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網路通路興起前後製造商最適通路設計之研究

本文分析網路興起前後，獨佔製造商最適的通路策略與產品線設計有何不同。在本文中消費者為異質，其往來實體通路之交通成本、對售前服務之需求、以及對產品品質的願付價格互不相同，且三者間呈正相關。獨佔廠商的目標為：針對不同的市場區隔設計不同品質的產品項目，並決定各產品項目應分別經由網路或實體通路販售，以獲致最大利潤。在兩個市場區隔、兩種產品品質的結構下，製造商的決策如下：先選擇產品的品質水準，再選擇經由實體通路或網路通路將產品銷售給消費者。相對於網路通路，消費者可在實體通路享有較好的售前服務，然而，在實體通路購物則須負擔較高的交通成本。本文發現，當所有消費者均可上網時，廠商在實體通路銷售低端產品，可有效利用消費者交通成本的異質性來區隔消費者。因此，即使所有消費者的交通成本均高於對售前服務的需求，「在實體通路銷售低端產品、在網路通路銷售高端產品」仍可能成為廠商的最適決策。當消費者交通成本的異質性提高時，在實體通路所銷售的低端產品的品質會對應提高；相反地，當消費者對售前服務有相同的需求，且對產品品質願付價格差異不大時，對廠商而言，在網路通路銷售低端產品絕非最適。

其次，本文繼續探討部份消費者無法上網的情況。我們發現低端產品的品質隨不同的通路策略而異。當低端產品透過網路通路銷售給低需求者，而高端產品透過實體通路銷售給高需求者時，低端產品的品質，比在任何其他的通路策略下都低。最後，我們考慮兩個極端的例子：高需求者完全無法上網、或低需求者完全無法上網的情況。當低需求者完全無法上網時，廠商的最適策略為在網路通路銷售高端產品給能上網的高需求者，並在實體的實體通路提供低端產品給低需求者與無法上網的高需求者。此時低端產品的品質可以獲得提昇，產品線的競蝕問題得以紓解。

關鍵詞：配銷通路、產品線設計、區隔顧客、網際網路

The Manufacturer's Optimal Distribution and Product Line Design Strategies In the Presence of the Internet

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Abstract

In this paper, we analyze a monopolistic manufacturer's optimal distribution strategy and quality choices for its product line, where the product items are targeted to different segments of consumers. Consumers differ in their valuations for quality and in their transportation costs, which are positively correlated. In a two-segment two-product framework, the manufacturer first chooses quality levels for its products and then chooses either the traditional channel or the Internet channel to distribute these products. Consumers can obtain better presale service at the traditional channel than at the Internet channel. However, they have to incur transportation costs when shopping at the traditional channel. In a scenario where all consumers have access to the Internet channel, we find that selling the low-end item through the traditional channel can take advantage of consumers' heterogeneity in transportation costs, thus better screening consumers. For this reason, even if all consumers' transportation costs are higher than their demands for presale service, selling the low-end item through the traditional channel and selling the high-end item through the Internet channel may be optimal for the firm. When consumers' heterogeneity in transportation costs increases, the quality of the low-end item sold at the traditional channel can be raised. In contrast, selling the low-end item through the Internet channel is never optimal for the firm if consumers' demands for presale services are the same and do not vary with dif ferent product items.

Then we consider the scenario where not all consumers have access to the Internet channel. We find that the quality of the low-end item varies under different channel strategies. In particular, when the low-end item is sold to low valuation consumers through the Internet channel and the high-end item is sold to high valuation consumers through the traditional channel, the quality of the low-end item is the lowest. Finally, we consider two extreme cases where either high valuation consumers or low valuation consumers are all non-Internet users and explore the effect of limited Internet reach on the firm's optimal distribution strategy for its product line. The results show that when all low valuation consumers are non-Internet users, it may be optimal for the firm to sell the high-end item through the Internet channel and to induce the high valuation consumers who can not be reached by the Internet channel to buy the low-end item. Doing so allows the firm to reduce the impact of the cannibalization problem in its product line, thus raising the quality of the low-end item toward the efficient level. *(Channels of Distribution; Product Line Design; Screening; The Internet)*

1 Introduction

The Internet represents not only a new medium through which manufacturers can communicate with consumers directly but also a new alternative distribution channel for manufacturers to sell their products. Some researchers propose that the Internet channel is more efficient than traditional channels in terms of lower transaction costs and lower consumer search costs and thus suggest that the Internet as a new and revolutionary distribution channel will finally replace traditional channels (see for example, Hoffman and Novak, 1996; Benjamin and Wigand, 1995). On the other hand, other researchers argue that some product attributes can only be examined with physical presence (Peterson, 1997; Lal and Sarvary, 1999; Alba et al. 1997;

Balasubramanian 1998), and suggest that the Internet channel can complement but not substitute traditional channels. In the presence of the Internet, an important issue facing manufacturers is whether they should expand into the Internet and whether they should give up traditional channels.

This channel design issue becomes even more complicated when manufacturers produce multiple items in a product line to appeal to different segments of consumers. In this situation, it is important to design the product line in such a way that consumers will indeed buy the products intended for them (Mussan and Rosen, 1978; Moorthy 1984). When consumers who have different valuations for product items with different qualities also have different preferences over distribution channels, what are manufacturers' optimal mix of product quality and distribution channel designated for each product item?

