E-commerce and the Market Structure of Retail Industries[1]

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Abstract

While a fast-growing body of research has looked at how the advent and diffusion of e-commerce has affected prices, much less work has investigated e-commerce's impact on the number and type of producers operating in an industry. This paper theoretically and empirically takes up the question of which businesses most benefit and most suffer as consumers switch to purchasing products online. We specify a general industry model involving consumers with differing search costs buying products from heterogeneous-type producers. We interpret e-commerce as having reduced consumers' search costs. We show how such reductions reallocate market shares from an industry's low-type producers to its high-type businesses. We test the model using U.S. data for two industries in which e-commerce has arguably decreased consumers' search costs considerably: travel agencies and bookstores. There is evidence in both industries of the market share shifts predicted by the model. Interestingly, while both industries experienced similar changes, the specific mechanisms through which e-commerce induced them were different. For travel agencies, the shifts reflected aggregate changes driven by airlines cutting agent commissions as consumers started buying tickets online. For bookstores, on the other hand, industry-wide declines in small book stores reflected aggregated market-specific impacts, evidenced by the fact that more small-store exit occurred in local markets where consumers' use of e-commerce channels grew fastest.

1   Introduction

This paper explores how the advent and diffusion of e-commerce impacts the structure of retail and similar industries. While there is a burgeoning literature studying how e-commerce has affected prices and price dispersion (e.g., Brown and Goolsbee (2002); Brynjolfsson and Smith (2000); Clay, Krishnan, and Wolff (2001); and Morton, Zettelmeyer, and Silva-Risso (2001)), much less work has looked at how the diffusion of the Internet has influenced the number or type of producers that operate in an industry. That is, questions of which businesses most benefit and most suffer (perhaps to the point of having to cease operations) from the new consumer-matching and distribution systems that e-commerce brings have received little attention. Anecdote-based conventional wisdom has suggested that such effects can be large and diverse in impact; the rapid growth of Orbitz, Travelocity, and Expedia at the expense of local travel agencies is one oft-cited example. Yet we do not yet know quantitatively just how large this particular effect has been or whether similar mechanisms operate across different industries. This paper seeks to begin to address these issues.

It is almost certain that more than just equilibrium prices are affected when e-commerce spreads in an industry. Market shares are very likely to change; given the reduction in consumer search costs that e-commerce can bring, any firm's price advantage will be multiplied in terms of market-share gains. Higher cross-price elasticities imply differential impacts on industry firms depending on whether they have a cost advantage or disadvantage relative to their competitors. It is also quite likely that these market share changes can be drastic enough to lead some firms to exit from the market entirely. On the other hand, lower search costs can lead to a market-expansion effect that induces new entry into the industry. Presumably, though, these entrants may differ on average from industry incumbents because e-commerce has raised the return to being efficient (or being able to produce high-quality goods). In such ways, e-commerce can have important entry and exit consequences as well.

Our investigative approach combines theoretical and empirical analyses. We first model equilibrium in an industry comprised of heterogeneous firms selling to a set of consumers who differ in their search costs. Firm types can be generally interpreted as differences in underlying abilities like production costs or output quality. We embody them as differing marginal costs for the sake of concreteness, though it is easy to modify the model to allow variation in product quality levels instead. Industry consumers search sequentially when deciding from whom to buy. Firms set prices given consumers' optimal search behavior as

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well as their own and their rivals' production costs. Firms that cannot cover their fixed costs exit the industry, but additional firms can enter upon paying an entry cost.

We interpret the advent and diffusion of e-commerce as a leftward shift in the consumer search cost distribution. We use our model to show how e-commerce activity impacts equilibrium market structure. The richness of the model offers predictions about not just equilibrium prices but also market shares, the number of producers, and the producer type (marginal cost) distribution. One advantage of our framework is that for many of our empirical predictions, we do not need to make assumptions about how consumer search costs are affected by e-commerce beyond simple first-order stochastic dominance.

