Association for Information Systems
AIS Electronic Library (AISeL)

ICIS 2003 Proceedings

International Conference on Information Systems (ICIS)

December 2003

Dual Pricing in Electronic Markets

Panos Markopoulos
University of Pennsylvania

Ravi Aron
University of Pennsylvania

Lyle Ungar
University of Pennsylvania

Follow this and additional works at: http://aisel.aisnet.org/icis2003

DUAL PRICING IN ELECTRONIC MARKETS[1]

Panos M. Markopoulos, Ravi Aron, and Lyle H. Ungar
University of Pennsylvania
Philadelphia, PA USA
markopou@unagi.cis.upenn.edu   raviaron@wharton.upenn.edu
ungar@cis.upenn.edu

Abstract

We model the availability of information about product attributes in Internet-based markets, focusing on a phenomenon that we term as information deficit (availability of less than perfect information about product attributes) and its impact on the equilibrium strategies of sellers and buyers in electronic markets. We create a model of a market for a differentiated product and investigate how buyer uncertainty regarding the attributes of the product drives market outcomes. We show that a market for product information can partly correct the inefficiencies that arise from imperfect information and predict that product information will begin to be traded once appropriate micro-transaction payment schemes become available. We formulate a mechanism by which sellers can charge an information rent for fine-grained information about product attributes which we term as a dual pricing mechanism wherein sellers extract an information rent in addition to the price of the product from buyers. We analyze the equilibrium that results and comment on the nature of welfare gains. A key finding of the paper is that allowing sellers to charge dual rents leads to more efficient markets.

Keywords: Electronic markets, product information markets, spatial differentiation, shopbots, shopbot business models

Introduction

Several articles appearing in the trade and business press have noted that while electronic markets could potentially feature fine-grained information about all attributes of a product or service, they rarely do. For instance, very few raltors offer three dimensional views of the interior of homes or the school district's performance statistics on their Web sites. Similarly, on-line travel agents do not offer information about airline movie schedules on long haul flights to even first class travelers, even as on-line retailers of high end stereo systems do not offer detailed information about the distortion in sound and loss of fidelity induced by different types of connection cables and wires. Yet, to many buyers of these services and products such information is indeed valuable and, furthermore, such information is available with the producer of the product (service). Thus, there is a widely observed phenomenon of less than perfect product information being furnished in these markets which we term the **information deficit** of the market.

We demonstrated in (Markopoulos et al. 2003) that sellers choose not to disseminate any more detailed product information than what is necessary to separate them from their competitors, for any positive cost, howsoever small, associated with the dissemination of such information in the absence of the ability to collect an information rent for providing such information. This paper formulates a mechanism by which sellers can charge an information rent for fine-grained information about product attributes, as a **dual pricing** mechanism in which sellers charge a product price and an information rent from the buyers.

We also demonstrate that more detailed information is valuable to consumers that are in the **switching threshold** of products, i.e., to customers that have identified a best option (product/service) but are likely to change their mind about their candidate

---

product in the light of more detailed information. An attendant issue that arises is: can product information be bought and sold by market participants? We show that the value of information is, under reasonable assumptions, orders of magnitude less than the products' prices and thus cannot be traded unless there is a widespread micro-transaction scheme available to market participants. We show that allowing sellers to charge an information rent results in *welfare gains* and under certain conditions such a move is actually a *pareto improvement*. In markets characterized by the dual pricing mechanism, the extent of the information deficit will be greatly reduced as sellers have incentives to sell detailed product information to interested buyers.

The paper is organized as follows. The related literature is reviewed and we introduce our model. We then discuss the reason why sellers that have no mechanism by which to charge buyers for information will not disseminate fine-grained information. We allow one seller only to charge for detailed product information, and show that this results to welfare gains for both buyers and sellers. We allow both sellers to compete in selling both their product and their detailed information and show that, again, welfare gains result for both sides of the market. Finally, we discuss the managerial insights and implications of our work and offer conclusions.

Related Literature

In 1929, Hotelling initiated the theory of spatial product differentiation with his *linear city* model. Samuelson (1967) introduced the *unit circle* model, which became well known with Salop's (1979) treatment. The unit circle model managed to avoid mathematical complications at the end points of the line segment, while preserving the explanatory and predictive power of the original model. A good map to this extensive body of literature can be found in Greenhut et al. (1987). For a unified treatment of both models see Takahashi and de Palma (1993).

Following Stigler's (1961) introduction of a theory of buyer search in product markets, an extensive body of literature has been developed in economics that studies the effects of imperfect information and buyer search to price dispersion, product differentiation and market structure (Akerlof 1970; Diamond 1971; Nelson 1970; for a review, see Stiglitz 1989). Optimal sequential consumer search in uncertain environments has also been studied extensively, (Lippman and McCall 1982; Weitzman 1979; for a review, see Rothschild 1973).

The effects of the reduction of consumers' search costs, with the advent of the Internet, have been studied as well. Bakos (1997) synthesized the prior work with the dynamics of the then emerging Internet markets. We adapt Bakos's model to focus on the flow of information by considering parallel, shopbot-aided search, as opposed to fast sequential search, and acknowledging that consumers may still be left with a degree of uncertainty, even after having studied the shopbot's results.

