Search Advertising Based Promotion Strategies for Online Retailers

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ABSTRACT

Web site addresses of small on line retailers are often unknown to customers. Therefore, web retailers use broadcast and search advertising to inform customers of their existence. We find that use of search advertising by a monopoly retailer may increase advertising costs and may not increase social welfare. In addition to the retailer's existence, customers may also be unaware of the quality of the product. A retailer selling a high quality product may want to signal this information to the customers. We find that use of search advertising as a signaling device is optimal when the quality differential between the high and low quality products is small. In a duopoly, there may be situations where one retailer is known to customers but its competitor is not. The profits of both retailers may increase if the known retailer uses its web site as a portal and charges a fee per transaction from the unknown retailer. When an unknown retailer competes with a known retailer in a large market, it uses more search advertising and less broadcast advertising compared to the case when both retailers are unknown. This response is reversed if the size of the market is small.

Keywords

search, consumer search, search advertising, signaling, competition

1. ADVERTISING BY ONLINE RETAILERS

There has been a proliferation of web based retailers in the business to consumer electronic market segment due to rising retail sales (around $172 billion in 2005, see article in the Wall Street Journal [10]) and low costs of operating businesses on line. Many of these retailers are small and do not have the brand recognition to attract shoppers on their own. Advertising is very important for these retailers since this is the only way to get customer traffic on their web sites. A comment by the marketing director of Jenson USA, an Ontario bicycle shop, while explaining the importance of advertising for their firm is pertinent in this regard (Los Angeles Times [5]), *"It helps us reach customers that wouldn't know our name otherwise."*

There are two modes of advertising available to on line retailers: Broadcast advertising and search advertising. Retailers do broadcast advertising by placing bannner or embedded advertisements on websites that get customer traffic relevant to these retailers. To do search advertising, retailers use the services of search engines such as Google or Yahoo. Search advertising exploits the possibility of targeting customers based on their on-line search behavior. All signs are that this mode of advertising has been a huge success, both for the retailers and the search sites. Wall Street Journal [10] reports that 87% of online retailers in a survey sample used search advertising. In addition, an article in Los Angeles Times [4] states that the strong earnings growth Google is enjoying is due to the search advertising services it provides. Other search engines have similar models driving their business growth.

The first question we raise is how should retailers balance their investments in the two modes of advertising? If a retailer opts for search advertising, how much savings can be expected in advertising budgets? The answer is interesting. We find that use of search advertising may result in higher advertising budgets than if the retailer were using broadcast advertising only. This is optimal because the retailer gets increased sales revenue which more than makes up for the additional expense on advertising.

From the standpoint of social welfare, search advertising can be expected to have a beneficial effect since it helps to provide better market coverage. However, we find that better targeting of customers through search advertising leads to increase in prices, which may be high enough to reduce social welfare.

In some situations, the customers may not be aware about the quality of the product being sold by a retailer. This would happen when the product being sold is not branded. Starting from the seminal works of Philip Nelson [8] and Richard Schmalensee [9], it is well known that pricing and advertising spending may be used as signaling devices to convey to consumers that the product being sold is of high quality. However, such signaling is costly because the retailer has to adopt sub-optimal pricing and advertising. The availability of search advertising introduces an interesting question in this context. Does the mechanics of search advertising allow the retailer to signal high quality using a less sub-optimal strategy as compared to advertising through broadcast advertising? The answer to this question is positive, but only in certain situations.

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Search advertising is also expected to change the nature of competition on line. Small retailers can compete with big online retailers more effectively using search advertising. In response to the competition from small retailers, a big retailer like Amazon.com, which is well known among the customers, may follow a strategy to let its competitors use its web site as a portal and charge them for these services. We find that such a strategy may be optimal for both retailers. Finally, we also look at how a retailer's strategy in using search and broadcast advertising changes as customers become informed about the competing retailers.

2. ADVERTISING LITERATURE

One of the important roles of advertising is to inform customers about his/her choices. In the context of Internet commerce, search advertising services are sold by intermediaries such as Google, Yahoo, and Mysimon.com. Recent work by Baye and Morgan [1], Bhargava and Feng [2] and Weber and Zheng [11] has concentrated on finding the optimal fee and the optimal design for the intermediary. Dewan, Freimer and Nelson [3] study how the ownership of the search engines impacts the market and social welfare. Mukhopadhyay, Rajan and Telang [7] show that low quality search engines can survive in the market since search services are typically free of cost for the customers. However, this literature ignores broadcast advertising, which is available to retailers in the form of banner advertising on the Internet. This paper addresses this gap. By considering both types of advertising simultaneously, we examine the tradeoffs between their efficiency of market coverage and cost structure.

If customers are unaware of the quality of the product, the amount of expenditure on advertising may signal the quality of the retailer's product. Important contributions in this research came from Nelson [8], Schmalensee [9] and Milgrom and Roberts [6]. The essence of these papers is that when advertising is useful only for signaling, wasteful (or excess) advertising is used to signal high product quality. Recently Zhao [12] has shown that when broadcast advertising plays the dual role of informing customers about the retailer and signaling, a high quality firm will do the reverse of what the previous literature states: It will reduce advertising to signal high quality. We extend this thread of research to examine the merits of signaling the quality of the product of a monopolist retailer with search advertising. Finally, we also model duopoly competition between retailers.

3. MONOPOLY RETAILER WITH A PRODUCT OF KNOWN QUALITY

Our setting consists of a monopoly retailer that is selling a product of known quality. The customers' willingness to pay for the product is represented by the parameter ρ, which is uniformly distributed between 0 and r with unit density. Each customer has the demand for one unit of the retailer's product.

The retailer sells its product on the Internet. We consider the case of a retailer that is unknown to customers unless they see its advertisement or find it on a search site. This is quite common for small regional sellers with a potentially large national market. We assume that the retailer informs the customers of its web address in one of two ways: Broadcast advertising such as banner and embedded advertisements, and search advertising on search sites such as Google and Yahoo.

