# Search and Product Differentiation at an Internet Shopbot 

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Erik Brynjolfsson
Astrid Andrea Dick
Michael D. Smith

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# Search and Product Differentiation at an Internet Shopbot 

Erik Brynjolfsson, ${ }^{*}$ Astrid A. Dick ${ }^{\dagger}$ and Michael D. Smith ${ }^{\ddagger}$

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#### Abstract

Price dispersion among commodity goods is typically attributed to consumer search costs. We explore the magnitude of consumer search costs using a data set obtained from a major Internet shopbot. For the median consumer, the benefits to searching lower screens are $\$ 2.24$ while the cost of an exhaustive search of the offers is a maximum of $\$ 2.03$. Interestingly, in our setting, consumers who search more intensively are less price sensitive than other consumers, reflecting their increased weight on retailer differentiation in delivery time and reliability. Our results demonstrate that even in this nearly-perfect market, substantial price dispersion can exist in equilibrium from consumers preferences over both price and non-price attributes.


[^0]
## 1 Introduction

Price dispersion in commodity markets is typically attributed to imperfect information and consumer search costs. Low consumer search costs are one of the most frequently discussed aspects of Internet markets both in the academic literature and the popular press. On the Internet, consumers can discover prices and product offerings from competing retailers much more easily than they could in a comparably conventional environment.

Nonetheless, empirical research has consistently found a high level of price dispersion across Internet retailers. For instance, Clay et al. (2002) find a price dispersion of 27 percent for a random selection of hardcover books and 73 percent for paperback bestsellers. Similarly, Brynjolfsson and Smith (2000) find that Internet retailer prices differ by an average of 33 percent for books and 25 percent for CD's. These findings contrast with the classic "Law of One Price" in spite of the fact that the products being compared are entirely homogeneous and the marginal costs of the books are essentially identical across retailers (Brynjolfsson, Hu and Smith 2003).

Building on Stigler's (1961) claim that "Price dispersion is a manifestation - and, indeed it is a measure - of ignorance of the market," consumer search theory provides a class of models which can explain equilibrium price dispersion in the presence of consumer search costs. According to the standard economic theory, price dispersion arises when individuals are not perfectly informed about the prices or qualities of what is being sold (see, for example, Butters (1977), Varian (1980), Burdett and Judd (1983), Rob (1985), Stahl (1989)). As information is usually costly to gather, a buyer will stop searching for better deals as soon as the anticipated price reduction falls short of her cost of search. Applying the predictions of these models to markets with low search costs, Sorensen (2001) notes:
"An intuitive result that arises from such models is that exogenous increases in consumers' propensities to search (for instance, due to a decrease in search costs) will constrain prices to be lower and less dispersed."

The economic prediction of these models regarding consumers weighing the costs and benefits of search has usually been a difficult prediction to test. The empirical work on search in the economics literature includes Sorensen (2000) and Sorensen (2001). Sorensen (2000) finds that patterns in price dispersion across prescription drugs are consistent with the predictions of a search model, as repeatedly purchased prescriptions show lower dispersion and price-cost margins. In subsequent work, Sorensen (2001) uses data on retail pharmacy transactions to make inferences about search
for prescription drugs, based on a structural model, and finds that search intensities are generally low and are higher for maintenance medications.

However, search costs are not the only possible explanation for significant price dispersion. In the studies of Internet price dispersion mentioned above, while the products themselves are identical across retailers, they differ in regard to retailer-level attributes such as shipping service, product availability, return policies, and retailer reputation. Even if search costs were zero, consumers might be willing to pay different prices for different sets of these characteristics.

Our research uses a flexible demand model to estimate consumer search benefits and costs among users of a major Internet shopbot. Shopbots are Internet services that allow consumers to easily compare prices and product offerings among competing retailers. At a shopbot's site, a consumer places a product search for a unique product and obtains a list of retailers' offers with price as well as other attributes such as shipping time and product availability, displayed in a tabular format. The consumer evaluates these offers and makes a selection by "clicking" on a particular offer.

These shopbots may represent a particularly important service for Internet markets. The increasing use of shopbots, or online comparison-shopping services, should dramatically reduce consumer search costs in markets where they are available. Stigler (1961) highlighted the important role of organizations that specialize in the collection and dissemination of product and price information. Likewise, Bakos (1997) observed that electronic marketplaces, such as those facilitated by shopbots, are likely to become increasingly pervasive, with significant effects on buyer and seller welfare.

Our data contain 10,627 actual consumer searches for books offers over a 12 month period resulting in 460,814 separate retailer offers. In the data, we observe what offers the consumer was shown, the position of the offers on the consumer's screen, and how the consumer responds through their observed selection of offers. By focusing on books, a homogeneous physical product, we are able to eliminate product heterogeneity and only focus on heterogeneity across retailer service characteristics such as reputation, return policies, and shipping services. We are also able to obtain detailed data on exactly what consumers are observing and what actions they take, data that would be difficult to obtain in a conventional environment: Do they scroll down to look at more offers? Do they re-sort the data by shipping time, availability, or other characteristic? Do they sequentially click on multiple alternative offers before choosing one?

Taking advantage of the format of our data, we are able to estimate consumer benefits to search as well as an upper bound for search costs. The former is based on the comparison of the welfare
generated by the first set of offers shown to the consumer in the default screen, and that generated by the entire set of offers, which the consumer could inspect by scrolling to lower screens. For those consumers that do scroll down in our data, this represents an upper bound to their search costs. We use a compensating variations approach to calculate the welfare, based on the estimates of consumers' marginal utilities.

Our random coefficients model estimates imply that the benefits to searching lower screens are $\$ 2.24$ for the median consumer, while the cost of carrying an exhaustive search of the offers is a maximum of $\$ 2.03$ for the median consumer that we observe chooses to search lower screens. Given a price dispersion of approximately $\$ 11$ in our data, as measured by the average standard deviation of the total price within a session, search costs represent just under 18 percent of this price dispersion for the median consumer.

Interestingly, in contrast to most search models, we find that increased search is associated with reduced price sensitivity in this setting. This search is driven by non-price factors, given that the first offer on the screen is the one with the lowest price. Across the various consumer types, we find, on the one hand, that consumers that stay within the first screen and therefore do not scroll down are the most price sensitive. Consumers that scroll down to lower screens, on the other hand, have low price sensitivity. Instead, brand appears to play a relatively important role for them. Presumably they choose to inspect lower screens because they care relatively more about other attributes besides price. Similarly, consumers that take the time to re-sort offers as well as those that inspect several offers before choosing one are particularly sensitive to brand and less sensitive to price. Our results suggest that even when seemingly homogenous products are considered, non-price factors can be important.

Our work is related to several earlier papers on consumer search costs. We use a similar dataset to Smith and Brynjolfsson (2001) (hereafter S\&B) but depart from their work in several ways. First, while S\&B study the importance of brand in the Internet, we model and estimate search costs and benefits. Second, we explicitly explore consumer heterogeneity and its implications for consumer behavior based on observable behavior of consumer across offers and screens. Third, this paper uses the random coefficients model, which allows for complex demand patterns. Fourth, while $S \& B$ use a sample for a period of roughly two months, our data covers a period of over twelve months, providing us with a richer set of options for our empirical work.

Our research is also related to recent studies analyzing customer behavior on the Internet. For example, Johnson, Bellman, and Lohse (2002) use MediaMetrix data to show that the time con-
sumers spend on web sites declines with experience and that the sites with the fastest declines also have the highest customer loyalty. Lynch and Ariely (2000) use an experiment to show that lowering the search costs for quality information at a simulated online store lowers consumer price sensitivity. Baye, Morgan and Scholten (2002) find that various identifiable sources of firm heterogeneity can account for some, but not all, of the observed price dispersion in their sample of 36 online markets. Finally, Ellison and Ellison (2001) use shopbot data to analyze consumer price elasticity and retailer obfuscation strategies. They find evidence both of extraordinarily strong price competition and strategies on the part of retailers to increase consumer search costs. Our approach differs from these papers in that we use observed consumer choice behavior to place bounds on consumer search costs.

