

Association for Information Systems AIS Electronic Library (AISeL)

AMCIS 2005 Proceedings

Americas Conference on Information Systems
(AMCIS)

2005

Internet Shopping Search: A Decision Theoretic Perspective

Taeha Kim

George Mason University, tkimc@gmu.edu

Alexander Talalayevsky

George Mason University, atalalay@gmu.edu

Follow this and additional works at: <http://aisel.aisnet.org/amcis2005>

Recommended Citation

Kim, Taeha and Talalayevsky, Alexander, "Internet Shopping Search: A Decision Theoretic Perspective" (2005). *AMCIS 2005 Proceedings*. 55.

<http://aisel.aisnet.org/amcis2005/55>

This material is brought to you by the Americas Conference on Information Systems (AMCIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in AMCIS 2005 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

Internet Shopping Search: A Decision Theoretic Perspective

Taaha Kim
George Mason University
tkimc@gmu.edu

Alexander Talalayevsky
George Mason University
atalalay@gmu.edu

ABSTRACT

Advances and widespread use of Internet shopping intermediaries have empowered consumers to collect detailed product information and discover the price dispersion for the product and its alternatives. These intermediaries provide in-depth decision support systems for consumers to search and sort out vast amount of information available on Internet. This paper examines the impact of these intermediaries upon consumer strategy and payoffs. We extend pioneering works in the area of information economics to find out optimal consumer search strategies varying level of market competition, signal qualities from intermediaries, and search costs. Our major findings are: (1) consumer payoff is continuous along the quality of signal dimension, but it may have kinks because of strategy changes, (2) cost of search decreases the incentive to search, and (3) market competition increases the incentive to search. This work reinforces the existing literature propositions on the impact of search costs in a stochastic problem setting and includes an intriguing analysis of market competition and corresponding consumer strategies. Our findings should assist firms in their design of infomediaries and precipitate in improved understanding of the impacts on market competition and rationale for consumer behavior and strategies.

Keywords

Shopping intermediaries, decision tree, individual decision support, shopping-bot design.

INTRODUCTION

The progress and widespread use of Internet of shopping intermediaries have empowered consumers with novel but easy-to-use decision support systems including shop-bots, search engines, deal websites, and online forums. As the Internet continues to mature, consumers can increasingly access, learn, and share peer product reviews, mix of on and offline promotions, shopping strategies, and the like using such infomediaries. However, the vast amount of semi-structured information about goods or services leads to revitalizing the intrinsic and traditional research question: *How much should consumers search in order to maximize their payoffs?* Consumers maximize their utilities (or payoffs) or the value of the product less price and search costs. We view the amount of search as the determinants of value and price and thus we propose to explore how much consumers need to search to maximize their payoffs.

This work extends the research stream of information economics models that evaluated the value of information in different market settings (Ahituv and Wand 1984, Marsden and Pingry 1993, Zwick et al. 2003). We apply Ahituv-Wand model to examine how the value of information and market structure affect shopping strategies and thereby consumer value.

One example is an online hotel reservation. The sale of hotel reservations require virtually no exchange of physical items and are purely informational. Online hotel reservation intermediaries that includes sites such as *Expedia*, *Hotwire*, *Orbitz*, and *Priceline* allow consumers to compare a variety of channels and discounting avenues. However, consumers face a broad search space and may expend significant time and effort to visit and compare alternatives.

Online shopping enables consumers to have access to a wealth of information with far less transactional cost and effort. However, online shopping may also motivate consumers to expand their search: in many instances it may be too much or too little (Zwick et al. 2003). Consumers typically have some prior knowledge about the price dispersion of goods and services when they start to search. Shoppers continue to search additional stores or websites to learn or collect "enough" information for those products. We postulate that there exists an optimal stopping point that maximizes the benefit of consumer search as the cost for additional visit increases whereas the additional value for each visit diminishes (Zwick et al. 2003, Jaillet and Stafford, 2001; Marsden and Pingry, 1993; Ahituv and Wand 1984; Yang 1974). As the search continues, the cost of visiting (or finding) each additional supplier may increase whereas the additional value for each visit may change based on the underlying cost structure and associated probabilities that are discovered during the course of the search. Therefore, there

exists an optimal point where a buyer should stop searching because the marginal cost of each successive visit is no longer greater the derived benefit (of learning). The major research questions are constant with those that have appeared within the stream of IS literature:

1. What is the impact of search cost and market structure upon the amount of search?
2. What is the optimal amount of search?