The purpose of this paper is to analyze a manufacturer's optimal distribution strategy and the associated quality choices for a line of its products which are targeted to different segments of consumers. In the marketing literature on channel issues, distribution structures are often assumed to be exogenously given or restricted to be an "all-or-nothing" choice.[1] Moreover, since the Internet reduces consumer search costs and affects consumer shopping behavior, the optimal distribution strategy should be reanalyzed by

[1]For example, McGuire and Staelin (1984) and Coughlan and Wernerfelt (11991) consider the choice between a vertically integrated structure and a delegated channel (with independent retailers) for two competing manufacturers. One exception is Purohit(1997), who considers dual distribution channels, where rental agencies may be allowed to sell old cars, thus creating competition between rental agencies and dealers.

incorporating the new aspects of the Internet channel. [2]

To address the issue of channel and product line design in the context of target marketing, we assume that consumers differ in their valuations for products and in their transportation costs, which are positively correlated. Two kinds of distribution channels are available for a manufacturer's choice when determining the distribution structure for its products in a product line: the traditional channel and the Internet channel. The Internet channel allows consumers to shop without incurring any transportation costs while the traditional channel is more efficient in providing presale services according to consumers' idiosyncratic needs. Thus the transportation costs incurred at traditional channels intend to capture the extent of inconvenience at traditional channels relative to the Internet channel. On the other hand, buying on the Internet is assumed to decrease consumers' valuation for products because of the lower presale services provided on the Net compared with traditional channels. These assumptions are consistent with previous literature. For example, Eastlick and Feinberg (1994) has shown that convenience is a central reason for the patronage of direct channels. Lal and Sarvary (1999) use "non-digital" attributes, and Blasubramanian (1998) uses "lack of fit of products to the direct channels" to reflect the features of the Internet channel that consumers can not inspect products physically, thus attaching lower

[2] Chou and Young (1999) analyze a manufacturer's optimal channel design in the presence of the Internet. They find that using both distribution channels allows the manufacturer to better screen consumers. As a result, it may be optimal for the manufacturer to use both channels despite the inefficiency of either channel.

value for products purchased at the Internet channel.

To focus on the impact of consumers' heterogeneity on the manufacturer's optimal distribution and product line design strategies, we first assume that the Internet's reach is complete. We then relax this assumption to explore how the extent of the Internet's reach influences the manufacturer's distribution strategy and the associated product line design. [3] The results show that when the Internet's reach is complete distributing the low-end item at the traditional channel instead of the Internet channel allows the firm to take advantage of consumers' heterogeneity in transportation costs, and hence achieve better screening of consumers. When consumers' heterogeneity in transportation costs is high enough, high valuation consumers' incentives of buying the low-end item would be automatically curbed by their differentially high transportation costs relative to low valuation consumers. In this case, the quality of the low-end item can be raised toward the efficient level. In contrast, selling the low-end item via the Internet channel and the high-end item through the traditional channel is never optimal for the firm, when consumers' demands for presale services are the same and do not vary with different items in a product line. The idea behind this result is the following. If the above mentioned channel strategy is preferred to selling both items

[3] Zettlemyer (2000) also explores the impact of the Internet's reach on manufacturers' strategies, however, Zettlemyer considers the scenario where both distribution channels are employed and focuses on manufacturers' communication and pricing strategies. In contrast, this paper analyzes both the distribution strategy and product line design for a manufacturer, which allows us to capture the interaction between these two p's in the presence of the Internet.

via the Internet channel, then it must be the case that the transportation costs of high valuation consumers are lower than their demands for presale services. Then it is also true for low valuation consumers. However, in this case, it is better to sell both items than to sell the high-end item only at the traditional channels.

When the Internet's reach is not complete, different channel strategies imply different importance assigned to the low-end item relative to the high-end item, thus affecting the quality of the low-end item. For example, if the low-end item is sold to the low valuation Internet users through the Internet channel and the high-end item is sold to all high valuation consumers through the traditional channel, the resulting quality of the low-end item is the lowest among all distribution (targeting) strategies. It happens because this channel strategy reduces the demand from non-Internet users for the low-end item, and thus increases the importance of the high-end item intended for high valuation consumers. To reduce the impact of the cannibalization problem, the quality of the low-end item is reduced and the quality spectrum of the product line is enlarged accordingly. We then further analyze the manufacturer's optimal distribution strategies in two extreme cases: either low valuation consumers or high valuation consumers are non-Internet users. When all low valuation consumers are all non-Internet users, we find that it may be optimal for the firm to sell the high-end item through the Internet channel and to induce the high valuation consumers who can not be reached by the Internet channel to buy the low-end item. Doing so allows the firm to reduce the impact of the cannibalization problem in its product line, thus raising the quality of the low-end item toward the efficient level.

The article is organized as follows. Section 2 introduces the model. Section 3 discusses the results. Section 4 summarizes the results and discusses future research.

