Comment on "Reducing Buyer Search Costs: Implications for Electronic Marketplaces"

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1. Introduction

One of the most crucial distinctions between electronic retailing and conventional retailing concerns consumer search. It would seem obvious that, at least for some types of information, searching is less costly when it is among online sellers. More interesting, perhaps, is the difference in the structure of search costs and what its implications might be for competition among online sellers. In one of the first papers to explore this issue, Bakos (1997) considers a model of search in a market with differentiated products. One of the more innovative features of his model is to allow for separate costs of searching over price and product characteristics:

> The ability to separate the search costs for price and product information is particularly interesting in the context of an electronic marketplace. These systems are unique in their ability to separately influence the search costs for price and product information through appropriate choices in system design. (Bakos 1997, p. 1687)

There are two particularly striking results in the paper related to this issue.

Result 1. When the cost of product information is positive but the cost of price information is close to zero, near perfect competition prevails when there are sufficiently many firms, that is, the equilibrium price is close to marginal cost.

Result 2. When the cost of price information is positive and the cost of product information is zero, the equilibrium price is decreasing in the cost of price information.

The first result states that it is the cost of price information that determines whether price competition is intense. If such costs are low, then prices are close to competitive prices regardless of how costly it is to acquire product information. The second result is that when product information is free, reducing the cost of learning the price of a product results in *higher* prices! These results are quite new to the literature on pricing in markets with search. Unfortunately, the first result is wrong, and the second result is based on an implicit assumption that is unreasonable. While there are a number of interesting and correct results in the paper, the analysis regarding the separation of search costs for price and product information is flawed.

2. Critique of Result 1

To briefly review, the paper assumes the circle model of product differentiation. There are m single-product firms whose products are equally spaced on the circle. In terms of their ideal products, n consumers are evenly distributed over the circle. The utility to a consumer located at point y from buying a product located at x at price p is $r - t|y - x| - p$, where $r, t > 0$. Consumers buy either zero or one unit. If they do not buy a unit, their utility is zero. Initially, consumers do not know product locations and prices. The costs of learning a product's price and its product location are c_2 and c_3, respectively. Firms simultaneously choose price, and then consumers search. Once searching is completed a consumer either purchases or not.[1]

[1] Although not cited in Bakos (1997), the circle model of product differentiation with consumer search was first analyzed in

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Concerning the first result mentioned above (which is stated in §5.1), Bakos shows that when $c_2 = 0$ (which implies that consumers learn all prices) and m is sufficiently large, the equilibrium price equals marginal cost (which is normalized to be zero). Although products are differentiated, a consumer's information on them is initially identical (before conducting any search on product information). It is then optimal for consumers first to acquire the product information of the product with the lowest price. Thus, by charging a price below its rivals' prices, a firm can induce all consumers to acquire information about its product. This generates very aggressive pricing among firms. Bakos then states (but only loosely argues) that the equilibrium price is $(mc_2)/2$ when $c_2 > 0$, but small. This obviously implies that the price goes to zero as $c_2 \to 0$. I will show, however, that an equilibrium price cannot converge to zero as the cost of conducting a search over price goes to zero.

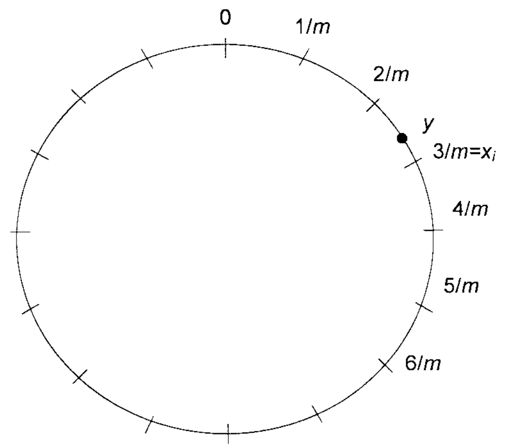
Let us consider a symmetric strategy profile so that consumers expect all firms to price at p. Suppose a consumer located at point y initially searches the product of firm i. The consumer learns that firm i's product is located at x_i (and, without loss of generality, assume $y < x_i$) and its price is p_i. The net surplus from buying this product is $r - t(x_i - y) - p_i$. Suppose firm i's product has the best location for this consumer, that is, $y - x_i < 1/2m$ (see Figure 1). This occurs with probability $1/m$. Now consider this consumer searching. To provide an upper bound on the value of searching, suppose the consumer anticipates realizing the best outcome, which entails finding the next best product (recall that all firms are anticipated to charge the same price). When that outcome is anticipated, the net surplus from searching and then buying is[2]

$$r - t\left[y - \left(x_i - \frac{1}{m}\right)\right] - p - c_2 - c_3. \tag{1}$$

