Repeated Price Search

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Abstract

Price search theory needs to incorporate the fact that consumers make many types of purchases at regular intervals, and what they learn in such price searches is the relative prices of sellers. Also, the development of the Internet has created two new types of sites that affect prices search: marketplace sites and meta-search sites. We explore these issues using students' online purchases of textbooks as an example. The experimental performance of subjects in determining relative prices is better than random but worse than optimal. By recording online prices for 19 days, we determine that students can achieve good performance by examining prices at only two large marketplace sites, which can list several hundred individual sellers for popular texts. In a survey of online textbook purchasing strategies, students reveal several factors that led to good performance. The developments in the Internet and smart phone applications indicate the need to revise standard price search theory.

1 Introduction

In the standard one-period price search theory, for example see McMillian and Rothschild (1994), consumers are assumed to perform a price search as a random drawing with a fixed cost. They continue drawing as long as the price found is greater than the reservation price that they calculate knowing the distribution of prices. The standard one-period price search theory is invalidated in experiments where subjects are given the price distribution. Kogut (1990) and Sonnemans (1998) show that consumers draw too few times on average indicating that either they can not make the calculations or they are using an alternative decision rule. The experimenters argue that subjects are considering the sunk costs and are not making a marginal cost decision based on the reservation price. Given that the fixed cost of searching an online site is low, one would expect from this theory that consumers search numerous online sites. In their study of the online searching of over 10,000 households, Johnson, Moe, Fader, Bellman, and Lohse (2004) find that on average consumers search less than 2 sites for books, CDs, and air travel services.

The standard one-period price search theory assumption of a random drawing ignores the fact that consumers learn the relative prices of sellers by performing repeated price searches. They use this information, thus invalidating the assumption of a random drawing. In this paper we investigate how consumers solve the repeated price search problem. We will show that they use heuristics involving very little calculation. The important question is: Can consumers using heuristics achieve good performance online checking a small number of sites? Our investigation has two parts:

1. Experiments investigating how subjects learn relative prices,

2. Questionnaires investigating how students buy textbooks online.

We investigate in several experiments how many times subjects check prices at both stores to learn the relative prices of two sellers in one, two, and four period problems. We compared the performance of a group of 49 subjects who had taken a university statistics course with the performance of a group of 49 subjects who had not taken a university statistics course. In the one period problem the performance of both groups was better than random choice and worse than optimal. The difference in both cases was statistically significant. The performance of the statistics course group was statistically superior to that of the non-statistics course group. Using regression analysis we determined that performance can be explained by a dummy variable identifying the statistics course group and a variable measuring the absolute difference between the two choices. In the two-period problem, many subjects in both groups demonstrated a lack of knowledge of Bayes theorem. We also studied the behavior of 25 subjects in 2 and 4 period problems. In all of the problems the subjects checked prices at both stores less than an optimal number of times and in three out of the four cases this difference was statistically significant.

In Section 4, we consider the textbook market at UT. We use four surveys to characterize the UT Co-op Bookstore buyers and online multisite buyers. As was the case of household online buying, students buying textbooks online only check a small number of sites. Three factors explain this behavior:

1. Market organization: Marketplace sites that can have many sellers and meta-search sites.

2. Prior information: Advice from experienced searchers.

3. Update the list: Students occasionally add sites and drop sites.

Because marketplace sites can can list several hundred sellers of popular first-year textbooks, a student only has to check a few sites to achieve good performance for different risk levels. Most students start searching online with good prior information by first seeking the advice of students with experience buying online. Analyzing the data we characterize a student online textbook search strategy as an "update the list" strategy.

In Section 6 we summarize how consumers can achieve good performance checking only a few sites online. We also briefly discuss how advances in the Internet and smart phone applications are fundamentally changing the nature of price search. Finally, this is the fifth paper in a series developing a procedural consumer model. The earlier papers are Norman et al (2001, 2003, 2004, 2008).

2 Experiments

We performed a series of experiments designed to test subjects' performances in solving problems associated with repeated price search. These experiments included a Bayesian multiperiod optimization experiment to test whether students are capable of devising a strategy to optimally learn which store has the lowest relative prices. As these optimization problems are often intractable, Norman and Shimer (1994), we obtained a computational tractable experiment by using discrete distributions and only three alternatives. The subject needs to buy a textbook each semester and has three choices each period:

1. Travel to store A and buy from store A

2. Travel to store B and buy from store B

3. Travel to both stores A and B, and buy from the cheaper store

The Bayesian question is how many times should the subject check prices at both stores in order to learn which store is cheaper and improve future performance. In this paper, we examine University of Texas at Austin economics students' online textbook buying behavior. In Austin, there are very few stores that sell new and used textbooks.