2 The Model

Consider a vertically integrated monopolist who designs its product line consisting of a high-end item and a low-end item targeted to two segments of consumers, the high segment and the low segment. The high segment and the low segment account for $1-\beta$ and β of the whole population, respectively. Consumers in the two segments differ in their valuations for quality and in their transportation costs. Consumers in the high segment have higher valuation for product quality, denoted by θ_2, and a higher transportation cost, denoted by t_2, than those (denoted by θ_1 and t_1) in the low segment. A problem facing the monopolist is to choose the qualities of items in its product line, which are targeted to the two segments, and to choose the channels of distribution for the two products. The manufacturer incurs C(q) for producing one unit of a product with quality q, where $C'(q) > 0$ and $C''(q) > 0$ to reflect the properties that it is more costly to produce a product of higher quality and the marginal cost of producing quality is increasing. For simplicity, we assume that $C(q) = \frac{cq^2}{2}$. Two kinds of distribution channels are considered: the traditional distribution channel and the Internet channel. A consumer in segment i can obtain presale services for products distributed through the traditional channel by incurring a transportation cost t_i, $i = 1, 2$. A consumer in segment i obtains gross utility $\theta_i q$ when buying a product with quality q through the traditional channel. Without loss of generality, assume that $\theta_2 > \theta_1$ and $t_2 > t_1$. In contrast, selling products through the Internet channel, where no presale services are provided, would reduce consumers' willingness to pay for the products, denoted by λ. Thus the game proceeds as follows. The firm first chooses its distribution strategy and the associated qualities of items in the product line. Then the firm carefully selects the prices of the products targeted at different segments. Facing the qualities and the prices of the products sold either at the traditional channel or the Internet channel, consumers decide which distribution channel to shop and which product to buy. There are four kinds of distribution strategies for the firm:(1) Selling both products through the traditional channel; (2) Selling both products through the Internet channel;(3) Selling the high-end item through the Internet channel while selling the low-end item through the traditional channel; (4) Selling the high-end item through the Internet channel while selling the low-end item through the traditional channel. Let (x, y) represent the distribution structure where the low-end item is sold through channel x, and the high-end item is sold through channel y, $x, y \in E, T$, where E denotes the Internet channel, and T denotes the traditional channel. Let $\Pi_{x,y}$, denote the manufacturer's profits associated with the distribution structure (x, y). Note that the high segment has a higher transportation cost than the low segment when shopping at the traditional outlets, thus having a lower preference toward the traditional channel than the Internet channel. As will be shown, the extent of the heterogeneity in consumers' transportation costs affects the firm's product line design in an important way. For the moment, we shall focus our attention on the following parameter space:

$$S \equiv \{t_2 - t_1 \leq \frac{(\theta_2 - \theta_1)(\theta_1 - (1-\beta)\theta_2)}{\beta c}, (1-\beta)\theta_2 \leq \theta_1 \leq (1-\frac{\beta}{2})\theta_2\}.^4. We shall expand this sp$$

$t_2 - t_1$ on the firm's optimal product design. (1)

We shall first assume that all consumers have access to the Internet and derive the manufacturer's optimal distribution strategy and the associated product line design for this simplified case. Then we shall relax this assumption later to further explore the effects of partial Internet reach on the firm's optimal product line design under different distribution strategies.

2.1 Complete Internet Reach

If all consumers have access to the Internet, then expanding to the Internet channel does not involve any reduction in demands. In this situation, if the firm who aims to maximize its profits still chooses (T,T) as its optimal

[4] The first inequality ensures that the interior solutions of qualities for the product line automatically satisfy the sorting conditions under which the firm can use the two distribution channels to screen the two segments of consumers

channel strategy, there must be factors other than the concern for restricted demand on the Internet channel account for that. To illustrate how the firm sets prices for and designs its product line, we analyze the firm's product line design problem for case (T, E) and case (E,T), where the low-end item and the high-end item are sold through different distribution channels.

Case (T, E)

Given the qualities and the prices of the two products, consumers choose which distribution channel to shop and which product to buy at the same time. The manufacturer maximizes its profits while making sure that each consumer segment buys the product he is supposed to buy at the corresponding distribution channel (incentive compatibility constraints, henceforth IC constraints), and that each consumer segment obtains nonnegative surplus from buying this product (individual rationality constraints, henceforth IR constraints). The high segment consumers obtain utility $\theta_2 q_2 - \lambda_2 - p_2$ if buying the high-end product at the Internet channel and $\theta_2 q_1 - t_2 - p_1$ if buying the low-end product at the traditional channel. To ensure that the high segment consumers prefer to buy the high-end item on the Internet, the following condition (IC_2) must hold:

$$p_2 - p_1 \leq \theta_2(q_2 - q_1) + t_2 - \lambda_2. \tag{2}$$

On the other hand, the low segment consumers, if buying the low-end item as the manufacturer would like them to do, obtain utility $\theta_1 q_1 - t_1 - p_1$, which must be nonnegative. That is, the following IR condition must hold:

$$\theta_1 q_1 - t_1 - p_1 \geq 0. \tag{3}$$

If $t_2 - t_1 \leq (\theta_2 - \theta_1)q_1$ (henceforth **condition T**), then from the existing literature(for example, Villas-Boas 1998), we know that the above IC constraint as well as the above IR constraint, must be binding[5], which yields the optimal price of the low-end item,

$$p_1^* = \theta_1 q_1 - t_1 - p_1,$$

and the price of the high-end item,

$$p_2^* = \theta_2 q_2 - \lambda_2 - (\theta_2 - \theta_1)q_1 + t_2 - t_1.$$

We shall verify later that for the parameter space we considered the optimal quality level q_1 chosen by the manufacturer satisfies condition T. As to product qualities, the firm aims to solve the following problem:

$$Max_{q_1,q_2} \beta(p_1^* - \frac{c}{2}q_1^2) + (1-\beta)(p_2^* - \frac{c}{2}q_2^2). \tag{4}$$

The quality levels for the low-end item and the high-end item are as follows:

$$q_1' \frac{\theta_1}{c} - \frac{\theta_1 - (1-\beta)\theta_2}{\beta c}, \tag{5}$$

and

$$q_2 = \frac{\theta_2}{c}. \tag{6}$$

[5]Note that when the above two constraints are binding, the high segment obtains nonnegative surplus and the low segment prefers to buy the low-end item through the traditional channel.