Finally, our research is related to recent empirical studies that analyze Internet market behavior. Brynjolfsson, Hu and Smith (2003) use sales rank data to infer sales volume for specific products and find that the ease of accessing the greater product selection at Internet book retailers has generated approximately one billion dollars of consumer surplus each year. Chevalier and Goolsbee (2002) apply a similar method to compare specific products at Amazon.com and Borders and from this estimate own and cross price elasticity for the two retailers. They show that Barnes and Noble faces much stronger competition from Amazon than Amazon does from Barnes and Noble. Brown and Goolsbee (2000) use survey data to show that the introduction of shopbots for life insurance products placed significant price pressure on products listed by these shopbots. Brynjolfsson and Smith (2000a) collect data on a matched set of products across Internet and conventional channels to show that Internet markets appear to be more efficient with regard to price and menu costs, but that significant levels of price dispersion persist in spite of presumed low search costs. Indeed, they find that by several measures, price dispersion is at least as high across Internet retailers as across conventional retailers. Other authors have studied retailer differentiation strategies (Clay et al 1999) and price discrimination strategies (Clemons et al 2002). However, none of these studies estimates search costs from direct observations of consumer choice behavior.

The rest of the paper is organized as follows. Section 2 presents the data and the empirical framework, including the discussion of consumer heterogeneity in our sample, the model of consumer behavior which is taken to the data, and how we identify search costs. Section 3 presents a brief review of the literature and introduces a simple theoretical framework of analysis. Section 4 presents results for both the logit and random coefficients model. Section 5 presents the implied price elasticities, and finally the estimated search benefits and costs. Lastly, we provide some concluding
remarks in Section 6.

## 2 Data

### 2.1 Description of the data

The data used in our analysis come from DealTime.com, ${ }^{1}$ a prominent online comparison-shopping service. ${ }^{2}$ As noted above, this dataset is similar to the one used by S\&B. However, while S\&B use data for a period of 69 days during August 25 to November 1, 1999, this paper uses a sample covering a period of over 12 months, roughly from September 1999 to September 2000. The sample is restricted to the top 100 bestselling books, as opposed to all searches carried on the shopbot (see Table 1 for a list of the top ten books in our dataset). To facilitate the use of our choice model we focus here on the subsample of U.S.-based customers, sessions that lead to at least one click-through by the consumer, and searches that return more than one retailer. Even with these restrictions, we are able to observe 10,627 book searches or sessions, with roughly 460,000 total offers by retailers. The maximum number of offers any consumer is presented in a single search session is 67 , including multiple offers by some retailers, for instance if they offer multiple shipping options. Table 3 shows the retailers and their shares of last clicks. There are 46 distinct retailers present in the dataset. During the sample period, we observe the behavior of 7,042 consumers.

In order to place a search, consumers must first choose the specific book they are interested in buying, which reduces their selection to a unique and physically homogeneous product, leaving item variation solely in terms of the retailers' conditions for price, shipping and product availability. When a consumer initiates a search, DealTime looks for offers for this selection in real time from a large set of retailers which account for the vast majority of books sold online. The information displayed to the consumer through DealTime is the same that the consumer would obtain were she to go directly to the retailer's web site. Once a specific book offer is chosen by the consumer, she enters her country and state location in order for applicable taxes to be calculated. The attributes of the product offers include item price for the underlying book, sales tax, shipping costs, shipping time and service, delivery time, and total price. Up to ten offers fit on a single screen, and the offers

[^1]are ranked by total price (item price plus shipping and taxes), from lowest to highest. By clicking on an offer, the consumer is taken directly to the retailer's web site to finalize the purchase. Our data include all the above information, as well as all consumer clicks, and whether the consumer sorts on a column other than total price (the default ordering).

It is important to note that in our data we only observe click-throughs as opposed to actual purchases. In related research Brynjolfsson and Smith (2000b) find that the factors that drive traffic to a site are also good predictors of sales at the retailer level. However, a conservative interpretation of our approach is as a model of click-throughs and not of sales per se. If the consumer clicks on multiple offers, we use the offer she clicks on last as an indicator of her final choice.

Table 2 shows summary statistics for the variables used in our analysis based on the total number of offers. Total price is defined as the sum of the item price, the shipping charge, and applicable taxes. Delivery time is provided by the retailer, and reflects both shipping time and what we call acquisition time, the time it takes the retailer to get the item out of the warehouse before it can be shipped, which includes product availability. ${ }^{3}$ Given that the retailer sometimes provides a time range for delivery, we construct the variable "average delivery time" which transforms this range into a single number, by taking the maximum and the minimum in the range and averaging them. "Delivery time not available" is an indicator variable for whether the retailer specifies a delivery time, which takes the value of one if the retailer did not provide the information. This variable basically reflects the item's availability, since the shipping time, the other component of delivery time, is always known. ${ }^{4}$ The variable "Big three retailers" refers to an indicator variable we construct for whether the offer is for one of the following large, well-known retailers: Amazon, Barnes \& Noble and Borders. See the Appendix for further description of the variables.

Given that our sample is restricted to consumers who choose to use DealTime in their book search, our analysis might be interpreted as being only applicable to consumers conditional on them choosing this shopbot first. The reason is that customers who elect to go through a shopbot, and in particular DealTime, might be systematically different from other consumers.

[^2]
### 2.2 Consumer heterogeneity across shopbot consumers

Consumer behavior is analyzed following the discrete choice literature. In our setup, a consumer places a search for a specific book on the shopbot's site and is then presented with several offers from various retailers, with several characteristics, such that as researchers we know exactly what the consumer sees before making choices.

On the shopbot screen, offers are sorted according to price, from lowest to highest. Yet what is remarkable in our data is that most consumers do not click on the offer with the lowest price. While the underlying good is homogeneous, the final product, including the bundled retailer services, is perceived as a differentiated product by the consumer. Clearly, in the case of consumers that choose to go to a shopbot as opposed to going directly to the retailer's site, total price should be an important component of the purchase decision. However, the consumer is expected to care about the overall utility derived from the final product, or the sum of the weighted product attributes, given the valuable diversity in terms of non-price attributes such as reliability, availability, and delivery time (Smith and Brynjolfsson 2001).

While shopbot consumers share some common characteristics, there are differences among them observable to the researcher. Based on what we observe consumers do in the shopbot, we can identify the following potentially distinct consumer groups: (i) those that click only on offers on the default screen, that is, the screen the consumer is shown after a search, which we call first screen consumers; (ii) those that scroll to lower screens by clicking in offers situated past the default screen, which we refer to as low screen consumers; (iii) those that sort by a column other than the total price column (the default sorting), which we call sorting consumers ${ }^{5}$; and (iv) those that choose to inspect more than one offer, by clicking on them, which we call multiple click consumers. Presumably, the preferences of these consumer types follow different distributional properties. By dividing consumers into the three groups listed above, we control for these differences and carry a more nuanced analysis of demand for books bought online.

In order to make inferences about search benefits and costs, it is appropriate to take into account consumer heterogeneity as much as possible. If a consumer chooses to scroll down the screen, this might not only be reflective of the search cost differences across consumers, but also of differences in preferences as well. For instance, heavily branded retailers (i.e., Amazon, Barnes and Noble, and Borders), often appear only on lower screens: 29 percent of sessions have no branded retailer in the

[^3]top ten offers (the first screen), and an additional 9 percent have only 1, with half of the sessions having no more than two branded retailers in the first screen. If brand, for instance, is important for a given consumer, she might choose to search offers on lower screens, if the option she is looking for is not available on the first screen. As a result, she might not only be less sensitive to price, all else equal, but also be more sensitive to branding. These facts highlight the possibility that more intensive search may be motivated by a desire to locate products with attributes other than merely low price, a scenario often neglected in theoretical work on search costs.

Table 4 reports how consumers are distributed based on their behavior at the shopbot. First screen consumers represent the majority, with almost 91 percent of the sessions falling in this category, while low screen consumers represent the remaining 9 percent. However, as mentioned earlier, inspite of the products being identical within a session as books with the same ISBN, most consumers do not choose the offer which has the lowest total price and is listed at the top of the Dealtime session screen. Sixteen percent of the sessions have consumers click in more than one offer and less than one percent of consumers choose to sort by a column other than the default column of total price. ${ }^{6}$

The main specification in our analysis is the random coefficients model. This flexible model allows for tastes to vary across consumers through interactions of an idiosyncratic utility component with product characteristics. As a result, we not only control for consumer heterogeneity a priori, by dividing consumers according to some observed characteristics, but also allow for consumer tastes to vary within a given consumer group.

## 3 Analytical framework

### 3.1 Literature on search under product differentiation

If books with a given ISBN are completely identical, and the first shopbot offer always has the lowest price, then why do most people search beyond the first offer? Clearly, consumers must care about the non-price retailer attributes bundled with the purchase of a given book. In other words,

[^4]they are looking for the best product fit possible, which is based on a multidimensional set of product characteristics.

