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THE OPTIMAL LAUNCH SCHEDULE FOR TWO NEW CANNIBALISTIC DURABLES: A DIFFUSION THEORY APPROACH

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This study presents the optimal timing framework for the seller who is going to launch two cannibalistic durables and commits the information of the products before he launches them. We find that the seller should adopt an appropriate introduction strategy in considering the unit profitabilities of his products. The product that is more profitable per unit should be launch first, and the less profitable in unit the other product is, the later the seller should launch it. Besides, cannibalization has shown to be of no concern for the introduction sequence of the products, but there is a positive relation between the cannibalization possibility and the launch timing of the product released later. The scale of the seller's announcement and the attitude of customers in information acquisition will also influence the launching schedule.

Keywords: Cannibalization, diffusion theory, time to market.

1. Introduction

Market leaders have always adopted the price skimming strategy in launching their new products to durable goods markets. The price skimming strategy allows sellers to earn a higher profit by extracting extra consumer surplus from customers. There is an extensive literature on this subject (see e.g., Besanko and Winston, 1990). As technology improves and the competition in the market becomes more turbulent, the life cycles of new products as well as the time interval between successive generations is getting shorter (Norton and Bass, 1987). Prospective sellers should plan introductions for a product line consisting of several products to the market simultaneously.

Regarding planning a product line introduction, it is not wise for the

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seller to ignore the cannibalization between his products as the seller's revenue will decrease when cannibalization become more serious. In addition to adjusting the relative positioning of his product line, the seller always adopts non-simultaneous product introduction to reduce his profit loss caused by the cannibalization. There are many examples that can be found in the consumer electronics market. For instances, Ericssion launched its cellular phone SH888 in June 1998, and five months later they released their model S868 which is similar to SH888 with no infrared transmission. The sequential product introduction strategy alleviates cannibalization by forcing the potential customers of the product that is not available to wait till it has been released, and the seller gains extra profits by that. In high-involvement purchase behavior, it is an important factor for customers in making their purchase decisions that to buy a product earlier is to enjoy it earlier. The seller may take advantage of this factor to convert the customer's product choice to favor his own revenue. Moreover, if the seller does not commit an exact launching schedule of the products, some customers will turn to purchase the product that is already available in the market, even if they perceive the unreleased product as giving a higher customer surplus. Then the cannibalization is alleviated. However, there is a disadvantage in the sequential introduction strategy. The seller's profit from his later released product will be postponed. The seller has to trade off between the alleviation of the cannibalization and the postponement of profit in adopting a sequential introduction.

This study presents the optimal introduction-timing framework for the seller who intends to launch two cannibalistic durables. The new product diffusion theory (Bass, 1969) is used to describe how the new product information that the seller announces before he launches them penetrates to the customers. As the customer acquires the information, he perceives the consumer surplus of both products. According to the consumer surpluses of both products, we classify customers into four-types, and establish a mathematical model from the discussion of the product choices of the customers in each type for the profit maximization seller. Via the sensitivity analysis of the relation between the optima of the model and some environmental factors, we provide important features of how to launch two cannibalistic durables for the seller. Our results show that (1) The unit profitabilities of the products determine the introduction strategy of the seller. (2) The seller should launch the product with a higher unit profit first. (3) Sequential introduction alleviates product cannibalization. (4) The higher the possibility of cannibalization, the later the seller launches his lower unit profit product. (5) The attitude of the customers in information acquisition as well as the scale of the seller's announcement of the product information will influence the launch schedule of the products.

2. Topic and Assumptions

Consider a seller who plans to launch two new durables, g_1 and g_2, at the prices of p_1 and p_2 respectively. Both the products are equipped with some common attributes so they are substitutable. However, they are differentiated by other attributes. The seller announces information on the products that consists of the prices and the features of both products to the market at the initial time 0 to give customers a hint that the products are going to be available soon. But he does not commit the exact launch timing of the products intentionally for the purpose of alluring some customers to give up waiting for the product that has not yet been released. The seller's planning horizon $[0, T]$, where T is defined as a future time that the seller estimates that the market situation remains stable before then. That is, during the time horizon, the customer's demand is stationary and known, and the unit costs of product are c_1 and c_2 respectively.