In order to examine these questions, we extend the Bayesian framework of Ahituv and Wand (1984). This work incorporates two additional notions to their framework: (1) search cost is incurred when a consumer increases the quality of information (2) one intermediary may be dominant in the market in providing best payoffs for its consumers.

We structure the paper by first introducing a Bayesian framework for consumer search in section 2. Based on the framework, we present a numerical model in section 3. Observations and findings from the numerical analysis are discussed in section 4. Section 5 concludes that discussion with implications and directions for future research.

MODEL

To formulate a consumer's problem to search Internet and purchase a travel deal, we adapt the model proposed by Ahituv and Wand (1984).

Quality per dollar for all available deals is a discrete set of $E = \{e_1, e_2, \dots, e_E\}$ with discrete probability of $\pi = \{\pi_1, \pi_2, \dots, \pi_E\}$, $\sum \pi_e = 1$. The probability of each outcome or deal is based on the number of access points to the deal. If a deal has more access points, it will have a higher probability of being found by the consumer.

A consumer initiates a search and thereby receives signals $S = \{s_1, s_2, \dots, s_S\}$. There exists an information structure P which maps events into signals. P is a stochastic matrix where its elements $P(e/s)$ is the probability that an event e results given a signal s . The cost of search is $C = C(P_{es})$. By increasing C , the consumer can increase the accuracy of P_{es} .

The consumer is able to selecting a deal out from a finite set of choices $A = \{a_1, a_2, \dots, a_A\}$. However, the actual deals (A) are available based on probabilities $F = \{f_1, f_2, \dots, f_A\}$.

The decision rule is represented by a matrix $D(a/s)$ that designates the probability that an action a is taken after signal s has been observed. The payoff U is a function of the action taken and the event that occurred such that:

$$U : E * A * F \rightarrow R, \text{ where } R \text{ is a real number.}$$

If each consumer knows the values of π , P , U , C , the problem is formulated as the maximization of the *expected value* of employing a decision rule D such that is formulated as:

$$EV(D, U) = \sum_{e,s,a} \pi_e P_{es} U_{eaf} D_{as} - C_s(P_{es})$$

So the consumer must optimize the following problem:

$$\begin{aligned} & \text{Max}_{D_{as}} \sum_{e,s,a} \pi_e P_{es} U_{eaf} D_{as} - C_s(P_{es}) \\ & \text{subject to:} \\ & \sum_a D_{as} = 1 \text{ for all } s, \\ & D_{as} \geq 0 \text{ for all } s \text{ and } a. \end{aligned}$$

The consumer's decision problem, as is described in (2), is a linear programming problem. Given this formulation, there exists at least one optimal solution which is pure strategy. Accepting the existence of the pure strategy, our interest is how much a consumer should search. This problem can be formulated as

$$\begin{aligned} & \text{Max}_{D_{as}, P_{es}} \sum_{e,s,a} \pi_e P_{es} U_{eaf} D_{as} - C_s(P_{es}) \\ & \text{subject to:} \\ & \sum_a D_{as} = 1 \text{ for all } s, \\ & \sum_e P_{es} = 1 \text{ for all } e, \\ & D_{as} \geq 0 \text{ for all } s \text{ and } a, \\ & P_{es} \geq 0 \text{ for all } e \text{ and } s. \end{aligned}$$

In order to find the optimal decision point (D) and amount of search (P) for this problem, we utilize numerical analysis within an MS-Excel spreadsheet and vary a number of parameters within our model. We arrive at the optimal decision by using a decision tree and optimal amount of search (P) algorithms.

A NUMERICAL EXAMPLE

We constructed an example that is based on the proposed model. Our example applies the model to an online search for a hotel reservation.

