

$$p_r = \frac{1}{2}[(1-\theta)\ \ \varphi + w + p_e^m]$$

(3)

The same as above, we can calculate the Hesse matrix 2:

$$H_2 = \begin{bmatrix} \frac{\partial \pi_m^{MS}}{\partial w^2} & \frac{\partial \pi_m^{MS}}{\partial w \partial p_e^m} \\ \frac{\partial \pi_m^{MS}}{\partial p_e^m \partial w} & \frac{\partial \pi_m^{MS}}{\partial {p_e^m}^2} \end{bmatrix} = \begin{bmatrix} -\frac{1}{1-\theta} & \frac{1}{1-\theta} \\ \frac{1}{1-\theta} & \frac{\theta-2}{\theta(1-\theta)} \end{bmatrix}$$

According to the Hesse matrix 2 , we can calculate the unique best response:

$$w^* = \frac{1}{2}\{\varphi + c_n + [B - \Delta\gamma - S(1-\gamma)]\delta\}$$

(4)

$$p_e^{m^*} = \frac{1}{2}\{\theta\varphi + c_n + [B - \Delta\gamma - S(1-\gamma)]\delta\}$$

(5)

Then we can calculate the retailer's first-order conditions characterize the unique best response:

$$p_r^* = \frac{1}{4}[(3-\theta)\varphi + 2c_n + 2(B - \Delta\gamma - S(1-\gamma))\delta]$$

(6)

B. Profit functions

Through the optimal sale price and Wholesale price, we can calculate the profits about manufacturer and retailer：

$$\pi_r^{MS} = \frac{(B-b)(\theta\varphi - c_n)\delta - [(B-b)(B - \Delta\gamma - S(1-\gamma) + 2\theta c_0)]\delta^2}{2\theta} + \frac{(1-\theta)}{16}\varphi^2$$

(7)

$$\pi_m^{MS} = \frac{[\theta\varphi - c_n + \delta(\Delta\gamma + S(1-\gamma) - B)]^2}{4\theta} + \frac{(1-\theta)\varphi^2}{8}$$

(8)

V. Analysis and results

Based on the calculate results, some observations can be made.

*Proposition1.*The best wholesale prices under traditional channels are unaffected by the extent preference of consumers. While the best selling price of the manufacturer's online channel increased by the level of consumer preference. The traditional retailer selling price have declined as it has increased. We can prove this proposition: according to formula(5) , w^* have no correlation with θ:

$$\frac{\partial p_e^{m^*}}{\partial \theta} = \frac{1}{2}\varphi > 0\ ,\ \frac{\partial p_r^*}{\partial \theta} = -\frac{\varphi}{4} < 0\ .$$

Proposition1 suggests that retailers are more passive in traditional wholesale prices, as retailers are constrained by manufacturers' direct sale channels. The consumer's preference for the online channel also directly affects the pricing of the members of the supply chain.

*Proposition2.*When manufacturers are dominant in the market, the wholesale price of the manufacturer's products, the price of online direct selling and the traditional retail price of the retailer are reduced by the recovery of products. We can prove this proposition:

$$\frac{\partial p_e^{m^*}}{\partial \delta} = \frac{\partial p_r^*}{\partial \delta} = \frac{\partial w^*}{\partial \delta} = \frac{B - \Delta\gamma - S(1-\gamma)}{2} < 0$$

$$\frac{\partial w^*}{\partial \gamma} = \frac{\partial p_e^{m^*}}{\partial \gamma} = \frac{\partial p_r^*}{\partial \gamma} = \frac{(S-\Delta)\delta}{2} < 0$$

Proposition2 suggests that when manufacturers increase their production success rates, the wholesale prices of manufacturer, direct online prices and retailers' traditional retail prices will decrease.

*Proposition3.*When manufacturers are dominant in the market, the wholesale price of the product, direct selling price and retail price of the retailer's traditional selling price are decreasing by the manufacturer re-produces cost savings increased. We can prove this proposition:

$$\frac{\partial w^*}{\partial \Delta}=\frac{\partial p_e^{m^*}}{\partial \Delta}=\frac{\partial p_r^*}{\partial \Delta}=-\frac{\gamma}{2}<0$$

$$\frac{\partial \pi_m^{MS}}{\partial \Delta}=\frac{\delta\gamma}{2\theta}>0;\ \frac{\partial \pi_r^{MS}}{\partial \Delta}=\frac{(B-b)\delta^2\gamma}{2\theta}\geq 0.$$

Proposition3 suggests that the waste product's re-manufacturing is beneficial to all members in the closed-loop supply chain, and the increasing of unit re-manufacturing cost savings, the wholesale price of the products and manufacturing chamber of commerce network channel sales prices are reducing, then the traditional retail prices lower.

VI. CONCLUSION

In this article, we focus on the product prices of the re-manufacturing closed-loop supply chain model under the manufacture dominant the market. This article assumed that consumers have different preference for the online and offline shopping.

The research results show that the optimal wholesale prices under traditional channel are not determined by the preferences of consumers' network channel. And the best selling price of the manufacturer's network channel are increasingly as the level of consumer network channel preferences improved.

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FIGURES

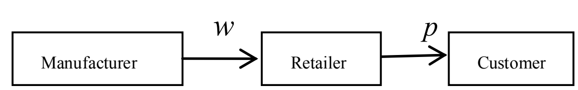

Figure 1(a)

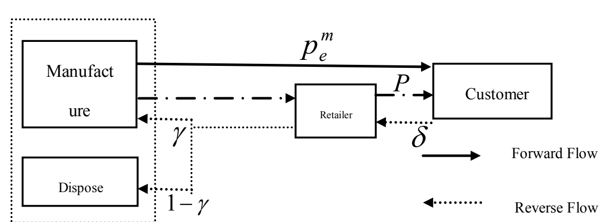

Figure 1(b)