Market Segmentation and Information Development Costs in a Two-Tiered Information Web Site

Frederick J. Riggins
Carlson School of Management
University of Minnesota, Minneapolis, MN
friggins@csom.umn.edu
Phone: 612-624-5760
Fax: 612-626-1316

February 2002

An earlier version of this paper was nominated for the Best Paper award at the Thirty-Fifth Annual Hawaii International Conference on Systems Sciences, January 2002.

Market Segmentation and Information Development Costs in a Two-Tiered Information Web Site

Abstract

We develop an analytical model of a separating equilibrium for a two-tier fee-based and sponsored-based information Web site. We examine the monopolist's choice of content quality and price for a fee-based site targeted at high type consumers and the content quality level for a sponsored site offered free to all consumers. We show how a reduction in the potential for advertising revenues results in lower content quality on the free site, but permits the seller to raise the fee charged to high type consumers. We also show how differences in consumer tolerances to ads impacts content quality, banner ad volume, and usage fees. In particular, the seller can increase profits by making ads more attractive to either high type consumers or low type consumers, but never both at the same time. We show the conditions that determine which consumer segment the seller should seek to improve ad relevancy.

Market Segmentation and Information Development Costs in a Two-Tiered Information Web Site

1. Introduction

The Internet and the World Wide Web have altered the way many people gather various types of information, ranging from daily news stories, to contact information for old high school classmates, to highly technical consultancy reports. In their search for a path to profitability, information providers have attempted various combinations of free sponsored sites and fee-based sites. Daily news stories, sports scores, and stock price information can be found on numerous sponsored sites such as CNN.com, Yahoo!, and BusinessWeek online. Due to the collapse of the dot-com economy, these sites have struggled as their potential for revenues from banner advertisers has plummeted. Other sites such as Classmates.com, Britannica.com, and AOL.com provide some content for free on a sponsored site, but seek to entice users to pay a subscription fee for unique content not easily found elsewhere. For example, Classmates.com allows the non-paying user to read a short bio of old classmates, but requires a $29.95 annual Gold Membership fee to be able to actually contact old friends and engage in chat and discussion board community features. Britannica.com offers some free content on a sponsored site, but continuously prompts the user to pay a $50 annual membership fee in order to receive full use of Britannica's unique information archive. AOL.com functions as a competitive Web portal, but offers various monthly pricing options whereby the user can upgrade to the proprietary AOL interface with its many unique features. A variation of the two-tier site model include companies such as Gartner and Forrester Research who provide some free information on their advertisement-free company home pages, with the hopes of enticing users to pay for other expensive services such as technical whitepapers and industry-specific consultancy reports. In a sense, the home page functions as an advertisement for the company itself, with the goal of building brand image and promotion of unique information products.

For two-tier sites like Britannica.com and Classmates.com, the challenge is to provide enough free content to keep users coming back in order to increase banner ad revenues, but at the same time, limit the free content such that high end users will still be

willing to pay to access the premium services and information. Similarly, the consulting firms desire to provide enough free content on their home pages such that visitors will think highly of the firm whereby guests can be converted to clients. What these information providers are essentially doing is degrading their information product to create a free version of the good that satisfies low type consumers, but holding back enough content so that high type consumers are not entirely satisfied and therefore are willing to pay for the fee-based site [12, 13].

In this paper, we consider an information monopolist that markets its web site to low type consumers who are not willing to pay for content on the Web, but may tolerate some degree of banner advertising, and high type consumers who are willing to pay for high quality content but have less tolerance for online advertising. We develop an analytical model of a separating equilibrium where the monopolist provides a free sponsored site to both high and low type consumers and a fee-based portion targeted at high type consumers. The seller must select content quality and price levels for the fee-based portion of the site, and the degraded quality level for the free sponsored site.

Firms that simultaneously cater to high-end and low-end clientele have been the focus of much analytical modeling by researchers employing economic modeling techniques. Based on work by Spence [14], Tirole [15], and Varian [16], information systems researchers have analyzed the use of second degree price discrimination where firms operate within the Internet economy to sell a high quality, expensive product to high type consumers and a low quality, inexpensive product to low type consumers simultaneously [2, 4, 5, 6, 10]. Because the seller is not able to know the type of a given consumer, the seller is forced to create a *separating equilibrium* by setting price and quality levels so that consumers self-select into the appropriate categories.