The model predicts, as the previous literature has focused on, a decline in equilibrium average price levels and price dispersion. The more novel implications of our work, however, regard what happens to the equilibrium distribution of firm types. Here the model predicts that the introduction of e-commerce into an industry should result in the shrinking and sometimes exit of low-type (i.e., high-cost) firms, a shift in market share to high-type (low-cost) firms, and with some additional assumptions about the firm type and consumer search cost distributions, a drop in the number of producers as well.

We test the model using U.S. County Business Patterns (CBP) data from 1994-2003. CBP data contain, at the detailed industry level, the total number of establishments (stores) as well as their size distribution. While we cannot measure producer types directly, we can use size as a proxy; hence shifts in the size distribution are informative about heterogeneous effects of e-commerce within an industry. The panel nature of the data allows us to focus on changes in the distribution over time within local markets, removing possibly confounding differences in technology or demand differences across markets. We identify local differences in the impact of e-commerce (i.e., the size of the shift in the local search cost distribution) using consumer-level survey data to measure the fraction of the local population who report buying goods and services online.

We focus the empirical tests on two industries perceived to have been considerably impacted by e-commerce: travel agencies and bookstores. The empirical patterns support the predictions of the theoretical model. Increases in purchases made using e-commerce infrastructure are linked to declines in the number of small (and presumably low-type) establishments, but either do not significantly impact or are even positively related to growth in the number of large establishments in the industry. Interestingly, while both industries experiences market share shifts of a similar nature, the specific mechanisms linking declining search costs to the shifts were different across the industries. The shifts

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in the travel agency industry reflected aggregate changes driven largely by airlines cutting agent commissions as consumers increasingly shifted to online ticket sources. In bookstores, on the other hand, the evidence suggests that the decline in small book stores reflect aggregated market-specific impacts.

We present the general industry model in the next section and explore its predictions for how shifts in search costs impact equilibrium in an industry with heterogeneous producers. The third section discusses the data used in the empirical analysis. This is followed by a presentation and discussion of the empirical results. A short discussion concludes.

2   Model

Consider an industry with L firms selling a homogenous good for consumption by a large number of consumers. Consumers have identical unit-elastic demand for the good being sold, but are heterogenous in their search costs, as in Rob (1985). Firms have different marginal costs of production, which are their private information. Consumers do not know the price each firm charges and learn them only through costly search.

The timing of decisions by firms and consumers are as follows. At the beginning of the period, potential firms consider entering the industry. If a firm decides to enter, it pays the sunk cost of entry, κ, and learns its own marginal cost c, which is drawn i.i.d. from a cumulative density function (cdf) $\Gamma(c)$ where $c \in [0, 1]$. Next, firms decide whether to stay in the industry or not. Those that choose to stay decide then how much to charge and produce. Production requires a fixed cost of operation ν, which is identical in all firms. This cost can be avoided if the firm chooses to stay out of the market.[1]

Consumers do not know the particular price each firm charges, but do know the price distribution, $F(p)$ (with density $f(p)$), in the market. Consumers are sequential searchers; they visit stores to learn their prices and then compare after every visit the cost and benefit of continuing search. If the expected price reduction from visiting another store is greater than the marginal (search) cost s, the consumer continues to search; otherwise, he buys the product at the lowest price in hand. Thus, as characterized by McCall (1970), the optimal stopping rule is characterized by a reservation rule given by:

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[1]We could have eliminated the fixed cost of operation from the model, but in that case, those firms that otherwise exit the market would stay in the market by charging prices equal to their marginal costs. Thus having a fixed cost in the model leads to the sensible implication that only firms that make positive profits stay in the market.

$$s = \int\limits_0^r (r - p) f(p) \, dp \qquad (1)$$

where s is the marginal cost of search and the right hand side is the expected benefit from finding a price less than the price in hand r. This implies that a consumer with zero search cost always buys from the firm with the lowest price. Taking the derivative of (1) with respect to s and using the fact that r is a function of s, we can express the reservation price rule as

$$s = \int\limits_0^r F(u) \, du \qquad (2)$$

Having defined the problem of consumers, we now turn to the sellers' problem. We assume that firms do not know the marginal costs and hence the prices set by their rivals, but instead know the cdf of marginal costs $\Gamma(c)$, with probability density function (pdf) $\gamma(c)$. Further, firms do not know the search cost of any individual consumer but do know the distribution of search costs. Taking the cdf of search costs $Q(s)$ (with pdf $q(s)$) where $Q(0) > 0$ as given[2], each firm determines its optimal price based on the demand it faces, characterized by the reservation price rule $r(s)$.