These are the standard results that the quality of the high-end item which is targeted to the high segment is at the efficient level while the quality of the low-end item is distorted downward to alleviate the cannibalization problem. Notice that the above two quality levels satisfy **condition T** if and only if $t_2 - t_1 \leq \frac{(\theta_2-\theta_1)(\theta_1-(1-\beta)\theta_2)}{\beta c}$, which holds for the parameter space we considered.[6]

Case (E, T)

When the manufacturer sells the low-end item on the Internet and the high-end item at the traditional channel, prices alone are not enough for preventing arbitrage behaviors by consumers. Instead, the manufacturer has to carefully design it product line to prevent consumers' arbitrage behaviors across different channels. To see this, note that the two incentive compatibility constraints for the high segment and for the low segment are:

$$p_2 - p_1 \leq \theta_2 q_2 - \lambda_2 - p_2 \geq \theta_2 q_1 - t_2 - p_1, \tag{7}$$

and

$$\theta_1 q_1 - \lambda_1 - p_1 \geq \theta_1 q_2 - t_1 - p_2. \tag{8}$$

Combining the above two inequalities yields

$$\theta_1(q_2 - q_1) + \lambda_1 - t_1 \leq p_2 - p_1 \leq \theta_2(q_2 - q_1) - t_2 + \lambda_1. \tag{9}$$

[6]When the heterogeneity of consumers in transportation costs is higher, the incentive problem of the high segment facing the manufacturer is less severe. For this reason, the quality of the low-end item will be raised and set proportionally to $t_2 - t_1$. When the heterogeneity of consumers in transportation costs is further increasing, the quality of the low-end item can be raised optimally even to the efficient level, i.e., $\frac{\theta_1}{c}$.

Thus the two IC constraints are compatible if and only if

$$t_2 - t_1 \leq (\theta_2 - \theta_1)(q_2 - q_1). \tag{10}$$

In other words, the manufacturer has to design its products with sufficient diversity in quality to prevent consumers from buying products at distribution channels which are not designated for them. With similar steps to the previous case, it can be shown that the optimal quality levels are the same as equation (5) and (6) for the parameter space we considered.[7] Similarly we can derive the optimal prices and quality levels for the other two distribution cases. For the parameter space we considered, the optimal quality levels are the same for all the four cases. Denote $q_1^* \equiv \frac{\theta_1}{c} - k$, and $q_2^* \equiv \frac{\theta_2}{c}$. The corresponding prices and profits for all four cases are summarized in the following table.

(X, Y)	Prices (p_1^*, p_2^*)	Profits
(T, E)	$p_1 = \theta_1 q_1 - t_1$ $p_2 = \theta_2 q_2 - \lambda - (\theta_2 - \theta_1)q_1 + t_2 - t_1$	$\beta(p_1^* - t_1 - \frac{c}{2}q_1^{*2}) + (1-\beta)(p_2^* - \lambda - \frac{c}{2}q_2^{*2}$
(E, T)	$p_1 = \theta_1 q_1 - \lambda$ $p_2 = \theta_2 q_2 - t_2 - (\theta_2 - \theta_1)q_1$	$\beta(p_1^* - \lambda - \frac{c}{2}q_1^{*2}) + (1-\beta)(p_2^* - t_2 - \frac{c}{2}q_2^{*2}$
(T, T)	$p_1 = \theta_1 q_1 - t_1$ $p_2 = \theta_2 q_2 - t_2 - (\theta_2 - \theta_1)q_1 + t_2 - t_1$	$\beta(p_1^* - t_1 - \frac{c}{2}q_1^{*2}) + (1-\beta)(p_2^* - t_2 - \frac{c}{2}q_2^{*2}$
(E, E)	$p_1 = \theta_1 q_1 - \lambda$ $p_2 = \theta_2 q_2 - \lambda - (\theta_2 - \theta_1)q_1$	$\beta(p_1^* - \lambda - \frac{c}{2}q_1^{*2}) + (1-\beta)(p_2^* - \lambda - \frac{c}{2}q_2^{*2})$

We now proceed to characterize the optimal distribution strategies for the manufacturer and list the corresponding conditions in the following three propositions.

[7]These quality levels satisfy equation (10) if $t_2 - t_1 \leq \frac{(\theta_2-\theta_1)^2}{\beta c}$. The latter condition is implied by $t_2 - t_1 \leq \frac{(\theta_2-\theta_1)(\theta_1-(1-\beta)\theta_2)}{\beta c}$ if $(1-\beta)\theta_2 \leq \theta_1 \leq (1-\frac{\beta}{2})\theta_2$.

Proposition 1 *For the parameter space S defined in (??), the manufacturer's optimal distribution strategy is*

1. *to sell the low-end item and the high-end item through the traditional channel and the Internet channel, respectively, if the following three conditions hold:*

$$t_2 \geq \lambda_2, \tag{11}$$

$$2(1-\beta)t_2 - t_1 \geq (1-\beta)\lambda_2 - \beta\lambda_1, \tag{12}$$

$$(1-\beta)t_2 - t_1 + \beta\lambda_1 \geq 0; \tag{13}$$

2. *to sell both items through the traditional channel if* $t_1 \leq t_2 \leq \lambda$*;*

3. *to sell both items through the Internet if*

$$t_1 \geq \lambda, t_2 \geq \lambda, (1-\beta)t_2 - t_1 + \beta\lambda_1 \leq 0. \tag{14}$$

Proof: Followed directly by comparing profits under different distribution strategies listed in table 1. For example, conditions (11)-(12) are derived by comparing profits under (T, E) with those under (T,T), (E, T) and (E,E), respectively.