Much of this research examines the implications of the so-called *cannibalization problem* where high type consumers may be tempted to purchase the product aimed at the low type consumers. Moorthy and Png [8] show how this distortion in the marketplace may result in low type consumers being under-served or in some cases not being served at all. Riggins and Narasimhan [10] extend these results to model a firm that sells to high and low type consumers in online channel and uses personalization technology, community access limitations, and intertemporal price discrimination to segment the

market. Both of these studies examine the cannibalization problem for the sale of physical goods. While several studies have examined the online pricing policies of information goods, the implications of cannibalizing high-end *information* goods have not been thoroughly examined.

The current analysis examines the cannibalization problem as it applies to information goods within the online channel. If a firm operates a two-tier Web site where a free, sponsored portion is offered to all consumers and a fee-based portion is targeted at high types, the seller may face the cannibalization problem if high type consumers receive sufficient value from the free content. We examine this problem in light of two trends regarding online advertising. First, due to the collapse of the dot-com economy the amount of money sites can charge for ad placement has declined in recent years, thereby putting pressure on the revenue generating potential of banner ads. Indeed, this trend casts some doubt on the very efficacy of the sponsored site business model. We show how a reduction in revenue potential from ads on the sponsored site results in lower quality of information on the free site, an increase in price or fees on the fee-based portion of the site, and lower total profits. Second, personalization tools allow Web sites to manage the placement of banner ads by providing impressions of ads that are more relevant and interesting to the specific user. Therefore, it could be that users' "discomfort" from having banner ads displayed might be lessened as personalization increases. We show how information quality, banner ad volume, and fees change as high and low type consumers' tolerance for online banner ads change. In particular, we show the conditions under which the seller will seek to make ads more relevant to either low type consumers or high type consumers.

In §2, we discuss the relevant literature concerning the pricing of goods when the cannibalization problem potentially exists, and recent work on the pricing of information goods. In §3, we present a stylized example of the cannibalization problem to illustrate its implications on the seller and both types of consumers. This is followed in §4 with the development of our model of a separating equilibrium for a two-tier Web site where a free, sponsored site is offered to all consumers, and a fee-based portion of the site is aimed at high type consumers. We develop several propositions related to information

quality and pricing levels as the potential for banner ad revenue declines and as consumers' tolerances for banner ads change. We conclude the discussion in §5.

2. Background Literature

A seller may practice first-degree price discrimination when it faces heterogeneous consumers and can distinguish the particular type of a given consumer. When this occurs the seller may potentially extract all consumer surplus by charging at each consumer's willingness-to-pay. However, in most cases the seller is not able to know the type of a given consumer. In addition, these consumers may not be inclined to truthfully reveal their type. In this situation, the seller may resort to second-degree price discrimination by offering a range of goods where consumers may be induced to reveal their preferences by self-selecting into the appropriate category. To investigate this problem, researchers commonly incorporate analytical models that investigate the pricing strategy of sellers that practice intertemporal price discrimination or that sell multiple products to multiple types of customers within a given channel.

For example, Conner [3] shows how a firm may spend aggressively on research and development to create a new product, only to set this new product aside until the old one is challenged by a competitor. Bensanko and Winston [1] and Levinthal and Purohit [7] both examine intertemporal price discrimination where prices of products today are influenced by the expectations of a new product tomorrow. The expectation of an improved product in the future can cannibalization sales in the current market. Purohit [9] further develops a two-period model of a manufacturer that offers a product in a rental market and a sales market.

Dewan, et al. [4] develop a model that shows how an early entrant into the online sales channel can use the personalization and customization features of the Internet to create a barrier to entry discouraging other online sellers from entering the market. Indeed, the early entrant may over-customize in an effort to block entry. In a follow-up analysis, Dewan, et al [5] extent Salop's circular city model [11] to develop a model of a firm that sells a range of customized products in addition to a standard product. The authors develop pricing and product-positioning strategies for a monopolist and a duopoly in light of changing customization and personalization capabilities.

Moorthy and Png [8] develop an analytical model of a seller that sells a product that can be differentiated along some measure of "quality" to both high and low types consumers within a single channel. High type consumers are distinguished from low types in that high type consumers are willing to pay more for a given level of quality than are low type consumers. Because the monopolist seller is not able to know a given consumer's type, it must create a separating equilibrium by setting prices and quality levels so that consumers self-select into the appropriate category. The problem is that in order to sell to low type consumers at a price level they are willing to pay, high type consumers will view the low product as an attractive alternative to the high quality good. This potential for cannibalization is a distortion that ultimately harms the low type consumers as the monopolist is forced to lower the quality of the low type product to make it less attractive to the high type consumers. The authors further develop the model by considering intertemporal price discrimination where the seller can segment the market using delay in addition to quality differences.