Information Search

There exist a number of websites that can be explored in order to generate alternatives:

1. Visit the hotel website and select the room and rate available.
2. Visit a shopping bot (such as *Travelocity*, *Expedia*, *Orbitz*, etc.) to search for hotels. These website disclose exact property and pricing.
3. Visit *Hotwire* to see the current offer prices for similar (same star rating) hotels within same vicinity. *Hotwire* does not disclose the exact location of the hotel (only general area) but it does disclose the pricing information.
4. Visit *BiddingForTravel* and discover which hotels cooperates with *Priceline* and what is the historical rates at those hotels. N.B. *Priceline* website does not offer exact location and the price is set by the buyer. *Priceline* offers no price information. As a result, you may decide to place a *Priceline* bid.

Each of these websites offers different degrees of certainty (such as location and proximity, as well as cancellation rules) and different degrees of information about the offerings in the particular geographic area. As such, each site offers a different degree of value and information. More extensive search for information at these sites does change the probabilities (of signal given event) within the information structure matrix. This search stage pre-determines the search effort and quality of information signal.

Within our model, consumers get the following three signals based on the amount of search: (1) narrow, (2) medium or (3) wide price per quality distribution. The search level predicts how attractive the actual deal will turn out to be: (1) bad, (2) medium, or (3) good. To increase the quality of signal, consumers can exert more search effort resulting in a convex increase in costs.

Actions

After exploring a number of sites the search may culminate in an action: a reservation attempt. If that reservation is successful the search will typically terminate. However, if the reservation attempt fails due to a failed bid attempt (at *Priceline*) the information about pricing, alternatives, and value may change. The bits of information resulting from this failure will yield a revision in the expectations of the buyer. The buyer may shift to other sources/sites because the perceived

value from each may change as a result repeated failures or learning. Furthermore, revised expectations have a significant impact on the search strategies and actions.

We took a pilot survey of hotel pricing for conferences listed (as of November, 2004) at *ISWORLD* and eliminated duplicates (parallel conferences). Table 1 depicts the variations in pricing via different online facilities. Note that *BiddingForTravel* prices are a proxy for best-case scenario in *Priceline* pricing.

Conference Event	Star rating	Conf. Rate	Orbitz	Hotwire	Bidding fortravel
Thirteenth Conference on Information and Knowledge Management	3	149.00	270.00	89.00	43.00
Information Systems Education Conference	4	229.00	sold out	N/A	90.00
International Conference on Information Quality	3	169.00	99.00	46.00	50.00
A SIGSOFT Workshop on Interdisciplinary Software Eng. Research	4	119.00	59.00	74.00	60.00
The 7th IASTED Int. Conference on Power and Energy Systems	3	119.00	99.00	75.00	70.00
ICIS 2004	4	174.00	179.00	85.00	80.00
HICCS	4	157.00	199.00	177.00	135.00
Int. Academy Of Business & Public Admin Disciplines	3	99.00	75.00	55.00	50.00
26th McMaster World Congress	3	95.20	88.80	84.00	38.00
EDUCAUSE Southwest Regional Conference 2005	4	142.00	139.00	116.00	48.00
PerEL Workshop on Pervasive eLearning	3	165.00	209.00	177.00	90.00
The 20th Annual ACM Symposium on Applied Computing	3	109.00	111.00	99.00	65.00
2005 WDSI annual meeting	5	153.00	133.00	94.00	105.00
ISOneWorld2005 Conference	3	76.67	64.00	65.00	40.00
Ieee Southeast Conference 2005	3	125.00	122.00	59.00	74.00
Fourth Annual Wireless Telecomm Symposium	2	89.00	76.00	80.00	n/a
2005 Irma International Conference	3	165.00	115.00	96.00	40.00
TRLD 2005 23rd annual international conference	4	200.00	149.00	101.00	78.00
CAA 2005 annual conference	3	162.00	140.00	57.00	65.00
IIE annual conference 2005	4	149.00	145.00	65.00	60.00

Table 1 Hotel Pricing for IS Conferences by Various Booking Means

The action is to select one of the online shopping mechanisms to acquire a travel reservation given an observed signal. Some actions are not always available. Since the bidding at *Priceline* is not guaranteed a success, the backup website in case of failure is provided in available actions. As such, we include a parameter for the success rate (such as 0.5) of bidding at *Priceline*. As a result there are six actions within our example problem:

1. Hotel website
2. *Travelocity*
3. *Hotwire*
4. *Priceline*->Hotel: Go to *Priceline* and if the bid is not accepted, then go to hotel website.
5. *Priceline*->*Travelocity*

6. Priceline->Hotwire

Events

We control for the quality of information and level of market dominance to examine the impact of the quality of information upon the expected payoff of consumers. We use discrete events: bad deal (e_1), medium deal (e_2), good deal (e_3). Each event has an associated probability. With in this example we used: 0.25 (π_1), 0.50 (π_2), 0.25 (π_3) respectively.