This is the fifth experiment in our series. We started with a time horizon of 8 semesters and with each improvement of the experiment we shortened the time horizon. Because subjects were not able to devise an optimal strategy for a potentially tractable two period Bayesian optimization problem requiring five arithmetic operations, we decided to probe more deeply into the actual heuristics they employ in one and two period problems. The third and fourth experiments led to improved instructions and design. To view the fifth experiment use Firefox and go to: http://www.eco.utexas.edu/Homepages/Faculty/Norman/00Julia.

On page 1 of the experiment the subjects were given general instructions. On pages 2 and 3 we present the subjects with two 1 period problems where the subjects have no information concerning the cheaper store. The problem description on page 2 is:

> **Information:** In this case one of the two listed stores is cheaper than the other most of the time. But, as you have had no previous experience with these two stores, you have NO information as to which store is cheaper.
> **Travel Costs:** If you check the price at only one store and buy from that store, it costs you $3. If you check the price at both stores and buy from the cheapest, your expected cost is $7. The expected cost of $7 would be your average cost that includes the fact that sometimes you would have to return to the first store.

Anticipated Price Differences: Now suppose you anticipate that one store will be cheaper than the other by $X where the values of X are given below. For each price difference indicate whether you would check the price at both stores.

Anticipated Price Differences

Stores	Anticipated Price Difference	Check prices at both stores
A and B	$5	Yes ◯ No ◯
C and D	$10	Yes ◯ No ◯
E and F	$15	Yes ◯ No ◯
G and H	$20	Yes ◯ No ◯
I and J	$25	Yes ◯ No ◯

The problem description for page 3 was the same as page 2 except the travel cost to one store was $5 and the expected travel costs to both stores is $12. The 1 period problems with no information on pages 2 and 3 will be referred to as 1PnoI 1 and 2. On page 4 subjects were shown the decisions they made on pages 2 and 3 and asked to write a description of their problem solving strategy for these two pages in an HTML textarea box.

On pages 5 and 6 we present the subjects with two 1 period problems where the subjects have perfect information. Page 5 is the same as page 2 except the Information description has been replaced with:

Information: In talking with seniors about the price at the listed stores below, you can assume that if you checked the price at both stores 100 times you would find that 65 times the first listed store (A, C, E, G, and I) would be cheaper and 35 times the second listed store (B, D, F, H, and J) would be cheaper.

On page 6 the problem description was the same as page 5 except the Information description has been replaced with:

Information: In talking with seniors about the price at the listed stores below, you can assume that if you checked the price at both stores 100 times you would find that 77 times the first listed store (A, C, E, G, and I) would be cheaper and 23 times the second listed store (B, D, F, H, and J) would be cheaper.

The 1 period problems with perfect information on pages 5 and 6 will be referred to as 1PperI 1 and 2. On page 7 subjects were shown the decisions they made on pages 5 and 6 and asked to write a description of their problem solving strategy for these two pages in a HTML textarea box.

On pages 8-11 the subject is presented with four 2 period problems. The problem description on page 8 was:

> **Information:** In this case you will make decisions as to checking the price at two stores, A and B for two semesters. If you did price-comparison shopping at the two stores 100 times, you would find one of the two stores was cheaper 90 times out of 100. But, as you have had no previous experience with these two stores, you have NO information as to which store is cheaper prior to your first semester decision. For your second semester decision you have one observation which store is cheaper if you check prices at both stores the first semester.
> **Travel Costs:** If you check the price at only one store and buy from that store, it costs you \$6. If you check the price at both stores and buy from the cheapest, your expected cost is \$14. The expected cost of \$14 would be your average cost that includes that fact that sometimes you would have to return to the first store.
> **Anticipated Price Differences:** You anticipate that one store will be cheaper than the other by \$5.
> **Two Semester Problem:** This is a 2-semester problem. Suppose in the first semester you decide to check prices at both stores in semester one and buy from the cheaper store. You would have one observation as to whether store A or store B is cheaper. Note: In semester 2 use the appropriate row based on what action you took in semester 1. In the tables below Check just one store means go to either store A or store B and buy without checking price at the other store and Check both stores means check price at both and buy from cheaper store.

Anticipated Price Difference = \$5

	Semester 1	
Check just one store ◯		Check both stores ◯
	Semester 2	
(blank textbox 1) ◯	(blank textbox 2) ◯	(blank textbox 3) ◯

Subject choice in Semester 1 defines the blank HTML textboxes in Semester 2:

Blank textbox is replaced depending on which ◯ is checked in Semester 1

Blank	Semester 1 check one	Semester 1 check both
1	Check just one store	Buy from cheaper store semester 1
2	Check both stores	Buy from more expensive store semester 1
3	DO NOT USE	Check both stores

Pages 9, 10, and 11 are the same as page 8, except that the Anticipated Price Difference becomes \$15, \$45, and \$65 respectively. The 2 period problems on pages 8-11 will be referred to as 2P 1-4. On page 12 subjects were shown the decisions they made on pages 8-11 and asked to write a description of their problem solving strategy for these four pages in a HTML textarea box.

