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by

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Abstract

Search costs models and search behavior models have experienced a renaissance due to dramatically reduced search costs on the Internet. This paper models the buyer search behavior, i.e. the decision whether to search sequentially or simultaneously for a homogenous product, in an electronic market and the effects of this decision for online stores. We will show that the simultaneous search is in general the better choice. The impact of reducing the search costs and an increase in the number of suppliers is analyzed. However in the presence of decreasing search costs, the advantage of the simultaneous approach diminishes until the consumer is indifferent between the two search methods when the search costs become negligible.

Keywords:

Search behavior; electronic market; reservation price; search cost; simultaneous search; sequential search

Introduction

With the advent of the Internet and the ongoing virtualization and digitization, markets are undergoing a fundamental shift. In these global and transparent markets, on the one hand competition is intensified and on the other hand opportunities arise for corporations to expand into new markets and to realize competitive advantages through new innovative (digital) products and services.

One key factor for market outcomes and consumer behavior is the search costs a buyer bears to locate an appropriate seller and purchase a product. Similar to searches in traditional markets, online searches can be carried out either sequentially or simultaneously. Surfing through different web stores evaluating products and prices is a sequential search; a price search based on a price database is an example of a simultaneous search . Ideally a search result of a simultaneous search looks like a table where all the relevant information is gathered, compressed, and structured and the consumer may directly decide to buy the least expensive product upon the search result by a single mouse click. Popular examples for already existing search agents include evenbetter.com (books, music, movies), shopping.altavista.de (any product), and CNET.com (technology products). As the Internet becomes more and more pervasive, search costs studies have recently experienced a renaissance. Search costs have dropped dramatically since physical distances have become much less relevant in net markets. A number of reasons contribute to decreasing search costs:

- In traditional, regional markets were often untraceable products. These products can now be found in the electronic market.
- New suppliers of already known products can be found.
- The data provided by online stores and intermediaries are generally accessible more quickly, richer in content, and more up-to-date.

Hence, more products can be found much faster compared to physical markets. The shift from a traditional market to an electronic market is not only complemented by a sharp drop in search costs, but also a trend of declining search costs in electronic markets is observable.

- The telecommunication markets in many countries have become more liberalized (e.g. in the EU) resulting in decreasing prices.
- Additionally, there is a high competition for online users among the ISPs leading to declining access fees. In fact, in the U.S. there are already a number of big players, such as Lycos, NBCi, and ExciteAtHome, offering free access to the Internet.
- Fast and dynamically emerging technologies facilitate the decrease of search costs (search engines, search agents, bargain finders)

There have been a considerable amount of search models that examine aspects and impacts of reduced search costs, e.g. Anderson (1999) [1], Will (1997) [14], Burdett/Coles (1995) [4] and Salop/Stiglitz (1982) [9] all deal with price dispersion as an equilibrium outcome that can be explained by the costly search of information. Davis/Holt (1996) [6] test the conclusions of Diamond's Paradox and Bakos (1997) [3] examines the role of buyer search costs in markets with differentiated product offerings. Steck/Will (1998) [12] identify action consequences for suppliers in electronic markets due to changing consumer behavior that is attributable to a change in search costs. Among the previous works are for example the famous original study on the economics of information by Stigler (1961) [13] and the article by Salop/Stiglitz (1977) [9] that addresses the problem of heterogeneity of consumer rationality.

Shy (1997) [11] examined the strategy of consumers searching sequentially in a commodity market and determined the expected number of store visits until a customer will buy a product. In this study, while allowing for more flexibility, we will build upon the work of Shy (1997) and extend it in the two different following directions.

1. We will combine the sequential with a simultaneous search model allowing us to fully examine consumer search behavior in a commodity market.
2. We will determine the total expected costs of a search process which concludes in the buying of a product for both search methods.

In the following section, we illustrate that the decision for a specific search method has a great impact on which product will be found and purchased. As this is certainly interesting information for online stores, we will draw conclusions for both the consumers and the suppliers. We will also identify the impacts of decreasing search costs and additional suppliers in the market – trends that are currently observable on the Internet – on the search behavior.