On the demand side, there are rational customers. Every customer has an equal chance to acquire the product information at any time in the seller's planning horizon. Once a customer has got the information, he makes the purchase decision based on the balance between his demand for the product and the value he perceives in the product, and the decision will alter only slightly in $[0, T]$. The customer buys a product only if he needs it and the product satisfies his demand as well. That is, we neglect the influences of other promotions, such as channels or places, on the customer's purchasing decision to focus on our topic. Since the seller's goods are durable as well as substitutable, there is no repetitive purchase: the customer will leave the market forever after he purchases one unit of the product. Under the above circumstances, the seller wants to maximize his discounted revenue of his products in $[0, T]$ by determining the launch timing for them.

As the seller announces the features and the prices of the products at time 0, the product information begins to diffuse through the market. Customers, such as opinion leaders, will acquire the product information first, and then they will communicate it to other customers by word of mouth effect. On the other hand, customers will spread the reputation of the product once they bought it. Both ways contribute to the diffusion of product information to other potential buyers. In order to describe the diffusion of the new product information, we define N as the number of customers who are loyal to the seller's brand and demand the product through the seller's planning horizon. Let $n(t)$ denote the cumulative ratio of the customers who are aware of the product information by time t with respect to N, and $n'(t)$ is the rate of change of $n(t)$ at time t,

$$n'(t) = (a_1 + a_2 n(t))(1 - n(t)), \quad n(0) = 0 \tag{1}$$

where a_1 and a_2 are positive constants, a_1 is called the coefficient of innovation and a_2 is called the coefficient of imitation. The solution of (1) is

$$\begin{cases} n(t) = \dfrac{1 - e^{-\beta t}}{1 + \alpha e^{-\beta t}} \\ n'(t) = (\dfrac{\beta^2}{a_1})\dfrac{e^{-\beta t}}{[1 + \alpha e^{-\beta t}]^2} \end{cases}, \text{ where } \alpha = \frac{a_2}{a_1},\ \beta = a_1 + a_2 \qquad (2)$$

See Norton and Bass (1987).

3. The Product Choice of Rational Customers

As a customer receives the information on the products, he evaluates the products simultaneously and generates a pair of the reservation prices (v_1, v_2) for both products jointly. We define the reservation price, v_i, of g_i for a customer as the highest price that the customer can afford and is willing to pay for g_i, where $i = 1, 2$. Generally speaking, when the customer gets a positive consumer surplus from a product, he will buy it. The customer will purchase g_i if both the following constraints hold (see Moorthy and Png, 1992).

(1) The market entrance constraint: $v_i - p_i > 0,\ i = 1$ or 2.

(2) The self-selection constraint: $v_i - p_i > v_j - p_j,\ i, j = 1, 2$, and $i \neq j$.

Unfortunately, the customer who gets the product information at the period of time that there is only one of the products available in the market while the other product has not been launched yet cannot adopt the constraints in his purchase decision-making. The customer learns the features and prices of both products, and he knows which product is worthier to buy. If the released product is the worthier product with respect to him, the customer can achieve his best choice by purchasing it immediately. What if the worthier product with respect to the customer has not been released when he gets the information? He may wait to purchase the product that is worthier in his judgment until it has been launched, or he may purchase the product that is already available but is less worthy to satisfy his demand earlier. We are going to discuss the possible choices for different customers who get the information at this moment by classifying all customers into four types, as shown in Figure 1. We assume the seller's introduction strategy is to launch one of his product, which is denoted as g_1, at time 0 and to launch the other product, which is denoted as g_2, at time x, where $x \in [0, T]$. Note that all introduction strategies for the seller can be handled by our assumption. Suppose a customer generates (v_1, v_2) for both products as he gets the product information at time t, where $t \in [0, T]$.