Riggins and Narasimhan [10] extend this model to examine the case where a monopolist markets a physical product to two types of consumers in the online channel. They show how the seller may use personalization technology to limit or perhaps eliminate the distortion caused by the cannibalization problem. Therefore, the seller may provide higher product quality levels and earlier product introductions for goods aimed at low type consumers. They show how personalization technology also lessens the adverse effects caused when the seller cannot credibly commit to future actions. In addition, because the seller overcomes the cannibalization problem by making sure the high type consumer buys the "correct" product the seller should focus all of its personalization efforts on high type consumers, and must concern itself with the level of patience of high type consumers and not low types. They also examine three different seller strategies for bundling the sale of the physical good with customer access to a seller-sponsored online community. When personalization capabilities are relatively low, the seller should segment consumers into two communities by allowing consumers to have access to the community associated with the type of physical good that was actually purchased. When personalization capabilities are sufficiently high, the seller should switch from the

segmented communities strategy and merge all consumers into one community to take advantage of externality effects.

The models considered above examine the pricing strategies of traditional physical goods. In these models, the marginal cost of producing a product of higher quality in convex as shown in Figure 1. Because high type consumers have a higher reservation value for a given level of quality, the seller will create two versions of the product and sell the higher quality version to the high types and the lower quality version to low type consumers.

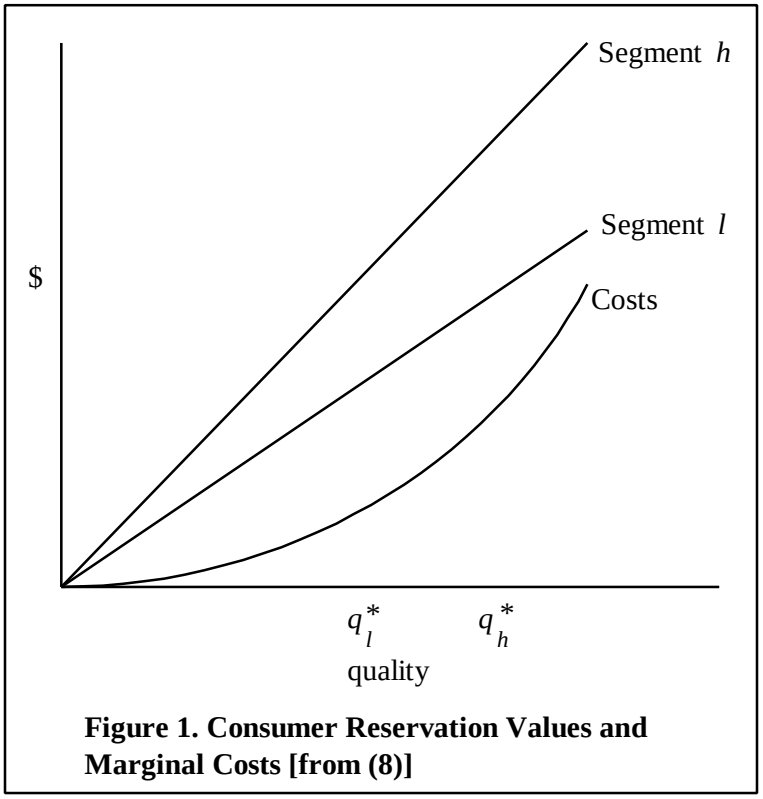

Figure 1. Consumer Reservation Values and Marginal Costs [from (8)]

Recent analytical modeling has examined the unique characteristics of information goods. Information goods are goods where the main value is derived from digitized content [2]. The major portion of the costs associated with information goods is in the development phase, rather than the production phase. Works of literature, music recordings, software programs, and full-production movies all require a significant up front-cost to produce the first copy of the good, but can then be duplicated for a minimal

cost [13]. Indeed, the presence of the Internet allows near costless download of countless copies of an information good that has already been produced. In this sense the marginal cost of producing another copy for sale is essentially zero. In contrast to the function in Figure 1, much of this literature assumes a concave marginal cost function or simply assumes a marginal cost of zero. In this context, Bhargava and Choudhary [2] show that the firm's optimal product line is dependent upon the benefit-to-cost ration of qualities in the choice menu. Therefore, product differentiation is not an optimal strategy and the seller should produce and sell only the highest quality product feasible. Replacing the convex function in Figure 1 with a concave function will clearly result in the seller maximizing profits by increasing quality as much as possible. In a similar approach Jones and Mendelson [6] show that the seller should offer only one product quality level.