Two important messages are sent from the above proposition. First, selling the high-end item through the traditional channel while selling the high-end item via the Internet channel is never optimal for the firm. As shown in the proposition, for (E,T) is preferred to (E,E), it must be true that $t_2 \leq \lambda$. Then it follows that $t_1 < t_2 < \lambda$, which implies (T,T) is preferred to (E,T). Second, (T, E) can still be preferred to (E, E) even if $t_1 \geq \lambda$. It happens because selling the low-end item at the traditional channel allows the manufacturer to better screen consumers by making it more costly for the high segment, who has a higher transportation cost, to pretend to be the low segment and buy the low-end item intended for the high segment. The extra benefit from better screening makes strategy (T, E) more attractive than (E, E) even if $t_1 \geq \lambda$. In the following, we consider the situation where the two segments are more heterogeneous in transportation costs, and explore how it affects the firm's optimal product design. In particular, we consider the following two situations :(1) $\frac{(\theta_2-\theta_1)(\theta_1-(1-\beta)\theta_2)}{\beta c} \leq t_2 - t_1 \leq (\theta_2 - \theta_1)\frac{\theta_1}{c}$; (2) $(\theta_2 - \theta_1)\frac{\theta_1}{c} \leq t_2 - t_1 \leq \frac{(\theta_2-\theta_1)^2}{\beta c}$. We focus on the case (T,T) and case (T, E), where the increase in $t_2 - t_1$ helps reduce the cannibalization problem, thus affecting the optimal quality level of the low-end item in the product line.

Heterogeneity in Transportation Costs ($\frac{(\theta_2-\theta_1)(\theta_1-(1-\beta)\theta_2)}{\beta c} \leq t_2 - t_1 \leq (\theta_2 - \theta_1)\frac{\theta_1}{c}$)

Recall that in case (T, E) for the high segment to obtain nonnegative surplus, condition T, $t_2 - t_1 \leq (\theta_2 - \theta_1)q_1$, must be satisfied. When consumers' heterogeneity in transportation costs increases and exceeds $(\theta_2 - \theta_1)(\theta_1 - (1-\beta)\theta_2)\beta c$, the cannibalization problem facing the firm is so relaxed that the firm can extract all the surplus of the high segment by setting the quality of the low-end item equal to $\frac{t_2-t_1}{\theta_2-\theta_1}$. This is also true for the case (T, T). Thus in this situation, the quality level of the low-end item can be increased[8] and set proportionally to $t_2 - t_1$. Thus the profits for case (T, E) are

$$\beta(\theta_1\hat{q}_1 - t_1 - \frac{c}{2}\hat{q}_1^{*2}) + (1-\beta)(\theta_2 q_2^* - \lambda - \frac{c}{2}q_2^{*2}), \tag{15}$$

and the profits for case (T,T) are

$$\beta(\theta_1\hat{q}_1 - t_1 - \frac{c}{2}\hat{q}_1^{2}) + (1-\beta)(\theta_2 q_2^* - t_2 - \frac{c}{2}q_2^{*2}). \tag{16}$$

For case (E, E) and case (E, T), the quality levels and the associated profits remain the same for this new parameter space.

Even Higher Heterogeneity in Transportation Costs ($(\theta_2 - \theta_1)\frac{\theta_1}{c} \leq t_2 - t_1 \leq \frac{(\theta_2-\theta_1)^2}{\beta c}$)

When consumers' heterogeneity in transportation costs keeps increasing to this level, the firm does not have to worry about the arbitrage behaviors by consumers in designing its product line. The only concern for the firm when maximizing it profits from its product line is to ensure nonnegative surplus for its customers. As a result, the optimal quality of the low-end item can be set at the efficient level, i.e., $\frac{\theta_1}{c}$. The profits for (T,E) and (T,T) have the same functional form as 15 and 16 except that q_1 is equal to $\frac{\theta_1}{c}$ rather than $\hat{q}_1$. We summarize the above results in the following lemma.

Lemma 1 *When there is higher heterogeneity in consumers' transportation costs, the quality level of the low-end item can be increased in case (T,E) and case (T,T). In particular,*

[8] This quality level $q_1 = \frac{t_2-t_1}{\theta_2-\theta_1} \leq \frac{\theta_1-(1-\beta)\theta_2}{\beta c}$ for the parameter space $t_2 - t_1 \geq (\theta_2 - \theta_1)(\theta_1 - (1-\beta)\theta_2)\beta c$

1. *if* $\frac{(\theta_2-\theta_1)(\theta_1-(1-\beta)\theta_2)}{\beta c} \leq t_2 - t_1 \leq (\theta_2 - \theta_1)\frac{\theta_1}{c}$, *the optimal quality level of the low-end item is set at* $\hat{q}_1 = \frac{t_2-t_1}{\theta_2-\theta_1}$;

2. *if* $(\theta_2-\theta_1)\frac{\theta_1}{c} \leq t_2-t_1 \leq \frac{(\theta_2-\theta_1)^2}{\beta c}$, *the optimal quality level of the low-end item is set at the efficient level, i.e.,* $\frac{\theta_1}{c}$.

2.2 Partial Internet Reach

The previous subsection characterizes the firm's optimal distribution and product line strategies in the limiting case, where all consumers have access to the Internet channel. We found that the higher the heterogeneity in consumers' transportation costs, the more favorable it is to sell the low-end item on the Internet channel. However, the reality right now is that quite a few consumers cannot have access to the Internet, which would affect the firm's product line design associated with different channel structures in an important way. We now proceed to analyze the impact of the partial Internet reach on the firm's optimal product line design under various distribution strategies. To focus on the effects of the extent of the Internet's reach in both the high segment and in the low segment, in this subsection we assume that the transportation costs of the two segments are the same, i.e., $t_2 - t_1 \equiv t$. Moreover, the proportion of Internet users in the high segment is denoted by α_2 and that in the low segment is denoted by α_1. For illustration purpose, in the following we analyze the case (E,T) where the low-end item is sold through the Internet channel, thus preventing non-Internet users from buying it. The results of other cases will be reported in table ??.