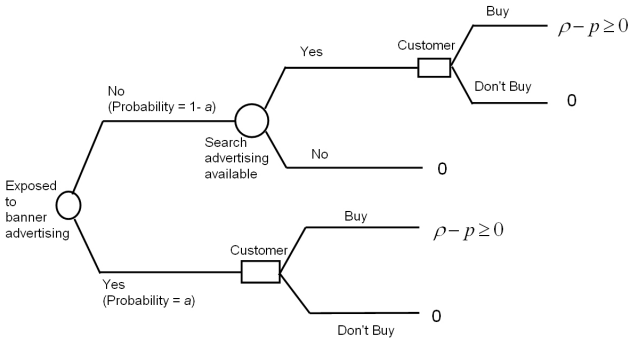

Figure 1: Decision tree for the customer with a monopoly retailer

Figure 1 shows the decision tree of a customer in the process of buying the product. The nodes indicated by circles are the event nodes and those indicated by rectangles are the decision nodes. Let a represent the probability with which a customer is exposed to the broadcast advertising of the retailer. If the price of the product is p and a customer with preference ρ knows the web address of the retailer, she can buy the product and make a net surplus of $\rho - p$. The lower branch of the decision tree shows that of the customers exposed to broadcast advertising, only those with $\rho - p \geq 0$ will buy the product. In case the customer is not exposed to broadcast advertising, she will search for the retailer's web address herself. If the retailer provides search based advertisements also, it is fairly easy to get its web address by specifying some keywords to define the product using the search sites. Therefore we assume that the customer will incur no search costs. Rational customers correctly anticipate the price put by the retailer, who calculates the profit maximizing price knowing that customers correctly anticipate this price. Thus a fulfilled expectations equilibrium ensues. Because of this, only customers who value the product at ρ such that $\rho - p \geq 0$ will search for and buy the product. If the retailer does not provide search advertising, the customer in unable to locate the web address of the retailer as a small retailer does not get a large number of click throughs and is therefore never important enough to have a substantially high ranking on the general search list provided by search engines. In this case, the customer cannot buy the product.

By its very nature, broadcast advertising is not targeted. To get an idea about the cost of this type of advertising, consider a banner advertising campaign on a web site. The longer the advertisement runs, the more new customers are exposed to it. At the same time, the frequent visitors to the web site are exposed to the advertisement many times. The retailer pays for banner advertisements on the basis of number of impressions. Therefore, while repeated exposure of frequent visitors does not increase the total number of customers exposed to the advertisement, it results in additional costs. So we assume that broadcast advertising expense is increasing and convex in the fraction of customers exposed to the advertisement. In particular, we assume that the retailer incurs a cost of ka^2 for achieving a broadcast adver-

tising reach of a.

Search advertising is a self-targeted type of advertising because the customer is exposed to the advertisement only when she consciously searches for the retailer's web site based on keywords describing the product. The search site which carries the retailer's search advertisement charges a fee to the retailer for every customer who clicks on the hyperlink provided by the search advertisement. This type of charge reflects the *pay per click* method of payment which is common in the search advertising industry. Let d represent the pay per click charge for every customer who visits the retailer's web site through search advertising.

Given the costs of search and broadcast advertising, the retailer chooses its advertising policy (which advertising modes, broadcast or search, to use and how much to advertise) and price. The customers then buy the product if they become aware of the retailer's web address through advertisements and if they get a positive surplus from buying the product.

Let us examine the advertising policy more closely. The retailer may choose any combination of search and broadcast advertising. Since broadcast advertising costs are taken to be ka^2, some broadcast advertising will always be provided. Thus there are two possible advertising policy choices for the retailer: One in which the retailer subscribes to both broadcast and search advertising(dual mode advertising strategy), and the other in which it subscribes to only broadcast advertising (single mode advertising strategy).

Before we formulate the retailer's problem, we will list some restrictions on the parameter values to focus on situations of interest.

ASSUMPTION 1. *The pay per click fee is less than the highest reservation price, i.e.,* $d < r$.

ASSUMPTION 2. $r < Min[\frac{4k}{d}, 2\sqrt{2k}]$. *This eliminates the uninteresting case of market saturation through broadcast advertising where the retailer gets 100% market reach through broadcast advertising alone.*

Note that for the assumptions 1 and 2 to be feasible together, we must have $d < \frac{4k}{d} \Longrightarrow k > \frac{d^2}{4}$.

3.1 Dual mode advertising strategy

Here the retailer's strategy is to provide both broadcast and search advertising. $(r-p)$ customers have a positive surplus from buying the product. A fraction $(1-a)$ of these customers are not exposed to the broadcast advertising. So they use the search advertisement route to obtain the retailer's web address. Thus the retailer incurs a search advertising cost of $(1-a)(r-p)d$. Normalizing the marginal cost to 0, the profit function of the retailer is:

$$\pi_d = (r-p)p - ka^2 - (1-a)(r-p)d$$

The retailer will maximize its profit with respect to the price p and broadcast advertising reach a. The Hessian matrix of π_d is negative definite due to assumptions 1 and 2. Therefore, the profit function is jointly concave in a and p.

The equilibrium values are:

$$a_d^* = \frac{d(r-d)}{4k-d^2}$$
$$p_d^* = \frac{2k(r+d)-d^2r}{4k-d^2}$$
$$\pi_d^* = \frac{k(r-d)^2}{4k-d^2}$$

The parameter d has an interesting effect on the equilibrium pricing and broadcast advertising reach. As d increases:

1 Equilibrium price increases if $r < \frac{4k+d^2}{2d}$ and decreases otherwise,

2 equilibrium broadcast advertising increases if $r > \frac{8dk}{4k+d^2}$ and decreases otherwise.

The pricing behavior can be explained as follows. As d increases, the margin per customer for a given price decreases. If $r > \frac{4k+d^2}{2d}$, there are a considerable number of customers with relatively high valuations who are outside the market due to high prices. As d increases, it becomes optimal to reduce prices and gain volume in the market. However, if $r < \frac{4k+d^2}{2d}$, then the optimal reaction is to increase the price to get a larger margin per customer from lesser number of customers. For explaining the effect on broadcast advertising, note that an increase in d increases the cost of getting a customer through search advertising. Therefore, one would expect that broadcast advertising should increase so that the marginal cost of getting a new customer through both advertising modes is balanced. However, if $r < \frac{8dk}{4k+d^2}$, the opposite happens. The reason is that price increases with increase of d for $r < \frac{8dk}{4k+d^2}$ (since $\frac{8dk}{4k+d^2} < \frac{4k+d^2}{2d}$). Thus the market coverage reduces. Consequently, the marginal cost of getting a new customer through broadcast advertising increases to be more than d. Hence broadcast advertising is reduced.

3.2 Broadcast Advertising Strategy

The profit function of the retailer under this strategy is:

$$\pi_b = a(r-p)p - ka^2$$

As before, the retailer will maximize its profit simultaneously with respect to the price p and broadcast advertising reach a. Three critical points exist out of which two imply a 0 value for π_b while the third provides a positive value. Since π_b is continuous, this third point is the global maximum.