Thus, the appropriate framework of analysis is one where consumers search under product differentiation, which in our setting comes primarily from retailer attributes such as service quality, reputation, and shipping policies. However, while the economics literature is well developed for both search and product differentiation, respectively, the former has focused on search under homogeneous products while the latter has mostly left search aside. Three important exceptions are Bakos (1998) and Anderson and Renault (1999) and Chen and Hitt (2003). Chen and Hitt develop a model that includes both retailer differentiation and search costs (through shopbot use). They find that Bertrand competition only occurs when both retailer differentiation is eliminated and when all consumers use shopbots. They also show that price dispersion and price premiums charged by heavily branded retailers can increase with increasing shopbot use. Bakos (1998) introduces search costs to a version of Salop's (1979) unit circle model of spatial differentiation. In the absence of product differentiation, the model follows the standard predictions in the literature: lower search costs lead to more competition and lower prices. However, in the presence of product differentiation, these predictions reverse: the model predicts that as sellers reduce the cost of obtaining information related to the non-price features of the product, prices increase as consumers care less about price and search more to find the right fit. Anderson and Renault (1999) draw on insight in Wolinsky (1986) to construct a model of price competition in the presence of search costs and product differentiation, modelled through the discrete choice approach. In their model, prices are first high when consumers have a very low value for product diversity, as in Diamond (1971) where consumers do not search at all, and subsequently fall and then rise as the taste for diversity becomes large enough and consumers engage in more search. The latter case coincides with Bakos's (1998) result.

### 3.2 A taxonomy of search and product diversity

The literature provides predictions about consumer behavior for situations of imperfect information under homogeneous products as well as product diversity without search. Using these insights, we can develop a simple framework to analyze the behavior that we would expect consumers in the shopbot which both search and care about product diversity.

Consumers are likely to be heterogeneous in both their taste for product diversity as well as their search costs. Product differentiation is at the heart of our analysis, with products defined over
a multidimensional space. While some models assume homogeneous consumer search, differences in the costs of search among consumers is likely to be prevalent in reality, as people have different costs of time and different tastes for search. In our data, we see a range of consumer behavior in the shopbot that suggests their heterogeneity, from consumers clicking on the first offer to those that click on multiple ones before deciding on an offer.

As far as search costs under product homogeneity, economic intuition and theory suggest that lower search costs lead to consumers increased search, as well as to lower prices, as the source of market power when products are homogeneous is derived only from the existence of imperfect information (see Stiglitz (1989) for a review of this literature). In terms of taste heterogeneity without search, the theory suggests that equilibrium prices increase as consumers value for diversity increases (Anderson, de Palma, and Thisse (1992), for instance). Here the source of market power is the intensity of preference for diversity.

Putting together these two dimensions of consumer heterogeneity can give us insight into consumer behavior when products are differentiated and information is imperfect. Thus, allowing consumers to be different in these two dimensions, we can expect the taxonomy shown in Figure 1. We can infer that for any given level of search costs, consumers should become less price sensitive and search more as their taste for variety increases. For any given level of variety, consumers should search more as their search costs decrease.

Consumers with a low taste for non-price attributes should be the most price sensitive, and will search less the higher their search costs. First screen consumers are likely to fall within the category of consumers with low value for differentiation and high search costs, especially those consumers that click on the first offer. Consumers with a high taste for non-price attributes should be the least price sensitive, given that they care a lot about other product characteristics. These consumers are willing to search more to find the right "fit," especially if they have low search costs. Low screen consumers are likely to fall within this category. Whether consumers with both low (high) search costs and taste for variety search a lot or a little will depend on the relative magnitudes of each. For instance, sorting consumers might have higher search costs than low screen consumers, but care enough about features that they choose to re-sort offers by a particular product attribute other than price.

## Consumer types and their presumed behavior

The above taxonomy is useful in terms of allowing us to make certain predictions about how we


Figure 1:
expect consumers on the shopbot to behave. Low screen consumers, who search the most intensively and by revealed preference care about non-price attributes, are expected to have lower search costs, a lower price elasticity and a larger weight on branding. First screen consumers, on the contrary, should have a higher price sensitivity and a low preference for branding. Within this group, those consumers that choose the first offer should be the most price sensitive. Multiple click and sorting consumers, clearly, search for attributes beyond total price, so that retailer attributes should be important.

## 4 Empirical framework

### 4.1 Model

## Base model

We start by introducing the base demand model for our analysis. Under the discrete choice framework, consumers are assumed to maximize an indirect utility function of the form

$$
\begin{equation*}
u_{i j} \equiv \delta_{j}+\epsilon_{i j} \equiv z_{j} \theta+\epsilon_{i j}, \tag{1}
\end{equation*}
$$

where $i$ stands for the consumer and $j$ for the offer, $z_{j}=\left(p_{j} x_{j}\right)$ is a $\mathrm{K}+1$-dimensional row vector of observed product characteristics, including the product price $p_{j}$ and the observed product
characteristics $x_{j}$, and $\epsilon_{i j}$ is a mean zero random disturbance. The $\mathrm{K}+1$ dimensional vector $\theta=$ $(\alpha, \beta)$ represents the taste parameters, where $\alpha$ is the coefficient on price. In particular, $z_{j} \theta=$ $x_{j} \beta_{j}-\alpha p_{j}$.

Assuming an extreme value distribution for $\epsilon$ implies that the conditional choice probability is given by the logit formula:

$$
\begin{equation*}
P_{j}(\delta)=\frac{\exp \left(\delta_{j}\right)}{\sum_{r=1}^{J} \exp \left(\delta_{r}\right)} \quad r=1, \ldots, J \tag{2}
\end{equation*}
$$

Note that given the above assumption on the distribution of $\epsilon$, the choice probabilities do not depend on individual characteristics.

## Random coefficients choice model

The utility model above assumes the additive separability between the two terms in (1), such that the $\delta$ term depends on product characteristics only, and the disturbance term solely on consumer characteristics. One implication from this utility model is that substitution patterns only depend on the $\delta_{j}$ 's. The random coefficients model overcomes this limitation by allowing for the interaction of consumer heterogeneity and observed product characteristics. If the coefficient on observed product characteristic $k$ is allowed to vary by consumer, $\theta_{i k}$, where $\theta_{i k}=\theta_{k}+\sigma_{k} \nu_{i k}$, one obtains the random coefficients model where each individual may assign a different utility level to each observable product characteristic (or some of them). The indirect utility function takes on the following form:

$$
\begin{equation*}
u_{i j} \equiv z_{j} \theta+\sum_{k} \sigma_{k} z_{j k} \nu_{i k}+\epsilon_{i j} \tag{3}
\end{equation*}
$$

where $\nu$ is i.i.d. across individuals and characteristics.
The choice probability of consumer $i$ choosing offer $j$ now becomes:

$$
\begin{equation*}
P_{i j}=\frac{\exp \left(\delta_{j}+\sum_{k} \sigma_{k} z_{j k} \nu_{i k}\right)}{\sum_{r=1}^{J} \exp \left(\delta_{r}+\sum_{r} \sigma_{r} z_{j r} \nu_{i r}\right)} \quad r=1, \ldots, J \tag{4}
\end{equation*}
$$

Therefore, unlike the basic multinomial logit, the choice probabilities depend on individual characteristics, which in terms of substitution patterns implies that consumers will substitute towards similar products (McFadden, 1984).

Price exogeneity assumption

Implicit in the above analysis is the assumption of the exogeneity of price. Given that we observe individual consumers making choices, in what constitutes a micro-level or disaggregate dataset, price can be assumed to be exogenous given that a single household should have no impact on a retailer's price, or any other attribute for that matter. However, this advantage of disaggregate demand models comes at the cost of being unable to carry out the type of counterfactual exercises that aggregate demand models allow for, since the assumption of price exogeneity is clearly inadequate in a forecasting context, as prices are determined by market forces (Goldberg, 1995).

### 4.2 Identification of search benefits and costs

When a consumer places a book search on the shopbot, she receives a list of up to ten retailers' offers, ranked by total price. We might expect consumers to find it somewhat costly to scroll down the screen in order to observe all offers, since this involves waiting time and cognitive effort for evaluating these offers (Shugan, 1980). Once the consumer inspects the first screen, she has knowledge about the attributes of the first ten offers, but is uncertain about the characteristics of the offers in lower screens unless she exerts additional effort. If shipping time or brand is important for a given consumer, she might choose to look at lower screens, if the options she is searching for are not available on the first screen, and she expects to obtain an increase in utility that is large enough to at least cover the cost involved in scrolling down to lower screens.

In this paper we exploit the nature of our data to estimate consumer benefits to search as well as an upper bound for search costs. The former is based on the comparison of the welfare generated by the first set of offers and that generated by the entire choice set of offers, which the consumer can inspect if she chooses to scroll down to lower screens. We use a compensating variations approach to calculate the welfare, based on the estimates of consumers' marginal utilities. Presumably, the reason why the consumer chooses to look at lower offers is that the expected utility gain is higher than the idiosyncratic search costs incurred in scrolling to lower screens, as she might get an offer that gives her greater utility.