Clearly, for information goods, the marginal cost is zero for producing additional ***quantity***. But what about creating a higher ***level of quality*** in the second unit? Is that costless? Consider a vendor of a software product of a certain quality. If a different customer desires a higher level of quality, producing a perfected version of the program can become very costly. Indeed, the cost function associated with improving the quality of software would likely be convex as it becomes harder and harder to perfect the program. This is because creating a higher quality version of an information good requires the seller to return to the development phase rather than the production phase. Indeed, the very concept of a "production phase" is misleading when considering information goods. Any deviation from the continuous duplication of the original copy of an information good could be considered a return to development. On the other hand, a manufacturer of a physical good need not return to the product development phase when a customer desires a higher quality product. Rather, the production line continues as before, albeit with higher quality raw materials. As another example, consider the writing of a mystery novel. One could create a version with shallow characters and a straightforward plot (Copy 1), but the costs to create a higher quality version with well-developed characters and an intricate plot line (Copy 2) can become a very daunting task. The same can be said of writing academic conference and journal papers where the cost of improving the quality of the manuscript is certainly convex.

The Bhargava and Choudhary [2] analysis lets the seller choose quality levels and shows how the seller would choose the one of highest quality. Suppose a software maker has already developed two versions of a software product (one of higher quality than the other) and the software can be costlessly downloaded from the seller's Web site. If a consumer is willing to pay for higher quality, and one version is no more costly to provide than the other, then only the higher quality version should be sold. Therefore, if we disregard the initial development costs the lower quality version will not be developed in the first place. Only the highest quality feasible will be offered, where the authors assume the quality limit is exogenously given. By disregarding convex development costs and considering zero or concave marginal costs, they avoid the issue of choosing the appropriate level of quality to develop in the first place.

In reality, sellers serve a variety of consumers who have differing valuations of quality and therefore willing to pay different amounts for a given product. In order to meet this demand, information providers typically provide versions of their information products where a free or low priced version may be a time-limited trial version, have limited functionality, or may contain some time delay to make it less valuable [12, 13]. What information providers typically do is develop the high-end good and then purposely degrade the quality of the low-end good. In our model in Section 4, we examine this particular problem where an information monopolist develops a high end information good based on a convex development cost function, then incurs some degradation cost to create the low end good. The seller's task is to select the two quality levels and the high quality price level that maximizes the firm's profit.

3. An Example of the Cannibalization Problem

The current analysis examines the implications of the cannibalization problem as outlined by Moorthy and Png [8] and further expanded upon by Riggins and Narasimhan [10]. In our model, we consider the implications of a monopolist offering a Web-based information good. However, before considering the information good case, it would be instructive to illustrate the classic cannibalization problem by considering an example of a simple physical good.

Consider the following example: a monopolist seller of a new type of television set seeks to sell its television sets in a market comprised of 75 low type consumers and 100 high type consumers. Within this new product line, televisions differ according to the number of lines of resolution (LOR) of the set. Market studies have shown that low type consumers are willing to pay \$0.60 per LOR, while high type consumers are willing to pay \$0.80 per LOR. In addition, the cost to manufacture and deliver a particular set to market is $C = \$0.0005\ LOR^2$. These market conditions are highlighted in Table 1.

		To Low Types		To High Types	
LOR	Unit Cost	Value	Profit	Value	Profit
300	\$45.00	\$180.00	\$135.00	\$240.00	\$195.00
400	80.00	240.00	160.00	320.00	240.00
500	125.00	300.00	175.00	400.00	275.00
600	180.00	360.00	180.00	480.00	300.00
700	245.00	420.00	175.00	560.00	315.00
800	320.00	480.00	160.00	640.00	320.00
900	405.00	540.00	135.00	720.00	315.00

Table 1. Illustration of the Cannibalization Problem

Inspection of Table 1 indicates that the seller would maximize its profits by selling a 600 LOR set to low type consumers with a price tag of \$360.00 per set and an 800 LOR set to high type consumers with a price tag of \$640.00 per set. If the seller were able to price its goods in this manner by pricing each type of set at each type's willingness-to-pay the seller could achieve profits of \$45,500 as shown in Table 2. However, consider a high type consumer's purchase decision when the seller doesn't know the consumer's type. A high type consumer must choose whether to pay \$640.00 for the 800 LOR set that she values at \$640.00, or pay \$360.00 for the 600 LOR set that she values at \$480.00. While the high type consumer places a high value on quality and will view the 800 LOR set as a reasonable value for \$640.00, she will view the 600 LOR set as a bargain that is too good to pass up. In purchasing the 800 LOR set, the consumer gets zero excess surplus, but by purchasing the 600 LOR set, the high type consumer gains a \$120.00 surplus. Clearly, all 175 consumers will purchase the 600 LOR set! This results in a profit of \$31,500 for the seller (Strategy 2).