The equilibrium values in this case are:

$$a_b^* = \frac{r^2}{8k}$$
$$p_b^* = \frac{r}{2}$$
$$\pi_b^* = \frac{r^4}{64k}$$

Next we find the condition when the dual mode advertising strategy is superior to broadcast advertising only.

LEMMA 1. *The strategy to adopt dual advertising modes maximizes the retailer's profit when the pay per click fee* $d < d_e = \frac{2(32k^2r - \sqrt{kr^4(r^2-8k)^2})}{r^4+64k^2}$

PROOF. We get this result by comparing π_d^* and π_b^*. □

Search advertising is becoming ubiquitous due to its targeting capabilities and many retailers feel that it is extremely effective in getting customers to their web sites. An important question for managers is whether employment of search advertising necessarily translates into smaller advertising costs. We answer this question in the next result.

PROPOSITION 1. *When it is profit maximizing to provide search advertising through the dual mode strategy, then at the margin defined by Lemma 1 ($d = d_e$), the total advertising cost is more than the advertising cost in the single mode strategy with broadcast advertising only.*

PROOF. The total advertising cost in the dual mode strategy is $k(a_d^*)^2 + (1 - a_d^*)(r - p_d^*)d$. In the single mode strategy with broadcast advertising only, these costs are $k(a_b^*)^2$. Comparing these costs at $d = d_e$ gives us the stated result. □

This proposition points out that when the retailer chooses to get the customers through both advertising modes, it may be profit maximizing to increase the total advertising costs to reach the optimal number of customers in the appropriate customer segments. Interestingly, a recent article in the Wall Street Journal [**?**] states that this seems to be happening in the industry.

Our next observation comes from analyzing the behavior of equilibrium prices. It is easily seen that the price in the dual mode strategy, p_d^*, is higher than the price, p_b^*, in the single mode strategy. Higher price with the dual advertising modes implies that a larger fraction of customers are excluded from the market since they get a non positive surplus from buying the retailer's product. In the single mode strategy, although the price is lower, the section of the market not exposed to broadcast advertising is excluded from the market. Thus welfare may increase or decrease with the availability of search advertisements. In particular, there is a possibility that welfare may reduce even when it is profit maximizing to employ the dual mode advertising strategy. The next proposition answers the question about welfare creation.

PROPOSITION 2. *When a retailer adopts the dual mode advertising strategy, then at the margin defined by $d = d_e$, social welfare is reduced.*

PROOF. The consumer welfare in the dual mode advertising strategy is $CS_d = \int_{p_d^*}^{r}(x - p_d^*)dx$, and in the single mode advertising strategy it is $CS_b = a_b^* \int_{p_b^*}^{r}(x - p_b^*)dx$. At $d = d_e$, the retailer profits in both advertising strategies are the same. Therefore, comparing CS_d and CS_b at $d = d_e$ gives us the statement of the proposition. □

Thus we find that the increase in price with the dual advertising modes is so high that it always reduces social welfare at the margin when the firm switches to the dual mode strategy. Social welfare will be created only when the cost of search, d, becomes low enough.

4. MONOPOLY RETAILER WITH A PRODUCT OF UNKNOWN QUALITY

In this section we consider a situation where the quality of a monopoly retailer's product is exogeneously fixed to be of either high or lwo quality. While the retailer knows the quality of its product, the customers are unaware of the actual quality. Henceforth, we will refer to the retailer as the high quality (low quality) retailer if he sells the high (low) quality product. In this situation, the customers' willingness to pay for the high quality retailer's product depends on their belief about the product's quality. If they believe that the product is of low quality, they will be willing to pay less than what the product is actually worth to them. Thus the uncertainty of customers about the quality of the retailer's product may have a negative impact on the high quality retailer's profit. Therefore, such a retailer has an incentive to inform the customers that its product is of high quality. In marketing literature, researchers have found that suitable modification of the price and advertising spending from their optimal levels when the customers are aware that the product is of high quality constitutes an effective mechanism to signal the product's quality to the customers. Milgrom and Roberts [6] showed that when all customers observe a firm's advertisements, the firm signals by increasing the advertising expenditure. Later on Zhao [12] considered the case where all customers do not observe the firm's advertisements, and only those customers who observe the firm's advertisements buy the product. In this case the firm signals by reducing its advertising expenditure, which is the reverse of what Milgrom and Roberts found.

To summarize, the high quality retailer may want to signal to the customers that its product is of high quality through a judicious mix of advertising and pricing policies. Observing these policies, rational customers arrive at correct conclusions about the actual quality of the product being marketed. The intent of this section is to study the effectiveness of dual mode advertising vis-a-vis the single mode strategy with broadcast advertising to signal the quality of the product for the high quality retailer.

If the high quality retailer adopts an advertising and pricing policy that a low quality retailer is unwilling to adopt, and if such a policy provides higher profits to the high quality retailer than if it adopts any other policy and is mistaken to be a low quality retailer, then the high quality retailer will adopt such a policy. Since this policy will not be adopted by the retailer if it were a low quality retailer, the customers will be able to correctly infer the quality of the product being sold on observing the policy of the retailer. In other words, a separating equilibrium will ensue. Henceforth, the superscripts H and L stand for the type of retailer (high quality and low quality) and the subscripts H and L stand for the beliefs that customers form about the retailer's type on observing its policy. Therefore, in a separating equilibrium a retailer will make a profit of π_H^H if it is selling a high quality product and a profit of π_L^L if it is selling a low quality product. If a low quality retailer mimics the policies that a high quality retailer would adopt, and is therefore mistaken to be a high quality retailer, it will earn a profit of π_H^L. In case a high quality retailer is unable to adopt a credible signaling policy, a pooling equilibrium will result in which the customers are unable to infer the quality of the product being sold. So they may mistake a high quality retailer to be

selling a low quality product. If this happens, a high quality and a low quality retailer would earn profits of π_L^H and π_L^L respectively. In order to enforce a separating equilibrium, the high quality retailer solves the following constrained optimization problem:

$$\begin{aligned} \max_{a,p} \quad & \pi_H^H \\ s.t. \quad & \pi_L^L \geq \pi_H^L \\ & \pi_H^H \geq \pi_L^H \end{aligned}$$

where the first constraint indicates that mimicry is not profitable if the retailer has a low quality product and the second constraint indicates that the retailer of the high quality product makes a higher profit in a separating equilibrium than if it were mistaken to be a retailer of the low quality product in a pooling equilibrium. If the mimicry constraint is not binding, there is no threat that a low quality retailer would mimic the policy of the high quality retailer. Essentially, the signaling is accomplished for free in this case. For the problem to be of interest, signaling should be costly, which implies that the mimicry constraint must be binding. We will consider only these situations. In the forthcoming proof of Lemma 2, we will indicate the conditions under which this will happen.