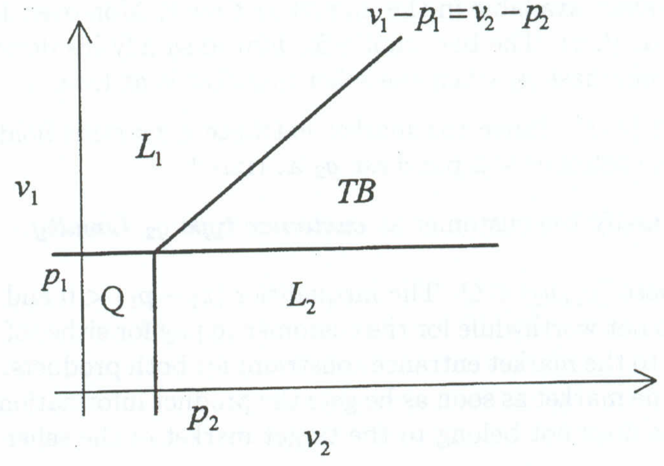

Figure 1. Different types of customers

(i) Suppose $(v_1, v_2) \in L_1$. The inequalities $(v_1 - p_1) \geq 0$ and $(v_1 - p_1) > (v_2 - p_2)$ stand, which means the market entrance constraint of g_1 holds and the consumer surplus of g_1 is greater than that of g_2 with respect to him. According to the self-selection constraint, the customer will purchase g_1 at time t. We classify the customer as ***customer type*** g_1 ***Loyalty***.

(ii) Suppose $(v_1, v_2) \in TB$. The inequalities $(v_1 - p_1) \geq 0$, $(v_2 - p_2) \geq 0$, and $(v_1 - p_1) < (v_2 - p_2)$ stand, which means the market entrance constraint holds for both products. Either one of the products is worthwhile for the customer to buy, and g_2 is worthier to him for he perceives a higher consumer surplus from purchasing it. Suppose

- ***(a)*** $t \in [0, x)$. The customer gets a higher customer surplus from purchasing g_2, purchasing g_2 is the best choice for him. But it cannot be achieved for there is nowhere to buy g_2 in $[t, x)$. As the seller did not announce the launch time of g_2, we assume that a customer will rather buy g_1 than wait for g_2 when both products are eligible for market entrance and only g_1 is available.

- ***(b)*** $t \in [x, T]$. Both g_1 and g_2 are already available in the market at time t. According to the self-selection constraint, the customer will purchase g_2 at time t.

We classify the customer as ***customer type Turn-Between***.

(iii) Suppose $(v_1, v_2) \in L_2$. The inequalities $(v_2 - p_2) > 0$ and $0 > (v_1 - p_1)$ stand, which means the market entrance constraint holds for g_2 but fails for g_1. Suppose

(a) $t \in [0, x)$. It is not worth for him to purchase g_1 that is the only product available in the market at time t. Moreover, he cannot buy g_2 at $[t, x)$. The best choice for him to satisfy his demand is to wait to purchase g_2 when the seller launches it at time x.

(b) $t \in [x, T]$. Since the market entrance constraint holds for g_2 only, the customer will purchase g_2 at time t.

We classify the customer as ***customer type*** g_2 ***Loyalty***.

(iv) Suppose $(v_1, v_2) \in Q$. The inequalities $(v_1 - p_1) < 0$ and $(v_2 - p_2) < 0$ stand. It is not worthwhile for the customer to pay for either of the products. According to the market entrance constraint for both products, the customer will leave the market as soon as he gets the product information. A customer of this type does not belong to the target market of the seller.

Examining the product choice of each type customer, we find the customer of Turn-Between type is the overlapped potential market of g_1 as well as g_2. They are the customers that cause cannibalization, and the possibility of cannibalization may be risen by a higher proportion of Turn-Between customers with respect to the total potential market of the product line.

4. The Optimal Introduction Timing of the Seller

We have shown that the sequential introduction forces some Turn-Between customers change their mind to purchase g_1, the strategy alleviates product cannibalization efficiently. On the other hand, the seller has to wait for his profit from g_2 when he launches g_2 later. The seller should balance the loss from cannibalization against the postponement of g_2 profit to maximize the total revenue of his product line; the key point of his balance is x, the launch time of g_2.

The following model is built to realize the optimal introduction timing of the products, that is, to find out the reasons why the seller should launch g_1 instead of g_2 first and when g_2 should be launched.