Let us now consider the maximization problem of a firm with marginal cost draw c that chooses to stay in the industry. We first determine market share as a function of the price p charged by the firm: $x(p)$.[3] Clearly, only consumers with reservation prices r above p will buy from the firm. Take one such consumer with reservation price r. If there are L firms in the industry, on average there will be $LF(r)$ firms charging a price less than r. This particular consumer is equally likely to buy from any of these firms. That is, the probability that she will buy from the firm charging price p is $1/LF(r)$.[4] Integrating over all such potential customers of this firm yields an expression for market share:

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[2]If there is a mass of consumers with zero search cost, the incentives to undercut the lowest price will always exit. Thus, the equilibrium will involve a price distribution and the Diamond (1971) Paradox will be avoided.

[3]In this paper, market share is used interchangeably with quantity supplied.

[4]Here, as in Rob (1985), we are assuming that there are enough number of firms so that the law of large numbers applies. If there are small number of firms, the equilibrium we will derive will be defined by the same equations where population distribution are being replaced by sample distributions. Depending on the marginal cost draws of firms, the equilibrium price distribution, number of firms, and the cutoff value of marginal cost can be different from the values determined by population distributions.

$$x(p) = \int\limits_{p}^{\infty} \frac{g(r)}{LF(r)} dr \tag{3}$$

where $g(r)$ is the pdf of reservation price.

The reservation price distribution is derived as follows. Using the reservation price rule (2), we can write the cdf of reservation price $G(r)$ as

$$G(r) = Q\left(\int\limits_{0}^{r} F(u)\, du\right) \tag{4}$$

Taking the derivative of $G(r)$ with respect to r, we find $g(r)$ as

$$g(r) = q\left(\int\limits_{0}^{r} F(u)\, du\right) F(r) \tag{5}$$

Inserting (5) into (3), the integral for market share simplifies to

$$x(p) = \frac{1}{L}\int\limits_{p}^{\infty} q\left(\int\limits_{0}^{r} F(u)\, du\right) dr \tag{6}$$

Thus the objective function of a firm with marginal cost c choosing to stay in the industry can be expressed as

$$\max_{p}\left\{(p-c)\frac{1}{L}\int\limits_{p}^{\infty} q\left(\int\limits_{0}^{r} F(u)\, du\right) dr - \nu\right\} \tag{7}$$

Going one stage back, the post-entry profit of a firm with marginal cost c is

$$V(c) = \max\left[0, \max_{p}\left\{(p-c)\frac{1}{L}\int\limits_{p}^{\infty} q\left(\int\limits_{0}^{r} F(u)\, du\right) dr - \nu\right\}\right] \tag{8}$$

The initial stage involves ex-ante identical potential entrants deciding whether or not to commence operations. We assume that there are enough potential entrants to ensure that the expected value of post-entry profits equals the sunk entry cost κ. That is,

$$E[V(c)] = \int V(c)\, d\Gamma(c) = \kappa \tag{9}$$

This free entry condition implies ex-ante zero profits and ex-post nonnegative profits. Once a firm learns its cost level, it decides whether to stay out of the market and avoid the fixed operating cost ν, or to stay in the market and choose price to maximize operating profits. The first order condition (FOC) to the operating profit maximization problem of firm with marginal cost c, (7), is

$$(p - c) q \left(\int_0^p F(u) \, du \right) = \int_p^\infty q \left(\int_0^r F(u) \, du \right) dr \tag{10}$$

The second order condition (SOC) to this maximization problem for a firm with marginal cost c is

$$-2q \left(\int_0^p F(u) \, du \right) - (p - c) q' \left(\int_0^p F(u) \, du \right) F(p) < 0 \tag{11}$$