As in the previous section the customers' willingness to pay for the high quality product is ρ which is uniformly distributed between 0 and r with unit density. The marginal cost for the high quality product is c and for the low quality product it is 0, where $c > 0$. Implicit in our optimization problem is the fact that the high quality retailer may adopt either the dual mode advertising policy, or the policy of providing broadcast advertising only. If it adopts the dual mode policy, its profit function is as follows:

$$\pi_H^H = (r-p)(p-c) - ka^2 - (1-a)(r-p)d$$

The formulation of this profit function is based on two observations. First, the customers know the actual price being charged by the retailer *before* they click on the link provided by search advertising. Second, the observation of price is alone is sufficient to convince the customers that the product is a high quality product. The first observation is based on the fact that many shopping web sites which provide search advertising services such as Findgift.net and Yahoo Shopping etc. display the prices of the retailers along with their links. Some prominent search services such as Google do not require retailers to display the prices. However, it is in the interest of a high quality retailer to display its price along with the display of its link. Not doing so would result in a deadweight loss for such a retailer because if the customers whose willingness to pay is greater than p do not click on the link the retailer looses potential buyers. If customers whose willingness to pay is less than p click on link, the retailer ends up paying a cost d for each such customer who will not buy the product. A random search on Froogle indicated that myflavia.com, a retailer for coffee espresso machines displayed its price of $99 on the search link itself. The logic for the second observation that price alone is sufficient to convince the customers that the product is of high quality will become clear in the forthcoming proof of Lemma 2. In view of the above discussion, all customers with willingness to pay between r and p will buy the product, and the expenditure on search advertising is $(1-a)(r-p)d$.

The next lemma provides the signaling solution for the case when the high quality retailer adopts dual mode advertising:

LEMMA 2. *With the dual mode advertising policy, the high quality retailer signals by lowering its broadcast advertising compared to the case when the product quality is known to the customers. The optimal advertising, pricing and profits are:*

$$a_H^{HD*} = \frac{d(r-d)}{4k-d^2} - \frac{d\sqrt{k(k(r-d)^2 - \pi_L^L(4k-d^2))}}{(4k-d^2)k}$$

$$p_H^{HD*} = r - \frac{2a_H^{HD*}k}{d}$$

$$\pi_H^{HD*} = \pi_L^L - \frac{2c\left(k(r-d) - \sqrt{k(k(r-d)^2 - \pi_L^L(4k-d^2))}\right)}{4k-d^2}$$

PROOF. Suppose that customers use only the pricing information to decide whether the retailer is selling a high or a low quality product. Is this a rational decision? In what follows, we will show that the optimal choice of advertising reach by a low quality retailer who prices as if it were a high quality retailer, is the same as the advertising reach chosen if it were a high quality retailer. Therefore, mimicry of price implies mimicry of advertising reach. Hence, observation of price alone is sufficient for the customers to decide whether the product is of high or low quality. Let p be the price chosen by the high quality retailer. The following function defines the profit earned by a low quality retailer when it mimics only the pricing of the high quality retailer and customers believe that the product is of high quality after observing this price:

$$\pi_H^L = (r-p)p - ka_M^2 - (1-a_M)(r-p)d$$

The optimal broadcast advertising reach a_M^* is obtained by solving the corresponding first order condition which gives:

$$p = r - \frac{2a_M^* k}{d} \tag{1}$$

We now consider the problem for the high quality retailer when the low quality retailer mimics only the pricing. We construct the relaxed problem without the constraint for the separating equilibrium. In Lemma 3 we will discuss when the separating equilibrium is likely to exist. The lagrangian of the optimization problem for the high quality retailer is:

$$\begin{aligned} \mathcal{L} &= (r-p)(p-c) - ka^2 - (1-a)(r-p)d \\ &\quad + \lambda\left(\pi_L^L - \{(r-p)p - (ka_M^*)^2 - (1-a_M^*)(r-p)d\}\right) \end{aligned}$$

The first order condition of $\mathcal{L}$ with respect to a is as follows:

$$(2ak - (r-p)d) = 0$$

From the above equation, we get

$$p = r - \frac{2ak}{d} \tag{2}$$

Both the equations (1) and (2) give the price p chosen by the high quality retailer. Equating them we see that $a_M^* = a$. In other words, mimicking the price is optimal only when the advertising reach is also mimicked. Therefore, observation of price alone is enough for the customers to conclude that the product is of high quality.

Next we determine what price is chosen by the high quality retailer to signal its quality, knowing that its choice of

advertising reach will also be mimicked. Substituting for p from Equation (2) and putting $a_M = a$ in the mimicry constraint we obtain:

$$a^2(\frac{4k^2}{d^2} - k) + a(2k - \frac{2kr}{d}) + \pi_L^L = 0 \quad (3)$$

Solving the above equation for a we obtain two possibilities:

$$a_1 = \frac{d(r-d)}{4k-d^2} - \frac{d\sqrt{k(k(r-d)^2 - \pi_L^L(4k-d^2))}}{(4k-d^2)k}$$

and,

$$a_2 = \frac{d(r-d)}{4k-d^2} + \frac{d\sqrt{k(k(r-d)^2 - \pi_L^L(4k-d^2))}}{(4k-d^2)k}$$

To find which one of these critical points constitute the global maximum (i.e give the high quality retailer a higher profit), we construct the unconstrained profit function of the high quality retailer as a function of a. This is done by substituting $p = r - \frac{2ak}{d}$ obtained from the first order condition of $\pi_H^H(a,p)$ with respect to a. The function we construct is:

$$\frac{ka\left(2d(r-c) - 4ak - (2-a)d^2\right)}{d^2}$$

and its second derivative with respect to a is $2k(1 - \frac{4k}{d^2})$, which has a constant negative value due to assumptions 1 and 2. Therefore, the unconstrained profit function is symmetric and concave and is maximized at $a_u^* = \frac{d(r-d-c)}{4k-d^2}$. Since $c > 0$, we have $\frac{d(r-d-c)}{4k-d^2} < \frac{d(r-d)}{4k-d^2}$. Therefore, $|a_1 - a_u^*| < |a_2 - a_u^*|$, which implies that the high quality retailer gets a higher profit by choosing a_1. The corresponding price is arrived at using equation (2). This completes the proof of the lemma.