4.1. The model and the optimal

Let $f(v_1, v_2)$ be the joint probability density function of the customer's valuation about g_1 and g_2, where $0 \leq v_1,\ v_2 < \infty$. We denote e^{-rt} as the seller's discount factor on the postponement of his profit, where r represents the seller's patience to wait till time t for the profit. For any given x, both the potential markets of g_1 and g_2 are listed as follows:

$N_1(t,x) =$ The number of customers who decide to purchase g_1 as soon as they learn the information at a unit time of t.

$$= \begin{cases} N \cdot n'(t) \cdot \iint_{L_1 \cup TB} f(v_1, v_2) dv_2 dv_1 & 0 \le t < x \\ N \cdot n'(t) \cdot \iint_{L_1} f(v_1, v_2) dv_2 dv_1 & x \le t \le T \end{cases}$$

$N_2(t,x) =$ The number of customers who decide to purchase g_2 at time $\begin{cases} x \\ t \end{cases}$ as they learn the information at a unit time of t, where $\begin{cases} 0 \le t < x \\ x \le t \le T \end{cases}$

$$= \begin{cases} N \cdot n'(t) \cdot \iint_{L_2} f(v_1, v_2) dv_2 dv_1 & 0 \le t < x \\ N \cdot n'(t) \cdot \iint_{TB \cup L_2} f(v_1, v_2) dv_2 dv_1 & x \le t \le T \end{cases}$$

$$\begin{aligned} L_1 &= \{(v_1, v_2) | p_1 \le v_1 < \infty,\ 0 \le v_2 < v_1 - p_1 + p_2\} \\ \text{where } TB &= \{(v_1, v_2) | p_1 \le v_1 < v_2 - p_2 + p_1,\ p_2 \le v_2 < \infty\} \\ L_2 &= \{(v_1, v_2) | 0 \le v_1 < p_1,\ p_2 \le v_2 < \infty\} \end{aligned}$$

The mathematical model is established for the seller to maximize the expected discount revenue of his product line in $[0,T]$. For simplicity, we use the notation $\iint_A f$ to replace $\iint_A f(v_1,v_2)dA$ hereafter.

$$\begin{aligned} \max_{0 \le x \le T} J(x) = N \cdot \{ & \int_0^x [e^{-rt} \pi_1 n'(t) \iint_{L_1 \cup TB} f] dt + \int_x^T [e^{-rt} \pi_1 n'(t) \iint_{L_1} f] dt \\ & + e^{-rx} \int_0^x [\pi_2 n'(t) \iint_{L_2} f] dt + \int_x^T [e^{-rt} \pi_2 n'(t) \iint_{L_2 \cup TB} f] dt \} \end{aligned} \quad (3)$$

where π_i denotes the unit profit of g_i. That is,

$$\pi_i = p_i - c_i, \quad i = 1, 2 \quad (4)$$

4.2. Which product launched first?

The optimal of (3), denoted as x^*, does not exist for $J(x)$ is a continuous function over $[0,T]$. The derivative of (3) with respect to x is

$$J'(x) = N \cdot [(\pi_1 - \pi_2) e^{-rx} n'(x) \iint_{TB} f - \pi_2 r e^{-rx} n(x) \iint_{L_2} f] \quad (5)$$

Examining (5) we find if $\pi_1 \leq \pi_2$, then $J'(x) < 0$, $\forall x \in [0, T]$, which implies $x^* = 0$. The result means if g_1 is less profitable per unit when compared with g_2, the seller has to launch both g_1 and g_2 at time 0 simultaneously to maximize his discount revenue. In this case, the simultaneous introduction is not the best but the only strategy for the seller. However, if the seller launches the higher unit profit product first, he may adopt a proper introduction strategy due to the change in the market; the seller's introduction strategy will become more flexible.

Consider the strategy adopted by most sellers: launching the high-end model before the low-end model. It has been taken for granted that the seller should launch his high-end model first to alleviate cannibalization (Moorthy and Png, 1992). In our opinion, there is no evidence to show that cannibalization will convert the launching sequence of the products: the high-end model is released first because of its higher unit profit. Generally speaking, the higher added value of the high-end model will contribute a higher unit profit to the seller. On the other hand, the seller may launch his low-end model first when it contributes a higher unit profit. So it is not the quality difference but the unit profit difference which dominates the introduction sequence of two cannibalistic durables (compared with Dhebar, 1994).

Under the premise that the seller launches the higher unit profit product first ($\pi_1 > \pi_2$), we discuss the problem that when the other product should be launched.

4.3. When to launch the lower profit per unit product?

First of all, we propose the principle of the unit profit to illustrate the relation between the unit profits and the introduction timing for the products.