Wolinsky (1983, 1984). The standard assumption of a single search cost associated with learning a product's characteristics and price was assumed, however.

[2] Recall that $x_i > y$ and x_i is the best product for this consumer. Hence, the next best product is the closest one just below the consumer's location. Since there are m products equally spaced around this circle, this product is located at $x_i - 1/m$.

Figure 1



It follows that this consumer prefers buying the product at x_i to searching when

$$\begin{aligned} & r - t(x_i - y) - p_i \\ & \quad > r - t\left[y - \left(x_i - \frac{1}{m}\right)\right] - p - c_2 - c_3 \Leftrightarrow \end{aligned} \tag{2}$$

$$p_i + t(x_i - y) < p + t\left[y - \left(x_i - \frac{1}{m}\right)\right] + c_2 + c_3. \tag{3}$$

Now let $p \to 0$ and $c_2 \to 0$ (the order in which these limits are taken does not matter):

$$p_i + t(x_i - y) < t\left[y - \left(x_i - \frac{1}{m}\right)\right] + c_3 \Leftrightarrow \tag{4}$$

$$p_i < 2t\left[y - \left(x_i - \frac{1}{m}\right)\right] + c_3. \tag{5}$$

Since $y - (x_i - 1/2m) > 0$ and $c_3 > 0$, the r.h.s. expression in (5) is bounded above zero. Hence, firm i has positive expected demand when its price does not exceed $2t[y - (x_i - 1/2m)] + c_3$. This implies that its expected profit is bounded above zero, so its optimal price must be positive. We have shown that the optimal price of an individual firm is bounded above zero if all other firms' prices go to zero as $c_2 \to 0$ (and consumers expect that). From this we can conclude that an equilibrium price does not converge to zero as $c_2 \to 0$. Either an equilibrium does not exist, or it involves all firms pricing above marginal cost.

Intuitively, there is a discontinuity in a consumer's search strategy at $c_2 = 0$. When $c_2 = 0$, it is optimal for a consumer to first learn the prices of all firms' products and then engage in sequential searching over product information. Given symmetric prior information on product locations, all consumers initially visit the product(s) with the lowest price. This provides a powerful incentive to price aggressively and, when m is large enough, results in the price equalling marginal cost. When $c_2 > 0$, however, it is now optimal to search sequentially with regard to both product information *and* price. Given that at a symmetric equilibrium consumers' prior beliefs about price and location are identical across firms' products, each consumer searches a particular product first with probability $1/m$, and, most important, this probability is independent of what a firm actually charges (as the price is not known until a price search is conducted). The incentive for a firm to price aggressively is considerably weakened, as one no longer can induce all consumers to initially search one's product location by undercutting the other firms' prices. With a positive cost associated with learning a firm's price, searches are based on expected prices and not actual prices. Hence, a firm that prices above the other firms can still expect consumers to learn about its product. This gives it some market power by virtue of the appeal of its product to some consumers and the additional search cost that a consumer must incur if he chooses not to buy and to continue to search. As a result, a firm's optimal price exceeds marginal cost when other firms are pricing close to marginal cost. In contrast to Bakos' statement, approximately competitive pricing does not prevail when the cost of acquiring price information is arbitrarily small. If a pure-strategy equilibrium exists, a little cost to searching over price results in prices being bounded above competitive prices.