## Equivalent variation: Benefits to search

One economic prediction is that consumers weigh the costs and benefits of search when making search decisions. In other words, a buyer will stop searching for better deals as soon as the anticipated price reduction falls short of her cost of search (Stigler, 1961). In our setup, if the consumer chooses to scroll down, she believes that the expected gain in utility will be at least as large as the
cost incurred in scrolling down, that is

$$
\begin{equation*}
\text { ExpectedUtilityGain } \geq \text { CostofScrollingDown } \tag{5}
\end{equation*}
$$

One way to measure the utility gain is by computing the consumer welfare change from adding the full set of offers. Just as consumer welfare is enhanced when consumers can select from 2 million books at Amazon instead of only 40,000 books at a typical conventional store (Brynjolfsson, Hu and Smith, 2003), so is welfare enhanced when additional retailers' offers, with varying prices, shipping times and branding, are made available for any given book title. Following Small and Rosen (1981), in the context of the discrete choice model, the change in welfare from expanding the set to all offers is similar to measuring the changes in welfare from changes in the choice set between periods $s$ and $s-1$ in some market $t$ as the expected equivalent variation $(E V)$ of the changes. The latter is defined as the amount of money that would make consumers indifferent, in expectation, between facing the two choice sets. This computation simply generalizes the methods of welfare economics to handle cases in which discrete choices are involved, representing a measure of compensating variation. Then, letting $\theta$ represent demand parameters, $x$ product attributes, and $p$ price, one has

$$
\begin{equation*}
E V=S_{s}\left(p_{t}, x_{t} ; \theta\right)-S_{s-1}\left(p_{t}, x_{t} ; \theta\right) \tag{6}
\end{equation*}
$$

where

$$
\begin{equation*}
S(p, x ; \theta)=\ln \left[\sum_{j}^{J} \exp \left(\delta_{j}\left(p_{j}, x_{j} ; \theta\right)\right)\right] . \tag{7}
\end{equation*}
$$

In our setup, $S_{s}$ represents the surplus generated by the entire set of offers, while $S_{s-1}$ the surplus generated by the first screen offers, with the $\theta$ parameters being identified from the full choice set. The equivalent variation represents as a result the benefits the consumer would obtain if she chose to search.

In other words, we measure the surplus generated to the consumer from the first screen offers, as well as the surplus generated from the full set of offers (all screens). The way the surplus is calculated will depend on consumer type, since first screen consumers should value price relatively more than brand, say, while consumers that scroll multiple screens should care relatively more about brand.

What is identified: Upper bound to search costs for consumers that scroll down

In the case of a consumer that we observe clicks in lower screens, the above measure of benefits represents an upper bound to search costs. ${ }^{7}$ In particular, we are able to measure her realized gains from scrolling. Presumably, the reason why the consumer chooses to look at lower offers is that the expected utility gain is higher than the idiosyncratic search costs incurred in scrolling to lower screens. This gain, however, is higher than the average gain from search for all consumers who search low screens. The reason is that there are some consumers that scroll down to lower screens but do not click-through in lower screens, and as a result we have no way to identify the fact that they surfed lower screens. These consumers get zero benefit from searching. In other words, our estimate is a conservative upper bound on search costs for consumers that we observe click on lower screens, since some zeros are omitted from the computation. Every consumer that clicks-through on a lower screen gets some benefit from searching, though this might be greater or less than what she expected. For multiple-click and sorting customers, it is possible to estimate this upper bound, based on the subsample of consumers that click on lower offers within each consumer category. Note that, by definition, there are no first screen consumers that scroll down.

The nature of this search is different from most prior analyses of search, where consumers care about finding a lower- priced product, all else equal. In our setup, consumers presumably perceive some degree of product differentiation and value other product attributes such as shipping and delivery time. This is confirmed by our results, presented later in the paper, and is consistent with the results in S\&B.

## 5 Estimation results

### 5.1 Logit model results

We first explore consumer behavior using the multinomial logit model. Table 5 reproduces one of the main logit results of $\mathrm{S} \& \mathrm{~B}$, and presents the results we obtain here with our sample under the same specification. As can be appreciated from the table, while our sample contains almost four times the number of observations of $\mathrm{S} \& \mathrm{~B}$ and covers a different time period, the results are very similar.

The specification includes price broken up into the item price, shipping charge and tax. Product attributes include the average delivery time, whether the delivery time was provided by the retailer,

[^5]and an indicator variable for whether the retailer belongs to the "big three" branded retailers: Amazon, Barnes and Noble, or Borders. These three retailers are well-known to consumers throughout the sample, and including this fixed effect should capture the intangible, non-contractible or unobserved retailer characteristics that play a role in the consumer decision. Note that the dependent variable takes on the value of one if the consumer picked the offer, and zero otherwise.

The point about brand deserves some explanation. Products sold over the Internet contain both contractible and non-contractible characteristics. They represent, from the perspective of the consumer, a kind of product bundle, including both an underlying product, as well as a service component provided by the Internet retailer, such as delivery and web site characteristics. Contractible aspects of the product bundle include attributes for which the consumer has clear avenues of recourse in the case the retailer defaults on any of them. In contrast, other characteristics, such as delivery time, are non-contractible. In the presence of non-contractible product characteristics, consumers may use a retailer's brand name as a proxy for their credibility in fulfilling their promises on non-contractible aspects of the product bundle (Wernerfelt, 1988).

As mentioned earlier, in order to examine consumer heterogeneity, we divide consumers into four groups based on some observable characteristics in our data. Column (i) of Table 6 reports results for the logit model for the entire sample. Column (ii) presents results for first screen consumers that only inspect offers in the first screen; column (iii) for low screen consumers that clicked at least once in offers in lower screens; column (iv) for sorting consumers that resorted the offers, and column (v) for multiple click consumers. Note that in these specifications we focus on total price which includes item price, shipping costs and tax, in order to keep our random coefficients analysis parsimonious in light of its greater computational demands. Also, note that the number of sessions for the sorting consumer group is very small relative to the other groups.

As we would expect, consumers in all groups are less likely to choose an offer with a higher total price. We find that first screen consumers are the most price sensitive, while low screen consumers who surf lower screens have the lowest coefficient on total price. These results coincide with our expectations that search in this setting is generally motivated by non-price factors.

Consumers also value shorter delivery times. Sorting consumers present the largest responsiveness to delivery time (though only significant at the 10 percent level of confidence), while multiple click consumers have the lowest. Both low screen and multiple click consumers appear to have a strong taste for brand, as they depict significantly higher, positive demand effects on the big-three retailers indicator. Again, this suggests the importance of non-price factors for search intensive
consumers in our setting.
The coefficient on the indicator variable for whether delivery time is not available is negative, suggesting that not listing the delivery time has an adverse effect on the demand for a retailer. Using the coefficient on the average delivery time (measured in days) to interpret this negative effect on demand suggests that, on average, the value the consumers put on the delivery information not being provided is equivalent to about 4 additional delivery days. However, for low screen and sorting consumers this variable presents no statistical significance at reasonable levels of confidence.

It is worth noting that even first screen consumers -who we expect to be the most price sensitive, and that, indeed, present the highest coefficient on price-, put significant weight on other attributes of the product-retailer bundle, highlighting the importance of retailer differentiation in this context.

### 5.2 Random coefficients model results

Tables 7-11 show results for the random coefficients specification, for the entire sample as well as for each consumer type. Note that each consumer is allowed to have an individual-specific marginal utility, as described in section 4 . The results are robust to various optimization routines and are based on sampling 125 individuals from a standard normal distribution. ${ }^{8}$

We present two specifications in each case. Model I allows the coefficient on total price to vary across consumers, while Model II allows all marginal utilities to differ across individuals, except for the brand effect, adding more flexibility to the model.

Across all specifications, the estimation results are consistent with the way we expect the coefficients to enter the indirect utility function. In Table 7, based on the entire sample, we find that consumers respond negatively to total price, as well as to delivery time. We also find a significant positive brand effect on demand for the big three retailers (Amazon, Barnes \& Noble, and Borders), as before. As evidenced in model II, all the random coefficients have a standard deviation that is significant at the one percent level of confidence. This suggests that it is appropriate to allow the marginal utilities to vary across consumers.

In terms of price sensitivity, it is low screen consumers who have the lowest absolute value coefficient, suggesting once again that they care relatively more about non-price attributes - evidenced by the high coefficient on branded retailers. Sorting and multiple click consumers, who also spend

[^6]more time searching through offers, present similar coefficients. First screen consumers, who do not search, have the highest coefficient on price and put the lowest weight on brand.