The following table summarizes the eight problems:

Table 1
Problem Summary

Problem Name	Travel Cost	Percent A cheaper	Range APC	# Periods
1PnoI 1	3/7	No Info	\$5-\$25	1
1PnoI 2	5/12	No Info	\$5-\$25	1
1PperI 1	3/7	0.60	\$5-\$25	1
1PperI 2	3/7	0.77	\$5-\$25	1
2P 1	6/14	0.90	\$5	2
2P 2	6/14	0.90	\$15	2
2P 3	6/14	0.90	\$45	2
2P 4	6/14	0.90	\$65	2

Where 3/7 means the travel cost to one store is \$3 and the expected travel cost to two stores and buying from the cheaper store is \$7. APC is the anticipated price difference.

We performed this experiment on two 49 member groups, EcoStat and NoStat where:

1. EcoStat: Economic majors who had completed the undergraduate economic statistics course, which includes a section on Bayes theorem.

2. NoStat: Students majoring in Liberal Arts (except Economics), Communications, Fine Arts, or Education who had not taken any university course in statistics. They also must not have taken more than 3 hours of economics or 6 hours of mathe-

matics.

Subjects gave us permission to verify these requirements and we did. We provided each subject in both groups with a calculator and a sheet of scratch paper to eliminate as many arithmetic errors as possible .

The incentives for the experiment were:

Incentives:
Assume you are being paid to advise 100 freshmen about buying a certain textbook. If your recommendations are better in the sense of lower costs on average, you earn more money. The maximum possible earnings is $21

1. You will receive a flat fee of $6 for coming to the experiment.
2. There are 34 questions. You will receive (your score)/(perfect score) times $15.

3 Results: Experiment

First let us compare the mean performance of the two groups. m_{NS} denotes the mean performance of the 49 NoStat subjects. m_{ES} is the mean performance of the 49 EcoStat subjects. Ran is the expected performance based on random selection. Opt is the performance based on optimal selection in price savings. The data and one tail t tests of the means are presented below. The $m_{NS} < m_{ES}$ test was performed with unequal variances.

Table 2
Mean Performance

Ran	m_{NS}	m_{ES}	Op
76	91.99	95.69	100

Table 3
t Tests of Differences in Mean Performance

Test	Ran< m_{NS}	Ran< m_{ES}	$m_{NS} < m_{ES}$	m_{NS} <Opt	m_{ES} <Opt
Sig	<0.001	<0.001	<0.001	<0.001	<0.001

We have three groups of problems, 1PnoI 1&2, 1PperI 1&2, and 2P 1-4. If we consider the performance on each of the groups separately, we get the same relative performance results with a significance of less than 0.025. In all cases, mean subject performance is closer to optimal performance than random performance.

Now let us consider the performance of the strategies of the two groups in the one period problems. Because all subjects had a calculator and scratch paper, arithmetic errors were not considered an important factor. All these problems were designed with a shift point, such that for all anticipated price differences less than the shift point, the correct choice was to only check prices at one store, and for all anticipated price differences greater or equal to the shift point, the correct choice was to check prices at both stores. The shift points for the one period problems, each of which had anticipated price differences of \$5, \$10, ... ,\$25, are:

Table 4

Shift Points for one period problems

Page	1PnoI 1	1PnoI 2	1PperI 1	1PperI 2
Shift Point	\$10	\$15	\$15	\$20

The subjects wrote a description of their strategy to solve the first two one-period problems on page 4, and the second two one-period problems on page 7. Very few subjects gave a succinct formula for their strategy. In many cases they described the strategy verbally or used an example. The correct rule for the first two problems, 1PnoI1&2 is:

if 1/2APC > Tra2, check both buy cheaper, else check one and buy there.

where APC is the anticipated price difference and *Tra2* is the expected travel cost to the second store. Two members of the EcoStat group and one member of the NoStat

group wrote this rule and executed it correctly. The most common strategy of the two groups was:

if APC > TraB, check both buy cheaper, else check one and buy there.

where *TraB* is the expected travel cost to both stores. Twenty members of the EcoStat group and ten members of the NoStat group wrote this rule and executed it correctly. This rule gives the correct response for the anticipated price differences used in the first two problems.

The correct rule for the second two problems, 1PperI1&2 is:

(1-P)APC>Tra2 check both buy cheaper, else check one and buy there.

where *P* is the probability that the first store is cheaper. Nine members of the EcoStat group and one member of the NoStat group wrote this strategy and correctly executed it. Twenty members of the EcoStat group and thirty three members of the NoStat group wrote they used an intuitive approach to solve the second set of two problems.