Having proven that a symmetric equilibrium price does not converge to the competitive price as $c_2 \to 0$, I will now show that there does not exist a symmetric pure-strategy equilibrium involving search. Suppose consumers anticipate that all firms charge the same price, denoted p^*. Consumers do not then expect to learn anything from incurring c_2, so they should only incur c_2 for the product they anticipate purchasing. Optimal search therefore involves initially searching over product information only and, when that search is completed, incurring the search cost for price. By an analogous argument to that in §3.1 (p. 1681), there exists some distance, call it d^*, such that a consumer will search until the distance between his location and a firm's product is less than or equal to d^*. Suppose firm i's location is x_i. Consumers who lie outside of $[x_i - d^*, x_i + d^*]$ will never incur the search cost c_2 to learn firm i's price; they will just move on with their search. In addition, some consumers who lie in that interval may not learn this firm's price because they find another acceptable firm first. Let θ denote the share of consumers in $[x_i - d^*, x_i + d^*]$ who stop their search over product information after learning the location of firm i's product and incur the search cost of c_2 to learn firm i's price.[3] If the firm charges the anticipated price of p^*, all those consumers will buy, and the firm receives profit of $p^* 2\theta d^*$. Now consider the marginal consumer who is distance d^* away from x_i. At the point that he was deciding whether to learn firm i's price, he was indifferent between (i) incurring c_2 and buying from firm i at a price of p^*, and (ii) continuing to search with respect to product information. Now that he has incurred c_2, he must strictly prefer buying from firm i at a price of p^* to continuing to search. Furthermore, since c_2 must be incurred to buy from any firm other than firm i, this consumer will now be indifferent between buying from firm i at a price of $p^* + c_2$ to continuing to search. It follows that profit can be increased to $(p^* + c_2)2\theta d^*$ by raising the price to $p^* + c_2$. Of course, this destabilizes a common price of p^* as a symmetric equilibrium. The only way to make it work is if a price higher than p^* induces this marginal consumer not to buy at all. Yet for that to be the case, the consumer's utility must satisfy $r - p^* - td^* = 0$, so that a price higher than p^* induces him not to buy. The consumer's utility from the entire enterprise of searching is bounded above by $r - p^* - td^* - c_2 - c_3 < 0$, but then searching is nonoptimal. This proves that there is no symmetric pure-strategy equilibrium in which consumers search. Whether an equilibrium with searching exists remains an open question.

[3] Note that θ does not depend on the actual prices that firms charge because consumers are only searching with respect to product information. It will depend on the number of firms, as that determines the distribution over product location.

3. Critique of Result 2

To consider the second result, it is useful to generalize Bakos' model. Define c_2^i as the cost of the ith price search. We are then letting the cost of learning a product's price depend on where it is in the sequence of searches by a consumer. It is not necessary for the forthcoming argument that these costs differ. Rather, I just want to be able to differentiate between them notationally. Second, assume that a fraction of a price search cost, denoted $\alpha \in [0, 1]$, is recoverable by the consumer if the product for which the price search cost was incurred was not purchased. Do not infer by making this assumption that I believe it is a reasonable one. My own reading of the model is that Bakos intends to assume $\alpha = 0$ and $c_2^i = c_2 > 0$, $\forall\, i$.

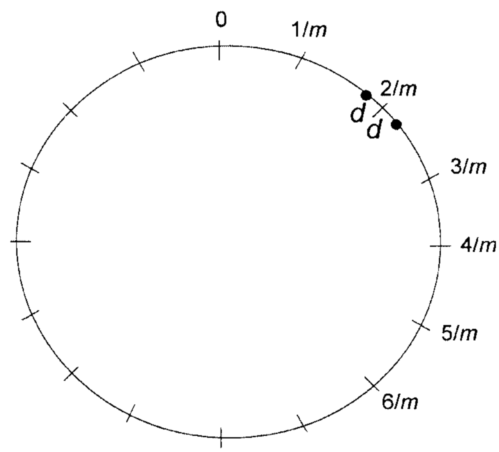
In §5.2, it is assumed that the cost of acquiring product information is small relative to price information. Specifically, $c_3 = 0$ so that all product locations are known to consumers and $c_2^i > 0$, $\forall\, i$. There are two cases that he considers. One is when equilibrium involves all consumers searching, and the other is when only some subset of consumers is searching. For the sake of brevity, we will only examine the latter case, although our conclusion is applicable to both. Consider a symmetric strategy profile in which all firms price at p and consumers within distance d of a product incur c_2^1, where $d < 1/2m$ (see Figure 2).[4] Let us focus on the marginal consumer who is distance d from the nearest product. After having acquired the price information for the product, his net utility from buying is $r - td - p$, while his net utility from searching (and then buying) is