Utility Matrix For Events And Actions

We explore two scenarios of utility matrix. Holding all other parameters constant, we investigate how search cost in both scenarios has an effect upon strategies and payoffs of consumers. One utility matrix (B) depicts an example where one site/action dominates in all events, whereas the other example (matrix A) has different sites/actions does not such dominance.

Scenario 1: Utility Matrix A¹

	Bad Deal	Medium Deal	Good Deal	EV of Action ²
Hotel	0	30	80	35.00
Travelocity	<u>50</u>	70	90	70.00
Hotwire	40	<u>90</u>	130	87.50
Priceline->Hotel	10	57.5	115	60.00
P->Travelocity	35	77.5	120	77.50
P->Hotwire	30	87.5	<u>140</u>	86.25

Scenario 2: Utility Matrix B

	Bad Deal	Medium Deal	Good Deal	EV of Action
Hotel	0	30	80	35.00
Travelocity	40	70	90	67.50
Hotwire	<u>50</u>	<u>90</u>	<u>130</u>	90.00
Priceline->Hotel	10	57.5	102.5	56.88
P->Travelocity	30	77.5	107.5	73.13
P->Hotwire	35	87.5	127.5	84.38

Results

In order to illustrate the role of the information search, we generate a number of figures to illustrate the effects of cost, payoffs, and strategy dominance. Figure 1 depicts scenario 1 where as Figure 2 depicts scenario 2.

¹ Highest utility payoff for each event/column is underlined; highest EV is bolded.

² Search costs are not included here.

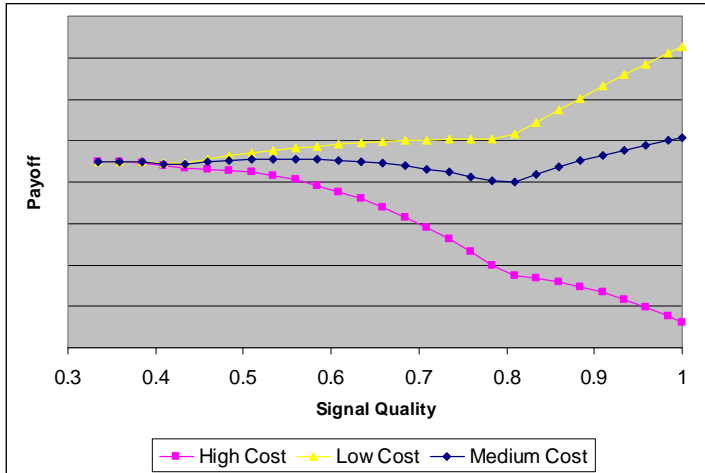


Figure Scenario 1: Search Cost, Signal Quality and Payoffs

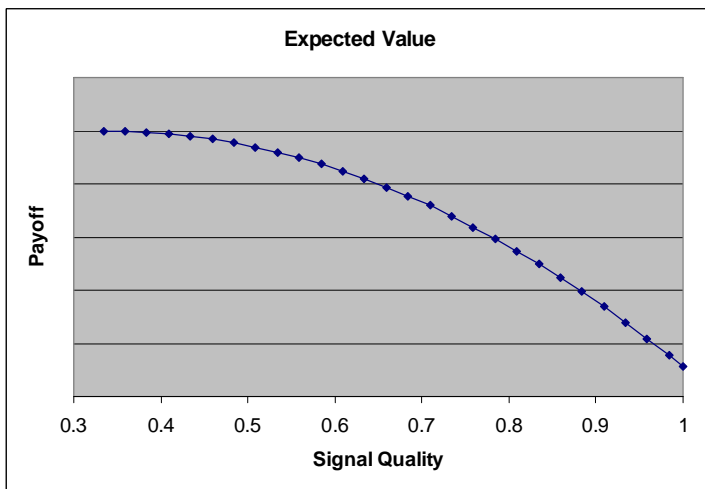


Figure Scenario 2: Search Cost, Signal Quality and Payoffs

It seems clear that there are no obvious and simple strategies that are optimal under all circumstances. However, there are some intriguing interpretations.