These results are similar to our previous logit results. However, the random coefficients model allows for more reasonable substitution patterns. For instance, if there were a zero standard deviation on the distribution of marginal utilities of delivery time, then when a low delivery time retailer increases its price, consumers who substitute away from this retailer will do so proportionately toward all other retailers, regardless of their delivery time, as substituting consumers have the same marginal utility as any other consumer. On the contrary, if the standard deviation on taste for delivery time were nonzero, as we find is the case here, when a low delivery time retailer increases its price, consumers who substitute away will do so towards other low delivery time retailers, as they originally showed a strong taste for low delivery time. The latter has to do with the way consumers decide on purchases by choosing the one which provides the highest utility: if a consumer found a low delivery time retailer to provide her with the greatest utility, on average this consumer will have a relatively large marginal utility for low delivery time.

Note that model II in all instances provides a better fit of the data, given that the estimates of the standard deviation of the distribution of tastes are usually significantly different from zero. The additional random coefficients, which allow the marginal utilities of other attributes besides price to vary per consumer, appear to be appropriate, and, as a result, we choose model II as our preferred specification in the analysis that follows.

### 5.3 Price elasticities

Based upon the above estimates, one can obtain price elasticities, which will allow for the interpretation of the coefficient magnitudes.

## Logit elasticities

Recalling that $z_{j} \theta=x_{j} \beta_{j}-\alpha p_{j}$, under the logit model, as defined in section 4, the price elasticity for offer $j$ is

$$
\eta_{j k}=\frac{\partial P_{j}}{\partial p_{k}} \frac{p_{k}}{P_{j}}=\left\{\begin{array}{lr}
-\alpha p_{j}\left(1-P_{j}\right) & \text { if } j=k  \tag{8}\\
\alpha p_{k} P_{k} & \text { otherwise }
\end{array}\right.
$$

Results for own-price elasticities are shown on table 12. We present various percentiles for the distribution of price elasticities for the entire sample as well as for each consumer group. The
median of the distribution of elasticities is -9.77 , so that for a one percent increase in the retailer's total price, there is a reduction of nearly 10 percent in the retailer's demand. This is quite high compared to most offline markets, as might be expected given the ease with which consumers can compare prices at a shopbot like Dealtime. Ignorance and geography are virtually eliminated as barriers to price search. At the same time, the median price elasticity is significantly less than the elasticities found by Ellison and Ellison (2001)in their analysis of a shopbot for computer memory chips, where retailer differentiation is less evident. In results below, we further explore this finding.

Another important result is the large variation across consumer types. In particular, low screen consumers have a remarkable low price elasticity with a median of only -0.68 . These results are directionally consistent with our expectations, as discussed in section 3.2 , although the small magnitude of the price elasticity is notable. First screen consumers, as we would expect, present the highest price elasticities, with a median of -14.46 .

## Random coefficients elasticities

As mentioned earlier, the flexibility of the random coefficients model has several advantages over the multinomial logit model. While the logit model is attractive due to its tractability, it imposes restrictions on the own- and cross-price elasticities (see McFadden, 1984; Berry, Levinsohn and Pakes, 1995). As we saw earlier, the price elasticities of the logit model are driven only by market shares. In the case of cross-price elasticities, for instance, this implies that if two retailers have similar market shares, whenever the price of a third retailer increases, consumers will substitute towards both retailers similarly, regardless of how far apart in the characteristics space the two retailers are located from each other. The random coefficients model allows for flexible price elasticities. Own-price elasticities in this model are driven by the different price sensitivities of diverse consumers, as opposed to the functional form assumptions of how price enters the indirect utility (additive separability). Cross-price substitution is driven by product characteristics, as the error term includes interaction between individual idiosyncrasies and characteristics.

In particular, the price elasticities derived from the random coefficients model introduced in section 4 are as follows:

$$
\eta_{j}=\left\{\begin{array}{lr}
\frac{-p_{j}}{P_{j}} \int \alpha_{i} P_{i j}\left(1-P_{i j}\right) d P(\nu) & \text { if } j=k  \tag{9}\\
\frac{p_{j}}{P_{j}} \int \alpha_{i} P_{i j} P_{i k} d P(\nu) & \text { otherwise }
\end{array}\right.
$$

where $P_{i j}$ is the choice probability for consumer $i$ for retailer $j$, as depicted in equation $4, \alpha_{i}=$
$\alpha+\sigma v_{i}, P(\nu)$ is the distribution of $\nu$ (which can be empirically estimated or imposed a priori as we do here), and

$$
\begin{equation*}
P_{j}=\int P_{i j} d p(\nu) \tag{10}
\end{equation*}
$$

The elasticities implied by this specification are reported in Table 13. Overall, this specification leads to substantially smaller elasticity estimates than the logit model. All of the elasticity distributions are shifted to the right. Note that the only elasticities that are modified only slightly are those of low screen consumers. This is not surprising, given that only the standard deviation on delivery time is significantly different from zero in the random coefficients model. That is, the implicit assumption of the multinomial logit about the standard deviation of the taste distribution being zero, actually holds true under the random coefficients for price and for the indicator for whether delivery time is not available.

In the case of the entire sample estimates, over a quarter of the elasticities are positive. This results from the fact that we let the individual characteristics be normally distributed, so that elasticities can take on any value. An alternative is to impose another distribution such as restricting the individual's marginal utility of price to take on negative values only. However, when we try imposing a log-normal distribution on the marginal utility of price, no convergence is obtained. Even if we did, however, we would be forcing the elasticities to be negative by imposing such distribution, and the validity of such an approach might be questionable. ${ }^{9}$

The ordering of the magnitudes of the elasticities (based on the median) remains the same under both the logit and the random coefficients. First screen consumers, as expected, have the highest price elasticity, with a median of -2.08 , followed by multiple click consumers, then sorting consumers, and finally low screen consumers with a low elasticity of -0.64 . For the median consumer, under the random coefficients model the elasticities have decreased significantly, with a 1 percent increase in price leading to a decrease in market share between 0.6 to 2 percent across consumer groups.

[^7]
### 5.4 Search benefits and costs

Using the random coefficients model estimates based on the entire sample and the equations in Section 4.2 above, we find that there is a median gain of $\$ 2.24$ from scrolling down to a lower screen. Table 14 shows the distribution of consumer welfare improvements from the full set of offers across various percentiles.

As discussed earlier, a consumer derives this consumer welfare gain when choosing one alternative from the full set of offers at the shopbot. In the case of low screen consumers, who click on offers beyond the first screen, this welfare gain actually represents an upper bound for search costs. Table 15 presents various percentiles for this upper bound for various consumer groups. The estimates are based on the subset of consumers, within each consumer type (entire sample, low screen, sorting and multiple click consumers), ${ }^{10}$ that scroll down to lower screens. The group of low screen consumers present the lowest search costs, with a median of $\$ 1.14 .{ }^{11}$

In other words, the estimates imply that the benefits to searching lower screens are $\$ 2.24$ for the median consumer, while the cost of carrying an exhaustive search of the offers is a maximum of $\$ 2.03$ for the median consumer that we observe chooses to search lower screens.

Given a price dispersion of approximately $\$ 11$ in our data, as measured by the average standard deviation of the total price within a session, for the median consumer search costs are equal to 18 percent of this price dispersion.

### 5.5 Discussion

The Internet has facilitated a substantial amount of consumer search by concentrating large amounts of data, particularly through shopbots. The data available at a shopbot is not only detailed in terms of price, but also on product features. This should have invariably decreased the cost of search for both prices and other product attributes. When products are homogeneous, economic theory suggests that as search costs decrease, prices should go down and become less dispersed. The fact that price dispersion has been documented to be high in the Internet (Brynjolfsson and Smith, 2000a) suggests the importance of product diversity sold on the Internet.

As searching on product features is made easier and product diversity is commonplace, the theory suggests that consumers will search more intensively on characteristics other than price

[^8]while becoming less sensitive to price (Bakos, 1997; Anderson and Renault, 1999), leading to an increase in price dispersion. Our results support this prediction.

Consistent with our expectations, we find that consumers that click in lower screens have low price sensitivity, high taste for diversity and low search costs. Multiple click and sorting customers exhibit similar behavior. First screen consumers are, as expected, the most sensitive to price and assign a lower value to brand. It is important to note, however, that all of these customers show rather low price elasticities, in spite of being shopbot customers - which are likely to be more price sensitive than the overall consumer base. This and the fact that they all appear to value branding, as well as other product attributes, is indicative of how consumers value product diversity.