Case (E,T)

When the low-end item is sold through the Internet channel, in the low-segment only the Internet users are able to buy the low-end item and thus served.[9] As to the high segment, there are two targeting strategies for the firm: inducing all high-segment consumers (henceforth strategy A) or inducing non-Internet users only to buy the high-end item through the traditional channel (henceforth strategy B). Unlike the former strategy, the latter strategy allows the firm to extract all consumer surplus from the non-Internet users in the high segment. As a result, the two strategies have different implications for the optimal product line design. When the former strategy is used, from the existing literature we know that the incentive compatibility constraint for the high segment:

$$p_2 - p_1 \leq \theta_2(q_2 - q_1) + \lambda - t_2, \tag{17}$$

and the IR constraint for the low segment

$$\theta_1 q_1 - \lambda - p_1 \geq 0, \tag{18}$$

are binding, which yields the optimal prices $p_1 = \theta_1 q_1 - \lambda$ and $p_2 = \theta_2 q_2 - t - (\theta_2 - \theta_1)q_1$. Thus the remaining problem facing the firm is to design its products to maximize its profits:

$$Max_{q_1,q_2} \alpha\beta(\theta_1 q_1 - \lambda - \frac{c}{2}q_1^2) + (1-\beta)(\theta_2 q_2 - t - (\theta_2 - \theta_1)q_1 - \frac{c}{2}q_2^2). \tag{19}$$

[9]As will be shown, the low segment consumers can not afford the price of the high-end item.

Differentiating the above objective function with respect to q_1 and q_2 gives us the the optimal quality levels for the low-end item and the high-end item:

$$q_1 = \frac{\theta_1}{c} - \frac{\theta_1 - (1-\beta)\theta_2}{\alpha\beta c}, \tag{20}$$

Note that the quality of the low-end item is distorted more than the case when the Internet's reach is complete. The lower the Internet's reach in the low segment (i.e., smaller α_1), the more the quality of the low-end item will be distorted. In fact, as a general rule, when the channel strategy results in a lower demand for the low-end item relative to that for the high-end item, the quality of the low-end item will be distorted more. When the latter strategy is used, the low-end item is targeted to all Internet users while the high-end item is targeted to the non-Internet users only in the high segment. Thus the optimal price for the low-end item remains the same, and the price for the high-end item is set at $\theta_2 q_2 - t$. The non-Internet users in the high segment are induced to buy the low-end item through the Internet channel and obtain positive consumer surplus. The firm then aims to choose the quality levels to maximize its profits:

$$Max_{q_1,q_2}(\alpha_1\beta+\alpha_2(1-\beta))(\theta_1 q_1 - \lambda - \frac{c}{2}q_1^2)+(1-\beta)(1-\alpha)(\theta_2 q_2 - t - \frac{c}{2}q_2^2). \tag{21}$$

Taking derivatives of the above objective function gives us the efficient quality levels for both products: $q_1 = \frac{\theta_1}{c}$, $q_2 = \frac{\theta_2}{c}$. Comparing the profits under the two different targeting strategies under (E,T), we derive the following lemma:

Lemma 2 *Assume that* $(\alpha_1\beta + (1-\beta))\theta_1 \geq (1-\beta)\theta_2$. *When (E,T) distribution strategy is adopted, the targeting strategy where the low-end item* *is targeted to all Internet users and the high-end item is targeted to only the non-Internet users in the high segment is preferred to the targeting strategy where the high-end item is targeted to all high segment consumers if the following condition holds:*

$$\alpha_2(1-\beta)(\frac{\theta_1^2}{c}-\frac{\theta_2^2}{c}+t-\lambda)+(1-\beta)(\theta_2-\theta_1)\frac{\theta_1}{c}\geq 0. \qquad (22)$$

Case (T,E)

When the low-end item is sold at the traditional channel, it is tempting for all high segment consumers to buy the low-end item unless the prices and qualities of both products are carefully designed. In fact, it is obvious that the best targeting strategy for the firm is to induce Internet users in the high segment to buy the high end item and all other consumers to buy the low-end item at the traditional channel. From the existing literature and the analysis above, the optimal quality level for the low-end item can be represented as

$$q_1=\frac{\theta_1}{c}-\frac{d_2(\theta_2-\theta_1)}{d_1 c}, \qquad (23)$$

where d_2 and d_1 are demands for the high-end item and the low-end item, respectively. Thus the optimal quality level for the low-end item for case (T,E) is

$$q_1=\frac{\theta_1}{c}-\frac{(\alpha_2(1-\beta)(\theta_2-\theta_1)}{\beta+(1-\alpha_2)(1-\beta)c}.$$

The optimal quality levels and demands for all the four channel strategies are reported in the following table.

Channel strategy	Demands (d_1^*, d_2^*)	Quality levels (q_1^*, q_2^*)
(T, E)	$d_1 = \beta + (1-\alpha_2)(1-\beta)$	$q_1 = \frac{\theta_1}{c} - \frac{d_2(\theta_2-\theta_1)}{d_1 c}$,
	$d_2 = \alpha_2(1-\beta)$	$q_2 = \frac{\theta_2}{c}$
$(\text{E, T})^A$	$d_1 = \beta\alpha_1$	$q_1 = \frac{\theta_1}{c} - \frac{d_2(\theta_2-\theta_1)}{d_1 c}$
	$d_2 = 1-\beta$	$q_2 = \frac{\theta_2}{c}$
$(\text{E,T})^B$	$d_1 = \alpha_1\beta + \alpha_2(1-\beta)$	$q_1 = \frac{\theta_1}{c} - \frac{d_2(\theta_2-\theta_1)}{d_1 c}$
	$d_2 = (1-\alpha_2)(1-\beta)$	$q_2 = \frac{\theta_2}{c}$
(T, T)	$d_1 = \beta$	$q_1 = \frac{\theta_1}{c} - \frac{d_2(\theta_2-\theta_1)}{d_1 c}$
	$d_2 = 1-\beta$	$q_2 = \frac{\theta_2}{c}$
(E, E)	$d_1 = \alpha_1\beta$	$q_1 = \frac{\theta_1}{c} - \frac{d_2(\theta_2-\theta_1)}{d_1 c}$
	$d_2 = \alpha_2(1-\beta)$	$q_2 = \frac{\theta_2}{c}$

Comparing the quality levels under different distribution/targeting strategies, we derive the following lemma.