Figure 1. Our Model of Product Differentiation

A Model of an Internet Market

We employ Salop's (1979) classical model of spatial differentiation, altered to account for uncertainty about the sellers' exact positions in product space. Our market consists of two sellers and a large number of buyers for a good that is spatially differentiated along a unit circle (see Figure 1). Each buyer has a most-preferred product location l^*. The buyer incurs a fit cost $U(l,l^*)$ when he purchases a good at location l. We assume the fit cost to be a linear function $t|l-l^*|$ of the distance between l and l^*. Buyers demand one unit of the good, subject to a reservation utility v which we assume is high enough so that all buyers are served. All players are risk neutral and sellers supply a single good with constant marginal cost (assumed for convenience to be zero). Thus, the utility that Buyer j, with ideal product location l_j^*, receives from buying a product from Seller i, located at l_i and priced at p_i is

$$v - p_i - t\left|l_i - l_j *\right|.$$

Sellers move first by simultaneously choosing a location for their product offering and choose their prices having observed each other's locations. We introduce the idea of a *parallel search* which is a mechanism that is analogous to a search using an
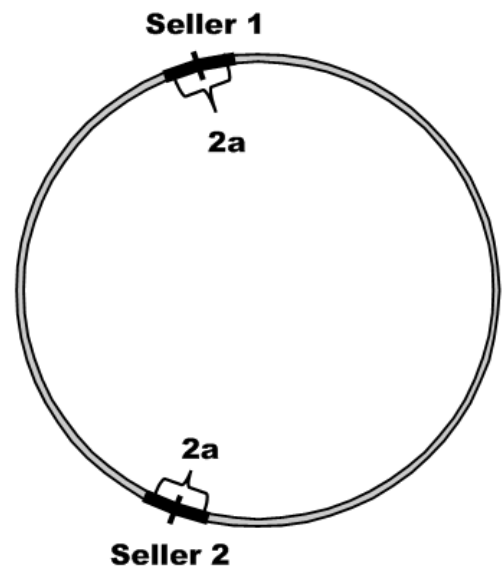
electronic search engine except that it returns the *approximate* location of a product (and therefore the seller's position). The central idea here is that in the absence of detailed and exhaustive product information, the buyer can only know an interval within which the product is located and not the exact location of the product (which happens to be a composite of all product attributes, not just the ones that are available to the search device). Thus, the buyer can only learn the sellers' approximate location within an interval of size *2a* such that the seller's true location is equiprobable anywhere within the interval. We term this interval as the seller's uncertainty interval. The buyer is assumed to use a free shopbot for a parallel search, incurring no search cost.

We now introduce the concept of a ***d-search***, meaning a *detailed* or *distance* search, which is a second search within the interval returned by the parallel search. After a parallel search has produced information about a seller, a buyer can choose to perform a d-search that will reveal the seller's true location. An important distinction between the d-search and the parallel search is that while the parallel search is not targeted at any particular seller, and will return both sellers' approximate locations, a d-search targets a particular seller's offering and returns its exact location. We assume that each seller *j* demands an information rent *Ij* to allow a d-search. The fee can range from zero (implying a free d-search), to any number *ex ante*, unbounded. Notice that the buyer is not obliged to perform a d-search in order to choose to purchase from a particular seller. The buyer might decide that she wants to buy the product and find out the details afterwards. Finally, we assume that each seller has a monopoly in his own detailed product information, and, thus, a seller cannot sell detailed information about the opponent. We relax this assumption later (see Management Insights and Implications).

Conceptually, the difference between the parallel search and a d-search represents two different components in the product's location information. One component, accessible through the parallel search, represents information that the buyer can extract about a product from visiting the seller's or an intermediary's Web page. However, this usually cannot produce all information relative to the product's true location. Finer details about the product are not always accessible and are known only to the seller. The seller controls this component of the buyer's search by deciding whether or not to reveal them. We have assumed, however, that a product's price and the seller's identity are among the product attributes that the buyer can extract, which is keeping in line with most currently functional electronic markets.

We are now able to present the exact timing of the game we analyze. The space of strategies open to sellers in each stage is exogenously determined. In stage one, the sellers simultaneously choose their location. In stage two, they are able to observe each other's location and choose their price. In stage three, sellers are able to observe each others' exact location and price and determine their d-search fee.

We proceed to calculate the expected fit costs for a buyer that purchases a product from a seller whose exact location is unknown, but his expected location is at distance x from the buyer's location. If $x > a$ the expected fit cost is $\int_{x-a}^{x+a} \frac{y \cdot t}{2a} dy = x \cdot t$. If $x < a$ the expected fit cost is given by $\int_{0}^{a-x} \left(\frac{1}{2a} yt \right) dy + \int_{0}^{a+x} \left(\frac{1}{2a} yt \right) dy = \frac{a^2 + x^2}{2a} t$.

So the expected fit cost from purchasing from a seller at expected distance x is given by:

$$g(x) = \begin{cases} x \cdot t, & if \ x > a \\ \dfrac{a^2 + x^2}{2a} t, & if \ x < a \end{cases}$$

Equation 1

where *2a* is the interval within which the seller's true position lies.