Principle of the unit profit: *The greater the difference between the unit profit of g_1 and that g_2 is, the later the seller launches g_2.*

Proof: We define $J'(0) = \lim_{t \to 0^+} \frac{J(t) - J(0)}{t}$ and $J'(T) = \lim_{t \to T^-} \frac{J(t) - J(T)}{t - T}$.

First, $J'(0) > 0$ only if $\pi_1 > \pi_2$ for

$$J'(0) = N(\pi_1 - \pi_2)n'(0) \iint_{TB} f = N(\pi_1 - \pi_2)\frac{\beta^2}{a_1} \iint_{TB} f$$

Second, $\frac{n'(x)}{n(x)}$ is a strictly decreasing function in $[0, T]$ for

$$\frac{d}{dx}\frac{n'(x)}{n(x)} = -(1+\alpha)\beta \frac{\beta e^{\beta x} + \alpha\beta e^{-\beta x}}{(e^{\beta x} - \alpha e^{-\beta x} + \alpha - 1)^2} < 0, \quad \forall x \in [0, T] \qquad (6)$$

Using the above conditions, we discuss the following cases:

Case 1. $J'(0) > 0$ and $J'(T) < 0$. Since $\dfrac{n'(x)}{n(x)}$ is a strictly decreasing function in $[0, T]$, there exists one and only one x^* in $(0, T)$ which satisfies

$$\frac{n'(x^*)}{n(x^*)} = \frac{\pi_2 r \iint_{L_2} f}{(\pi_1 - \pi_2) \iint_{TB} f} \tag{7}$$

That is,

$$\begin{cases} J'(0) > 0 \\ J'(T) < 0 \end{cases} \Leftrightarrow 1 < \frac{\pi_1}{\pi_2} \leq r \cdot \left[\frac{\iint_{L_2} f}{\iint_{TB} f}\right] \cdot \frac{n(T)}{n'(T)} + 1 \Rightarrow x^* \in (0, T) \tag{8}$$

Case 2. $J'(T) \geq 0$. It implies that $J'(x) \geq 0$, $\forall x \in [0, T]$, so $x^* = T$. By the same argument as the discussion in Case 1, we get a similar result:

$$J'(T) \geq 0 \Leftrightarrow \frac{\pi_1}{\pi_2} > r \cdot \left[\frac{\iint_{L_2} f}{\iint_{TB} f}\right] \cdot \frac{n(T)}{n'(T)} + 1 \Rightarrow x^* = T \tag{9}$$

Together with the cases, we find that x^* increases with the ratio of π_1 with respect to π_2. That is what we stated in the principle of the unit profit.

From the *principle of the unit profit*, we conclude that the seller should adopt the simultaneous introduction when the unit profit of g_1 is no more than that of g_2 ($\pi_1 \leq \pi_2$). On the other hand, if the ratio of the unit profit of g_1 to that of g_2 is so great as to satisfy (9), the seller should avoid launching g_2 before T, he can maximize his revenue by selling g_1 in the planning horizon only. The relative positioning of g_2 with respect to g_1 makes the unit profit of g_2 so small that the seller would rather ignore it when compared with that of g_1. If the seller wants to introduce g_2 in his planning horizon for other considerations (e.g., market share), he might re-position g_2 by adjusting the ratio of π_l to π_2 to match (8), then x^* is the unique solution to satisfy (7). The relations between those environmental parameters and x^* will be illustrated by the sensibility analysis among the parameters in (7). Figure 2 shows the curve of (7).

4.4. Sensitivity analysis

The interaction between cannibalization and x^*. We proposed that cannibalization could be alleviated as the sellers adopt a sequential introduction. On the other hand, the higher the possibility of cannibalization, the later the seller should launch g_2. First, the possibility of cannibalization rises and $\frac{\iint_{L_2} f}{\iint_{TB} f}$ falls as the population of Turn-Between increases. Second, we can easily find that x^* varies inversely with $\frac{\iint_{L_2} f}{\iint_{TB} f}$. Both reasons imply that the launch time of g_2 varies with the possibility of the cannibalization, which is what we stated. (Compare with Mazumdar *et al.*, 1996).