Observation 1: **The payoff curve may have 0 to (Number of Events -1) kinks.**

The scenarios have three events (bad, medium, and good). Strategies are a set of actions given the signal about the events. A consumer may have different strategies for different ranges of signal quality. These changes in strategy result in kinks in the payoff graph. Scenario 1 has two changes of consumer strategy along the quality of signal, while Scenario 2 has no change of the strategy as the signal quality increases.

Observation 2: **As cost parameter of search increases, the slope of payoff graphs decreases.**

This is quite intuitive observation and consistent with previous literature. The observation proposes that the optimal amount of search (or signal quality) should become smaller as the search cost increases. If the search cost is high enough, then it yields all slopes being downwards in all ranges of signal quality. In this case, kinks in payoff graphs are unimportant to a consumer decision (see low, medium, high cost in Scenario 1).

Observation 3: **Magnitude of kinks is determined by the differences in expected payoffs that result from a strategic action.**

Given a specific event and probability of that event, consumers may change their strategic action as the signal quality for that event increases. The difference in expected payoffs from these action changes, given the event, determines the magnitude of a kink.

Observation 4: **The optimal amount of search can be exhaustive in a competitive market with low search cost.**

The reason that the optimal search is exhaustive is counter-intuitive. Additional search can yield benefits because it decreases the uncertainty of the signal for the lower payoff events even though additional search cost is incurred. This phenomenon is exemplified by Low-Cost Line in Scenario 1. Additional search is increasingly justified by the lowered search costs or more competitive markets.

Observation 5: **Conversely, the optimal amount of search is "no search" in a less-competitive market or with high search cost.**

There exist many scenarios where searching is not advisable. There is no need to search if the search costs are high as Scenario 1 clearly depicts. Scenario 2 is the case where one firm dominates all the events.

Observation 6: **If perfect information may not be attainable, optimal search could be much less than exhaustive.**

Exhaustive search may not be realistic in some real world examples. As such, it is probably reasonable to assume that the search can progress to some limit where signal quality is significantly less than one. This assumption would shift more optimal solutions to the middle of the spectrum.

These observations underline the difficulty in the decision process that consumers face. There is no dominant strategy for all circumstances. In order to find out the optimal amount of search and strategy in response to search cost and market structure, we utilized the decision-tree and numerical analysis and found that:

- (1) The payoffs for consumers are continuous along the quality of signal but may have kinks because of strategy changes. (Observation 1 and 3)
- (2) The cost of search decreases the incentive to search (Observation 2, 4, and 5).
- (3) The market competition increases the incentive to search (Observation 3, 4, and 5)

We confirm the important propositions of previous literature relating to search costs and propose several counter-intuitive propositions about the market competition and strategy changes. Kinks are indifferntiable points on the payoff curve and thus, it is difficult for a consumer to predict their magnitude or consequences on the extent of the search. In particular, kinks may cause consumers to search too much or too little. Some may search too much because they may have an expectation of finding a kink upon a more extensive search. Too little searching may occur because the downward sloping curve for the payoffs could motivate early search termination by assuming that the future kinks are inconsequential.

CONCLUSIONS

With the help of richer information and new e-market mechanisms, many more buyers will become increasingly motivated to increase their search efforts because those efforts should grow to be progressively more profitable. We can assume that the search costs are dropping thus inducing additional search effort. Furthermore, as additional information and events become available in the market place, there will be more strategies, changes in strategies or kinks.

The resulting environment may become much more competitive. Clearly, if the Internet, with its improved and cheaper search costs and facilities, is making some products and services more commodity-like, then that could result in lower profit margins. Interestingly, many of the lower priced sites (such as *Hotwire* and *Priceline*) require additional effort in searching and learning about price, location, and availability. These sites also may offer the highest degree of risk or uncertainty about

location, facilities, and room types. The amount of risk and the magnitude of search costs will dictate if and how significant the profit erosion will turn out to be.