The greater the absolute difference between the anticipated price difference and the shift point the greater the absolute difference in value between the two choices. We hypothesize that the greater the absolute difference between the two choices, the greater the likelihood subject's strategies would select the correct choice as shown below:

Table 5
Number of subjects with correct answer (n = 49)

Problem (Page)	**1PnoI 1 (2)**					**1PnoI 2 (3)**				
APC	5	10	15	20	25	5	10	15	20	25
EcoStat	36	40	47	48	48	47	33	41	46	46
NoStat	41	24	44	44	44	42	36	31	43	41
Dif	1.5	1	3.5	6	8.5	4.5	2	0.5	3	5.5
Problem (Page)	**1PperI 1 (5)**					**1PperI 1 (5)**				
APC	5	10	15	20	25	5	10	15	20	25
EcoStat	45	33	37	45	45	45	41	30	38	42
NoStat	43	38	22	35	40	44	38	34	24	35
Dif	2.25	0.5	1.25	3	4.75	2.85	1.7	0.55	0.6	1.75

where APC is the anticipated price difference, and Dif is the absolute difference in performance between the two choices.

We postulated the following regression:

$$c_n = \alpha + \beta D_n + \delta \Delta_n + \epsilon \tag{1}$$

where c_n is the number correct, α, β , and δ are constants, D_n is a dummy variable, which = 0 for the EcoStat group and 1 for the NoStat group, Δ_n is the difference in performance, and ϵ is the error term that is assumed to be independent and distributed $N(0, \sigma_n^2)$. We tested the hypothesis of normal errors with the Shapiro-Wilf W, Shapiro-Francia W, and the Skewness/Kutosis tests. All three do not reject the hypothesis of normal errors with a significance level of 5%. We tested the hypothesis of homoskedasticity with the Breusch-Pagan (1979)/ Cook-Weisberg test and rejected this hypothesis with a significance level of 5%.

The results using White's robust regression that corrects for Heteroskedasticity are:

Table 6
Regression 2: Number correct
Number of obs = 40, F(2,37) = 18.39, and Prob > F < 0.0001

Var	Coef	Std Err	t val	P > |t|
δ	1.96	0.33	5.90	<0.001
β	-4.5	1.51	-2.98	.005
α	36.23	1.31	27.59	<0.001

As can be seen, all three coefficients are significant. The larger the gap in performance between the two choices, the better the performance of the subjects' formula and intuitive heuristics. On average, the EcoStat group has 4.5 more correct responses than the NoStat group.

Now let us consider the 2 semester problems for which 3 members of the EcoStat group and 2 members of the NoStat group got all four pages correct.. The rule for the first semester is:

if 1/2APC + ([(.9)(.9) + (.1)(.1)]APC -1/2APC) = 0.82APC > Tra2 check both buy cheaper, else check one and buy there.

The shift point for this rule is 9.76 and the rule for the second semester is:

if 0.18APC > Tra2, check both, buy cheaper, else check one and buy there.

The shift point for this rule is 44.44. No subject wrote the correct rule for either problem.

The decision that is revealing is the second semester decision for a price difference of \$45 and \$65. Let us consider the behavior of the 46 EcoStat subjects and 40 NoStat subject that correctly choose to check prices at both stores in the first period. The breakdown of their behavior in the second period is shown in the following table:

Table 7

2nd semester decision for APC of $45 and $65

Group	1 and 1	2 and 1	1 and 2	2 and 2
EcoStat	25	1	4	16
NoStat	20	1	1	18

where for 1 and 1, ..., and 2 and 2 the first number is the number of stores checked in the $45 case and the second number is the number of stores checked in the $65 case.

The behavior of the various groups is reflected in ther strategies they wrote in the HTML textarea box. The 25 EcoStat subjects and the 20 NoStat subjects that chose 1 and 1, either explicitly in their responses or implicitly in their actions, assumed that if they checked prices at both stores in the first period, the store that they found had with the cheaper price would have the cheaper price in the second period with a 90% probability. One EcoStat subject even calculated that the APC would have to be $80 to warrant checking both prices in the second period.

Of the 16 EcoStat and 18 NoStat subjects that chose 2 and 2, the most common strategy of these subjects was the heuristic that the greater the APC relative to the TraB, the greater the incentive to check both. One example is, "As the price difference increases, the risk of losing money increases, yet a 90% probability makes it more difficult to decide whether to check both stores. But as the difference goes farther and farther away from $14 dollars, it becomes more and more convenient to check both stores." Only two EcoStat subjects and one NoStat subject clearly indicated that with only one observation, it was not possible to know with certainly which store was the cheaper 90% of the time.

In conclusion on average subjects performed statistically better than random selection and statistically worse than optimal selection. The subjects with economic

statistics had better performance, but many of this group did not understand Bayes theorem, a topic in their statistics course. The subjects in this experiment were less Bayesian than those of El-Gamal and Grether (1995).