The paper is organized as follows. In section 2 we will present the model, and derive conclusions taking into consideration decreasing search costs and an increase in the number of suppliers. Discussing the limitations of the analysis will be the issue of section 3. Finally in section 4 the basic results and conclusions will be summarized.

Search for Homogenous Products

Model and its Assumptions

First, the offered product is homogenous and sufficiently described by its price.

Second, in an electronic market there are n virtual stores selling a homogenous product. With no loss of generality[1], we assume that the price charged by each store of type i, $i = c, c+1, \dots, e$ with $0 \le c \le e \le \infty$ and $n = (e - c + 1)$, is $p_i = i$. That is for example a store of type 3 charges $p_3 = 3$. Note that for the case when $c = 0$ we also have a store of type 0 that charges $p_0 = 0$. Prices are exogenously given, and stores do not change prices[2].

Third, the risk neutral consumer knows the distribution of the prices but does not know which price is charged by a particular store. That is, the consumer knows that in the market there are n prices in the range of $p = c, c+1, \dots, e$ but they do not know the exact price offered by each individual virtual store. The consumer can decide to search simultaneously or sequentially. If she decides to search simultaneously she bears a constant search cost (including possible fees from the search agent) of $\alpha_{si} > 0$ per search. If she decides to search sequentially she bears a constant search cost of $\alpha_{se} > 0$ for each time she visits a store.

Fourth, the consumer will opt for the search method with the lowest expected total cost, that is the expected costs for the search and the expected product price.

Fifth, new market entrants can either charge a lower price than store c or a higher price than store e.

The distribution of the prices can be graphically illustrated in Figure 1. In this example the lowest price is $p_c = 0$[3].

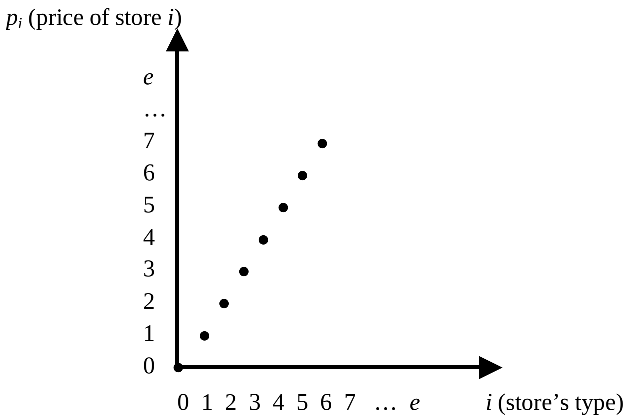

Figure 1: Supplier prices and store distribution, [11]

Zero prices are a phenomenon that can often be observed on electronic markets concerning digital products. Some rational reasons for this pricing behavior are listed below.

- First, a supplier can decide to generate its revenues from online advertisements (paid banners or paid links) rather than charging the consumers a price for their products.
- Second, a supplier aims to utilize the lock-in effect, hence it is providing its digital product for free (e.g. the Acrobat Reader or the Netscape Communicator).
- Third, in order to become well known a new supplier in the market might provide its digital product for a limited period for free.
- Fourth, marginal cost of digital products approach zero, excluding any copyrights duties. Hence, suppliers may charge a subscription fee to cover their high fix costs but nothing for the product or service.

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1 We assume a known distribution of the prices to simplify the analysis. Rothschild (1975) has shown that in many cases the qualitative characteristics of optimal search strategies with known distribution of prices are equal to those where the customer at first knows nothing about the distribution of prices but learns during her search about it [8].