One final point to make is if $a_u^* < a_1$, then the high quality retailer can maximize its profit by choosing a_u^* as the optimal advertising reach, while simultaneously satisfying the mimicry constraint as it is slack at a_u^*. From the expression of a_u^*, note that this condition will happen if the marginal cost of the high quality product, c, is large enough. As mentioned earlier, our analysis is confined to the interesting case where c is small so that the mimicry constraint is binding. □

The results in Lemma 2 are reminiscent of Zhao [12] where the broadcast advertising is reduced to signal a high quality product in a setting where the broadcast advertising is the only mode of information for customers.

Our next result establishes that a separating equilibrium will exist with the dual mode advertising policy.

LEMMA 3. *When the dual mode advertising policy is adopted a separating equilibrium will exist if the cost of search advertising, d, and the marginal cost, c, are small.*

PROOF. We outlined the solution to the relaxed problem with dual mode advertising for the high quality retailer in Lemma 2. If the constraint we did not consider, $\pi_H^H \geq \pi_L^H$, is also satisfied with this solution, then a separating equilibrium will be established.

Suppose that the highest reservation price for the low quality product is r_L, where $r_L < r$. Also, let d be small enough so that dual mode advertising is the preferred policy for both the high and low quality retailers in a pooling equilibrium. From the analysis in section 3.1, then, $\pi_L^L = \frac{k(r_L-d)^2}{(4k-d^2)}$. Similarly, when the high quality retailer is mistaken as a low quality retailer in a pooling equilibrium, it will adopt optimal advertising and pricing policies in anticipation of the pooling equilibrium, i.e., $\pi_L^H = \frac{k(r_L-c-d)^2}{(4k-d^2)}$. Substituting the values of π_H^H from Lemma 2, and π_L^H and π_L^L from the previous analysis in the constraint $\pi_H^H \geq \pi_L^H$ and simplifying, we obtain:

$$c \leq 2\left(-(r-r_L) + \sqrt{(r-r_L)(r+r_L-2d)}\right)$$

Note that $r_L > d \Longrightarrow \left(-(r-r_L) + \sqrt{(r-r_L)(r+r_L-2d)}\right) > 0$. Thus, if c is small enough the constraint $\pi_H^H \geq \pi_L^H$ will be satisfied and a separating equilibrium is established. □

If the high quality retailer adopts the policy of utilizing broadcast advertising only to signal high quality, then the profit functions are as follows:

$$\pi_H^H = a(r-p)(p-c) - ka^2$$
$$\pi_H^L = a(r-p)p - ka^2$$

We assume as in Zhao [12] that the customers who are exposed to broadcast advertising, are also informed about the expense incurred on it. This problem is the same as that solved by Zhao. Therefore, qualitatively similar results are expected. However, in our formulation, the solution is algebraically complicated and is not easy to analyze directly. Therefore, we will not provide its solution in an explicit form. We represent the optimal value of profit for this case by π_H^{HB*} and the corresponding values of decision variables by p_H^{HB*} and a_H^{HB*}. Now we concentrate on characterizing the situations where the high quality retailer prefers the dual mode advertising policy over the single mode policy with broadcast advertising only to signal high quality. Our next proposition incorporates this result.

PROPOSITION 3. *Dual mode advertising is more likely to be the optimal policy to signal the quality of the high quality product as the low quality product becomes more profitable i.e. as π_L^L increases.*

PROOF. The solution to the high quality retailer's problem with the dual mode advertising policy is available from Lemma 2 and Lemma 3.

Next, we characterize the solution to the high quality retailer's problem when it chooses to adopt the single mode advertising policy with broadcast advertising only. We consider the relaxed problem of the high quality retailer without the constraint for the separating equilibrium. The lagrangian is:

$$\Gamma = a(r-p)(p-c) - ka^2 + \gamma\left(\pi_L^L - \{a(r-p)(p) - ka^2\}\right)$$

The first order conditions of Γ with respect to a and p are

$$(r-p)(p-c) - 2ak - \gamma((r-p)p - 2ak) = 0$$

and,

$$(r+c-2p) - \gamma(r-2p) = 0$$

Eliminating γ from the above two equations we get

$$p = r - \sqrt{2ak} \tag{4}$$

Substituting p from equation (4) in the mimicry constraint for this case, we arrive at

$$\pi_L^L + 3a^2k - \sqrt{2k}a^{3/2}r = 0 \tag{5}$$

We can write $\pi_H^{HB*} = a_H^{HB*}(r - p_H^{HB*})(p_H^{HB*} - c) - k(a_H^{HB*})^2$. From the mimicry constraint we have $\pi_L^L = a_H^{HB*}(r - p_H^{HB*})p_H^{HB*} - k(a_H^{HB*})^2$. Therefore we have $\pi_H^{HB*} = \pi_L^L - a_H^{HB*}c(r - p_H^{HB*})$. Similarly, we can write $\pi_H^{HD*} = \pi_L^L - (r - p_H^{HD*})c$.

The condition for the profits with the dual mode advertising policy to be greater than the profits with the single mode advertising policy is:

$$\pi_H^{HD*} > \pi_H^{HB*} \tag{6}$$

Substituting p_H^{HD*} and p_H^{HB*} using equations (2) and (4); and further using equation (5) to substitute for $(a_H^{HB*})^{\frac{3}{2}}$ in the above inequality and simplifying we get:

$$\pi_L^L > \frac{2kr}{d}a_H^{HD*} - 3k(a_H^{HB*})^2 \tag{7}$$

The left side of the above inequality is just π_L^L and so its slope with respect to π_L^L is 1. Next, we will show that the slope of the expression on the right side of the inequality may become less than 1 as π_L^L increases. We obtain the expressions for the derivatives of a_H^{HD*} and a_H^{HB*} with respect to π_L^L by differentiating equations (3) and (5). These derivatives are:

$$\frac{da_H^{HD*}}{d\pi_L^L} = \frac{-1}{2a_H^{HD*}(\frac{4k^2}{d^2} - k) + (2k - \frac{2kr}{d})} \tag{8}$$

and,

$$\frac{da_H^{HB*}}{d\pi_L^L} = \frac{-1}{\sqrt{ka_H^{HB*}}(6\sqrt{ka_H^{HB*}} - \frac{3r\sqrt{2}}{2})} \tag{9}$$