Case I: Dual Pricing Is Infeasible

Analysis

In this section, we assume that sellers cannot charge buyers for the information and are forced to set their d-search fee to zero. This assumption represents a world where there is no mechanism for the sellers to charge buyers for a d-search. They can only

refuse to provide the information, or provide it for free. We relax this assumption in the sections that follow and contrast the results. We assume that the decision to allow d-searches carries a very small cost for the seller. For simplicity we will assume that this cost is smaller than any other positive quantity that appears in our analysis, yet strictly greater than zero.
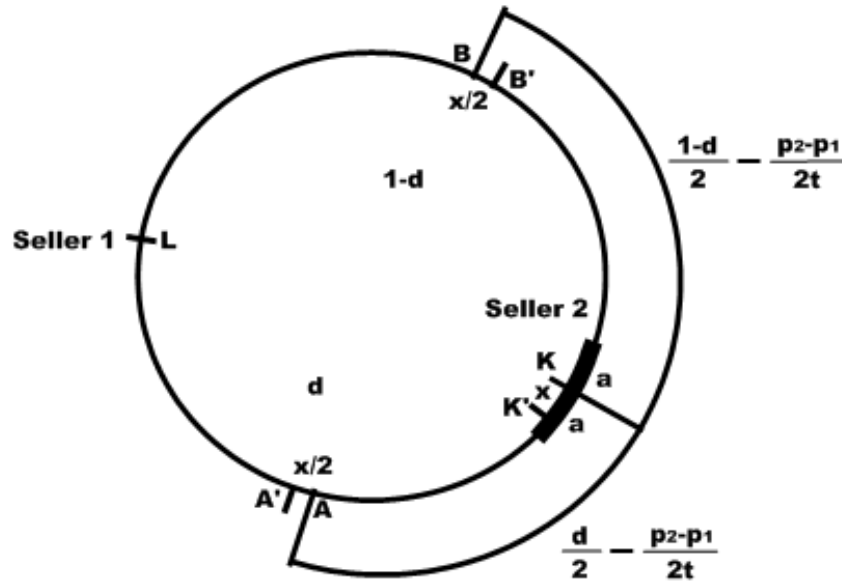

**Figure 2. Seller 2's Product Revenues Are the Same Whether He Disallows
D-Searches, or Provides Them for Free**

> **Theorem 1**: *For sufficiently small uncertainty intervals, in a fully served market, if the sellers cannot charge for their detailed product information, then for any positive cost associated with disseminating detailed information, they will choose not to disseminate it, even under competition for overlapping market segments.*

We have proved this Theorem in previous work (Markopoulos et al. 2003), where we studied the full range of $N \geq 2$ sellers' incentives toward product information dissemination. Intuitively, from Figure 2, if seller 2 does not allow d-searches he will sell to buyers in $\overline{AKB}$, and if he allows d-searches, he will sell to buyers in $\overline{A'KB'}$, with $\overline{A'KB'} = \overline{AKB}$. So the seller will be indifferent between allowing and disallowing d-searches. Then, for any cost associated with allowing d-searches, he will chose not to allow them.

In our previous research (Markopoulos et al. 2003), we have shown that sellers will provide just enough product information so that their uncertainty intervals do not overlap, but no more information than that, for any positive cost associated with information dissemination. We have further shown that in the presence of strong consumer preferences (high values of the t—fit cost—parameter), sellers will tend to provide even more information, while never quite reaching the perfect information regime, where their uncertainty intervals would be reduced to zero size.

The result that is relevant to this paper, is the price equilibrium of this model, which has been shown to have both sellers charging $pi* = pj* = p* = t/2$ for their products. A simple proof is as follows: In equilibrium, each seller will serve a territory of size ½, which corresponds to half the market. A price decrease of δ will result in an increase in territory by δ/t. Let $Qi(pi,pj)$ denote the size of seller i's territory when sellers i and j charge pi and pj for their products respectively. On equilibrium, a seller will be marginally indifferent in providing the δ discount when no revenue change occurs:

$$\frac{d}{dp_i}\left[p_i Q_i\left(p_i, p_j\right)\right]_{pi=p*} = 0 \Leftrightarrow Q_i(p_i*, p_j*) + p * \frac{d}{dp_i}\left[Q_i\left(p_i, p_j *\right)\right]_{pi=p*} = 0$$

We know that $Q_i(p_i^*, p_j^*) = 1/2$, and that $dQ_i(p_i^*, p_j^*) = \dfrac{\delta}{t} = \dfrac{-dp_i}{t} \Leftrightarrow \dfrac{d}{dp_i} Q(p_i^*, p_j^*) = -\dfrac{1}{t}$. So we have

$$\frac{1}{2} - \frac{p^*}{t} = 0 \Leftrightarrow p^* = \frac{t}{2}.$$

If the sellers cannot charge buyers for d-searches and can only disallow them or provide them for free, then for any positive cost associated with allowing d-searches the equilibrium is as follows: in stage one, the sellers chose their locations uniformly, since they play simultaneously and cannot coordinate, and set their prices to $p = t/2$ disallowing the d-searches in all subsequent stages. This result is validated by most Internet consumer markets today, as product comparison Web sites usually provide only basic product information, leaving out richer attribute level descriptions of many product characteristics.

Discussion of Results

Arguably there are costs associated with keeping track of detailed product information and being able to disseminate it. In our airline example, an investment is needed for the airlines to keep track of service parameters such as in-flight entertainment, leg room in different classes, etc. Likewise, computer retailers find that it is costly to furnish detailed information about all product features, and archive it in such a way as to make parallel search feasible. For instance, keeping track of every bundled software piece and every component manufacturer's features is costly and, therefore, the consumer often finds out about these features after the purchase on the point of consumption.