## 6 Concluding remarks

Shopbots are free Internet-based services that offer a comparison-shopping search tool that presents prices and other product characteristics from various competing retailers. To researchers interested in learning about consumer behavior patterns, they provide a unique opportunity to observe consumers revealing their preferences by making actual choices. This opens up a rich new set of possibilities for testing not only theories about search, but about the decision-making of consumers, retailers and intermediaries more generally.

In this paper, we quantify consumer benefits to search and place an upper bound on consumer search costs. We find that search costs are significant in our setting, amounting to 18 percent of the price dispersion in the market. We also analyze the consumer heterogeneity present in the data and what the implications are in terms of consumer behavior and search benefits and costs. Across the various consumer types, we find that first screen consumers are the most price sensitive. Consumers that scroll down multiple screens, on the other hand, have low price sensitivity but brand appears to play a relatively important role for them, as presumably they choose to inspect lower screen because they care relatively more about other attributes besides price. Similarly, multiple click and sorting consumers appear to assign a high value on brand and are less price sensitive. Clearly, on all these dimensions, increased search intensity is not correlated with greater price sensitivity, contrary to common assumption in most search cost theory.

Collectively, the results highlight two important factors regarding Internet commerce. First, the presence of search costs in this setting of nearly-perfect price and product information provides one possible explanation for the continuing presence of high levels of price dispersion in Internet
markets. Second, the importance of non-price factors even for homogeneous physical products highlights the importance of retailer differentiation on the Internet through service characteristics and reputation. This is consistent with recent observations that in a modern economy, ancillary services take on an increased importance relative to the physical product. This also suggests that the future development of analytic models in the context of the Internet should take into account both consumer search costs and retailer differentiation. Analytic models that ignore retailer differentiation may not be that relevant for homogeneous physical products such as books - not to mention more complex and differentiated products such as electronics, cars, and computers.

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Table 1: TOP TEN BESTSELLERS IN DATASET

| Book Title | Author(s) | Number of last clicks |
| :--- | :--- | ---: |
| Harry Potter and the Goblet of Fire | J.K.Rowling | 1303 |
| Harry Potter and the Chamber of Secrets | J.K.Rowling | 408 |
| Harry Potter and the Prisoner of Azkaban | J.K.Rowling | 349 |
| Java How to Program | P.J.Deitel and H.M.Deitel | 318 |
| C++ How to Program | H.M.Deitel and P.J.Deitel | 233 |
| The Carbohydrate Addict's Lifespan Program | R.F.Heller | 214 |
| A Tale of Two Cities | C.Dickens | 203 |
| Computer Networks | A.Tanenbaum | 191 |
| Harry Potter and the Sorcerer's Stone | J.K.Rowling | 186 |
| Who Moved My Cheese? | S.Johnson and K.H.Blanchard | 180 |

Table 2: SUMMARY STATISTICS

|  |  |  |  |  |
| :--- | ---: | ---: | ---: | ---: |
| Variable | Mean | St. Dev. | Min | Max |
|  |  |  |  |  |
| Click (1=yes) | 0.0300 | 0.1705 | 0 | 1 |
| Last click (1=yes) | 0.0231 | 0.1501 | 0 | 1 |
| Total price | 52.11 | 32.78 | 1.25 | 212.91 |
| Item price | 42.14 | 31.42 | 0.50 | 180.40 |
| Shipping price | 9.70 | 6.66 | 0 | 59.92 |
| Tax | 0.26 | 1.04 | 0 | 13.08 |
| Minimum delivery time | 6.23 | 8.74 | 0 | 63 |
| Maximum delivery time | 9.47 | 12.69 | 0 | 85 |
| Average delivery time | 7.85 | 10.53 | 0 | 73.5 |
| Delivery time not available $\dagger$ | 0.4298 | 0.4951 | 0 | 1 |
| Big three retailers (1=yes) | 0.1813 | 0.3853 | 0 | 1 |
| Cookie on (1=yes) | 0.9576 | 0.2016 | 0 | 1 |
|  |  |  |  |  |
| Number of observations (offers) | 460814 |  |  |  |
| Number of sessions | 10627 |  |  |  |
| Number of consumers | 7042 |  |  |  |
| Source: Information constructed on the basis of Dealtime.com |  |  |  |  |
| data. †the variable equals 1 if the retailer did not provide the |  |  |  |  |
| delivery time. |  |  |  |  |

Table 3: RETAILERS AND THEIR CLICK SHARES

| Retailer | Share rank | No. last clicks | Click share |
| :---: | :---: | :---: | :---: |
| Borders | 1 | 1173 | 0.1103792 |
| 1Bookstreet | 2 | 1090 | 0.1025689 |
| ecampus.com | 3 | 923 | 0.0868542 |
| Amazon | 4 | 876 | 0.0824315 |
| the BigStore.com | 5 | 707 | 0.0665287 |
| Fat Brain | 6 | 603 | 0.0567423 |
| Amazon.co.uk | 7 | 495 | 0.0465795 |
| Alphabetstreet | 8 | 464 | 0.0436624 |
| BN.com | 9 | 428 | 0.0402748 |
| Half.com | 10 | 408 | 0.0383928 |
| AlphaCraze | 11 | 348 | 0.0327468 |
| elgrande.com | 12 | 319 | 0.0300179 |
| A1Books | 13 | 292 | 0.0274772 |
| Countrybookstore | 14 | 280 | 0.0263480 |
| Shopping.com | 15 | 251 | 0.0236191 |
| Classbook.com | 16 | 240 | 0.0225840 |
| Unknown | 17 | 237 | 0.0223017 |
| buy.com | 18 | 202 | 0.0190082 |
| uk.bol.com | 19 | 187 | 0.0175967 |
| ChaptersGLOBE.com | 20 | 169 | 0.0159029 |
| Davista | 21 | 79 | 0.0074339 |
| bol.de | 22 | 75 | 0.0070575 |
| Bookbuyer's Outlet | 22 | 75 | 0.0070575 |
| Internet Book Shop | 24 | 74 | 0.0069634 |
| Wordsworth | 24 | 74 | 0.0069634 |
| Hamilton Books | 26 | 69 | 0.0064929 |
| AllBooks4Less.com | 27 | 67 | 0.0063047 |
| Blackwells | 27 | 67 | 0.0063047 |
| Angus and Robertson | 29 | 52 | 0.0048932 |
| Dymocks | 30 | 43 | 0.0040463 |
| seekbooks | 31 | 40 | 0.0037640 |
| Page1Book | 32 | 36 | 0.0033876 |
| StudentBookWorld.com | 33 | 33 | 0.0031053 |
| lion.cc | 34 | 30 | 0.0028230 |
| Powells | 35 | 23 | 0.0021643 |
| Textbook.com | 36 | 20 | 0.0018820 |
| BCYbookloft.com | 37 | 19 | 0.0017879 |
| Amazon.de | 38 | 15 | 0.0014115 |
| Brians | 39 | 11 | 0.0010351 |
| 1000's of Discount Books | 40 | 10 | 0.0009410 |
| WHSmith Online | 41 | 9 | 0.0008469 |
| BookCloseOuts | 42 | 5 | 0.0004705 |
| Lesezone | 42 | 5 | 0.0004705 |
| Magusbooks | 44 | 3 | 0.0002823 |
| WATERSTONES Online | 45 | 1 | 0.0000941 |
| ChristianBooks.com | 46 | 0 | 0 |
| Cherryvalley | 46 | 0 | 0 |
| Books For Cooks | 46 | 0 | 0 |

Table 4: SUMMARY STATISTICS: SEARCH

|  | Percentage of sessions |
| :--- | ---: |
|  |  |
| First screen consumers (clicked only within default screen) | $90.76 \%$ |
| Low screen consumers (scrolled down) | $9.24 \%$ |
| Multiple click consumers (clicks $>$ 1) | $16.48 \%$ |
| Sorting customers | $0.79 \%$ |
|  |  |
| Last-clicked in offer number one | $49.68 \%$ |
| Last-clicked one of the first three offers | $75.49 \%$ |
| Last-clicked offer in second screen | $4.23 \%$ |
| Last-clicked offer in third screen | $1.55 \%$ |
| Scrolled to lower screens but chose first screen offer | $1.16 \%$ |
| Number of sessions |  |