$$r - t\left(\frac{1}{m} - d\right) - p + \alpha c_2^1 - c_2^2. \tag{6}$$

Since product information is freely available, this expression is based on acquiring the price information for the consumer's next closest product that, if his nearest product is distance d away, is distance $(1/m) - d$ away. In performing this second search, a

[4] Hence, consumers whose distance from the nearest product lies in $[0, d]$ choose to search over price and then buy. Those whose distance from the nearest product lies in $[d, 1/2m]$ choose not to search and thus do not buy.

Figure 2



consumer incurs cost c_2^2 but recovers αc_2^1 from his first search. Next, note that

$$r - td - p > r - t\left(\frac{1}{m} - d\right) - p + \alpha c_2^1 - c_2^2 \Leftrightarrow \tag{7}$$

$$2t\left(\frac{1}{2m} - d\right) + c_2^2 > \alpha c_2^1, \tag{8}$$

which is indeed true if I assume $c_2^2 \geq \alpha c_2^1$ which I will.[5] Thus, having performed his initial search, he strictly prefers buying to continuing to search. The other option is for the consumer not to buy at all. In that case, he receives net utility of αc_2^1, which is the refundable portion of the search cost. If $r - td - p > \alpha c_2^1$, this consumer prefers to buy. This, however, is inconsistent with equilibrium because a firm could slightly raise its price and this consumer would continue to prefer to buy (and, from the above analysis, continue to prefer buying to searching).[6] Since this is true for the consumer who is most distant from

[5] Since $\alpha \leq 1$, I need only assume that the second price search costs no less than the first price search. This holds if there is a constant cost of acquiring price information, which is what Bakos assumes.

[6] Note that a higher price does not alter the marginal consumer's location. Those consumers within distance d of this firm will search it based on their expectations of what the firm will charge. This analysis concerns whether the firm actually prices as consumers anticipate. Its actual price can affect whether those consumers who do visit it choose to buy but cannot affect which consumers decide to visit. Its maximal demand is $2d$ regardless of the price it eventually sets.

the product's location, it is clearly true for all other consumers who have searched this product. The firm thus can marginally raise its price without changing its demand. This results in an increase in profit, which violates the conditions for equilibrium.[7] Equilibrium then requires that $r - td - p \leq \alpha c_2^1$. Yet, it cannot be true that $r - td - p < \alpha c_2^1$, as then some consumers, in equilibrium, will search a store but not buy. This yields an expected net surplus of $-(1-\alpha)c_2^1$, which is clearly less than not searching at all (at least when $\alpha < 1$ and $c_2^1 > 0$). We conclude that if an equilibrium exists, its price is $p^* = r - td - \alpha c_2^1$.[8]

In equilibrium, the net surplus of the marginal consumer is $r - td - p^* - c_2^1$ once one includes the initial search cost. This must be nonnegative if searching is to be optimal. Substituting for the equilibrium price, we have

$$r - td - \left(r - td - \alpha c_2^1\right) - c_2^1 \geq 0 \Leftrightarrow (\alpha - 1)c_2^1 \geq 0. \quad (9)$$

Hence, the strategy profile that Bakos puts forth as an equilibrium is an equilibrium in this more general model if and only if $\alpha = 1$ and/or $c_2^1 = 0$. Since Bakos clearly assumes $c_2^1 > 0$, it follows that he is implicitly assuming $\alpha = 1$. This assumption is never stated and, more to the point, is not very plausible. By what mechanism would a consumer be refunded for his search costs if he did not purchase the good?