2 The price determination process of online stores is not analyzed, so store prices are taken to be given.

3 Note that in contrast to Shy's model, the lowest price can be any positive integer, allowing for more flexibility.

To summarize, the consumer knows the distribution of the prices and will calculate the total expected costs before starting to search. She will opt for that search method that leads to the lowest possible total cost. This scenario can be visualized in Figure 2:

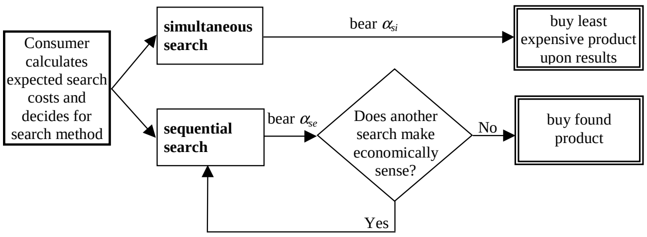

Figure 2: Consumer search for homogenous products

In a first step we will have a closer look at the sequential search (2.2). In a second step we will examine the expected costs for a simultaneous search (2.3), and combine these approaches in the section 2.4.

Sequential Search

Suppose a consumer has decided to search sequentially, how can she determine when to stop the search process with a price offer p_i in hand? In a sequential search our consumer has a strict sunk cost perspective. This means a consumer will never look back and stop her search because of the loss caused by several searches in the past. Each time she visits a store and gets the price information p_i, she calculates the expected price reduction from visiting one additional store and compares this with her search cost α_{se}. Since the consumer by assumption knows the prices and each price is realized with probability $1/n$[4], the expected reduction *epr* is

$$epr(p_i) = \frac{(p_i - p_c)\cdot((p_i - p_c)+1)}{2\cdot n} \qquad (1)$$

If the consumer concludes the search by buying the product, then her "loss" is p_i. In contrast, if she rejects the price offer and searches one more time, then the expected loss is the sum of an additional search cost α_{si}, plus the current price offer, minus her expected gain from searching one more time. Formally, the consumer with an offer p_i in hand minimizes

$$L(p_i) = \begin{cases} p_i & \text{if she buys and pays } p_i \\ \alpha_{se} + p_i - epr(p_i) & \text{if she searches one more time} \end{cases} \qquad (2)$$

Thus, a consumer continues searching if and only if the price in hand p_i satisfies $epr(p_i) > \alpha_{se}$. We call this a reservation-price strategy.

The reservation price $\bar{p}$ represents that price when the consumer is indifferent between affording another search or just buying the product with the price offer p_i in hand. Formally, by solving the equation $\alpha_{se} = epr(p_i)$ for p_i, we get for the reservation price:

$$\bar{p} = p_c + \frac{-1+\sqrt{1+8\cdot\alpha_{se}\cdot n}}{2} \qquad (3)$$

Proposition 1: In a sequential search market both new less expensive suppliers and declining search costs will increasingly drive more expensive established suppliers out of the market.

In most cases, new less expensive suppliers ($p < p_c$) entering the market and declining search costs will cause a decrease in the reservation price[5], making a consumer reject more offered products before she is willing to buy it. New more expensive suppliers will cause an increase in the reservation price. If the search costs become negligible, thus $\alpha_{se} = 0$, the consumer will search till she finds p_c. Storekeepers have to acknowledge the fact that due to the reservation price strategy a buyer that once decided not to buy in a found store will never buy there during this search process, even if she comes back to his store coincidentally. Interestingly, if a storekeeper knew the buyer's search cost (and like the buyer the price distribution[6]) he could guarantee the customer – if appropriate – that another search makes economically no sense.

Example 1: Suppose the consumer wants to buy a book on the Internet and knows that there are 25 suppliers offering the product between \$30 and \$54 (p_c = 30, p_e = 54). A search agent is not available hence the consumer may only search sequentially. She calculates her reservation prices for several scenarios that are presented in Table 1.