Seller's Strategy	Profit
1. All Consumers Buy at Their WTP (Best-Case)	$45,500
2. All Consumers Buy 600 LOR Set	31,500
3. Seller Sells Only 800 LOR Set	32,000
4. Lower *p* of High Good By $120.00	33,500
5. Lower *p* of High Good and *q*, *p* of Low Good	36,166

Table 2. Seller's Profits For Five Different Strategies

This distortion in the market that costs the seller $14,000 is the cannibalization problem that all sellers face when trying to service multiple types of consumers in the same channel when the seller can't know a given consumer's type. Indeed, Moorthy and Png [8] calculate a measure of cannibalization $R = \frac{n_h}{n_l}\left(\frac{v_h}{v_l} - 1\right)$, where n_h and n_l are the number of high and low type consumers respectively, and v_h and v_l are the respective valuations of a unit level of quality for each type of consumer. When $R = 0$, there is no potential for cannibalization. This is because there are either no high types in the market or high and low types have the same valuation of quality. Note that in the television example, $R = .\overline{44}$, which is also the percentage different between the actual profits (Strategy 2) and the best-case profits (Strategy 1).

Inspection of Table 2 shows three other strategies the seller could pursue. What is particularly interesting about this stylized example is that the seller could improve its profits using Strategy 3 by removing the low quality good from the market entirely and only selling the high quality good to the high type consumers!

Recall from Table 1 that when the high type consumer buys the 600 LOR set, she receives a $120.00 surplus. The seller could consider reducing the price of the high good by $120.00 to $520.00, thereby making the high type consumers indifferent (Strategy 4). This will result in all consumers buying the "right" product, but it will also reduce profits on the more profitable high-end good.

The fact is that when trying to sell to low type consumers in the same channel as high types, the high type consumers will need to get a reduced price, such that the seller cannot extract the entire surplus from the high type consumers. However, the seller can reduce the required discount for the high quality good by making the low quality good

less attractive to the high type consumers. Moorthy and Png [8] show that the seller should set prices at $p_h = v_h q_h - (v_h - v_l) q_l$ and $p_l = v_l q_l$, and set quality levels at $q_h = \frac{v_h}{2c}$ and $q_l = \frac{v_l}{2c}(1-R)$, whereby the optimal solution is to lower the price of the high-end good, but also reduce the quality and price of the low-end good (Strategy 5). Here the 800 LOR set should be priced at $573.33, while a 333.33 LOR set is priced at $200.00 for the low type consumers. Notice that the seller extracts the entire surplus from the low type consumers and prices just to ensure that they participate in the market. On the other hand, the seller knows the high type consumers will participate in the market. The seller just needs to make sure she buys the right good.

4. A Model of Separating Equilibrium for a Two-Tiered Web Site

We consider a monopolist producer and seller of an online information good that can be differentiated along some dimension of quality, q. The producer sells to a market that is made up of two types of consumers – a high type, h, and a low type, l, with market sizes n_h and n_l respectively. The two consumer types value a product of quality q at $v_h q$ and $v_l q$ respectively, where $v_h > v_l > 0$. For this particular model we impose an additional limitation in that while low type consumers have a positive "value" for the information good, low type consumers are unwilling to actually pay for access to the information. Instead, they are willing to incur the inconvenience of viewing banner advertising at a discomfort rate of $d_l a^2$, where a is a unit measure of advertisement and the discomfort rate is convex in a. Similarly, high types have a discomfort rate of $d_h a^2$, where $d_h > d_l > 0$. Each time a consumer accesses the good from the sponsored site, the seller receives advertising revenue of ra where $r > 0$ and is exogenously given. Also, we assume that the cost of producing the *first copy* of the good with quality q is cq^2, where $c > 0$, and it is costless to produce additional copies of the *same good*. In addition, the seller can create a degraded version of the good at a fixed cost k, where q_h is the original good and q_l is the degraded version. Given this scenario, the seller may produce two versions of the product to be targeted at the two consumer segments. Specifically, a product of high quality, q_h, will be targeted at the high type consumers for an access fee

of p_h, and a product of low quality, q_l, will be available for free to all consumers with revenues of ra for each consumer that accesses the good.

Because of the lack of information about a specific consumer's type, the seller must practice second-degree price discrimination and price the high quality good and set quality levels so that the high type consumers self-select by subscribing to the fee-based content. The cannibalization problem arises because the seller is not able to prohibit the high type consumer from accessing the free content and avoiding the fee-based site. In our model, the potential for cannibalization forces the seller to give the high type consumer a fee discount and lower the quality of the low quality good to the point that the high type consumer still finds the high quality site desirable.