We include some results from one of our prior experiments that had 4 periods. For this experiment the subjects for this experiment were 25 students from an author's freshman economics class. We offered a flat fee of $10 for participating and as much as $25 more for answering questions correctly. In this experiment we were interested in whether subjects could devise an optimal strategy and paid them if they could.

The parameters and the results for the earlier experiment are shown in the table below:

Table 8: Parameters and Results

	Problem 1	Problem 2	Problem 3	Problem 4
Periods	2	4	4	4
Information	NoP=80	NoP=80	NoP=80	NoP=80
Travel Costs	(5,10)	(5,10)	(5,10)	(5,10)
Anticipated Price Difference	$30	$10	$20	$15
Optimal # to check both	2	1	3	2.32
No. Subjects Correct	6	10	3	2
Avg Checks	1.4	0.88	1.52	1.48
No. Skips	1	7	4	5

The experiment can be viewed at: http://www.eco.utexas.edu/Homepages/Faculty/Norman/00Ashley/

This experiment has two important results. For all three problems the average number of checks of prices at both stores was less than the optimal number of checks and this difference is significant for an α of 0.05 for Problems 1, 3 and 4. Also, a subject should check prices at both stores at the beginning with no skips. The row

labeled No. Skips indicates the number of times subjects skipped before checking prices at both stores.

From our experiments we conclude that subjects solve relative price search problems using heuristics and they have a tendency to check prices at both stores less than an optimal number of times. Now let us consider whether consumers can achieve good performance using heuristics.

4 Buying Textbooks Online

The data for this section comes from student surveys of textbook buying behavior and from checking the prices of economics textbooks online. Of the economics students who bought their textbooks online, we had 107 students fill in a four-page questionnaire and 51 students fill in a later one-page questionnaire; 34 students filled in both surveys. We also had 66 students who bought their textbooks only from the UT Co-op Bookstore fill in a two-page survey. These students were either attending a meeting of the Texas Economics Association or were enrolled in an upper division economics class. Students were paid $1 per page for their time taking the survey. We also recorded online prices for 23 economics textbooks for 19 days between 28 Dec 07 and 19 Jan 08, collecting 437 data points to determine the lowest prices in the market.

Students at UT buy textbooks each semester. The professor usually defines exactly which materials are needed for the class, but the students still face a wide selection of textbook types. Popular textbooks are frequently available in U.S. editions, less expensive soft-cover foreign editions printed in color on quality paper, and much less

expensive soft-cover foreign editions printed in black and white on newspaper quality paper. Though there are some legal issues in selling these foreign editions in the U.S., students can take advantage of the lower prices by buying these editions online.

Students can purchase textbooks from the UT Co-op Bookstore online or at the stores near campus. They have the choice of buying a new U.S. edition at the specified price or a used U.S. edition at 75% of the list price regardless of the condition of the used book. Since many students add or drop classes, the UT Co-op Bookstore offers a 12^{th} class day return policy. If students keep the book past the 12^{th} class day, they can sell it back to the Co-op at the end of the semester for half of its current price, regardless of whether the copy was purchased new or used and assuming a professor has requested the book for the next semester. Students buying textbooks at the UT Co-op Bookstore pay 8.25% sales tax, but at the end of the academic year, they have the opportunity to receive a 10% rebate towards future Co-op purchases.

Students search multiple sites online hoping to save about 40% from the UT Co-op Bookstore prices, but they risk that the book will be delivered late, not delivered, or in a condition different than listed. Based on the survey, online textbook buyers contribute more of their personal income to textbook purchases as opposed to their Co-op counterparts, 27.1% versus 8.7% respectively. Seventy-eight percent of the online buyers purchase online so that they can spend their savings on other needs. Students buy from the UT Co-op Bookstore for convenience and for certain delivery. If their parents allow them to buy from the UT Co-op Bookstore with their credit card, the students lack incentives to shop around. Seventy percent of the UT Co-op Bookstore buyers buy from the Co-op to receive books immediately and not risk a

late delivery.

One of the surprising results of our research was to discover how few online sites that students checked for prices. For example, in the one-page survey, online textbook buyers were asked: "How many sites did you check before you made your final textbook purchases last semester?" The average of the 51 economic majors was 3.2 sites. From our experiment, we would assume that given the low cost of checking online sites, students would check a large number of sites. Student behavior can be explained by three factors:

1. Market organization: Internet textbook markets have marketplace sites and meta-search sites.

2. Prior information: Before starting their search, most students obtain information from experienced online buyers.

3. Update the list: Students add new sites and eliminate sites to reduce risk and failures at finding the lowest priced book.