This section argues that the information deficit phenomenon, has an economic justification. It exists due to ***asymmetries of the buyers' and sellers' incentives*** *toward more and better information*. Sellers do not always care to provide such information, since it is as likely to please a customer as it is to fall short of the customer's expectations. However, it is always the case that at least some buyers will want information of higher quality that would help them identify their best option. For those buyers, the detailed product information has a definite economic value.

Case II: Dual Pricing is Feasible by Only One Seller

Analysis

We relax the constraint from the earlier sections to allow one seller (only) to charge an information rent for providing d-search information. We formulate a model in which nature endows one seller (only) with the technological capability such as the ability to collect micro-payments to support a d-search. Thus seller 1 does not support d-searches while seller 2 charges a fee *I2* from buyers who perform d-searches. This section is a stepping stone for the more complicated analysis in the next section, where both sellers can charge for d-searches and thus compete in two dimensions, selling their product and selling their detailed information.

Let *d* be the distance between point *L* and the expected location of seller 2 (see Figure 3). Since on the unit circle the two sellers neighbor on two sides, let *d* be the shortest distance between the two. In Figure 3, only buyers in the *MN* interval are interested in performing d-searches. Buyers outside this interval would always prefer the seller that appears closer to their ideal location, regardless of the sellers' exact location in the uncertainty intervals. It can easily be shown that the distance *MN* is of size *a*, independent of seller's prices. Note that since *a* is an exogenous parameter, the *fraction of buyers* that want to obtain detailed product information is independent of the *sellers' choice of prices*.

In area A, buyers prefer seller 1 and achieve a buyer surplus given by: $v - p_1 - \left(\dfrac{d}{2} + \dfrac{p_2 - p_1}{2t} - x_1 \right) t$. They may discover that

seller 2 is preferable, once they perform a d-search on seller 2. We can show that a buyer situated at distance $x_1 \in [0, a/2]$ to the left of the middle point of *MN* would have an expected increase in surplus from performing a d-search on seller 2, given by

$\dfrac{t}{4a}(a - 2x_1)^2$. Similarly, the surplus that a buyer situated at distance $x_2 \in [0, a/2]$ to the right of the middle point of *MN*,

would achieve by performing a d-search on seller 2, is calculated to be $\dfrac{t}{4a}(a - 2x_2)^2$.
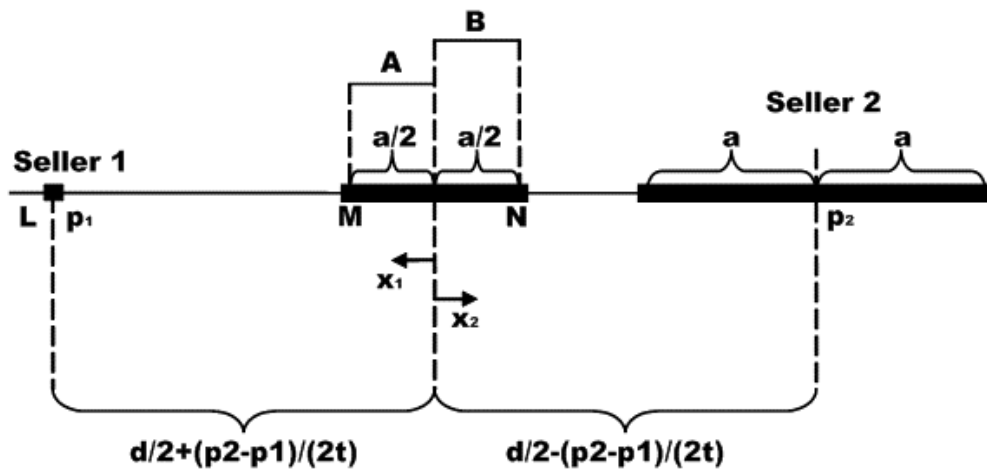
Figure 3. Detailed Information Is Valuable to Buyers That Are "In Between" Sellers

Notice that the value of information only depends on the parameters a and t and the distance from the middle point of MN and is independent of v, p, and d. Whether the buyer is in A or B, if the distance from the middle point of MN is x, she is willing to pay up to $\frac{t}{4a}(a-2x)^2$ for a d-search. If the seller charges $I2$ to allow a d-search, the maximum distance from the middle point in which buyers are still willing to pay for a d-search is obtained by solving $\frac{t}{4a}(a-2x)^2 = I_2$ for x, obtaining $x = \frac{a}{2} - \sqrt{\frac{a \cdot I_2}{t}}$.

And the size of the area in which buyers are willing to pay and perform a d-search is $x = a - 2\sqrt{\frac{a \cdot I_2}{t}}$ (see Figure 4).
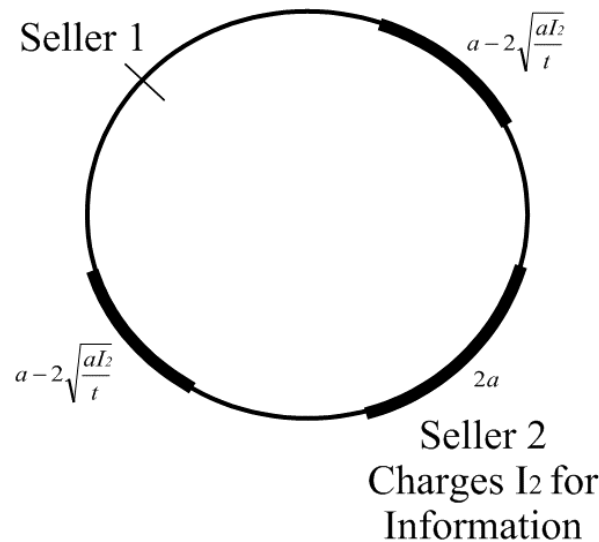

