OPTIMAL PRICING AND TRADE-IN REBATE STRATEGY FOR REMANUFACTURABLE/REUSABLE DURABLE GOODS

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Abstract: Firms can increase their profitability by remanufacturing. On the other hand, trade-in rebates can be seen as a marketing tool for promoting early replacements. A dynamic model is developed in order to determine the optimal pricing and trade-in rebate decisions for a profit maximizing firm selling durable goods which can be remanufactured. The market is divided into two segments as first time buyers and replacement customers. The customer's purchase decisions are modeled using a utility function while considering product and market characteristics as well.

Keywords: *Remanufacturing, Pricing, Marketing, Trade-In, Reverse Logistics*

1. Introduction

In recoverable product environments, products are reused, remanufactured or recycled rather than being discarded. Increased recovery of products aims at closing current material flows into loops, and thus reducing the requirements for virgin materials, energy consumption, and landfill space. More recently, real examples like the remanufacturing of mobile phones have pointed out the profitability of recovery activities and its value-creation rather than environmental aspects (Guide and Wassenhove, 2001)

At this point, the most important issue for a firm that aims to recover assets is how to effectively and efficiently get the products from where they are not wanted to where they can be processed, reused, and salvaged. The return flow of products that are induced by trade-in rebates can serve as a significant source of revenue for the firm. A special discount offered to the customers who want to upgrade to a new, higher quality product , provided that they return their existing product, is referred as a trade-in rebate. If customers can be persuaded to return their products before the end of their useful life, firms might be able to generate some revenue either by remanufacturing these products or at least disassembling the returned product and reusing some products. Examples of trade-in rebates can be found in a wide variety of products ranging from mature goods such as cars, power tools, furniture, refrigerators, televisions, photocopiers, to moderately innovative products like computers and even for many sophisticated data services equipment. In this study the brand-new durable goods with low rate of technological obsolescence are considered.

The combination of new and remanufactured products creates a unique product portfolio in the sense that the remanufactured products exists only due to previous sales of the new product.(Debo, Toktay and Wassenhove, 2003) .Thus, in this study the focus is on both type of customers: first-time buyers for the product, and replacement customers who already own the product, but are willing to replace it with a new one. Price is the major factor that affects the buying decision of a durable product for a first-time customer. On the other hand replacement customers are influenced by the price of the new product as well as perceived residual value of the existing product (Okada, 2001). While designing the optimal pricing strategy, manufacturers have to take into account the price sensitivity of the customers and the residual value of the currently owned product which is related the durability of the product. The revenues generated from the collected used products and the age distribution of the currently owned products are other important issues that should be considered.

By offering trade-in rebates the company increases the frequency of purchase through price discrimination (Ackere and Reyniers ,1995). The increase in earlier replacement will depend not only on the trade-in price, but also on the age distribution of the currently owned products since this would affect the customers reaction to the trade-in opportunity. Besides these, the magnitude of additional revenues generated through trade-in rebates is also tightly coupled with the age of the returned products since newer products lend themselves to more opportunity for remanufacturing or component reuse (Klausner and Hendrickson, 2000).

In this paper, we study the optimal pricing and trade-in rebate decisions for a profit-maximizing firm selling durable remanufacturable products. All the issues considered above highlights the complicated nature of the problem. A dynamic pricing policy is considered and the prices are determined periodically. This dynamic setting enables to investigate the impact of price and trade-in decisions in each period on the future revenues, age distribution of the currently owned products .The study also addresses how key product and marketing characteristics such as durability, remanufacturability, quality, mental cost and customer price sensitivity influence the optimal price and the trade-in rebate in each period .

2. Model Development and Analysis

The firm serves two customer segments: first-time buyers segment of size M_N and another replacement segment of size M_R . The first segment will be referred as new customers and they are charged a regular price denoted as p_N. The second segment is strictly replacement customers and they are charged by a discounted price p_R. so, the trade-in rebate for these customers is (p_N - p_R).