Table 1: Reservation Prices for Sequential Search

# of Suppliers (Price range) Search costs	**25** (\$30 – \$54) *Initial situation*	**30** (\$25 – \$54) *5 new cheaper suppliers*	**30** (\$30 – \$59) *5 new more expensive suppliers*
\$10	\$51.90	\$49.00	\$54.00
\$5	\$45.30	\$41.80	\$46.80
\$2	\$39.50	\$35.50	\$40.50
\$1	\$36.60	\$32.30	\$37.30

To determine the total expected costs of a sequential search, the chronological order of how costs are incurred was evaluated. The consumer visits the first store *i*, looks at the price p_i, compares the price with her reservation price and decides either to buy the product, thus incurring total cost of one search and product price p_i or to go on searching. If

[4] If the consumer keeps track of the stores she has already visited, this probability will change as the search progresses. The probability would be $1/(n - k)$ where *k* is the number of stores already visited. For the sake of simplicity in the presented model, it is assumed that the customer does not keep track of her store visits.

[5] This holds only true for $\alpha_{se} < (2n + 1)$ which is most often the case.

[6] In the author's opinion, it is reasonable to assume that a supplier knows the offers of his competitors at least as well as its customers.

she goes on searching, in the next shop it is just the same except for the total cost consisting now of two searches and the "new" product price. Formally the consumer will calculate the expected number of store visits *esv* to find an appropriate price times the search cost α_{se} and the expected product price *epp*.

If the price of a found product is below the customer's reservation price, she will buy it without any further searches. Obviously, when the reservation price is greater than the highest price in the market[7] the consumer will always buy the first found product right away. Hence the expected product price is given by $(p_e - p_c)/2$. If the reservation price is below the most expensive product in the market, the consumer will expect to pay $(\overline{p} - p_c)/2$ since she will only buy a found product that costs at most the reservation price. Formally we get

$$epp = \begin{cases} \dfrac{\overline{p} + p_c}{2} & \text{if } \overline{p} \le p_e \\ \dfrac{p_e + p_c}{2} & \text{if } \overline{p} > p_e \end{cases} \tag{4}$$

Shy (1997) has shown that the expected number of stores to be visited by our customer equals one over the probability that she buys in a single store visit. Here, the probability that she will buy in a single store is $(\overline{p} - p_c + 1)/n$ since she will reject all price offers greater than her reservation price. In the case where the expected number of visits becomes analytically smaller than 1, we assume that the consumer searches at least once. Hence the expected number of store visits *esv* is

$$esv = \begin{cases} \dfrac{2 \cdot n}{1 + \sqrt{1 + 8 \cdot n \cdot \alpha_{se}}} & \text{if } \alpha_{se} < \dfrac{n-1}{2} \\ 1 & \text{if } \alpha_{se} \ge \dfrac{n-1}{2} \end{cases} \tag{5}$$

Combining (4) and (5) and substituting $\overline{p}$ using (3) yields the expected total costs TC_{se}.

$$\begin{aligned} TC_{se} &= \begin{pmatrix} \text{expected \# of searches} \\ \cdot \text{ search cost per search} \end{pmatrix} + (\text{expected product price}) \\ &= \begin{cases} \dfrac{2 \cdot n \cdot \alpha_{se}}{1 + \sqrt{1 + 8 \cdot n \cdot \alpha_{se}}} + p_c + \dfrac{-1 + \sqrt{1 + 8 \cdot n \cdot \alpha_{se}}}{4} & \text{if } \alpha_{se} < \dfrac{n-1}{2} \\ \alpha_{se} + \dfrac{p_c + p_e}{2} & \text{if } \alpha_{se} \ge \dfrac{n-1}{2} \end{cases} \end{aligned} \tag{6}$$

Equation (6) can be simplified as follows:

$$TC_{se} = \begin{cases} p_c + \dfrac{-1 + \sqrt{1 + 8 \cdot n \cdot \alpha_{se}}}{2} & \text{if } \alpha_{se} < \dfrac{n-1}{2} \\ \alpha_{se} + \dfrac{p_c + p_e}{2} & \text{if } \alpha_{se} \ge \dfrac{n-1}{2} \end{cases} \tag{7}$$

Proposition 2: In a sequential search market the total expected cost associated with searching and buying a product equals the reservation price of the customer.

Equation (7) presents a very interesting outcome. Initially, the reservation price was the basis for our customer to decide whether she should search once again or buy the product in hand. Now we have shown that the reservation price implicitly also represents the total expected costs for finding and buying a commodity in a sequential search market.