A firm's optimal price depends on its type c and the distributions of marginal cost and search cost. Given distribution functions, the equilibrium pricing strategies of firms will thus be only type-dependent. We denote this equilibrium price function as $p = h(c)$. Inserting this into the FOC of the profit maximization problem, we write the best response function of the firm with marginal cost c as

$$(h(c) - c) q \left(\int_0^{h(c)} \Gamma(h^{-1}(u)) \, du \right) = \int_{h(c)}^\infty q \left(\int_0^r \Gamma(h^{-1}(u)) \, du \right) dr$$

where $F(p)$ is replaced by $\Gamma(h^{-1}(p))$.[5]. By a change of variables, for each c, this is equivalent to

$$(h(c) - c) q \left(\int_{h^{-1}(0)}^c \Gamma(y) h'(y) \, dy \right) = \int_{h(c)}^\infty q \left(\int_{h^{-1}(0)}^{h^{-1}(r)} \Gamma(y) h'(y) \, dy \right) dr \tag{12}$$

It is convenient to take the derivative of (12) with respect to c and solve for the equilibrium price rule as a function of marginal cost. The resulting differential equation is

$$(2h'(c) - 1) q \left(\int_{h^{-1}(0)}^c \Gamma(y) h'(y) \, dy \right) + (h(c) - c) q' \left(\int_{h^{-1}(0)}^c \Gamma(y) h'(y) \, dy \right) \Gamma(c) h'(c) = 0 \tag{13}$$

2.1 Some Characteristics of Industry Equilibrium

First, note that there is a fixed cost of production ν, so every firm operating in the market charges a price higher than its marginal cost. This can be seen from (12). The derivations of the following properties are provided in the Appendix.

Using the SOC (11) and the differential equation (13), we can show that $h'(c) > 0$. That is, price is increasing with marginal cost.

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[5]The equality of $F(p)$ and $\Gamma(h^{-1}(p))$ is shown in the Appendix.

Property 1 *The equilibrium price of an operating firm is increasing with its marginal cost; $h'(c) > 0$.*

Using Property 1 and taking the derivative of market share (6) with respect to c, we can show that market share is decreasing with marginal cost. That is, letting $x(c)$ denote the market share of a firm with unit cost c, we have that $x'(c) < 0$.

Property 2 *The market share of an operating firm is decreasing with its marginal cost; $x'(c) < 0$.*

Let $\pi(c)$ represent the profits of an operating firm with marginal cost c. Taking the derivative of the maximand in (7) with respect to c and using the FOC (12), we find that

$$\pi'(c) = -\frac{1}{L}(h(c) - c) q \left(\int\limits_0^{h(c)} F(u) \, du \right) < 0$$

Property 3 *The profits of an operating firm is decreasing with its marginal cost; $\pi'(c) < 0$.*

Property 3 implies that there is a firm that is indifferent between staying in the industry or not. The marginal cost of that firm, $c > \overline{c}$, satisfies the equality

$$(h(\overline{c}) - \overline{c}) \frac{1}{L^*} \int\limits_{h(\overline{c})}^{\infty} q \left(\int\limits_{h^{-1}(0)}^{h^{-1}(r)} \Gamma(y) h'(y) \, dy \right) dr - \nu = 0 \tag{14}$$

where L^* is the equilibrium number of firms. Firms having drawn marginal cost levels $c > \overline{c}$ stay out of the industry and lose their sunk entry cost.

2.2 What happens when search costs decline?

In this section, we study the effect of a decline in consumers' search costs, which we believe embodies the impact of increasing access to the Internet and its associated e-commerce infrastructure. Since such access can only serve to reduce search costs, the new search cost distribution $\widehat{Q}(s)$ will then dominate the initial distribution in the sense of first order stochastic dominance (FOSD). That is, $\widehat{Q}(s) \geq Q(s)$ for all s.