Figure 4. If Seller 2 Charges *Ij* for D-Searches, Buyers That Fall in Two Intervals of Size
$$x = a - 2\sqrt{\frac{a \cdot I_j}{t}}, \text{ Will Be Willing to Pay for the Detailed Information}$$

For $I > \dfrac{at}{4}$ the size of the area is zero and thus no buyer performs a d-search on seller 2. These observations lead us to our second result:

> **Theorem 2** *If only one seller sells detailed product information, product revenues are independent of the fee the seller charges to reveal the information.*

The proof can be found in Markopoulos (2003). Intuitively, as in case I, for any combination of fee and location in product space, the market share that the seller gains on one side is exactly offset by an equal loss on the other side.

Since both sellers know that product revenues are independent of the information rent charged, they will maximize their product revenues as in case I, by choosing $p1 = p2 = t/2$.

Seller 2 will maximize his expected information revenue per buyer $R = 2I_2 \left(\dfrac{a}{2} - \sqrt{\dfrac{aI_2}{t}} \right)$. Taking FOC, the revenue maximizing information rent is given by $I_2 = \dfrac{at}{9}$.
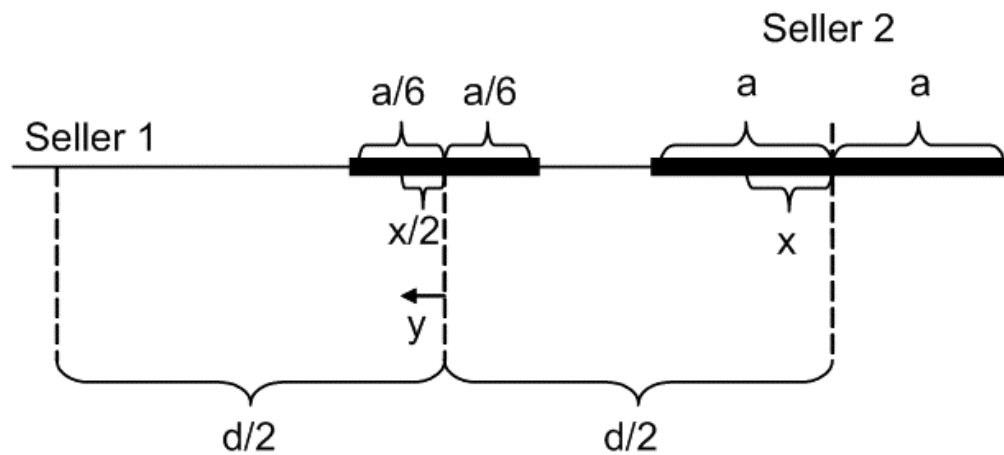

Figure 5. Measuring the Market's Efficiency Increase

The equilibrium characterization is as follows: both sellers set their product prices to $t/2$ and for a small information dissemination cost, Seller 1 forbids d-searches (since he has no mechanism to charge buyers for them), and seller 2 sets his d-search fee $I2$ to $at/9$.

We will use Figure 5 to calculate the total increase in market efficiency. In equilibrium, seller 2 sets $I2$ to $at/9$ and the size of the area in which buyers will pay for a d-search is, from the analysis above, $a - 2\sqrt{\dfrac{aI_2}{t}} = \dfrac{a}{3}$, extending for $a/6$ on both sides of the middle point between the two sellers' expected locations. Of course, there will be two such areas, since the sellers neighbor on two sides of the circle.

Let the seller's true location be at distance x to the left of his expected location. Consider a buyer located at distance $y < x/2$ from the middle point of the distance between the two sellers. That buyer, in the absence of detailed product information would have bought from seller 1 with expected utility $v – p – (d/2 – y)t$, but will now buy from seller 2 with utility $v – p– (d/2 – x+y)t$. The buyer's utility increase is $(x – 2y)t$.

For $x < a/3$, only buyers in an interval of size $x/2$ increase their utility by $(x - 2y)t$, as they are the ones that change their decision from seller 1 to seller 2. An equal number of buyers on the other side of seller 2 (not visible in Figure 5) change their decision from seller 2 to seller 1 with the same utility increase relative to their distance from the middle point between the two sellers on the other side of the circle. The expected utility increase per buyer is $2\int_0^{x/2}(x-2y)tdy = \dfrac{tx^2}{2}$, accounting for buyers on both sides of seller 2's location. For $x > a/3$, the size of the area in which buyers increase their utility is now less than $x/2$, as only buyers in the interval of size $a/6$ to the left of the middle point in Figure 5 perform d-searches. Same as in the previous case, the expected utility increase per buyer is $2\int_0^{a/6}(x-2y)tdy = \dfrac{at}{18}(6x-a)$.

The expected total market utility increase per buyer is obtained by integrating over all possible actual locations for seller 2:

$$\frac{1}{a}\int_0^{a/3}\frac{tx^2}{2}dx + \frac{1}{a}\int_{a/3}^{a}\frac{at}{18}(6x-a)dx = \frac{19a^2t}{162}.$$

Seller 2's expected utility increase per buyer is the product of the probability that a buyer will perform a d-search with seller 2's d-search fee: $2\cdot\dfrac{a}{3}\cdot\dfrac{at}{9} = \dfrac{2a^2t}{27}$. Thus seller 2 captures $\dfrac{2a^2t}{27}\Big/\dfrac{19a^2t}{162} = \dfrac{12}{19}$ of the increase in total market utility. Buyers get the remaining 7/19 of the increase.