Table 5: RESULTS: S\&B vs. CURRENT RESULTS

|  | Dependent Variable: $0 / 1$ |  |
| :--- | :---: | :---: |
| Explanatory Variable | (i) | (ii) |
| Item price | -0.193 | -0.190 |
|  | $(0.001) * *$ | $(0.002) * *$ |
| Shipping price | -0.367 | -0.386 |
|  | $(0.002) * *$ | $(0.004) * *$ |
| Tax§ | -0.361 | -0.265 |
|  | $(0.012) * *$ | $(0.024) * *$ |
| Average delivery time | -0.018 | -0.038 |
|  | $(0.001) * *$ | $(0.002) * *$ |
| Delivery time not available | -0.361 | -0.235 |
|  | $(0.015) * *$ | $(0.025) * *$ |
| Big three retailers | 0.332 | 0.356 |
|  | $(0.014) * *$ | $(0.027) * *$ |
|  |  |  |
| Sessions | 39,635 | 10,627 |
| Pseudo R-squared | 0.285 | 0.365 |
| NOTE.- Standard errors are in parentheses. ${ }^{* *}$ significant at |  |  |
| 1\%. See text and Appendix for description of variables. §S\&B |  |  |
| use weighted tax, which tries to take into account locality taxes, |  |  |
| unobserved to the researcher, in addition to state sales tax. S\&B |  |  |
| sample covers all book searches during Aug.25-Nov.1.1999. Our |  |  |
| sample is restricted to the top 100 bestseller book searches, and |  |  |
| covers the period Sep. 1999-Sept. 2000. |  |  |

Table 6: RESULTS: LOGIT MODEL

| Explanatory Variable | Dependent Variable: 0/1 |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Entire sample <br> (i) | First screen (ii) | $\begin{gathered} \hline \text { Low } \\ \text { screen } \\ \text { (iii) } \\ \hline \end{gathered}$ | Sorting <br> (iv) | Multiple Clicks (v) |
| Total price | $\begin{aligned} & \hline-0.239 \\ & (0.002) * * \end{aligned}$ | $\begin{aligned} & \hline-0.353 \\ & (0.003) * * \end{aligned}$ | $\begin{aligned} & \hline-0.016 \\ & (0.002) * * \end{aligned}$ | $\begin{aligned} & \hline-0.126 \\ & (0.017) * * \end{aligned}$ | $\begin{gathered} \hline-0.103 \\ (0.003) * * \end{gathered}$ |
| Avg. delivery time | $\begin{aligned} & -0.026 \\ & (0.002) * * \end{aligned}$ | $\begin{aligned} & -0.032 \\ & (0.002) * * \end{aligned}$ | $\begin{aligned} & -0.020 \\ & (0.005) * * \end{aligned}$ | $\begin{gathered} -0.040 \\ (0.022) \dagger \end{gathered}$ | $\begin{aligned} & -0.014 \\ & (0.003) * * \end{aligned}$ |
| Delivery time $N / A$ | $\begin{aligned} & -0.096 \\ & (0.025) * * \end{aligned}$ | $\begin{aligned} & -0.290 \\ & (0.028) * * \end{aligned}$ | $\begin{gathered} -0.042 \\ (0.073) \end{gathered}$ | $\begin{gathered} 0.074 \\ (0.265) \end{gathered}$ | $\begin{gathered} -0.138 \\ (0.056) * \end{gathered}$ |
| Big 3 retailers | $\begin{aligned} & 0.258 \\ & (0.027) * * \end{aligned}$ | $\begin{aligned} & 0.174 \\ & (0.031) * * \end{aligned}$ | $\begin{aligned} & 0.867 \\ & (0.069) * * \end{aligned}$ | $\begin{gathered} 0.580 \\ (0.278) * \end{gathered}$ | $\begin{aligned} & 0.759 \\ & (0.060) * * \end{aligned}$ |
| Observations | 460814 | 416373 | 44441 | 3209 | 75620 |
| Sessions | 10627 | 9645 | 982 | 84 | 1751 |
| Pseudo R-squared | 0.336 | 0.452 | 0.031 | 0.204 | 0.178 |
| NOTE.- Standard er at $5 \%$; ** significant a | s are in pa \%. See tex | arentheses. and Appen | $\dagger$ significant ndix for des | at $10 \%$; * <br> scription of | gnificant ariables. |

Table 7: RESULTS: RANDOM COEFFICIENTS MODEL (ENTIRE SAMPLE)

| Explanatory Variable | MODEL I | MODEL II |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Mean | Standard <br> deviation | Mean | Standard <br> deviation |
| Total price | -0.5898 | 0.3596 | -0.6362 | 0.3844 |
| Average delivery time | $-0.0085) * *$ | $(0.0070) * *$ | $(0.0103) * *$ | $(0.0077) * *$ |
|  | $(0.0020) * *$ | -0.0574 | 0.0559 |  |
| Delivery time not available | -0.4894 | $(0.0032) * *$ | $(0.0038) * *$ |  |
|  | $(0.0300) * *$ | -0.5724 | 1.4187 |  |
| Big three retailers | 0.3967 | $(0.0380) * *$ | $(0.1184) * *$ |  |
|  | $(0.0320) * *$ | 0.4208 |  |  |
|  |  | $(0.0341) * *$ |  |  |
| Sessions |  |  |  |  |
| NOTE.- Robust standard errors are in parentheses. |  |  |  |  |
| text and Appendix for description of variables. |  |  |  |  |

Table 8: RESULTS: RANDOM COEFFICIENTS MODEL FOR FIRST SCREEN CONSUMERS

| Explanatory Variable | MODEL I | MODEL II |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Mean | Standard <br> deviation | Mean | Standard <br> deviation |
| Total price | -0.7028 | 0.3644 | -0.8138 | 0.4267 |
| Average delivery time | $-0.0105) * *$ | $(0.0081) * *$ | $(0.0149) * *$ | $(0.0105) * *$ |
|  | $(0.0022) * *$ | -0.0661 | 0.0692 |  |
| Delivery time not available | -0.6116 | $(0.0038) * *$ | $(0.0047) * *$ |  |
|  | $(0.0336) * *$ | -0.7811 | 2.0753 |  |
| Big three retailers | 0.2984 | $(0.0506) * *$ | $(0.1294) * *$ |  |
|  | $(0.0359) * *$ | 0.2637 |  |  |
|  |  | $(0.0510) * *$ |  |  |
| Sessions |  |  |  |  |
| NOTE.- Robust standard errors are in parentheses. |  |  |  |  |
| text and Appendix for description of variables. |  |  |  |  |

Table 9: RESULTS: RANDOM COEFFICIENTS MODEL FOR LOW SCREEN CONSUMERS

| Explanatory Variable | MODEL I |  | MODEL II |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Mean | Standard <br> deviation | Mean | Standard <br> deviation |
| Total price | -0.0158 | 0.0001 | -0.0016 | 0.0008 |
|  | $(0.0023) * *$ | $(0.0002)$ | $(0.0024) * *$ | $(0.0065)$ |
| Average delivery time | -0.0195 | -0.0261 | 0.0216 |  |
|  | $(0.0050) * *$ | $(0.0082) * *$ | $(0.0113) *$ |  |
| Delivery time not available | -0.0420 | -0.0602 | 0.0040 |  |
|  | $(0.0710)$ | $(0.0752)$ | $(0.2295)$ |  |
| Big three retailers | 0.8671 | 0.8576 |  |  |
|  | $(0.0697) * *$ | $(0.0701) * *$ |  |  |


| Sessions $982 \quad 982$ |
| :--- |
| $\begin{array}{l}\text { NOTE.- Robust standard errors are in parentheses. } \\ \text { significant at } 1 \% \text { significant at } 5 \% ;{ }^{* *}\end{array}$ |

Table 10: RESULTS: RANDOM COEFFICIENTS MODEL FOR CONSUMERS THAT SORT

| Explanatory Variable | MODEL I |  | MODEL II |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Mean | Standard <br> deviation | Mean | Standard <br> deviation |
| Total price | -0.2760 | 0.1793 | -0.3270 | 0.2178 |
| Average delivery time | $-0.0493) * *$ | $(0.0433)$ | $(0.0625) * *$ | $(0.0588) * *$ |
|  | $(0.0266) * *$ | -0.1368 | 0.0998 |  |
| Delivery time not available | -0.2257 | $(0.0486) * *$ | $(0.0363) * *$ |  |
|  | $(0.2956)$ | -0.3228 | 1.6767 |  |
| Big three retailers | 0.4267 | $(0.4529)$ | $(1.5598)$ |  |
|  | $(0.3086)$ | 0.3696 |  |  |
|  |  | $(0.3378)$ |  |  |
| Sessions |  |  |  |  |
| NOTE.- Robust standard errors are in parentheses. |  |  |  |  |
| text and Appendix for description of variables. |  |  |  |  |
| 84 |  |  |  |  |