Suppose the industry is initially in equilibrium. Now let consumers' search costs decline so that the new distribution becomes $\widehat{Q}(s)$. The following proposition indicates that equilibrium prices fall at any given marginal cost level. Let $\widehat{p} = \widehat{h}(c)$ denote the price a firm with marginal cost c charges when the search cost distribution is $\widehat{Q}(s)$. Then we have:

Proposition 1 *If consumers' search costs decline and the new distribution $\widehat{Q}(s)$ dominates the initial search cost distribution $Q(s)$ in the sense of first order stochastic dominance, the price a firm with marginal cost c charges declines; i.e., $\widehat{h}(c) \leq h(c)$.*

Proof. *In the Appendix.* ∎

The weak inequality in the proposition can be explained by considering the following case. Suppose that the only change in the search cost distribution is a small decline in the search cost of a consumer with the highest cost. Before, the consumer would buy from the first store she came across, since her cost of continued searching was so high. But if the decline in her search cost is small enough, she will continue to buy from the first store. This change will therefore not affect the marginal condition (12) of any firm in the industry. To see this, note that the right-hand-side of (12) indicates the demand a firm charging price p faces. Since that particular consumer chooses the first store she notices, her reservation price should be higher than any price in the market. Therefore, the integral on the right-hand-side, which includes this particular consumer, will stay the same. The second term on the left-hand-side, which indicates the demand coming from customers with the lowest search cost possible, will stay the same as well. The equality in (12) will be satisfied if that firm continues to charge price p. Therefore, firms will charge the same prices as before and the price distribution will remain the same.

Now consider another example where there is a small decline in the search cost of a consumer who is the marginal customer of firm with cost $\bar{c}$. Using similar arguments, we can observe that the price that firm finds it optimal to charge will decline. Since there is no change in the marginal demand other firms face, all other firms will continue to charge the same prices as before, make positive profits, and hence stay in the market. Under these conditions, if the firm with $\bar{c}$ happens to stay in the market, L^* will be the same and the left-hand-side of (14) will become negative. Therefore, this cannot be an equilibrium outcome; instead, the firm with $\bar{c}$ chooses to exit, reducing the equilibrium number of firms in the market.

These two examples suggest that the effects on the cutoff marginal level $\bar{c}$ and the equilibrium number of firms L^* depend on the type of changes in the search cost distribution. Furthermore, they indicate that if a firm is to exit the market, it must be the firm with the highest marginal cost $\bar{c}$ since profits are decreasing with marginal cost (Property 3). This also implies that if the cutoff cost value $\bar{c}$ declines with a change in the search cost distribution, the equilibrium number of firms L^* declines as well. The following proposition formalizes these results.

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Proposition 2 *Consider a market initially in equilibrium.*

(i) If the consumers' search costs decline and the new distribution $\widehat{Q}(s)$ dominates the initial search cost distribution $Q(s)$ in the sense of first order stochastic dominance, i.e., $\widehat{Q}(s) \geq Q(s)$ for all s, then the new equilibrium values of cutoff marginal cost $\left(\widehat{\overline{c}}\right)$ and the number of firms $\widehat{L}^*$ are less than or equal to their initial counterparts; $\left(\widehat{\overline{c}}\right) \leq \overline{c}$, $\widehat{L}^* \leq L^*$.

(ii) If, in addition to that, $\widehat{Q}(s)$ satisfies the condition $\widehat{Q}(s) > Q(s)$ for $s \geq \overline{s}$, where $\overline{s}$ is defined as

$$\overline{s} = \int\limits_0^{h(\overline{c})} F(u)\, du,$$

then the new equilibrium values of cutoff marginal cost $\left(\widehat{\overline{c}}\right)$ and the number of firms $\widehat{L}^*$ are less than their initial counterparts; $\left(\widehat{\overline{c}}\right) < \overline{c}$, $\widehat{L}^* < L^*$.

Proof. *In the Appendix.* ■

Intuitively, to change the equilibrium number of firms and identity of the marginal producer, the decline in search costs should be significant enough to affect the demand less efficient firms face. If search costs decline only for consumers who already had sufficiently low search costs, only relatively efficient firms reduce their prices and suffer profit losses. Since the marginal condition of less efficient firms is not distorted, $\overline{c}$ and L^* stay the same.