Discussion of Results

A key observation is that the ratio of the equilibrium information price to product price for seller 2 is *2a/9*. This explains why, today, sellers do not sell detailed product information to buyers. To see why, assume that the amount of a seller's information that is not included in the product description is 2 percent of the product's attribute space. As per our model, *2a = 2%*, or *a = 1%*. Comparing the product price given by *t/2* to the information price of *at/9*, we find that product information should be 1/450 of the product price. Even for a product that costs $300, information price would be less than 67 cents. The 67 cents cannot be absorbed in the product price, as we have seen that these quantities maximize different components of the seller's revenue. In the absence of a widespread micro-transaction payment scheme, sellers today are not capable of charging these small information fees to buyers that require more detailed product information. On the other hand, in cases where information has considerably higher value, for example, for higher uncertainty *a*, higher product prices (which in our model translates to higher *t*), or for a buyer that requires multiple units of the product, there is already a market for consumer reports, as predicted by our model. Indeed for industrial products such as steel and copper that are used in creating direct engineered goods, the product attributes (such as thermal conductivity, shearing stress, etc.) are of so much significance that there are fully developed markets for the selling of such information.

Product information in not currently being traded with the form that we predict due to the absence of a widespread micro-transaction scheme. The question, "why haven't we seen such product information markets" has a rather surprising answer. It turns out that our results depend critically on the buyers' ability to perform the first search that identifies the sellers' location with some uncertainty, *in parallel*. This new buyer ability, enabled by the Internet, is not present in traditional markets, where search is sequential. More specifically, Theorem 1 does not hold, were we to model buyers as sequentially searching for sellers in the product space. Our prediction of the emergence of product information market depends on two critical components coming together: **parallel search ability** and a widespread **micro-transaction payment scheme**. Traditional markets can accommodate micro-payments (in order of cents) but will forever lack a parallel search ability. Internet and wireless networks are already making the parallel search ability a reality, but currently lack micro-payments. However, this is expected to change in the near future. Our paper predicts the emergence of product information markets when parallel search and micro-payments become commonplace among buyers.

By selling detailed product information, a seller is able to **price discriminate** and optimize revenues: some buyers in the market pay *p = t/2* for a product, while those that require detailed product information pay *t/2 + at/9*. By allowing a seller to sell detailed product information, price discrimination becomes possible, since buyers self-select their type when they chose to perform a d-search or not.

Buyers also benefit from the existence of a product information market. There is an increase in market efficiency as measured by the decrease in aggregate *deadweight loss*, which is the sum of all buyers' fit costs. Clearly, this represents the **welfare gains** from charging an information rent.
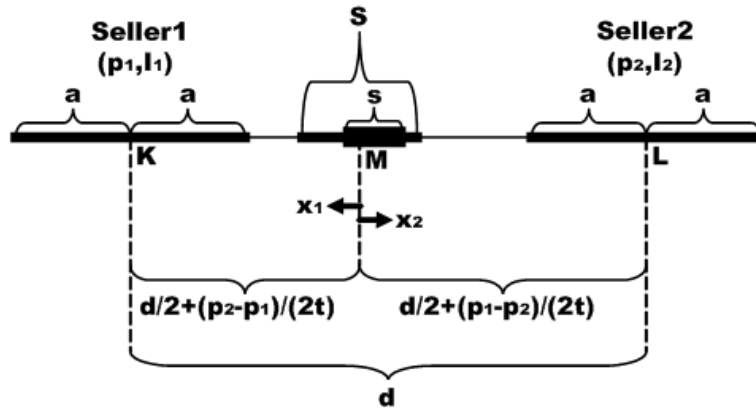

Figure 6. Buyers That Are in the "Switching Threshold" Perform Either One or Two D-Searches

Case III: Dual Pricing and Seller Competition

Analysis

In this section, we extend our game to account for both sellers' ability to employ dual pricing. The space of strategies is exogenously determined and there is an infinite number of stages. In stage one, the sellers simultaneously choose their price and location, and observe the opponent's choices. In each of the subsequent infinite number of stages, the sellers first set their d-search fees and one buyer, randomly chosen from the population, enters the market to purchase one unit of the good. The sellers are thus allowed to change their d-search fees between successive buyers, which corresponds to the assumption that sellers can easily reconfigure their information services, namely d-searches, while it is relatively difficult for them to reconfigure their actual product.

In Figure 6, sellers 1 and 2 respectively charge $p1$ and $p2$ for their products and $I1$ and $I2$ to allow d-searches. Let K and L be the expected locations of sellers 1 and 2 respectively, in the middle of their uncertainty intervals of size $2a$. Let M be the point in between the two sellers that a buyer is initially indifferent between the two sellers.

Buyers to the left of the S interval will always prefer seller 1, and will not wish to pay any positive amount for a d-search, and buyers to the right of the S interval will always prefer seller 2. Buyers in the S interval are willing to incur the cost to perform one d-search, and a subset of them, in the s interval will find that they will require a second d-search after they receive detailed information on the first seller that they chose. Equation 2, below, will reveal that the S interval has M as its middle point and its size is independent of product prices and depends on the fit cost coefficient t, the uncertainty parameter a, and the two sellers' d-search fees $I1$ and $I2$. The problem that the buyers face when they are considering a second d-search is mathematically the same as the problem they face when only one d-search is available. Thus, from case II, we know that the size of the s interval depends on a, t, and the d-search fee of the second seller to be searched. However, its position depends on the results of the buyers' first d-search, or in other words on the exact position of the first seller to be d-searched.