To explain why Bakos found the equilibrium price to be decreasing in the cost of acquiring price information, consider the equilibrium price when $\alpha = 1:$ $p^* = r - td - c_2^1$. Note that it is decreasing in the cost of the *initial* search but is unaffected by the cost of further searching. Intuitively, one would expect prices to be driven by what a consumer could achieve by continuing to search, which would involve c_2^2 rather than c_2^1. Yet, in that case, since $\alpha = 1$, a consumer only pays c_2^1 if the product is purchased. In that case, the consumer prefers buying, then not buying at all if and only if $r - td - p \geq c_2^1$. The consumer receives the term on the l.h.s. of the inequality if he buys and recovers c_2^1 by not buying. A higher value for c_2^1 makes not buying more attractive, and the price must be lowered to induce the consumer to buy. Because this search cost is recoverable, any increase in it must be offset by a fall in the price if the consumer is to buy. This is why price is decreasing in search costs.

To my knowledge, all previous search models assumed $\alpha = 0$ and, to ensure the existence of an equilibrium, that the initial search is free: $c_2^1 = 0$; see, for example, Diamond (1971) and Stahl (1989). Under this assumption and using the logic in Diamond (1971), the equilibrium price is the monopoly price and it is independent of the cost of searching over price as long as it is positive. To see this result, define $\Gamma(p, x_i)$ as the set of consumers who prefer buying product x_i to any of the other $m-1$ products (when all products are priced at p) and to not buying at all. Assume symmetry so that $|\Gamma(p, x_i)|$ is the same $\forall\, i$, $\forall p$. Note that $\Gamma(p, x_i)$ does not depend on search costs. If buyers anticipate a common price of p, then $\Gamma(p, x_i)$ is the set of consumers who initially incur the cost of acquiring price information about x_i (recall that the initial price search is free and all product searches are free). Next, define $\Delta(p_i; \Gamma(p, x_i))$ as the subset of $\Gamma(p, x_i)$ who prefer buying x_i at price p_i to not buying at all. Define

$$\phi(p) \in \arg\max p_i |\Delta(p_i; \Gamma(p, x_i))|. \quad (10)$$

$\phi(p)$ is the profit-maximizing price for firm i when it faces consumers $\Gamma(p, x_i)$. Next define the following fixed point: $\hat{p} = \phi(\hat{p})$. Assuming $\hat{p}$ exists, I want to argue that it is an equilibrium price. Suppose consumers expect all firms to price at $\hat{p}$. A firm at x_i can expect the consumers in $\Gamma(\hat{p}, x_i)$ to acquire price information on its product. Because it faces demand from those consumers, the profit-maximizing price is $\phi(\hat{p})$ or $\hat{p}$. We then have that firms are optimally pricing, consumers are optimally searching,[9] and consumers'

[7] Note that in equilibrium consumers search only once because a consumer initially knows all product locations and all firms charge the same price. Hence, there will be no other consumers searching this product.

[8] In deriving this result, we assumed $\alpha > 0$ and $c_2^1 > 0$. Note, however, that when $\alpha = 0$ and/or $c_2^1 = 0$, the equilibrium price is still $r - td - \alpha c_2^1$ or $r - td$. For if $r - td - p < 0$, then the consumer at distance d buys when the net surplus from doing so is less than that from not buying, which violates equilibrium. Hence, $r - td - p = 0$ when $\alpha = 0$ and/or $c_2^1 = 0$, which implies $p^* = r - td$.

[9] If firm i prices at $\hat{p}$ and all other firms are expected to price at $\hat{p}$, then a consumer for whom x, is his most preferred product will search for it and then buy.

beliefs are fulfilled in equilibrium. $\hat{p}$ is then an equilibrium price. Note that $\hat{p}$ is the same price that a monopolist would set if it controlled the prices of all m products.[10] Most important, this price is independent of search costs. Of course, this result is based on the assumption that the initial search cost is zero. Although standard in the literature, it is arbitrary and lacks a proper rationale.

In conclusion, the most interesting results of the analysis of Bakos do not survive closer scrutiny. On a positive note, Bakos' paper raises some important issues related to electronic commerce that, hopefully, will encourage further research into this emerging area.

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——. 1984. Product differentiation with imperfect information. *Rev. Econom. Stud.* **51**(1) 53–61.

[10] In choosing $\hat{p}$, a firm is acting as if it has monopoly power over the set of consumers in $\Gamma(p, x_i)$.