Note also that the combination of the decline in the cutoff level of marginal cost and Proposition 1 (and Property 1) implies a downward shift in the equilibrium price distribution. Since the cutoff marginal cost level declines, the range of the price distribution also declines, in line with earlier results in the literature finding reduced price dispersion (if "dispersion" is defined as the range of the distribution).

Before ending this section, a final remark is in order. In the second proposition, we are comparing an industry before and after a change in search cost distribution. We are not studying two industries that start with two different search cost distributions such as $Q(s)$ and $\widehat{Q}(s)$. If a market starts with $\widehat{Q}(s)$ from the beginning, the equilibrium outcome would be different from the outcome that market reaches when $Q(s)$ becomes $\widehat{Q}(s)$ later in time. When there is an initial equilibrium with $Q(s)$, the decline in search costs affect the firms already in the market, i.e., firms that paid the entry cost κ. If a market starts with $\widehat{Q}(s)$, all potential firms are affected and the values of $\overline{c}$ and L^* are determined jointly.

The next two sections turn to special distribution functions and study the equilibrium outcomes. We first illustrate the results of this section in an example that can be solved analytically. We then provide a numerical algorithm to characterize industry equilibrium for

general parametric specifications and demonstrate the equilibrium outcomes in an example solved by this algorithm.

2.2.1 Uniform Search Cost Distribution

Here we solve the model for an analytically tractable case where both search costs and firm productivity levels (marginal costs) are uniformly distributed. The derivations are provided in the Appendix.

Let the search cost and marginal cost distributions be given by

$$Q\left(s\right) = \frac{1}{a} + \frac{s}{a}, \ 0 \leq s \leq a - 1, \ a > 1,$$

$$\Gamma\left(c\right) = c, 0 \leq c \leq 1.$$

Using (12), we can find that the best response function of a firm with marginal cost c is

$$h\left(c\right) = \frac{1}{2}c + \sqrt{a - 1} \tag{15}$$

Under these circumstances, the cutoff level of marginal cost $\bar{c}$ is determined through equation (14) and is given implicitly by

$$\frac{1}{aL^*}\left(\sqrt{a-1} - \frac{1}{2}\bar{c}\right)^2 = \nu \tag{16}$$

Suppose that there is a decline in search costs such that

$$\widehat{Q}\left(s\right) = \frac{1}{\widehat{a}} + \frac{s}{\widehat{a}}, 0 \leq s \leq \widehat{a} - 1 < a - 1 \tag{17}$$

With a decline in a, the left-hand-side of (16) now becomes less than ν. In fact, it is shown in the Appendix that $d\bar{c}/da > 0$. Therefore, the firm that was previously only marginally profitably now exits the market. As the less efficient firms exit the market, the number of firms in the market declines.

Note that as a approaches one, consumers' search costs approaches to zero. When $a = 1$, everyone has zero search-cost and searches until they find the lowest price. In this limit case, only the firms with zero marginal cost can survive.

2.2.2 Numerical Simulations

To investigate the comparative statics of the model for more general model parameters, equation (13) can also be solved numerically. The algorithm used to solve it can be summarized as follows. Differential equation (13) can be solved up to an initial condition. The

initial condition is determined by the constraint that the marginal entrant's post-entry profit equals zero. However, this also requires that we find the equilibrium number of firms in the market, which is determined by the free-entry condition.

The parameters of the model are $Q(s)$, the cdf of consumer search costs (with pdf $q(s)$); $\Gamma(c)$, the cdf of marginal costs; κ, the sunk entry cost; and ν, the fixed operating cost. In the following set of figures, we simulate equilibrium market structure using the specification $Q(s) = 1 - \lambda_0 e^{-\lambda_1 s}$, $s \geq 0$, $\lambda_0 = 0.9$, $\Gamma(c) = c$, $0 \leq c \leq 1$, $\nu = 0.0008$, $\kappa = 0.001$. We vary λ_1 to get a set of search cost distributions that vary in the first-order stochastic dominance sense.