It can be shown that the increase in utility that a buyer will have from first performing a d-search on seller i, given that the buyer is situated at distance x from M (see Figure 6), regardless on whether $x = x1$, to the left of M or $x = x2$, to the right of M, is given by:

$$U_i(x) = \begin{cases} \dfrac{4I_j\sqrt{\dfrac{aI_j}{t} + a^2t + 3tx^2 - 3a(I_j + tx)}}{3a}, & if \quad x < \sqrt{\dfrac{aI_j}{t}} \\[4em] \dfrac{4I_j\sqrt{\dfrac{aI_j}{t} + a^2t + 3tx^2 - 3a(I_j + tx) + x\left(3I_j - \dfrac{t}{a}x^2\right)}}{3a}, & if \quad x > \sqrt{\dfrac{aI_j}{t}} \end{cases}$$

Equation 2

The derivation of equation 2 is provided in Markopoulos (2003). It is derived by integrating over-all possible seller positions, with the buyer deciding sequentially, on the number of total (zero, one or two) d-searches to be performed.

One important observation about equation 2 is that the increase in the buyer's utility from performing a d-search on seller *i* does not depend on product prices or the distance between the sellers. It depends on the distance from point *M* but is independent of whether the buyer is to the right or the left of this point. That means that, for any combination of d-search fees, the value of seller *i*'s detailed information is symmetrical around point *M*. As in case II, this guaranties that seller *i* will not experience any change in product market share from the operation of the information market. Any market gain on one of two sides that the sellers neighbor on the circle will be exactly offset by a loss on the other side. A proof of this can be found in Markopoulos (2003). This observation implies that the sellers, knowing that they cannot influence their product market shares with their d-search fees, and cannot influence information market shares with their product prices, will maximize product and information revenues separately, and as in cases I and II, will set their product price to *p1 = p2 = p* = t/2*.

> **Theorem 3** *Product revenues are independent of the fees that the sellers charge to reveal their detailed information.*

The proof can be found in Markopoulos (2003).

To study the market's equilibrium, we first observe that $S > s$. When sellers compete in selling their detailed product information at the same time as they compete in selling their product, the two revenues will be maximized separately. However, it can easily be shown that there is no pure strategy equilibrium if the sellers were to set their d-search fees in a one stage game. This is because a slight undercut of the opponents d-search fee captures all first searches in the *S* interval which leads to a discontinuous increase in seller revenues. This contrasts, for example, with the case of product price competition, where an δ undercut of the opponent's product price leads to an increase in market share that is a function of δ. However, d-search fees are not driven down to zero, as the sellers can at least receive second d-searches, which are maximized according to the analysis in case II.

Formulating the game to have an infinite number of stages, where sellers compete in selling information, reflects our belief that competing for a pure information good allows for much more flexibility than competing for a physical product. We expect sellers to be much more flexible in repricing their d-searches than repricing their products. It is widely accepted that the most likely outcome in this case is that sellers will achieve implicit collusion, as they can *credibly* threaten their opponent with a d-search fee undercut.

We cannot solve for this equilibrium analytically, due to the form of equation 2, but we can numerically calculate it as follows: first we calculate the size of *S*, with the help of equation 2, by requiring that *Ui(x)-Ii=0*. We already have the analytical result for the size of *s* from case II. Finally, we maximize expected information revenues per buyer, given by $I_i\left(\dfrac{1}{2}|S| + \dfrac{1}{2}|s|\right)$, where $|S|$ and $|s|$ are the sizes of *S* and *s* respectively.

We can also numerically calculate the increase in market efficiency, by the reduction in total deadweight losses, as measured by the aggregate fit costs that buyers incur. Once the size of *S* is calculated numerically, the analysis is essentially the same as case II. The difference is that buyers that fall in the *s* interval will make their decision being even better informed, since they would know both sellers' exact locations.

Discussion of Results

We showed that information is valuable to consumers that are in the switching threshold between two products. Of course, this is a well known result in decision theory: Information has maximum value under maximum uncertainty.

This can be understood better with the following example. Imagine a business traveler that needs to purchase a ticket from New York City to London for an early morning meeting. Imagine that there are two flights available for the same price. The first leaves at 5:00 p.m. and the second at 10:00 p.m. If the traveler wants to be on time for the meeting, the 10:00 p.m. flight is too late. The question that we ask is, "How much would the traveler be willing to pay to obtain in-flight information, such as menu or movie schedule, that would help her decide which ticket to purchase?" The answer in this case is that the traveler would not want to pay anything for this information, because it cannot potentially influence her decision to purchase the ticket to the early flight. Now, imagine instead that both flights leave at 5:00 p.m. for the same price. Now the question probably has a non-zero answer. For example, the traveler can pay to learn the movie schedules on both flights, so she can choose the flight that would make her trip more pleasant.

Airlines would have the incentive to incur the cost of collecting such in-flight information and make it available to travel agents and ticket reservation systems. In the absence of an ability to charge for this information, they would not find it profitable to provide it.