Market Organization: Most of the online sites that students use to purchase textbooks are what we call "marketplace websites" that list third-party sellers, who describe their offering and set a price. These third party sellers can be students, bookstores, or even other marketplace websites. Amazon.com Marketplace, Half.com, BookByte.com, and AbeBooks.com are examples of this genre. The most important characteristic of marketplace sites is their large of listings for the same item, allowing the consumer to easily find the lowest price. Unfortunately, there is a risk that the third-party seller will not ship the book on time or will fail to accurately describe

the product. To combat this problem, marketplaces provide a rating system of sellers based on comments from previous buyers, but these rating systems vary among marketplace sites and are frequently not comparable.

Another variety of product search sites is meta-search sites, such as PriceGrabber.com, CampusBooks.com, Bigwords.com, and Froogle.com. These sites search a variety of mid to large sized sellers to provide a list of vendors ordered by price. By using such a site, a consumer can search many marketplaces for their desired product, covering a broader selection of sellers with less effort. However, because they also do not search continuously, a student can go to a site to find the low cost book indicated by the meta-search site only to find that the book is no longer available.

Now let us consider the prices of economics textbooks online. We recorded the lowest online market prices for 23 of the undergraduate economics course textbooks for 19 days between between 28 December 2007 and 19 January 2008. We considered three editions: U.S., international color, and international black and white. We also considered two levels of risk: cheapest price with no concern for the reliability rating of the seller and cheapest price from a seller with a 95+ rating with at least 30 transactions. For those sites that used a different rating system, we used as close an approximation as possible. For the U.S. books, we also recorded three quality levels of textbooks: (1) new U.S. edition; (2) good quality U.S. edition with no missing pages, highlighting, or writing; and (3) acceptable used book. For the international editions, only prices for new textbooks were recorded.

In order to determine what sites to check, we started with the meta-search sites. Of these, we found CampusBooks.com and directtextbook.com to be the most useful.

From these search engines, we determined which sites would be most useful to check on a daily basis. We checked A1.com, Abebooks.com, Alibris.com, Amazon.com, BN.com, Biblio.com, eBay.com, Express.eBay.com, Half.com, Textbooks.com, Textbooksnow.com, TextbooksRus.com, TextbooksX.com, and Valorebooks.com. We consider the search comprehensive because smaller sellers, who have their own websites, frequently list textbooks at the large marketplaces such as amazon.com and half.com.

In the table below, we show the frequency at which sellers had the lowest price in each of the three categories and the two risk levels for U.S. published textbooks. Sellers who had the lowest price in less than 5% of the surveys were combined into the "Other" category.

Table 9
Cheapest sites in price survey: % of 437 data points

Site	New	New R95	Good	Good R95	Fair	Fair R95
Half.com	28	48	30	49	28	49
Amazon.com	35	31	34	30	21	23
AbeBooks.com	5	5	9	7	12	12
Textbooksnow.com	4	5	2	0	9	8
Valore.com	6	0	6	7	6	1
Other	22	11	19	7	24	7

If students buying economics textbooks only checked prices at Half.com and Amazon.com and then bought from the cheaper, they would find the lowest price at least 49% of the time. However, the real issue is how close students to the optimal strategy; if they miss the cheapest book half the time but only pay a cent extra, the difference is negligible. We can estimate how good a strategy is by comparing the students' performances with checking all sites, just Half.com, just Amazon.com, or both Amazon.com and Half.com for the lowest prices. This is shown in the following table where performance is measured relative to the cheapest price set to 1.

Table 10
Performance of Amazon.com and Half.com Strategies

Strategy	New	New 95	Good	Good 95	Fair	Fair 95
Both	1.05	1.03	1.06	1.02	1.08	1.02
Amazon.com	1.12	1.14	1.13	1.12	1.14	1.12
Half.com	1.12	1.06	1.12	1.06	1.13	1.05

Assuming the students are searching for "Fair" quality textbooks, the table shows that checking both Amazon.com and Half.com would result in a strategy that is at most 8% higher than the lowest price we found. In the cases where students are searching for new textbooks and use a 95+ rating to reduce risk, the increase is no greater than 3%. We then compared these prices with the listed UT Co-op Bookstore prices. In an earlier version of the paper we showed that there is a slight upward trend in price data. Therefore, we show this comparison for three different days in the table below:

Table 11
Cheapest Prices relative to UT Co-op Bookstore (Percent)

Day	New	New 95	Good	Good 95	Fair	Fair 95
28 Dec	58	64	66	69	65	68
6 Jan	61	66	68	77	66	72
19 Jan	60	67	73	83	72	78

We assume that students buying online would start their search by checking the ISBN numbers of their course textbooks and recording the listed prices. These prices would be lower than the online prices 1%, 2%, and 6% of the time in the cases of "New 95," "Fair," and "Fair 95" respectively. However, the buyer could not tell whether the UT Co-op Bookstore actually had the textbook in stock without a phone call or actually visiting the store, an additional labor cost. By the time the semester has started, the UT Co-op Bookstore frequently has run out of some textbooks.