The seller's problem is to set the quality, price, and advertising levels in order to

$$\max_{q_h, q_l, p_h, a} \; ra(n_l + n_h) + n_h p_h - c q_h^{\,2} - k \tag{1}$$

subject to:

$$v_l q_l \geq d_l a^2 \tag{2}$$

$$v_h q_l \geq d_h a^2 \tag{3}$$

$$v_l q_h - v_l q_l \leq p_h \tag{4}$$

$$v_h q_h - v_h q_l \geq p_h. \tag{5}$$

Constraints (2) and (3) are the *participation constraints* for the two consumer segments that ensure that all consumers visit the sponsored site. Constraints (4) and (5) are the self-selection constraints to ensure that the low type consumer will not subscribe to the fee-based content, but the high type consumer will do so. The model is different from the Moorthy and Png [8] and Riggins and Narasimhan [10] analysis in that the cost terms are not marginal costs but rather the development cost associated with producing the *first copy* of the good at that particular quality level. Each additional copy of that version is costless to produce and is not included in the objective function. Therefore, $[ra(n_l + n_h) - k]$ represents the total profit potential to be generated from the sponsored site and $[n_h p_h - c q_h^{\,2}]$ is the total profit potential from the fee-based site. Further notice that

(4) and (5) take into account a unique aspect of information goods – having already consumed the free content, the fee-based site user receives the *incremental benefit* of the difference between q_h and q_l when paying the subscription fee. In other words, having consumed a certain amount of information once, consuming the *same* information a second time results in zero additional benefit. Therefore, having already visited the free sponsored site, a subscriber to the fee-based site receives an additional quality of only $q_h - q_l$.

We can calculate the *efficient* quality level of the fee-based portion of the site as the quality that the seller would provide if first-degree price discrimination were possible. This would occur if the seller were able set $p_h = v_h q_h$. Solving the objective function results in

$$q_h^* = \frac{n_h v_h}{2c} \tag{6}$$

for the high quality good. This leads us to Proposition 1.

PROPOSITION 1. *For information goods on a fee-based site, the optimal level of quality produced in the development stage is proportional to the expected size of the market for that good.*

This is in contrast to the physical good case where quality levels are based on the marginal cost of producing another unit. For information goods the major cost, or in many cases the only cost, is the development cost, whereas production costs are essentially zero. Therefore, the size of the potential market must be strongly considered before embarking on costly information product development.

Returning to the problem in (1) - (5), consider the participation constraints (2) and (3). The seller wants to make sure the low type consumer participates via (2). The seller would also like to make sure the high type consumer visits the free site using (3) in an effort to promote the fee-based site. Suppose the seller binds (2) so that $v_l q_l = d_l a^2$. Then (3) is satisfied provided that $d_h \geq d_l$, where $d_i = v_i/d_i$ is the consumer's *value-discomfort*

index. However, if $d_h < d_l$ then the seller would bind (3) and have (2) be satisfied. The seller will bind the participation constraint of the consumer with the *lower* value-discomfort index. Since the seller will set the level of advertising to make this consumer indifferent between visiting or not visiting the sponsored site, we call this consumer type the *advertising target* of the sponsored site. This is the marginal consumer type from whom the seller is able to extract all consumer surplus regarding the sponsored site.

Now consider (4) and (5). If we assume that (2) and (3) are satisfied, then all consumers will visit the sponsored site. Then (5) assures that high type consumers will subscribe to the fee-based site and (4) ensures that low type consumers will not subscribe. The seller will bind (5) such that $p_h = v_h q_h - v_h q_l$. Note that the high type consumers receive a discount from their willingness to pay, $v_h q_h$. Given that $v_l \leq v_h$, then

$$v_l q_h - v_l q_l \leq v_h q_h - v_h q_l = p_h \tag{7}$$

such that (4) will be satisfied if we bind (5).

Case 1: $d_h \geq d_l$. Bind (2) and (5).

In this case, the advertising target is the low type consumer. Binding (2) to ensure the low type visits the sponsored site gives

$$a = \sqrt{\frac{v_l q_l}{d_l}} \tag{8}$$

as the appropriate amount of advertising for a given level of quality on the free portion of the site. As low type consumers' discomfort with banner ads increases, the number of ads should decrease. On the other hand, when low type consumers value quality content more, the seller can increase ads on the free site.

Binding (5) and using (8) allows us to solve the objective function with respect to the two levels of quality, such that

$$q_h = \frac{n_h v_h}{2c} \tag{9}$$

and

$$q_l = \left[\frac{r(n_l + n_h)}{2v_h n_h}\right]^2 d_l \tag{10}$$

where the seller's profits for case 1 are

$$\Pi_1 = \frac{r^2(n_l + n_h)^2}{4v_h n_h} d_l + \frac{v_h{}^2 n_h{}^2}{4c} - k\,. \tag{11}$$

Case 2: $d_h < d_l$. Bind (3) and (5).