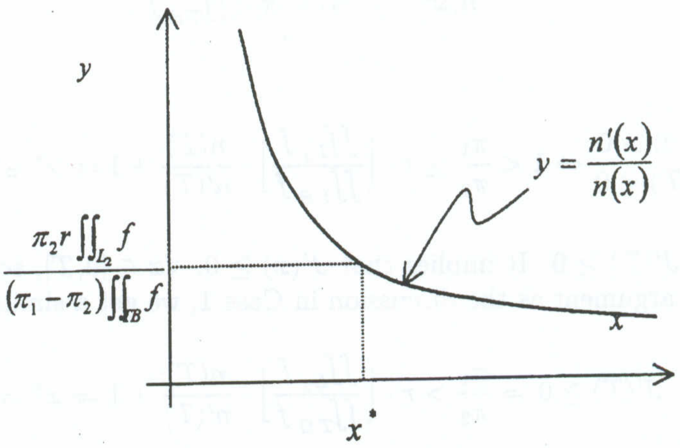

Figure 2. The relation between the optimal and other environmental factors

The influence on x^* as the price sensibility of the customer varies. Based on the price sensibility of the different type of customers with respect to p_1 and p_2, the seller may also adjust x^* to maximize his product line profit. Since $\frac{n'(x)}{n(x)}$ is a strictly decreasing function in $[0, T]$, the logarithm of (7) is

$$\ln \frac{n'(x^*)}{n(x^*)} = \ln \pi_2 + \ln r + \ln \iint_{L_2} f - \ln \iint_{TB} f - \ln(\pi_1 - \pi_2) \tag{10}$$

The derivative of (10) with respect to p_1 is

$$\frac{\partial}{\partial p_1} \ln \frac{n'(x^*)}{n(x^*)} = \frac{\frac{\partial}{\partial p_1} \iint_{L_2} f}{\iint_{L_2} f} - \frac{\frac{\partial}{\partial p_1} \iint_{TB} f}{\iint_{TB} f} - \frac{1}{\pi_1 - \pi_2}$$

Therefore

$$\frac{\partial}{\partial p_1} \frac{n'(x^*)}{n(x^*)} > 0 \Leftrightarrow \frac{\frac{\partial}{\partial p_1} \iint_{L_2} f}{\iint_{L_2} f} - \frac{\frac{\partial}{\partial p_1} \iint_{TB} f}{\iint_{TB} f} > \frac{1}{\pi_1 - \pi_2} \tag{11}$$

The meaning of (11) is if the difference between the proportionate rate of change of the number of the customers of g_2 Loyalty and that of the number of the Turn-Between customers is greater than $1/(\pi_1 - \pi_2)$ as p_1 changes one unit, then x^* varies inversely with p_1. That is, if the customers of g_2 Loyalty are more sensitive to the change of p_1 when compared to the Turn-Between customers to this specific extent, the higher p_1 is, the earlier the seller launches g_2. If the difference between the p_1 sensibility of the former and that of the latter is not significant, g_2 should be launched later for a higher p_1.

Examining the derivative of (10) with respect to p_2 leads to

$$\frac{\partial}{\partial p_2}\frac{n'(x^*)}{n(x^*)} < 0 \Leftrightarrow \frac{\frac{\partial}{\partial p_2}\iint_{TB} f}{\iint_{TB} f} - \frac{\frac{\partial}{\partial p_2}\iint_{L_2} f}{\iint_{L_2} f} > \frac{\pi_1}{\pi_2}\cdot\frac{1}{\pi_1 - \pi_2} \tag{12}$$

The meaning of (12) is if the difference between the proportionate rate of change of the number of the Turn-Between customers and that of the number of the customers of g_2 Loyalty is greater than $\frac{\pi_1}{\pi_2}\cdot\frac{1}{\pi_1 - \pi_2}$ ad p_2 changes one unit, then x^* varies with p_2. That is, if the Turn-Between customers are more sensitive to the change of p_2 when compared with the customers of g_2 Loyalty to the specific extent, the higher p_2 is, the later the seller launches g_2. If the difference between the p_2 sensibility of the former and that of the latter is not significant, g_2 should be launched later for a lower p_2.