We also checked prices for new international black and white and new international color at two risk levels each. The low cost sites are shown below:

Table 12

Cheapest sites for new international editions (Percent)

Site	NIB	NIB R95	NIC	NIC R95
Abe.com	53	84	28	33
eBay .com	16	14	30	42
TextbooksRUS.com	9	1	21	7
a1.com	22	0	7	0
Valore.com	0	0	4	13
Other	0	0	9	4

Again, a strategy just to check prices at Abe.com and eBay.com results in the lowest price 69%, 98%, 58% and 75% of the time for the four categories. In the case of international editions, we did not collect data in order to determine how close the top two would be to optimal.

Given the organization of the online textbook market, students only have to check prices at a small number of sites in order to achieve good performance.

Prior Information: Now we can discuss how students obtain knowledge about their alternatives for purchasing textbooks. Of the 107 students who filled in the four-page questionnaire, we excluded 11 for indicating a major other than economics and 4 for too much missing data. When asked for their information sources, the students responded as shown in the following table:

Table 13
Data sources for students using many sellers (n=92)

Source	Number	%
Friends/Relatives	73	78
Professors	17	18
Search Engines	54	58
Advertisements	23	24
Other	4	4

In our survey, when asked "From how many people did you obtain advice?" the average response of those that sought advice was 3.5 people. Is this enough to obtain good advice?

Let us consider the sites students would recommend. On page three of the survey participants were given a list of sites and asked which sites (1) they would recommend freshmen check textbook prices, (2) they had checked prices, (3) they had bought textbooks, and (4) they were previously unaware. Their responses are displayed below:

Table 14
Questions about sites (n=92)

Source	Recommended this site	Checked this site	Bought from site	Unaware of site
SE1: PriceGrabber.com	5	25	1	57
SE2: Froogle.com	7	21	1	62
SE3: BigWords.com	2	8	3	78
SE4: CampusBooks.com	14	36	10	48
OL1: AbeBooks.com	28	40	26	48
OL2: Alibris.com	7	19	10	66
OL3: Amazon.com	76	85	75	0
OL4: B & N Online	15	67	12	8
OL5: BookByte.com	5	15	7	63
OL6: eBay.com	46	74	43	1
OL7: Half.com	62	72	63	8
OL8: Texbooks.com	8	34	10	44
OL9: UT Co-op Online	10	73	32	8
PS1: Half-Price Books	22	57	28	13
PS2: UT Co-op Bookstore	13	76	58	0

As can be seen from the table, students most frequently recommend and buy from Amazon.com. Half.com is second in these two categories. All but one of the students recommended at least one of these two sites, and 63 out of the 92 recommended both. Considering international edition textbooks, 58 out of the 92 students international edition textbooks and recommended at least one of these latter sites was 68%. Therefore, students do not have to talk to many previous buyers to obtain good information concerning relative prices, and this limits their need to search a large number of sites. Also, 57% of these students used at least one of the meta-search sites, which eliminates the need to check prices at listed sites without low prices.

Update the list: This data concerning sites represents the accumulated behavior from prior searches of students at the time they took the survey. It is important

to question whether students improve their performance over time and how they modified their buying strategy. On page two of the survey, subjects were asked, "For those years you bought books at sites other than the UT Co-op or UT Co-op Online, please estimate to the nearest 10% how much you saved relative to the UT Co-op price (new or used as appropriate)?" Subjects were asked to fill in their percent savings in boxes for "First year," "Second year," "Third year," and "Fourth year." The mean of the 77 observations for students who had bought textbooks online for at least two years was 29.9% for the first year and 34.5% for the second year. The difference is statistically significant for a one-tail test with a significance level of 0.1%, indicating that students believe their performance improves with experience.

The data shows students have searched for textbooks online from multiple sources an average of 5.01 times with a range from 1 to 12 times. Let us consider using regression analysis how their behavior changed with the number of times they search for textbooks online. We postulated the following regressions with the assumption that β_1, β_3, and β_4 would be positive and that β_2 would be negative:

$$ch_n = \alpha_1 + \beta_1 sem_n + \epsilon_{1n} \tag{2}$$

$$unk_n = \alpha_2 + \beta_2 sem_n + \epsilon_{2n} \tag{3}$$

$$buy_n = \alpha_3 + \beta_3 sem_n + \epsilon_{3n} \tag{4}$$

$$rec_n = \alpha_4 + \beta_4 sem_n + \epsilon_{4n} \tag{5}$$

where sem_n is the number of semesters and summer sessions the student bought textbooks online, ch_n is the number of sites the students checked over all searches, buy_n is the number of sites from which the student bought over all searches, rec_n

is the number of sites the student recommended from the searches, and unk_n is the number of unknown sites after completing the searches. We tested the hypothesis of normal errors for these four regressions with the Shapiro-Wilf W, Shapiro-Francia W, and the Skewness/Kutosis tests. All three test rejected the hypothesis of normal errors with a significance level of 5% for the fourth regression above, but all three tests did not reject the normal hypothesis for any of the other regressions. We tested all four regressions for the hypothesis of homoskedasticity with the Breusch-Pagan/ Cook-Weisberg test. The hypothesis of homoskedasticity was not rejected with a significance level of 5%. The results for OLS regressions are displayed below:

Table 15
Regression 2: Number Checked
Number of obs = 92, F(1,90) = 8.24, and Prob > F < 0.01

Coef	Value	Std Err	t val	P > |t|
α_1	6.26	0.60	10.5	<0.001
β_1	0.30	0.10	2.87	.005

Regression 3: Number Unknown
Number of obs = 92, F(1,90) = 14.43, and Prob > F < 0.001

Coef	Value	Std Err	t val	P > |t|
α_2	8.12	0.63	12.8	<0.001
β_2	-0.42	0.11	-3.8	<0.001

Regression 4: Number Bought
Number of obs = 92, F(1,90) = 5.64, and Prob > F < 0.02

Coef	Value	Std Err	t val	P > |t|
α_3	3.34	0.38	8.76	<0.001
β_3	0.16	0.07	2.38	.02

Regression 5: Number Recommended
Number of obs = 92, F(1,90) = 2.73, and Prob > F < 0.103

Coef	Value	Std Err	t val	P > |t|
α_4	3.12	0.44	7.1	<0.001
β_4	0.13	0.08	1.65	0.102

As can be seen from the tables, the F tests for the first three regressions are significant at less than a 5% level and the F test for last regression is significant

only if a significance level slightly greater than 10% is considered acceptable. The signs of β_1, β_3, and β_4 are positive with decreasing significance. These coefficients have small values indicating that these variables change slowly with an increasing number of searches. The sign of β_2 is significantly negative and larger in absolute value than the coefficient β_1. The fact that $\beta_1 - \beta_4$ have small values demonstrates the fact that student start with a good search strategy and make small adjustments with subsequent searches.

The forty students who filled in both the one-page and four-page questionnaires on average checked prices at 6.6 sites during all their searches and 3.3 sites the last time they checked prices. One student checked the same number in both measures and the rest checked more sites during all their searches. The difference is significant for a significance level of $1.0 \times 10^{-8}\%$.

Now let us consider the reasons that students drop sites from future consideration. On the one-page survey students were asked the following question:

"7. Suppose you went to a website and did not find the lowest price for any of your textbooks. How many more times would you revisit that website before you stopped using it if each time you went you had no success?

a. If it is a site that was recommended to me: ____ (Number such as 0,1, 2 or greater)

b. If it is a minor site that was not recommended to me: ____ (Number such as 0,1, 2 or greater)

c. If it is a major site that was not recommended to me: ____ (Number such as 0,1, 2 or greater)"

The averages for a, b, and c are 2.47, 0.85, and 2.63 respectively. Thus, students drop

sites that do not have lowest prices.

Another reason students drop sites is to reduce future risk of late delivery or of no delivery at all. Of the 92 students, 54 had a book delivered late, and 2 had a book that was never delivered. Of these students, 12 dropped the seller from future consideration. In addition, students limit their search to reduce risk. When asked, 47% of the one-page survey students checked "I prefer to check prices at sites with a large number of buyers and sellers such as Amazon.com or Half.com because they have a well-defined rating system that I use to reduce risk." Also, 47% of these students indicated that they were not looking for new sites because it was not worth the effort or risk.

5 Conclusion

How can students obtain good performance in searching for textbooks online using heuristics involving little calculation and checking only a few sites:

1. Market organization: Sites like Half.com and Amazon.com can list hundreds of sellers for popular textbooks so that checking these two sites means the student has checked hundreds of sellers whose prices can be arranged in ascending order.

2. Students learn about these sites from student who have experience in textbook price searching online. Another approach is using meta-search sites.

The Internet market organization has marketplace sites like Amazon.com and meta-search sites like PriceGrabber.com so consumers are able to obtain good performance in price search for many different types of products by checking just a few sites.

The marketplace on the Internet is undergoing continual change. Business to consumer sales are growing, and the use of the Internet to do background research about prices and products is growing even faster. The growth of price searching online is indicated by the fact that Experian bought PriceGrabber.com in 2005 for $485 million, see http://www.socaltech.com/experian_buys_pricegrabber_for__485m/s-0002787.html

Price search is in flux because of new technology such as price search applications, such as ShopSavy, on the iPhone and other smart cell phones. The consumer takes a picture of a barcode on a product in a store and the app gives the consumer prices from competing sellers. On the Friday after Thanksgiving 612,488 consumers used ShopSavy to find the best price, see http://www.geardiary.com/2009/12/02/shopsavvy-iphone-app-black-friday-numbers. Also, with a smart phone a consumer can access the marketplace and meta-search sites on the Internet almost anywhere.

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