Here, the high type consumer is the advertising target who has the lower value-discomfort index such that the seller extracts all of the high type consumer's value from the sponsored site. Using the same procedure, binding (3) gives

$$a = \sqrt{\frac{v_h q_l}{d_h}} \tag{12}$$

as the appropriate amount of advertising that keeps the *high type consumer* interested in the sponsored site. As high type consumers' discomfort with banner ads increases, the number of ads should decrease. On the other hand, when high type consumers value quality content more, the seller can increase ads on the free site.

Binding (5) and using (12) in the objective function results in

$$q_h = \frac{n_h v_h}{2c} \tag{13}$$

and

$$q_l = \left[\frac{r(n_l + n_h)}{2v_h n_h}\right]^2 \delta_h \tag{14}$$

where the seller's profits for case 2 are

$$\Pi_2 = \frac{r^2(n_l + n_h)^2}{4v_h n_h}\delta_h + \frac{v_h{}^2 n_h{}^2}{4c} - k\,. \tag{15}$$

Notice that in both cases, the quality of the high good is at the efficient amount shown in (6). On the other hand, the low quality good is degraded to an amount that is proportional to the value-discomfort index of the marginal consumer type.

For both cases, we are interested in knowing the implications of changes in *r*, which is exogenously given. Due to the collapse of the dot-com economy providers of free sponsored sites have struggled to find a profitable business model based on advertising revenues. This is because the fees these sites can charge advertisers have decreased as cash-strapped dot-com companies have exited the marketplace or cut back on their advertising expenditures. In our model, this would correspond to a reduction in *r*. As shown in (10) and (14), q_l is increasing in *r*, so that when *r* decreases the seller lowers the quality of the content on the free site since there is less revenue potential from low type consumers visiting that portion of the site. Stated more formally,

PROPOSITION 2. *When fees charged for online advertising decrease, the seller decreases the quality of content on the sponsored portion of the Web site.*

Provided that *r* is sufficient such that

$$\frac{r^2(n_l + n_h)^2}{4v_h n_h}\delta_l \geq k \quad \text{where } \delta_l = \min\{\delta_h, \delta_l\} \tag{16}$$

the seller will degrade the high quality product to create the low quality good and offer the sponsored site.

While Proposition 2 is not particularly surprising, we see from (7) that a reduction in q_l impacts the fee charged to high type consumers. Specifically, when the seller has less revenue from ads on the sponsored portion of the site, the seller reduces the quality of the free content thereby making it less attractive to high type consumers. The seller is then free to increase the fee charged to these premium customers.

PROPOSITION 3. *When fees charged for advertising on the sponsored portion of the Web site decrease, the seller is able to raise the access fee charged to consumers of the fee-based portion of the site.*

When the advertising revenues are reduced, the seller is able to make up some of the loss by raising subscription fees, however, from (11) and (15) we see that $\frac{\partial \Pi}{\partial r} \geq 0$ such that profits are reduced with r is reduced. Therefore, a reduction in advertising potential results in lower quality on the sponsored site, high access fees for the fee-based site, and overall lower profits for seller. The opposite would occur if r were to increase.

We are also interested in examining the implications of changes in the value-discomfort index. While the seller needs to take the relative quality valuations, v_i, as given, the seller may be able to change a given consumer's discomfort due to banner ads. For example, one sponsored site mentioned earlier not only places a banner ad at the top of each Web page, but also uses Flash-based multimedia advertisements to pop-up and move across the screen even to the point of blocking content. To many users, this increases the discomfort level, d_i, associated with accesses the free information. On the other hand, Web-based personalization tools allow the information provider to display ads that are based on the particular user's personal interests, thereby lowering the user's discomfort level.

What, then, are the implications in changes to d_i? Recall that $\dot{q} = v_i/d_i$. From (10) and (14) we see $\frac{\partial q_l}{\partial d_l} \leq 0$ for Case 1 and $\frac{\partial q_l}{\partial d_h} \leq 0$ for Case 2. In other words lowering the

discomfort level for the advertising target consumer segment allows the seller to increase the quality of the content on the sponsored site and thereby increase the amount of advertising on the sponsored site. Further, we know that this forces the seller to lower the fee for the high quality content, but results in overall higher profit levels. Specifically, we can state Proposition 4 as

PROPOSITION 4. *If the seller can use personalization technology to improve ad relevancy and thereby lower the discomfort rate of visitors to the sponsored site, the seller should seek to make ads more relevant to the consumer type with the lower value-discomfort index, $d_i = v_i/d_i$, only.*

Of course, it should be noted that while lowering d_i will result in increased profit, it would also increase d_i. In other words, for Case 1, efforts to lower d_l may result in d_l becoming greater than d_h, causing a switch to Case 2 (and vice versa). The reader should notice from (11) and (15) that $\Pi_1 = \Pi_2$ when the two consumer segments have the same value-discomfort index. A continuous effort to improve ad relevancy may reach a steady state point where $d_l = d_h$, and the seller focuses on making ads relevant for both types of consumers simultaneously.