Lemma 3 *1. If $\alpha_2 \geq \alpha_1$, then the order of the quality levels for the low-end item under different channel strategies are as follows:*

$$q_1^{(E,T)_B} \geq q_1^{(T,E)} \geq q_1^{(T,T)} \geq q_1^{(E,E)} \geq q_1^{(E,T)_A}.$$

2. If $\alpha_2 < \alpha_1$, then

$$q_1^{(E,T)_B} \geq q_1^{(T,E)} \geq q_1^{(E,E)} \geq q_1^{(T,T)} \geq q_1^{(E,T)_A}.$$

This lemma shows that when the Internet's reach is not complete, the firm's channel strategy determines the demands for and thus the relative importance of the two products. The higher the importance of the low-end item relative to the high-end item, the less distortion in quality for the low-end item would be. It is easy to derive the profits associated with different channel strategies by substituting the corresponding new demands and quality levels into the profit functions in table 1.[10] To simplify our analysis of the optimal channel strategy and highlight the effect of limited Internet reach on the firm's channel and product line decisions, we consider two extreme cases: the case where there are few high-segment consumers who have access to the Internet channel (by assuming $\alpha_2 = 0$), and the case where there are few low-segment consumers who have access to the Internet channel (by assuming $\alpha_1 = 0$).

High segment consumers do not have access to the Internet ($\alpha_2 = 0$) It seems that it is the perfect situation for selling the low-end item through the Internet channel and the high-end item through the traditional channel. Doing so prevents the high segment consumers from buying the low-end item, and thus enables the firm to extract all consumer surpluses from them. The drawback of this strategy is the decrease in the demand for the low-end item. The optimal channel strategy reflects the trade-off between these two effects. We report the optimal channel strategy in the following proposition.

Proposition 2 *Suppose that $\theta_1 \geq \frac{(1-\beta)\theta_2}{1-\beta(1-\alpha_1)}$. If all high segment consumers do not have access to the Internet channel, then the optimal channel strategy is to sell all items through the traditional channel if*

$$\frac{1-\alpha_1\beta^2}{2\beta C}\theta_1^2 - \frac{1-\beta}{\beta c}\theta_1\theta_2 + \frac{(1-\beta)^2}{2\beta c}\theta_2^2 - \beta(t - \alpha_1\lambda) \leq 0, \tag{24}$$

and to sell the low-end item through the Internet channel and the high-end item through the traditional channel otherwise.

[10] The only exception is $(E,T)_B$, where the price for the high-end item is $\theta_2 q_2 - t_2$.

The (E,T) channel strategy accomplishes perfect price discrimination at the expense of reducing the demand for the low-end item. This strategy is optimal if consumers' transportation cost is high relative to their demands for presale service, and the valuation the high segment is high enough relative to that of the low segment.

The Low-segment Consumers do not have access to the Internet

Usually it is the high-segment consumers that have the incentive of switching to buy the low-end item. Therefore, when all low-segment consumers are non-Internet users, selling the high-end item through the Internet channel does not help solve the high segment's incentive problem. Moreover, it forces the non-Internet users in the high segment to buy the low-end item through the traditional channel. The following proposition shows that this (T,E) strategy can still be preferred to the (T,T) strategy.

Proposition 3 *Suppose that* $\theta_2 \geq \sqrt{2ct}$ *and* $\theta_1 \geq (1-\beta)\theta_2 + \beta\sqrt{2ct}$. *Define* $k' = \frac{\alpha_2(1-\beta)(\theta_2-\theta_1)}{(1-\alpha_2(1-\beta))c}, k = \frac{(1-\beta)(\theta_2-\theta_1)}{\beta c}$, *and* $s = k - k'$. *When all low segment consumers are non-Internet users, if*

$$\beta(csk' + \frac{c}{2}s^2) + (1-\alpha_2)(1-\beta)(\frac{\theta_1^2}{2c} - \frac{c}{2}k'^2 - \frac{\theta_2^2}{2c}) + \alpha_2(1-\beta)(t-\lambda)$$

$$-\alpha_2(1-\beta)(\theta_2-\theta_1)(\frac{\theta 1}{c} - k') + (1-\beta)(\theta_2-\theta_1)(\frac{\theta_1}{c} - k) \geq 0, \qquad (25)$$

t

hen the optimal channel strategy for the firm is to sell the high-end item through the Internet channel and the low-end item through the traditional *channel; otherwise, it is optimal to sell both items through the traditional channel.*

The condition $\theta_1 \geq (1-\beta)\theta_2 + \beta\sqrt{2ct}$ ensures that (E,T) is dominated by (T,T) and (E,E) is dominated by (T,E). To understand the above proposition, first recall that the quality level of the low-end item increases in its demand. Selling the high-end item through the Internet channel forces the non-Internet users in the high segment to buy the low-end item, thus decreasing the impact of the cannibalization problem in the product line. For this reason, the quality level of the low-end can be raised toward the efficient level when the firm chooses (T,E) as its optimal channel strategy. The price paid for that benefit is that the non-Internet users in the high segment have no choice but to buy the low-end item even though they are willing to pay a high price for quality.

3 Discussions

To illustrate the impact of the limited Internet's reach on the firm's optimal distribution strategy, we consider the following numerical example.