Although it is difficult to see in our formulation of the problem, from Zhao (2000) we know that $a_H^{HB*} \leq a_b^*$, where $a_b^* = \frac{(r-c)^2}{8k}$ (from analysis shown in section 3.2, but with marginal cost $c > 0$). Therefore, the denominator of equation (9) is negative. Hence, $\frac{da_H^{HB*}}{d\pi_L^L} > 0$. The derivative of the expression on the right hand side of Inequality (7) with respect to π_L^L is:

$$\frac{2kr}{d}\frac{da_H^{HD*}}{d\pi_L^L} - 6a_H^{HB*}k\frac{da_H^{HB*}}{d\pi_L^L}$$

Substituting the value of the derivatives from equations (8) and (9) in this expression and simplifying we get

$$\frac{r}{r - d - \frac{a_H^{HD*}(4k-d^2)}{d}} + \frac{6ka_H^{HB*}}{6ka_H^{HB*} - \frac{3\sqrt{2}}{2}r\sqrt{ka_H^{HB*}}}$$

The denominator of the first term is positive since we know from Lemma 2 that $a_H^{HD*} \leq \frac{d(r-d)}{4k-d^2}$. The denominator of the second term is negative since $a_H^{HB*} = \frac{(r-c)^2}{8k}$, as discussed earlier. For the above expression to be weakly less than 1, we must have

$$2\sqrt{2ka_H^{HB*}} \geq d + \left(\frac{4k - d^2}{d}\right)a_H^{HD*} \tag{10}$$

If π_L^L is close to 0, then the low quality retailer will mimic any policy that a high quality retailer would adopt. This is because any policy that gives a positive profit to the high quality retailer will certainly provide a positive (and higher) profit to the low quality retailer as its marginal cost is lower than that for a high quality retailer. The only way for the high quality retailer to stop mimicry by the low quality retailer is to advertise such that its own profits are zero. For this, the high quality retailer must choose $a_H^{HB*} \to 0$ for the single mode broadcast advertising policy and $a_H^{HD*} \to 0$ for the dual mode advertising policy. In both cases, this will lead to an optimal price equal to r (see equations (4) and (2)). This results in zero market size and zero profit for the high quality retailer. In this situation, the inequality (10) will not be satisfied because of the constant term d on the right hand side.

From the discussion in the previous paragraph, we also know that as $\pi_L^L \to 0$, the left and right side expressions in Inequality (7) go to zero. Further, we saw that the slope of the expression on the left side (=1) is less than the slope of the expression on the right (> 1) since Inequality (10) is not satisfied. Thus Inequality (7) cannot be satisfied if π_L^L is close to zero i.e. the dual mode policy cannot be the optimal policy.

From earlier analysis, we know that $\frac{da_H^{HB*}}{d\pi_L^L} > 0$. Therefore, the Inequality (10) may be satisfied as π_L^L increases i.e. the slope of the right side of the expression in Inequality (7) may become less than 1. Hence, the dual mode policy may become more profitable as π_L^L increases. From Lemma 3 we also know that that a separating equilibrium with the dual mode advertising policy will exist for some parameter range.

This completes the proof of the statement in the proposition. □

The important insight from the previous proposition is that high quality retailers are likely to choose the dual mode advertising policy when faced with the issue of differentiating themselves from a low quality retailer whose quality is relatively high. When does the dual mode advertising policy become superior to the single mode broadcast advertising only policy? To understand this, we have to first understand why signaling works. From the results in Lemma 2 it can be shown that in the dual advertising mode, the high quality retailer signals by raising its price. Similarly, Zhao [12] shows that in the single mode advertising policy with broadcast advertising only, the high quality retailer signals by raising price and reducing advertising reach. In both cases, these policies reduce the number of customers who can buy the product. If the low quality retailer mimics the policy of the high quality retailer, its profits are reduced much more than the high quality retailer's profits since it enjoys a greater profit margin per customer at a given price due to lower marginal costs. Thus the tendency of the low quality retailer to mimic is checked by adopting pricing and advertising policies that reduce its profits much more than that of the high quality retailer.

Let us see when signaling through dual mode advertising

may work better for the high quality retailer. Inequality (6) can be written as $a_H^{HB*}(r-p_H^{HB*})c > (r-p_H^{HD*})c$. Note that $a_H^{HB*}(r-p_H^{HB*})$ is the number of customers who buy the retailers product when it adopts the single mode advertising policy with broadcast advertising. Thus $a_H^{HB*}(r-p_H^{HB*})c$ is the additional profit that the low quality retailer makes over the profit of the high quality retailer by mimicry. Similarly, $(r - p_H^{HD*})c$ is the additional profit that the low quality retailer makes by mimicry when the high quality retailer adopts the dual mode advertising policy. The condition implies that the dual mode advertising policy becomes superior when the additional profits made by the low quality retailer under the dual advertising mode become lower than the additional profits made by the low quality retailer under the single mode policy. Essentially, the inherent advantage lies with the policy that provides lesser additional profits to the low quality retailer if it resorts to mimicry.

5. DUOPOLY

The purpose of this section is to characterize the strategic choices of the retailers under a competitive scenario. Competition can be in an asymmetric information setting, in which case the web site of one of the retailers is already known to customers and so it does not require to invest in advertising; or it can be in a symmetric information setting, in which case customers are not aware of the web sites of both the retailers and so both of the retailers have to advertise. We model both these scenarios.

We are specifically interested in situations where the cost of search advertisement, d, is low so that dual mode advertising is the optimal strategy for a retailer whenever it requires to do advertising. The duopoly is modeled as a Bertrand competition between a retailer selling a high quality product (the high quality retailer) and a retailer selling a low quality product (the low quality retailer). The quality of the products are known to customers. The low quality product represents the base product and all the customers are willing to pay B for it. The premium that customers are willing to pay for the high quality product is represented by the parameter ρ which is uniformly distributed between 0 and r with unit density. As in the previous section, the marginal cost of low quality product is normalized to 0, and the marginal cost of the high quality product is $c > 0$. In our exposition, the subscripts H and L will represent the high and the low quality retailers respectively. In addition, there will be two superscripts for each variable. The first superscript will represent whether the customers know the high quality retailer (K), or do not know about it (U). The second superscript with similar notations will represent whether the customers know the rival low quality retailer or not.