5. Conclusion

We have analyzed the seller's information quality development problem when the majority of costs are associated with development and not production. This is common with most information goods offered through the online channel including music, literary works, software, and video presentations. Unlike the conventional production of physical goods we have shown that the optimal level of quality for the fee-based content is proportional to the expected size of the market. This indicates that providers of unique information product must consider the overall size of the potential market in order to recover the huge fixed development costs.

We have also shown that a reduction in the potential for advertising revenues from online banner ads results in a reduction in quality of free information offered on sponsored sites and an increase in fees charged for high quality information services.

This is because a reduction in quality of the free information makes that content less attractive to high type consumers and therefore decreases the likelihood the seller will cannibalize the fee-based content. With the continued decline of the dot-com economy and a depressed online advertising market, we should expect to see less unique information offered on free Web sites and higher fees for high quality content. These reductions in advertising rates also result in reduced profits for the information provider.

We have also shown that when personalization tools can be used to make banner ads more relevant, thereby decreasing user discomfort associated with the sponsored site, the seller can raise the quality of the sponsored site content and increase the amount of advertising on the site resulting in higher profits. The seller must correspondingly lower the price for the fee-based content to avoid cannibalization. Also, we have shown that the seller will focus such efforts on the advertising target consumer, that is, the consumer with the lower value-discomfort index, v_i/d_i.

Further extensions of this analysis currently underway include consideration of the seller's problem with future commitment is not possible and the inclusion of a product degradation cost. In particular, the strategy many information providers employ is to develop the high quality good first, and then purposely degrade that product to create the low quality version.

References

[1] Bensanko, D., W.L. Winston. "Optimal Price Skimming by a Monopolist Facing Rational Consumers," *Management Science*, 36, 5, (May 1990), 555-567.

[2] Bhargava, H.K., V. Choudhary, "Information Goods and Vertical Differentiation," *Journal of Management Information Systems*, 18, 3, (Fall 2001).

[3] Conner, K.R., "Strategies for Product Cannibalization," *Strategic Management Journal*, 9, (Special Issue 1988), 9-26.

[4] Dewan, R., B. Jing, A. Seidmann, "Adoption of Internet-based Product Customization and Pricing Strategies," *Journal of Management Information Systems*, 17, 2, (Summer 2000), 9-28.

[5] Dewan, R., B. Jing, A. Seidmann, "Product Customization and Price Competition on the Internet," working paper, Simon School of Management, University of Rochester, 2001.

[6] Jones, R., H. Mendelson, "Product and Price Competition for Information Goods," working paper Stanford University, 1998.

[7] Levinthal, D.A., D. Purohit, "Durable Goods and Product Obsolescence," *Marketing Science*, 8, 1, (Winter 1989), 35-56.

[8] Moorthy, K.S., I.P.L. Png, "Market Segmentation, Cannibalization, and the Timing of Product Introductions," *Management Science*, 38, 3, (March 1992), 345-359.

[9] Purohit, D., "Dual Distribution Channels: the Competition Between Rental Agencies and Dealers," *Marketing Science*, 16, 3, (Summer 1997), 228-245.

[10] Riggins, F.J., S. Narasimhan, "Overcoming Product Cannibalization in the Online Channel Using Personalization Technology, Community Access, and Intertemporal Price Discrimination," working paper, Carlson School of Management, University of Minnesota, 2001.

[11] Salop, S., "Monopolistic Competition with Outside Goods," *Bell Journal of Economics*, 10, 1, (January 1979), 141-156.

[12] Shapiro, C., H. R. Varian, "Versioning: The Smart Way to Sell Information," Harvard Business Review, (Nov-Dec 1998).

[13] Shapiro, C., H. R. Varian. *Information Rules*, Harvard Business School Press, Boston, MA, (1999).

[14] Spence, A.M., "Multi-Product Quantity-Dependent Prices and Profitability Constraints," *Review of Economic Studies*, 47, 5, (October 1980), 821-841.

[15] Tirole, J. *The Theory of Industrial Organization*, MIT Press, Cambridge, MA, 1988.

[16] Varian, H. *Microeconomic Analysis*, 3rd Edition, Norton, 1992.