The customers in the replacement market will take into account both the price and the remaining value of product in use. This value is assumed to be directly proportional to the remaining lifetime (t_m- t) of the product, where t_m denotes the maximum length of use and t denotes the age of the product.

We model the customer's purchase decisions using utility functions. Each customer has an inherent willingness to buy the product called reservation utility U_o and it is represented by a uniform distribution in the interval [0,a] where a denotes the maximum actual utility provided by the product. The actual utility of a product for a new customer is

$$a\text{-}bp_{N.,} \tag{1}$$

where b is the measure of the price-sensitivity of the customer. On the other hand, the actual utility of a replacement customer having a product of age t and charged price p_R is

$$a\text{-}k(t_m\text{- }t)\text{-}bp_{R.,} \tag{2}$$

The term $k(t_m\text{-}t)$ can be viewed as the mental cost of retiring the product and k is a measure of the durability of the product. Both type of customers will make a purchase provided that their reservation utility is less than their actual utility.

In order to complete our model, we need to incorporate the operational benefits that accrue to the firm as a result of product returns from customers. as mentioned before remanufacturing a product is cheaper than purchasing a new one or manufacturing it. The revenue associated with a product return is precisely these savings, which will decrease with the age of return. Handling cost associated with collecting, inspecting, remanufacturing (if any) and transporting operations is denoted as c and c_h is the production cost. We model the net revenue $R(t)$ from a return of age t as a decreasing function with $R(0)= c\text{-}c_h >0.$

The objective of the firm is to maximize its total expected profit which can be represented as the sum of the profits from two customer segments. In order to evaluate the objective function, revised simplex search procedure is implemented. As an initial step for this study, we model a profit-maximizing firm which offers a two period trade-in campaign. At the first period there are only new customers which means that there are no currently owned products and there is no available age distribution. The customers who have purchased a product in the first period are potential replacement customers for the second period.

3. Results

First, it is clear that a replacement customer will require a lower price corresponding to a new customer to make him/her buy a new product. Furthermore, the newer the product he/she owns, the less will be the price he/she is willing to pay.

Our results indicate that a firm that has a higher potential for generating revenues from returned products would provide a higher trade-in rebate and would induce more replacements. Since our preliminary model considers only new customers in the first period, we have not studied the affect of the product age distribution and return revenue structure on the pricing strategy in detail yet. Studies will continue in this area.

There are number of product and market characteristics other than the product age distribution and return revenue structure. More specifically, we have investigated the impact of maximum inherent utility a, the customer price sensitivity bas well as the durability measures k and t_m.

The impact of price sensitivity b is exactly what we expected. As customers become more price sensitive, the optimal replacement price decreases. Similarly, higher the maximum utility of a purchase, more is the likelihood of replacement for any customer, so the optimal trade-in price increases. In both cases p_N also changes with a and b. But, it is clear that the optimal trade-in rebate (p_N-p_R). is decreasing in customer price sensitivity b and increasing in maximum utility a.

Durability measures k, and t_m have different impacts on the optimal strategy. As the durability increases, the probability of replacement decreases, and the firm needs to offer a deeper rebate to induce customers to replace their existing products. However, if the product durability further increases, it becomes more difficult for the firm to acquire products for every marginal rebate offered. As a result, beyond a certain point, it does not pay off for the firm to offer higher rebates.

4. Conclusions and Further Research Opportunities

In this paper we developed and analyzed a pricing framework for durable goods not addressed before in the literature. Our model will help managers to determine optimal pricing and trade-in rebate strategy. It is proved that the structure of optimal policy depends critically on the durability of the product and if the product returns generate more revenues for the firm, then it is optimal for the firm to offer larger rebates. The analysis of the impact of marketing and product characteristics sheds further light on the key drivers of the firm's optimal strategy.

There is a number of possible extensions of our model. First of all, the effect of product life cycles and the age distribution of the currently owned products on the pricing/trade-in rebate strategy can be considered in detail. Another extension is to take into account not only the age of the product but also its version while generating revenue function. Finally experiments can be carried out for more than two periods to view the change in the age distribution of the product.

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