Table 11: RESULTS: RANDOM COEFFICIENTS MODEL FOR CONSUMERS WITH MULTIPLE CLICKS

| Explanatory Variable | MODEL I |  | MODEL II |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Mean | Standard <br> deviation | Mean | Standard <br> deviation |
| Total price | -0.1802 | 0.1183 | -0.1946 | 0.1289 |
| Average delivery time | $-0.0069) * *$ | $(0.0067) * *$ | $(0.0085) * *$ | $(0.0079) * *$ |
|  | $(0.0037) * *$ | -0.0287 | 0.0242 |  |
| Delivery time not available | -0.3564 | $(0.0056) * *$ | $(0.0092) * *$ |  |
|  | $(0.0609) * *$ | -0.4211 | 1.7411 |  |
| Big three retailers | 0.8190 | $(0.0858) * *$ | $0.3661) * *$ |  |
|  | $(0.0634) * *$ | 0.8729 |  |  |
|  |  | $(0.0675) * *$ |  |  |
| Sessions |  |  |  |  |
| NOTE.- Robust standard errors are in parentheses. ${ }^{* *}$ significant at $1 \%$. See |  |  |  |  |
| text and Appendix for description of variables. |  |  |  |  |

Table 12: LOGIT PRICE ELASTICITY PERCENTILES

| Price | $10 \%$ | $25 \%$ | Median | $75 \%$ | $90 \%$ |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Entire sample | -23.89 | -18.15 | -9.77 | -5.56 | -4.11 |
| First screen | -35.14 | -26.80 | -14.46 | -8.20 | -5.96 |
| Low screen | -1.62 | -1.18 | -0.68 | -0.38 | -0.30 |
| Sorting | -13.08 | -9.75 | -4.36 | -2.76 | -2.14 |
| Multiple clicks | -10.74 | -8.43 | -5.35 | -2.66 | -1.92 |

NOTE.- Based on estimates from Table 6. Figure indicates percentage change in the choice probability for a given retailer given a 1 percent increase in the retailer's price.

Table 13: RANDOM COEFFICIENTS PRICE ELASTICITY PERCENTILES

|  | $10 \%$ | $25 \%$ | Median | $75 \%$ | $90 \%$ |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Entire sample | -2.62 | -1.99 | -0.86 | 1.90 | 6.04 |
| First screen | -3.84 | -3.19 | -2.08 | 0.99 | 5.43 |
| Low screen | -1.51 | -1.15 | -0.64 | -0.38 | -0.30 |
| Sorting | -2.76 | -2.15 | -1.47 | 0.62 | 4.03 |
| Multiple click | -3.05 | -2.57 | -1.62 | -0.38 | 1.93 |
|  |  |  |  |  |  |

NOTE.- Based on estimates from model II. Figures represent U.S. dollars.

Table 14: BENEFITS TO SEARCH (\$ units)

|  | $10 \%$ | $25 \%$ | Median | $75 \%$ | $90 \%$ |
| :--- | :---: | :---: | :--- | :---: | :---: |
| Entire sample | 0.46 | 1.09 | 2.24 | 4.12 | 9.01 |
| First screen | 0.28 | 1.02 | 2.60 | 5.09 | 10.97 |
| Low screen | 0.91 | 1.05 | 1.14 | 1.27 | 1.41 |
| Sorting | 0.43 | 0.81 | 1.03 | 2.01 | 8.47 |
| Multiple click | 0.69 | 0.98 | 1.30 | 2.41 | 5.59 |
|  |  |  |  |  |  |

NOTE.- Based on estimates from various random model specifications. Figures represent U.S. dollars.

Table 15: UPPER BOUND TO SEARCH COSTS (\$ units)

|  | $10 \%$ | $25 \%$ | Median | $75 \%$ | $90 \%$ |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Entire sample $(n=982)$ | 0.69 | 1.22 | 2.03 | 3.41 | 9.37 |
| Low screen $(n=982)$ | 0.91 | 1.05 | 1.14 | 1.27 | 1.41 |
| Sorting $(n=14)$ | 0.42 | 0.99 | 1.92 | 3.62 | 9.43 |
| Multiple click $(n=471)$ | 0.84 | 1.03 | 1.30 | 1.84 | 5.31 |

NOTE.- Based on estimates from various random model specifications. Figures represent U.S. dollars.

## APPENDIX: DESCRIPTION OF VARIABLES

| Variable | Description |
| :--- | :--- |
| Click | $=1$ if the offer was one on which the customer clicked <br> (which may not be the last click). <br> =1 if the offer was the last one on which the customer <br> clicked on. |
| Last click | Total price as listed in the shopbot's screen. Total <br> price = item price + shipping cost + sales tax. |
| Total price | Item price as listed in the shopbot's screen. |
| Item price | Shipping price as listed in the shopbot's screen. <br> Shipping price <br> Tax |
| Minimum delivery time tax as listed in the shopbot's screen |  |
| The smallest number in the range specified by the re- |  |
| tailer for delivery time, whenever a range as opposed |  |
| to a single number of days is provided. |  |


[^0]:    *Sloan School of Management, Massachusetts Institute of Technology, erikb@mit.edu.
    ${ }^{\dagger}$ Federal Reserve Board, astrid.dick@frb.gov.
    ${ }^{\ddagger}$ H. John Heinz III School of Public Policy and Management, Carnegie Mellon University, mds@cmu.edu. We thank Susan Athey and Nancy Rose for their useful and careful comments. Any errors are our own.

[^1]:    ${ }^{1}$ Formerly EvenBetter.com, acquired by DealTime.com on May 19, 2000.
    ${ }^{2}$ Shopbots are free Internet-based services that provide a comparison-shopping search tool that presents prices of an item, as well as other product attributes, from various competing retailers. Shopbots have been changing through time, however, as they have gone from more objective presentation of price data to listing only products from companies that pay to be included in the search, or favoring retailers that advertise on their sites or pay a premium for a logo. Smith (2001) reviews the academic literature relating to shopbots.

[^2]:    ${ }^{3}$ Due to the item's availability component, the average delivery time variable sometimes may take on very large values.
    ${ }^{4}$ Note that if delivery time is not provided by the retailer, we set the delivery time equal to the shipping time, since this is all the information the consumer has. The indicator variable for whether delivery time is not available should capture the effect that the lack of information has on the consumer's decision to choose the offer.

[^3]:    ${ }^{5}$ Shopbot consumers have the option to sort by any of the columns shown, including item price, shipping price, ship time, availability, type of shipping service, tax and retailer.

[^4]:    ${ }^{6}$ Within the group of consumers that sort, the majority ( 55 percent) sort by item price. Around 20 percent sort by product availability, 11 percent by retailer, 7 percent by number of shipping days, and the remaining 7 percent sort by tax, shipping price or shipping service. Given the scant number of sessions where consumers sort, we pool these observations together as opposed to dividing the group further by what consumers chose to sort on. It is interesting that sorting customers choose to sort mostly by item price. This might suggest that these consumers care not only about the total price they will need to pay, but also about how that price is apportioned to components like item price, shipping cost, and taxes. Smith and Brynjolfsson (2001) reported precisely such an effect, and retailers themselves often tout "free shipping" and other partitions of pricing, in addition to the total price charged itself.

[^5]:    ${ }^{7}$ Note that search costs are inferred from the utility model we impose; they are not a free parameter.

[^6]:    ${ }^{8}$ Based on Train (1999), we use Halton draws instead of random draws, a type of what is known in the literature as "intelligent" draw, to save computation time. Train finds that the simulation variance in the estimation of random coefficients is lower with 100 Halton draws than with 1000 random draws, confirming earlier results in the literature. In our computations, we have benefited greatly by the insights of the estimation algorithm developed by Kenneth Train, David Revelt and Paul Ruud.

[^7]:    ${ }^{9}$ The fact that such a large percentage of elasticities are positive is somewhat disturbing. However, as mentioned earlier, this is understandable given that we let the random draws be drawn from a normal distribution, so that in principle, the tail of the distribution can take on positive values. This is common in the results in the literature. Nevo (1997), for instance, finds as many as 13 percent of the price coefficients to be positive. It is through the flexible interactions with demographics, which we do not have as part of our data set here, that Nevo (2001) obtains, in subsequent, related work, a dramatic reduction in the positive price coefficients, to only 0.7 percent. As demographic data are included, the distribution of demographics, which is not normal, modifies the final coefficient distribution away from the normal.

[^8]:    ${ }^{10}$ Note that, by definition, there are no first screen consumers that scroll down.
    ${ }^{11}$ Note that the search costs and search benefits are the same for the low screen consumer group. Also, the estimate for sorting consumers is based on only 14 observations, given that only 14 customers sort and also scroll down.