Managerial Insights and Implications

Our paper predicts that with the advent of a widespread micro-transaction scheme, product manufacturers and online retailers will have the opportunity to sell fine-grained product information to interested buyers. Currently, companies have a passive stance toward much of the information that describes their products and services. For example companies like Sony, GE, Palm, and Staples outsource the collection and dissemination of their detailed product information to companies such as Active Decisions that specialize in this field.

We expect this passive stance to change in the near future, with companies actively seeking the compilation of profitable ***product information bundles***. These bundles will contain not only information that is today unavailable to consumers, but also information of a higher degree of *quality*. For example, exact color samples for home appliances, instead of photos, whose even slight color distortion may be unacceptable to color sensitive consumers.

We derived the equilibrium prices for the detailed product information, under the assumption that sellers retain complete monopoly over their detailed product information. In the real world there would be third parties that can compete with sellers in providing the same information. For example, what if *Consumer Reports* or online buyer communities sell the same information as the sellers attempt to sell[2]? In this case the sellers would be the lowest cost producer of their own information (it is readily available to them) and would compete with high cost producers, such as *Consumer Reports*, which have to somehow extract it. The high costs associated with information extraction is probably the reason why *Consumer Reports* usually rates the most popular products in each category. However, even then, the premium that the sellers would be able to extract for their detailed product information would be much lower than the case when each seller has a complete monopoly over detailed product information. This is, of course, bad from the point of view of the seller, but it is positive for social welfare, as can be seen from the inverse relationship between product information price and the number of buyers that receive more information, each with an *a priori* expected increase in utility. From a social point of view, the more competitive the product information markets, the more useful they are.

Competition from online buyer communities has further implications that we have not addressed in detail. These communities are more likely to focus on qualitative attributes of the product, while the unit circle model can only handle horizontal (i.e., non-qualitative) spatial differentiation.

---

[2] We also assumed that sellers are always truthful, when revealing their detailed product information. This corresponds to the assumption that a seller that provided misleading information would not be able to sell it in the future, except, maybe, at a steep discount.

Conclusions and Extensions

This paper demonstrated that *a market for product information can partly correct the inefficiencies that result from the availability of less than perfect product information in internet markets*. We predict that product information will begin to be traded once an appropriate micro-transaction payment scheme becomes available. It follows from our analysis that allowing sellers to charge an information rent leads to more efficient markets.

As part of our work's future extensions, we intend to study the mechanism of product information dissemination in much more detail, incorporating vertical product attributes, such as quality. Initial results suggest that a phenomenon analogous to our definition of the information deficit, may be present for quality parameters as well, and that product information markets may be also applicable in these cases. A more in-depth study of the product information dissemination mechanism will also shed light on the types of products for which our ideas are more likely to be applicable. For example, we are interested in examining product categories for which, in reality, there seems to be too much information available. A complete model of the role of detailed product information in markets should be able to provide an explanation for such phenomena.

We will bring together these analyses to comment on the implications of dual pricing markets and investigate the conditions under which these lead to welfare gains.

References

Akerlof, G. A. "The Market for 'Lemons': Qualitative Uncertainty and the Market Mechanism," *Quarterly Journal of Economics* (89), 1970, pp. 488-500.

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

Diamond, P. A. "A Model of Price Adjustment," *Journal of Economic Theory* (3), 1971, pp. 156-168.

Greenhut, M. L., Norman, G., and Hung, C. S. The Economics of Imperfect Competition: A Spacial Approach,. Cambridge: Cambridge University Press, Cambridge, UK, 1987.

Hotelling, H. "Stability in Competition," *Economic Journal* (39), 1929, pp. 41-57.

Lippman, S., and McCall, J. "The Economics of Uncertainty. Selected Topics and Probabilistic Methods," *Handbook of Mathematical Economics* (2:6), 1982, pp. 213-225.

Markopoulos, P. M. "Product Information Dissemination in the Internet and Markets for Product Information," Unpublished Ph.D. Dissertation Proposal, proposal, University of Pennsylvania, 2003.

Markopoulos, P. M., Aron R., and Ungar L. H. "The Information Deficit in Electronic Markets," unpublished manuscript, University of Pennsylvania, 2003.

Nelson, P. "Information and Consumer Behavior," *Journal of Political Economy* (78:2), 1970, pp. 311-329.

Rothschild, M. "Models of Market Organization with Imperfect Information: A Survey," *The Journal of Political Economy* (81:6), 1973, pp. 1283-1308.

Salop, S. "Monopolistic Competition with Outside Goods," *Bell Journal of Economics* (10), 1979, pp. 141-156.

Samuelson, P. "The Monopolistic Competition Rrevolution," in *Monopolistic Competition Theory*, R. Kuenne (ed.), John Wiley & Sons, New York, 1967.

Stigler, G. "The Economics of Information," *The Journal of Political Economy* (69:6), 1961, pp. 213-225.

Stiglitz, J. E. "Imperfect Information in the Product Market," in *Handbook of Industrial Organization*, R. Schmalensee and R. Willig (eds.), North-Holland, New York, 1989, pp. 769-847.

Takahashi, T., and de Palma, A. "A Unified Treatment of the Segment and the Circular Market Models," in *Does Economic Space Matter?*, H. Ohta and J. F. Thisse (eds.), St. Martin's Press, New York. 1993.

Weitzman, M. "Optimal Search for the Bbest Alternative," *Econometrica* (47:3), 1979, pp. 641-654.