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Effect of Return Policy on the Circulation of Remanufactured Products in the Market

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Abstract: *With the increasing number of products produced in the market, the supply of recycled products has become more and more concerned by people. People have a preference for the pricing aspect of recycled products, but there is still some psychological barrier towards them. In fact, the quality of recycled products is comparable to that of new products. This article studies the equilibrium problem of return policies for new and remanufactured products, so that resources can be used more rationally and the profits of all parties in the supply chain can be maximized.*

Keywords: *Return policy, Remanufactured products, Supply chain, Recovery, Profit maximization, Balanced*

1. Introduction

As the number of remanufactured products increases in the market, more and more consumers have a deeper understanding of remanufactured products. Because remanufactured products have lower prices and better performance. But consumers generally desire new products more strongly than remanufactured products. By adjusting the differences in the corresponding return policies, the balance between recent product sales and remanufactured product sales throughout the supply chain is achieved to maximize the profits of supply chain members.[3] The more generous the return policy, the lower the earnings of supply chain members; Conversely, a worse return policy may affect consumers' desire to buy, resulting in fewer sales[1-3].

The remainder of this article is organized as follows: Section 2 proposes the symbols, assumptions, and model settings; Section 3 calculates the corresponding return policy for maximizing profit; Section 4 provides the analysis; Section 5 summarizes our research and presents the key management implications for business managers.

2. Model settings

We consider a supply chain that includes a new product supplier(N), a remanufactured product supplier(S), a retailer and consumers[4].

According to microeconomic theory, we define the market size as a and the product price as P. The demand function is shown below.

$$q_i = a - p_i + p_j \tag{1}$$

The return policy for new products is better than that of remanufactured products. We assume that the difference between the return policies for new and remanufactured products is represented by r, and the threshold value for the effect of prices on similar products is represented by b.

$$q_N = a - p_N + bp_S + r;\ \ q_S = a + bp_N - p_S - r \tag{2}$$

The manufacturing cost of new products is higher than the cost of remanufactured products due to the costs of recycling and refurbishing. We assume that the difference between the costs of new and remanufactured products is represented by c. We can assume that the total cost of remanufactured products is 0, and the cost of new products is c. The wholesale price of new products is represented by ω_N, and the wholesale price of remanufactured products is represented by ω_S. The profit of each member of the supply chain is represented by π.

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$$\pi_O = (p_N - \omega_N)q_N + (p_S - \omega_S)q_S \quad (3)$$

$$\pi_N = (\omega_N - c)q_N \quad (4)$$

$$\pi_S = \omega_S q_S \quad (5)$$

3. Calculate

Given the wholesale prices of both products, retailer O solves the following problem to maximize its profit:

$$\max_{p_N}(p_N - \omega_N)(a - p_N + bp_S + r) + (p_S - \omega_S)(a + bp_N - p_S - r)$$

$$\max_{p_S}(p_N - \omega_N)(a - p_N + bp_S + r) + (p_S - \omega_S)(a + bp_N - p_S - r)$$

which yields

$$p_N = \frac{a + ab + r - br + \omega_N - b^2\omega_N}{2(1 - b^2)}$$

$$p_S = \frac{a + ab - r + br + \omega_S - b^2\omega_S}{2(1 - b^2)}$$

Bring it into the parallel solution of the profit function of supplier N and supplier S:

$$\frac{\partial \pi_N}{\partial \omega_N} = 0$$

$$\frac{\partial \pi_S}{\partial \omega_S} = 0$$

we have the optimal wholesale price:

$$\omega_N = \frac{2a + ab + 2c + 2r - br}{4 - b^2}$$

$$\omega_S = \frac{2a + ab + bc - 2r + br}{4 - b^2}$$

Substituting it back, we derive the optimums:

$$p_N = \frac{(b-2)(b-1)(3+2b)r - (1+b)[a(-6+b+2b^2) + 2(-1+b)c]}{2(4 - 5b^2 + b^4)}$$

$$p_S = -\frac{6r + (1+b)[a(-6+b+2b^2) + (-1+b)bc + b(-5+2b)r]}{2(4 - 5b^2 + b^4)}$$

Based on this, we can calculate the total profit of the supply chain:

$$\pi = -\frac{3a^2}{2(-2+b)^2(-1+b)} + \frac{a^2 b}{(-2+b)^2(-1+b)} - \frac{3ac}{2(-2+b)^2} + \frac{abc}{(-2+b)^2} + \frac{3c^2}{(-2+b)^2(2+b)^2} - \frac{9b^2c^2}{4(-2+b)^2(2+b)^2} + \frac{b^4c^2}{2(-2+b)^2(2+b)^2} - \frac{3cr}{2(2+b)^2} - \frac{bcr}{(2+b)^2} + \frac{3r^2}{2(1+b)(2+b)^2} + \frac{br^2}{(1+b)(2+b)^2}$$

To maximize the total profit of the supply chain, we can obtain:

$$r = \frac{1}{2}(1+b)c$$

Due to different return policies, the retail prices and wholesale prices of new and remanufactured products may vary. However, our research always focuses on maximizing profits under this parameter. When the return policy follows the given values, the overall profit of the supply chain reaches its maximum[5-6].

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4. Analysis

Because retailers face consumers directly, their profit maximization is considered first. We also need to consider better feedback to consumers, so in section three of the calculation, we found the maximum retail price. Secondly, we consider the maximization of the supplier's profit while ensuring the retailer's profit, and we derive the pricing for the wholesale and retail prices as mentioned above. By displaying the results, we found that when the difference in return policy r is larger, the wholesale price for new products from suppliers is higher, while the wholesale price for remanufactured products is lower.

5. Conclusion

We should consider the highest profit of the entire supply chain. Our results are helpful to product retailers, suppliers selling remanufactured parts, and suppliers selling new products. This indicates that decision-makers can allocate resources more reasonably to ensure their profits while maintaining production capacity. All parties can profit, and can also give customers more preferential treatment to promote products better. In addition, our research content can further save resources, make the use of natural resources purer, improve resource utilization, and protect our ecological environment.

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