To maintain consistency with the situation that the cost of search advertising d is low, we make the following assumptions on the parameter values.

ASSUMPTION 3. $k > \dfrac{cd}{2}$

ASSUMPTION 4. $c > d$

To explain our next assumption, similar to section 3.1, the pay per click fee plus the marginal cost of the high quality product is less than the reservation price. In addition, the highest reservation price is never so high so that it becomes optimal to saturate the whole market through broadcast advertising alone.

ASSUMPTION 5. $c + d < r < \dfrac{4k}{d}\dfrac{3k-d^2}{4k-d^2} + \dfrac{2kc}{4k-d^2}$

We start by modeling the case of competition in an asymmetric information setting.

5.1 Asymmetric information about retailers

The customers may be unaware of either the high quality retailer or the low quality retailer. First, consider the case where they know the low quality retailer only. When the high quality retailer prices at p_H^{UK} and the low quality retailer at p_L^{UK}, the indifferent customer (ρ_I) between the high and low quality product is given by $B+\rho_I-p_H^{UK} = B-p_L^{UK}$. Thus $\rho_I = p_H^{UK} - p_L^{UK}$ and the market sizes for the high and low quality retailers are $r - \rho_I$ and ρ_I respectively. Here we assume that $p_L^{UK} < B$ so that all customers get a positive surplus from buying the low quality product. As in section 3.1, we also assume that a fulfilled expectation equilibrium exists so that the customers will be charged the price that they expect to be charged.

The profit functions of the two retailers, when the high quality retailer adopts the dual mode advertising policy, are:

$$\pi_H^{UK} = a_H^{UK}\left(r - (p_H^{UK} - p_L^{UK})\right)(p_H^{UK} - c) + (1 - a_H^{UK})\left(r - (p_H^{UK} - p_L^{UK})\right)(p_H^{UK} - c - d) - k(a_H^{UK})^2$$

$$\pi_L^{UK} = (p_H^{UK} - p_L^{UK})p_L^{UK}$$

The high quality retailer chooses a_H^{UK} and p_H^{UK}, while the low quality retailer chooses p_L^{UK} in a simultaneous game. Both the profit functions are jointly concave in their respective decision variables (from the assumptions). The equilibrium values are:

$$a_H^{UK*} = \frac{2dr - d(c+d)}{6k - d^2}$$

$$p_H^{UK*} = \frac{2(2k(c+d+r) - rd^2)}{6k - d^2}$$

$$p_L^{UK*} = \frac{2k(c+d+r) - rd^2}{6k - d^2}$$

$$\pi_H^{UK*} = \frac{k(4k-d^2)(2r-c-d)^2}{(6k-d^2)^2}$$

$$\pi_L^{UK*} = \frac{((2k-d^2)r + 2(c+d)k)^2}{(6k-d^2)^2}$$

Besides advertising through the search and broadcast modes, an interesting advertising possibility arises if the retailer whose web site is known to customers allows the unknown retailer to piggyback on its web site so that the unknown retailer does not engage in advertising and instead pays a fixed fee per transaction, t, to the known retailer. Such a situation is seen at the Amazon.com web site where Amazon allows small (most of whom are unknown) sellers to be listed on its web site. The customers visiting Amazon's web site can buy either from Amazon or from the sellers listed on its web site.

We use a second subscript, P, to represent piggybacking. To ascertain that the prices of the low quality retailer with piggybacking, p_{LP}^{UK*} and p_{LP}^{KU*}, are less than B so that the customers get a positive surplus from the low quality product, we make another assumption.

ASSUMPTION 6. $t < B - \frac{r+c}{3}$

The profit functions of the two retailers with piggybacking are:

$$\pi_{HP}^{UK} = \left(r - (p_{HP}^{UK} - p_{LP}^{UK})\right)(p_{HP}^{UK} - c - t)$$
$$\pi_{LP}^{UK} = (p_{HP}^{UK} - p_{LP}^{UK})p_{LP}^{UK} + (r - (p_{HP}^{UK} - p_{LP}^{UK}))t$$

The high quality and the low quality retailers choose prices p_{HP}^{UK} and p_{LP}^{UK} simultaneously. The profit functions are jointly concave in their prices decisions. The equilibrium values are:

$$p_{HP}^{UK*} = \frac{2(r+c)+3t}{3}$$
$$p_{LP}^{UK*} = \frac{r+c+3t}{3}$$
$$\pi_{HP}^{UK*} = \frac{(2r-c)^2}{9}$$
$$\pi_{LP}^{UK*} = \frac{(r+c)^2}{9} + rt$$

As done above, we can also analyze the case when the customers know the web site of the high quality retailer only. Now the profit functions of the retailers when the low quality retailer adopts the dual mode advertising policy are:

$$\pi_H^{KU} = \left(r - (p_H^{KU} - p_L^{KU})\right)(p_H^{KU} - c)$$
$$\pi_L^{KU} = a_L^{KU}\left(p_H^{KU} - p_L^{KU}\right)p_L^{KU} + (1 - a_L^{KU})\left(p_H^{KU} - p_L^{KU}\right)(p_L^{KU} - d) - k(a_L^{KU})^2$$

As before, the profit functions turn out to be jointly concave in their decision variables. The equilibrium values are:

$$a_L^{KU*} = \frac{d(r+c-d)}{6k-d^2}$$
$$p_L^{KU*} = \frac{2(2dk + (4k-d^2)(r+c))}{6k-d^2} - c - r$$
$$p_H^{KU*} = \frac{2dk + (4k-d^2)(r+c)}{6k-d^2}$$
$$\pi_H^{KU*} = \frac{(2k(c-d) + r(d^2-4k))^2}{(6k-d^2)^2}$$
$$\pi_L^{KU*} = \frac{k(4k-d^2)(r+c-d)^2}{(6k-d^2)^2}$$

With piggybacking, the profit functions for this case are:

$$\pi_{HP}^{KU} = \left(r - (p_{HP}^{KU} - p_{LP}^{KU})\right)(p_{HP}^{KU} - c) + (p_{HP}^{KU} - p_{LP}^{KU})t$$
$$\pi_{LP}^{KU} = (p_{HP}^{KU} - p_{LP}^{KU})(p_{LP}^{KU} - t)$$

The equilibrium values with piggybacking are:

$$p_{HP}^{KU*} = \frac{2(r+c)+3t}{3}$$
$$p_{LP}^{KU*} = \frac{r+c+3t}{3}$$
$$\pi_{HP}^{KU*} = \frac{(2r-c)^2}{9} + rt$$
$$\pi_{LP}^{KU*} = \frac{(r+c)^2}{9}$$

The next result states the importance of the piggybacking strategy for the retailers.