The conclusions that can be derived from equation (7) are generally the same as the ones for (3). A decrease in the consumer search costs decreases the expected total cost. Decreasing search costs favor the cheaper suppliers since the consumer will search more often. If the search costs become negligible, the expected total cost would just be p_c because the consumer searches until she finds the lowest price without bearing any search costs. In such a market all other suppliers would not sell a product anymore. An increase in the number of stores in the market would decrease the expected total cost if cheaper suppliers enter the market and increase the expected total cost if more expensive suppliers enter the market. A market entry in such a market makes sense if and only if $\alpha_{se} \ge (n-1)/2$ Otherwise no revenues can be expected since already slightly cheaper suppliers are not able to sell a product.

Example 2: The consumer in Example 1 wants to calculate her total expected cost for finding and buying the book on the Internet. Since she already calculated her reservation prices for various scenarios (see Table 1) she implicitly has already determined her total expected costs. A new calculation is not necessary.

Simultaneous Search

Determining the results of a simultaneous search is much easier compared to the sequential approach. Assume that the information broker or search agent has the same information as the consumer[8], hence the result of the simultaneous search will be store *c* offering the product at price p_c. So, – and this is quite noteworthy – the consumer can be sure to get the best offer, if she chooses to search with the information broker or search agent. To get the total cost incurred by a simultaneous search we just have to sum the least expensive offer and the search cost α_{si}. Hence we get:

$$TC_{si} = \alpha_{si} + p_c \tag{8}$$

Proposition 3: In a simultaneous search market the least expensive supplier will always be found and only this supplier will generate revenues.

A decrease in search costs reduces the total cost for the buyer but does not affect the found supplier. An increase in the number of stores in the market has only an impact on total cost if cheaper suppliers entering the market. In a market where buyers just search simultaneously only the

[7] This can occur when there are only a few suppliers in the market and the search cost are relatively high. Formally if. $\alpha_{se} \ge (n-1)/2$.

[8] Often the search agent will have an information advantage over the customer. For the sake of simplicity we assume that this is not the case.

least expensive supplier will survive. It makes no sense economically to enter such a market with more expensive products.

Example 3: Suppose our consumer in Example 1 discovers that there is a search agent available that allows searching simultaneously for the wanted book on the Internet. For the total expected costs she calculates the following for the different scenarios.

Table 2: Total Expected Cost for Simultaneous Search

# of Suppliers (Price range) Search costs	**25** ($30 – $54) *Initial situation*	**30** ($25 – $54) *5 new cheaper suppliers*	**30** ($30 – $59) *5 new more expensive suppliers*
$10	$40.00	$35.00	$40.00
$5	$35.00	$30.00	$35.00
$2	$32.00	$27.00	$32.00
$1	$31.00	$26.00	$31.00

Combined Approach

With both approaches in hand, we can now determine whether the consumer will decide to search simultaneously or sequentially. She simply calculates the expected total costs of the sequential search and compares these with the total costs of the simultaneous search[9]. She will use an information broker or search agent if and only if the total cost of the simultaneous search is lower than the expected total cost of purchasing a product using a sequential search.

$$TC_{si} < TC_{se}$$
$$p_c + \alpha_{si} < \begin{cases} p_c + \dfrac{-1+\sqrt{1+8\cdot n\cdot \alpha_{se}}}{2} & \text{if } \alpha_{se} < \dfrac{n-1}{2} \\ \alpha_{se} + \dfrac{p_c + p_e}{2} & \text{if } \alpha_{se} \geq \dfrac{n-1}{2} \end{cases} \quad (9)$$

Proposition 4: A consumer will search sequentially if and only if her reservation price is lower than the least expensive product price plus the simultaneous search charge.