A Numerical Example $\theta_1 = 3/5$, $theta_2 = 1$, $\beta = c = 1/2$. From table 2 in the previous section, the qualities of the low-end item under different distribution strategies are derived as follows:

$$q_1^{(T,T)} = 2/5,$$

$$q_1^{(E,T)_B} = \frac{5}{6},$$

$$q_1^{(T,E)} = \frac{12 - 10\alpha_2}{10 - 5\alpha_2},$$
$$q_1^{(E,E)} = \frac{6\alpha_1 - 4\alpha_2}{5\alpha_1}.$$

Notice that $q_1^{(T,E)}$ decreases with the proportion of Internet users in the high segment, α_2, and $q_1^{(E,E)}$ increases with $\frac{\alpha_2}{\alpha_1}$. When the proportion of the Internet users in the high segment is higher than that in the low segment($\alpha_2 > \alpha_1$), the quality of the low-end item will be lower in the pure Internet channel than in the pure traditional channel. The profits under different distribution strategies can be easily derived as functions of α_1 or (and) α_2. For example, $\Pi^{(E,T)_B} = \frac{175+47\alpha_1-128\alpha_2}{400}$, which decreases with α_2 and increases with α_1. Assuming $\alpha_2 = 0.4$ and $\alpha_1 = 3/4$, we have the following rank order of profits: $\Pi^{(E,T)_B} = 0.3976 > \Pi^{(T,T)} = 0.395 > \Pi^{(T,E)} = 0.275 > \Pi^{(E,E)} = 0.1841$. Note that $\Pi^{(E,T)_B}$ increases with α_1 and decreases with α_2.

4 Conclusions

In this paper, we characterize the manufacturer's optimal distribution and product line design strategies. When the Internet's reach is complete, it is found that the heterogeneity in consumers' transportation costs and the magnitudes of them relative to their demand for presale services play important roles in determining the firm's optimal distribution strategy and the associated product line design. Selling the low-end item through the Internet channel is never optimal for the firm. In contrast, selling the low-end item at the traditional channel allows the firm to better screen consumers by increasing the high segment's opportunity cost of buying the low-end item, namely their high transportation costs. For this reason, when the low-end item is sold through the traditional channel, the higher the heterogeneity in consumers' transportation costs, the more likely the quality of the low-end item will be raised.

When the Internet's reach is not complete, we find that the quality of the low-end item crucially depends on the distribution structure choosed.Selling the low-end item at the Internet channel to the low valuation Internet users and the high-end item at the traditional channel to all high valuation consumers results in the lowest quality of the low-end item. In the extreme case where all high valuation consumers are non-Internet users, selling the low-end item through the Internet channel allows the firm to prevent high valuation consumers from buying the low-end item, thus extracting all consumer surplus from them. However, even in this case, the reduction in the demand for the low-end item resulting from the limited Internet's reach in the low segment may diminish the profitability of this channel strategy. On the other hand, if all low segment consumers are non-Internet users, it may be optimal for the firm to sell the high-end item through the Internet channel. It happens because in this way the firm induces non-Internet users in the high segment to buy the low-end item, thus reducing the firm's concern for the cannibalization problem, which in turn increase the quality of the low-end item toward the efficient level.

Some assumptions made in this article deserve further discussions. First, consumers' demands for presale services are assumed to be the same between different segments. If consumers are heterogeneous in their demands for presale services, then the correlation between the demands for service and the vauations for products together with consumers' heterogeneity in transportation costs would affect the optimal channel strategy of the manufacturer. In addition, the introduction of either intra-brand or inter-brand competition should produce more insightful results.

Referenes

Alba, Joseph, John Lynch, Barton Weitz, Chris Janiszewski, Richard Lutz, Alan Sawyer, and Stacy Wood (1997), "Interactive Home Shopping: Consumer, Retailer, and Manufacturer Incentives to Participate in Electronic marketplaces," Journal of Marketing, 6(July), pp. 38-53.

Bakos, J. (1997), "Reducing Buyer Search Costs: Implications for Electronic Marketplaces," *Management Science*, 43(12), pp. 1676-1692.

Balasubramanian, Sridhar (1998), "Mail Versus Mall: A Strategic Analysis of Competition between Direct Marketers and Conventional Retailers," *Marketing Science*, 17(3), pp. 181-195.

Benjamin, Robert and Rolf Wigand (1995), "Electronic Markets and Virtual Value Chains on the Information Superhighway," *Sloan Management Review*, 36(winter), pp. 62-72.

Hoffman, Donna L. and Thomas P. Novak (1996), "Marketing in Hypermedia Computer-Mediated Environments: Conceptual Foundations," *Journal of Marketing*, 60(July), pp. 50-68.

Lal, Rajiv and Miklos Sarvary (1999), "When and How Is the Internet Likely to Decrease Price Competition?" *Marketing Science*, 18(4), pp. 485-503.

Lee, Ho Geun (1998), "Do Electronic Marketplaces Lower the Price of Goods?" *Communications of the ACM*, 41(1), pp. 73-80.

Lee, Ho Geun, J. Christopher Westland and Sewon Hong (1999-2000), "The Impact of Electronic Marketplaces on Product Prices: An Empirical Study of ACUNET," *International Journal of Electronic Commerce*, 4(2), pp. 45-60.

Pahigian, B. P. (1995): *Price Theory and Applications*, McGraw-Hill, Inc., New York.

Peterson, Robert A., Sridhar Balasubramanian and Bart J. Bronnenberg (1997), "Exploring the Implications of the Internet for Consumer Marketing," *Journal of the Academy of Marketing Science*, 25(4), pp. 329-346.

Florian Zettelmeyer, Florian (1999a), "Expanding to the Internet," Journal of Marketing Research, Vol. 37 (August), 292-308.