PROPOSITION 4. *With piggybacking, both the retailers can achieve higher profits compared to the case when the unknown retailer adopts the dual mode advertising policy.*

PROOF. First, consider the case when the high quality retailer is unknown and the low quality retailer is known. We have $\lim_{d\to 0} \pi_H^{UK*} = \frac{(2r-c)^2}{9}$. This represents the upper bound of the profits achievable for the high quality retailer with dual mode advertising because the retailer gets its customers at zero advertising costs. Further, we have $\pi_{HP}^{UK*} = \frac{(2r-c)^2}{9}$. Thus with the piggybacking strategy, the high quality retailer achieves profits that equal the upper bound on its profits with dual mode advertising. Further, $\pi_{LP}^{UK*} = \frac{(r+c)^2}{9} + rt$. Hence, if t is large enough, the low quality retailer can make profits exceeding the profits it earns when the high quality retailer adopts dual mode advertising.

In the case when the high quality retailer is known and the low quality retailer is unknown, note that $\lim_{d\to 0} \pi_L^{KU*} = \pi_{LP}^{KU*} = \frac{(c+r)^2}{9}$ and $\pi_{HP}^{KU*} = \frac{(2r-c)^2}{9} + rt$. Using logic analogous to the one used above, we see that both the retailers can achieve higher profits with the piggybacking strategy.

The constraint on increasing the value of t comes from Assumption 6. Therefore, if B is large enough, a transaction fee $t > 0$ can always be found so that the known retailer can also improve its profits enough for piggybacking to be profitable for both retailers. □

5.2 Symmetric information about retailers

Here we model the situation where neither retailer has the advantage of previous customer knowledge of its web site. As before, we assume a low search advertising cost d so that both retailers adopt dual mode advertising. A customer can make a search specific to the high or the low quality product since the two products are different and can be described separately on search sites. Assuming a fulfilled expectations equilibrium, the profit functions of the two retailers are:

$$\pi_H^{UU} = a_H^{UU}\left(r - (p_H^{UU} - p_L^{UU})\right)(p_H^{UU} - c) + (1 - a_H^{UU})\left(r - (p_H^{UU} - p_L^{UU})\right)(p_H^{UU} - c - d) - k(a_H^{UU})^2$$
$$\pi_L^{UU} = a_L^{UU}(p_H^{UU} - p_L^{UU})p_L^{UU} + (1 - a_L^{UU})(p_H^{UU} - p_L^{UU})(p_L^{UU} - d) - k(a_L^{UU})^2$$

The two retailers decide on their price and advertising simultaneously. The profit functions are jointly concave in terms of their decision variables. The equilibrium values are:

$$a_H^{UU*} = \frac{2dk(2r-c) - rd^3}{4k(3k-d^2)}$$
$$a_L^{UU*} = \frac{2dk(r+c) - rd^3}{4k(3k-d^2)}$$
$$p_H^{UU*} = \frac{(d^4 - 6d^2k + 8k^2)r + 2ck(4k-d^2) + 4dk(3k-d^2)}{4k(3k-d^2)}$$
$$p_L^{UU*} = \frac{r(2k-d^2)^2 - 2k(d^2(c+2d) - 2k(c+3d))}{4k(3k-d^2)}$$

In the next result, we aim to define the strategic response of a retailer as a function of whether the customers know its competitor or not.

PROPOSITION 5. *If the premium on the high quality product is high (large r), and if the customers are informed about a retailer's competitor, it will employ more search advertising and less broadcast advertising compared to if the customers were not informed about the retailer's competitor. This strategic response is reversed if the premium on the high quality product is low.*

PROOF. First, consider the case when the high quality retailer is unknown. The optimal expense incurred by this retailer on search advertisement when the low quality retailer is also unknown is $ES_H^{UU*} = (1-a_H^{UU*})\left(r-(p_H^{UU*}-p_L^{UU*})\right) d$; and when the low quality retailer is known, it is $ES_H^{UK*} = (1-a_H^{UK*})(r-(p_H^{UK*}-p_L^{UK*}))d$.

We find that $ES_H^{UK*} > ES_H^{UU*} \Leftrightarrow$
$r > \dfrac{6(12k^3+4cdk^2-cd^3k-4d^2k^2)}{d(d^4-18d^2k+48k^2)}$, using some algebra.

The optimal expense incurred by the high quality retailer on broadcast advertising when the low quality retailer is also unknown is $EB_H^{UU*} = k(a_H^{UU*})^2$; and when the low quality retailer is known, it is $EB_H^{UK*} = k(a_H^{UK*})^2$. We find that $EB_H^{UK*} > EB_H^{UU*} \Leftrightarrow r < \dfrac{2(12ck^2+6dk^2-3cd^2k-2d^3k)}{d^4-18d^2k+48k^2}$.

We perform analogous calculations for the case when the low quality retailer is unknown and find that similar results hold even for this case. Clearly, the nature of strategic response is not contingent on the quality of product being marketed by the retailer. □

6. CONCLUSION

Search advertising has emerged as a preferred way of advertising on the Internet. It's targeting capability ensures that only the customers who are interested in buying a product are ever exposed to the advertising message. The payment method is also unique. The advertising fee becomes due only when customers reaffirm their interest in buying the product by clicking on the link provided by the search advertisement. Should the targeting capability and cost efficiency of search advertising then enable online retailers to reduce their advertising budgets? The answer may be in the negative because it might be beneficial to spend more on advertising to get larger number of customers. Since search advertising allows for better targeting, retailers may want to increase their price. This price increase may cause a reduction in social welfare.

When customers are uncertain about the quality of product being sold by the retailer, a retailer selling a high quality product may want to use price and advertising as signals of its product quality. It turns out that utilization of search advertising for signaling is more likely if the quality differential between the high quality and the alternative low quality product is small. This shows that the utility of search advertising as a signaling tool is limited and alternative means of signaling may be required if the quality differential between the high and low quality product is significant.

In a competitive duopoly, both retailers may be better off if the retailer with an established brand value (i.e. who is known to customers) uses its web site as a portal. The retailer without the brand value lists its web site on the portal for a fee instead of resorting to advertising. If both retailers are unbranded, the relative amount of search and broadcast advertising changes as the competing retailer becomes more established in the market.

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