Unless information about the differences in the search costs α_{si} and α_{se} is available we can not generally recommend one search method. Obviously, if the search costs become negligible, the consumer is indifferent between the two search methods and will find the least expensive offer without bearing any search costs. An increase in the number of cheaper stores in the market would decrease both the total expected costs for both the sequential and the simultaneous search. A store might be able to charge more than p_c for its product only if the sequential search is the better choice

[9] Since the consumer is by assumption risk neutral we can compare here the *expected* total costs of a sequential search and the *certain* total cost of a simultaneous search.

Example 4: Suppose the consumer of the Examples 1 to 3 faces search costs of $10 for a simultaneous search and $2 for each sequential search and still wants to buy the book. The results are gathered in Table 3. While the sequential search is the better choice in the initial situation, this changes with 5 new – either cheaper or more expensive – suppliers.

Table 3: Combined Approach - Consumer's Decision

# of Suppliers (Price range) Search Costs	**25** ($30 – $54) *Initial situation*	**30** ($25 – $54) *5 new cheaper suppliers*	**30** ($30 – $59) *5 new more expensive suppliers*
Simultaneous Search Cost: $10	$40.00	$35.00	$40.00
Sequential Search Cost: $2	$39.50	$35.47	$40.47
Consumer Decision	*Search sequentially*	*Search simultane-ously*	*Search simultane-ously*

The search cost on the Internet for both methods will often be approximately the same since most search agents do not charge an extra search fee and the time it needs to search with a search agent is pretty similar to the time it needs to browse a virtual store. Hence on the Internet $\alpha_{si} \approx \alpha_{se}$ will hold true in many circumstances. This leads to a general preference for the simultaneous search because the reservation price is always greater or equal to p_c.

Proposition 5: In a market with equal costs for both search methods, the buyers will search simultaneously to discover the least expensive offer with its supplier being the only one to survive in the market.

Having presented a combined approach to examine buyer search behavior in an electronic market we will now discuss some limitations of the analysis.

Limitations of the Analysis

In general a search agent will have an information advantage over a consumer. Rothschild (1975) has shown that in many cases the qualitative characteristics of optimal search strategies with known distribution of prices are equal to those where the customer at first knows little or nothing about the distribution of prices but learns about the prices during her search [8].

The assumed risk neutrality of the consumer will often not hold true. Many people prefer a certain result (here: the simultaneous search) to an uncertain event (here: the sequential search), hence they are risk averse. The model can be easily adjusted to take also into account the consumer attitude towards risk. Given the assumption that consumers are risk adverse, they will favor the simultaneous search even more.

In this paper we assumed that search cost are either positive or zero. This need not hold true for all the Internet buyers. Many people enjoy surfing and browsing the WWW looking for good deals or just for pleasure. Hence, searching the Internet could provide a customer with utility that may outweigh the opportunity cost of time and the online fees.

Even when buying commodity products like books, price is often not the only important factor that influences the buyer's decision. For example delivery time and reliability and reputation of the online store are probably also relevant factors that customers take into account. However in the future with established trusted third parties and more sophisticated logistics and distribution systems, one may argue that these factors become less important.

Concluding Remarks and Outlook

In this paper the customer decision process for using either a sequential or a simultaneous search method in a commodity market has been examined. In the context of a sequential search, the outcomes reveal that the reservation price is not only the price where a consumer is indifferent between searching another time and buying the product in hand. It represents also the total expected costs associated with a search process and concluding the search in buying the product. If suppliers knew the distribution of the prices in the market and the reservation price of a consumer, they could provide – if appropriate – the consumer with a guarantee that another search does not make sense economically.

It has been shown that both approaches to examining buyer search behavior in (electronic) commodity markets can be comfortably combined. In the absence of special search charges by search agents, a strong preference for the simultaneous search method could be proven. In such a setting, a strong pressure on the prices in the commodity market should be observable since the simultaneous search yields always the least expensive supplier. Hence, a market entry will only make sense when offering the homogenous product less expensive.

In light of the analysis and with advancing technology of search agents and comparison shopping it is questionable whether competing on price will be a sustainable business model in electronic commodity markets in the future. New strategies – like building customer trust relationships – may have to be found to successfully compete in such a marketplace.

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