The influence on x^* as c_i varies. Consider the respective derivatives of the RHS of (7) with respect to c_i, we get

$$\frac{\partial}{\partial c_1}\frac{\pi_2 r\iint_{L_2} f}{(\pi_1 - \pi_2)\iint_{TB} f} = \frac{\pi_2 r\iint_{L_2} f}{(\pi_1 - \pi_2)^2\iint_{TB} f} > 0$$

and

$$\frac{\partial}{\partial c_2}\frac{\pi_2 r\iint_{L_2} f}{(\pi_1 - \pi_2)\iint_{TB} f} = -\pi_1\frac{r\iint_{L_2} f}{\iint_{TB} f} < 0$$

x^* varies inversely with c_1 and varies with c_2. From (3), either the decreasing of c_1 or the increasing of c_2 will contribute to a greater difference between the unit profit of g_1 and that of g_2 for fixed p_1 and p_2. According to the ***principle of the unit profit***, the seller should launch g_2 later under these conditions.

The interaction between the attitude of the customers in information acquisition and x^*. The attitude of the customers toward product information acquisition varies with the different target markets the seller faces. Using Taylor's expansion of e^{kx} to expand the LHS of (7) we get

$$\frac{n'(x^*)}{n(x^*)} = \frac{1}{[x^* + \frac{(a_1+a_2)^2(x^*)^3}{3!} + \cdots] + (a_1 - a_2)[\frac{(x^*)^2}{2!} + \frac{(a_1+a_2)^2(x^*)^4}{4!} + \cdots]} \tag{13}$$

which means $\dfrac{n'(x^*)}{n(x^*)}$ varies inversely with a_1 for any fixed a_2 (see Figure 3), which implies that x^* varies inversely with a_1. That is, the more the innovation adopters there are, the earlier the seller launches g_2. The seller should advance the launch of g_2 when he faces customers that are more aggressive in information acquisition. On the other hand, the more passive in information acquisition customers are, the later the seller launches g_2.

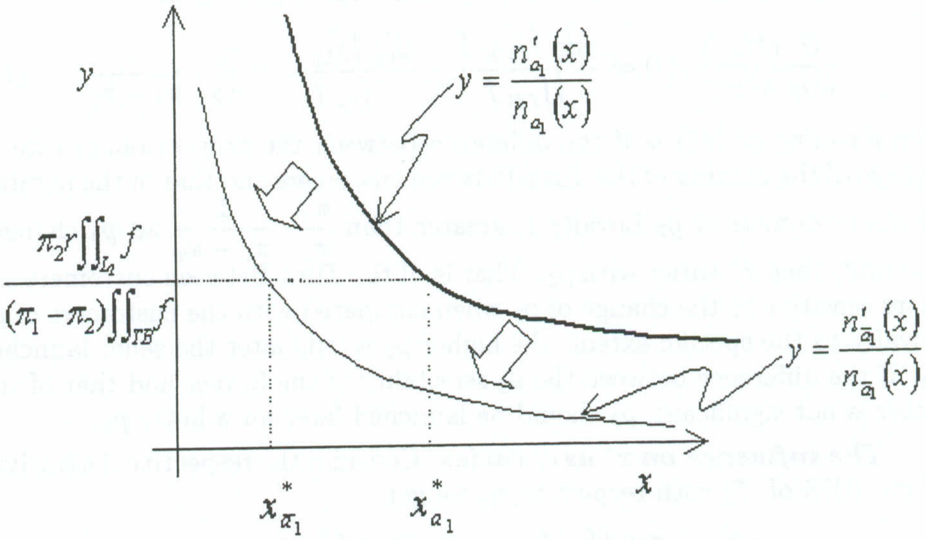

Figure 3. The influence of the coefficient of innovation on x^*, where $a_1 < \bar{a}_1$

The interaction between the scale of seller's announcement and x^*. On behalf of the seller, to control the advertisement budget is to control the scale of his announcement of product information. Examining the derivative of the LHS of (7) with respect to α, we get

$$\frac{\partial}{\partial \alpha}\frac{n'(x^*)}{n(x^*)} = \beta\frac{(e^{\beta x/2} - e^{-\beta x/2})^2}{(e^{\beta x} - \alpha e^{-\beta x} + \alpha - 1)^2} > 0 \tag{14}$$

so x^* varies with α (see Figure 4). The meaning of the result is that the seller should advance the launch of g_2 as he enlarges the scale of his announcement. The enlarged announcement scale will allow more customers to learn about the product from the seller's advertisements instead of from word-of-mouth. That is, to lower α, the ratio of the coefficient of the imitation to that of the innovation. Hence, the launch of g_2 should be advanced according to (14). On the other hand, if the seller reduces the scale of his announcement about product information, g_2 should be launched later. The seller takes advantage of word-of-mouth effect to accelerate the diffusion of the product in this case.