Travel reservations are certainly different from other products and services and have benefited more significantly and more rapidly from the Internet than others (Lewis & Talalayevsky, 1997; Lewis et al., 1998). However, other products and services may be following soon. For example, the information and search for new automobile purchases has been moving to the Internet in large numbers and similar forums exist: (1) B&M neighborhood dealer, (2) Auto-by-tel that offers no price information; (3) third party sites and forum that offer price information such as Edmunds (4) many of the larger dealer are posting actual sales prices and not just asking prices (MSRP), (5) most automobile dealers now have Internet manager/sales that offer far different pricing, and (6) reverse auctions for automobiles are available at *mycar.com* and actions at eBay and offer additional price information. Arguably, we see similar patterns developing for this product: buying a new automobile sight-unseen is similar to bidding for a hotel within some area of the city.

Clearly, additional market mechanisms and price information has to be available before the benefits proposed in this paper can materialize. However, there exist noteworthy practical implication as to what types of products and services will eventually fit this model. The real issue is the cost of the actual good or service: if the price is significantly high (hundreds or thousands of dollars) the search cost could be justified. Consumers typically minimize the cost of acquiring a good or service that is comprised of the purchase and search costs. As such, it is easy to justify a more extensive search for a hotel room that could cost over \$100 per a night or an automobile costing over \$20,000. Obviously, the search cannot be justified for smaller ticket items. However, the search costs associated with finding lower priced goods are probably too high to entice more buyers to actually search.

The Internet was been seen as giving better firms access to consumers but there is additional impact that it has on consumer online practices. Given that consumers are changing their search strategies and behaviors, online firms need to reconsider the marketing, pricing, and information related strategies. Clearly, if firms can increase consumer search costs (as per Scenario 1), they will encourage consumers to search less. After all, if additional search efforts on the part of the consumer are rewarded with lower purchase prices, then the aftermath from that trend will typically cut profit margins for the firm. Firms can try to dominate particular markets (Scenario 2) and assure consumers that they offer best access to a variety of deals. Conversely, new entrants to the market place can increase market penetration by favoring pricing and information environments that result in kinked payoffs (Scenario 1). Interestingly, the consumer must learn to appreciate the higher value and rewards of searching longer. For example, stand alone bidding at *Priceline* can typically yield excessive bidding failure (futile search) or significant overbidding. However, *Hotwire's* current price information and historical price and property specific information at *BiddingForTravel* should lead to greater understanding of rewards that result from undertaking more extensive searches.

REFERENCES

1. Ahituv, N. and Y. Wand (1984) "Comparative Evaluation of Information under Two Business Objectives," *Decision Sciences*, 15 (1) 31-51.
2. Brynjolfsson, Erik and Michael D. Smith (2000) "Frictionless commerce? A comparison of Internet and conventional retailers", *Management Science*, 46(4), 563-586.
3. Jaillet, P. and M. Stafford (2001) "Online Searching," *Operations Research*, 49(4), 501-516.
4. Klein, Lisa R. and Gary T. Ford (2003) "Consumer Search for Information in the Digital Age: An Empirical Study of Prepurchase Search for Automobiles", *Journal of Interactive Marketing*, 17 (3), 29-49.
5. Lewis, I. and A. Talalayevsky (1997) "Travel agents: Threatened Intermediaries?" *Transportation Journal*, 36(3), 26-30.
6. Lewis, I., J. Semeijn, and A. Talalayevsky (1998) "The Impact of Information Technology on Travel Agents", *Transportation Journal*, 37(4), 20-25.
7. Marsden, J. and D. Pingry (1993) "Theory of Decision Support Systems Portfolio Evaluation," *Decision Support System*, 9(2), 183-200.
8. Melnyk, S. A and D. R. Denzler (1996) *Operations Management: A Value Driven Approach*, Irwin,.
9. Rapoport, Amnon, Ido Erev and Rami Zwick (1995), "An experimental study of buyer-seller negotiation with one sided incomplete information and time discounting," *Management Science*, 41(3), 377-394.
10. Yang, M. C. K. (1974) "Recognizing the maximum of a random sequence based on relative rank with backward solicitation", *J. Appl. Prob.* **11**, 504-512.
11. Zwick, Rami, Amnon Rapoport, Alison King Chung Lo and A. V. Muthukrishnan (2003), "Consumer Search: Not Enough Or Too Much?" *Marketing Science*, 22(4), 503-519.