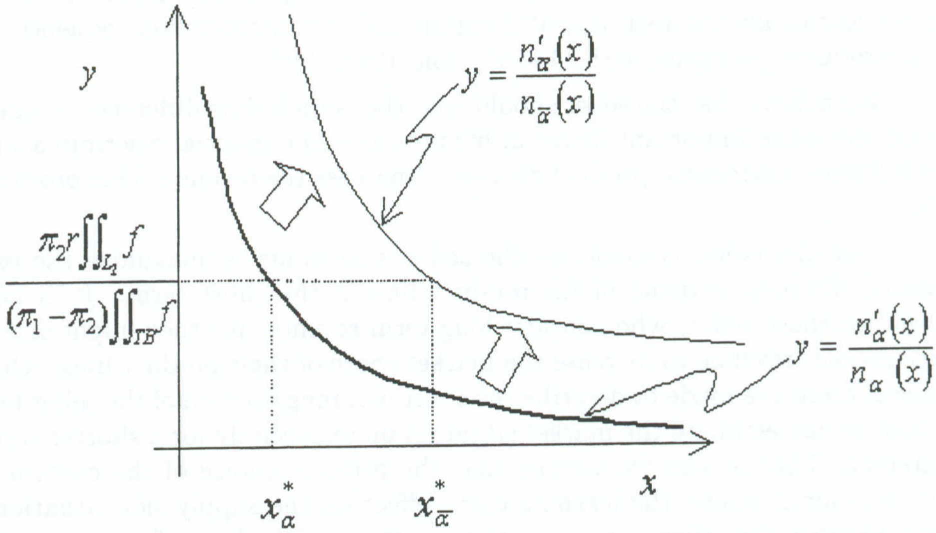

Figure 4. The influence of the scale of the seller's announcement on x^*, where $\alpha < \bar{\alpha}$

5. Conclusions

This study probes the introduction strategy for the seller who is going to introduce a product line consisting of two cannibalistic durables. Originated from the consideration of the customers' purchase behavior, we present scrupulous managerial implications for the seller. First of all, our result has shown that the comparison between the unit profitabilities of the products is the decisive factor for the seller in selecting an appropriate introduction strategy among simultaneous introduction, sequential introduction, and one product only introduction. According to the *principle of the unit profit* that we proposed, the seller should launch the product that is more profitable per unit first. As to when the product that is less profitable per unit should be launched, it is a tradeoff between loss from cannibalization and the postponement of profit for the seller. We proved that the less profit the product contributes per unit, the later the seller launches it. The evidence of our sensibility analysis also shows that the optimal timing of the lower unit profit product introduction varies with other environmental factors, such as the unit costs of the products, the price sensibility of the different types of customers, etc. Besides, we find that the more aggressive the attitude of the potential customers in product information acquisition and the lager the scale of the seller's announcement would advance the lower unit profit product launch time. Furthermore, we show sequential introduction can alleviate cannibalization, and the higher the possibility of the cannibalization is, the later the seller launches the lower unit profit product. However, there is no connection between cannibalization and the introduction sequence of the products (compare with Moorthy and Png, 1992).

We believe that the seller should take the launch time difference of both products as an important factor in his products line internal discriminating to influence customers' product choices to increase the revenue of his product line.

Our discussion is made for the seller who wants to maximize the expected discount revenue of his product line in the short term. It is not valid for those sellers who consider long-term revenue, for they might sacrifice present revenue to increase the market share of their product lines. Our assumptions are made to describe the short planning horizon of the seller because he can estimate the market situation more precisely for a shorter time interval. That is why we assume that the product choice of the customer will not alter, ignore the learning curve effect on the supply side situation, etc. Besides, the seller's announcement of the product line information will be trust worthier to the customers for a shorter horizon (see Bayus, 1992).

For further research, the situation whether the seller should commit the features of the products before they launched is an interesting topic. In addition, customers are different in their willingness to wait to purchase the product that is not available yet till the seller launches the product as they acquire the product information. We propose to take the individual differences in demand side situation into consideration for later research to provide some useful hints for sellers.

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