In figure 1, we plot the search cost distributions used in the simulations. We used three levels of search costs, $\lambda_1 \in \{0.5, 1, 2\}$, where the mean search cost is given by λ_0/λ_1. Given the search cost distribution, we solve for the equilibrium entry and pricing decisions of the firms.

Figure 2 plots the equilibrium size (sales) of a firm with a given marginal cost draw, c. Intuitively, the figure shows that more efficient (lower marginal cost) firms are larger in industry equilibrium. However, we are most interested in the comparative static result as to what happens to firm size as search costs decline. As can be seen from the figure, as search costs decline (λ_1 increases from 0.5 to 2), more efficient firms increase their sales more than less efficient firms do – i.e., market share is reallocated between firms in a way that favors more efficient firms. As can also be seen from the right end of the figure, the marginal cost cutoff for operation becomes smaller as search costs decline – higher search costs allow less efficient firms to survive in equilibrium.

We have replicated the above qualitative result (that more efficient firms grow larger the decline in search costs) with several different specifications of search cost distributions, productivity distributions, fixed and sunk costs. The Matlab programs for the simulations are available from the authors upon request.

This analysis, in combination with that above, outlines the main empirical hypothesis of our model: search cost declines driven by the advent and diffusion of e-commerce have differing effects across businesses in an industry. Low-type sellers are hurt, sometimes to the point of being forced to exit. Higher types, however, actually gain from the shift.

3 Data

Our empirical analysis uses data from two primary sources: industry employment and establishment counts from the U.S. Census Bureau's County Business Patterns (CBP), and U.S. consumers' online purchasing behavior from Forrester Research Technographics surveys. We briefly describe these data sets here, as well as discuss our market definition.

3.1 County Business Patterns

Annual County Business Patterns data contain, by detailed industry, the number of establishments in each U.S. county. Establishments are unique geographic locations where economic activity takes place (i.e., offices in the travel agency industry and storefronts in the bookstore industry). A firm can own one or more establishments.[6] Both the total number of establishments and establishment counts by employment range are included in the data.[7] In cases where disclosure of confidential information is not an issue, total industry employment and payroll in the county are also reported. However, these are often missing in the industries we study, particularly in smaller counties that are served by only a handful of firms. We can, however, impute total employment by multiplying the establishment counts in an employment range category by an estimate of the average number of employees per establishment in the category. We use the simple average of the categories' endpoints for this estimate. While imputations invariably introduce measurement error, we are reassured by the fact that the correlation between imputed and actual reported employment for those counties where the latter is available is quite high. Further, most of the empirical work below focuses on establishment counts, which are never imputed.

We use data spanning 1994 to 2003, which surrounds the period when the advent of browser software began the Internet's diffusion into the broader population. It is also the

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[6]While it would be very interesting to study the issues at hand in the context of within- and across-firm shifts, there is unfortunately no way to identify firms in the CBP data. "Firms" in the model above can be interpreted here as distinct operations (agency offices or storefronts) in an industry. While it is possible that common ownership may affect individual establishments' reactions to the shift to e-commerce, we think that the model's basic implications about the relative impacts on low- versus high-type producers to a large extent remain even within multiple-establishment firms. For example, all else equal, a firm seeking to reduce its size will tend to close its low-type operations first.

[7]The reported ranges are: 1-4 employees, 5-9, 10-19, 20-49, 50-99, 100-249, 250-499, 500-999, and over 1000 employees. Since large establishments are relatively uncommon in the industries we study here, we aggregate the four largest categories into a single 100 employees and over category.

time span over for which CBP data are available with the level of industry detail necessary for our purposes here. We focus on two industries: travel agencies (SIC 4724/NAICS 561510) and bookstores (SIC 5942, NAICS 451211). While a major change in the industry classification scheme occurred in 1997 (from the SIC system to the NAICS taxonomy), both industries' boundaries remained unaffected, so values before and after the change are comparable.

3.2 Household Internet Use

The data on households' e-commerce activity comes from Forrester Research, a market research company that has a program focusing on consumers' technology use. Its annual Technographics survey is designed to be nationally representative and includes the responses of roughly 55,000 people living in the continental U.S.[8]

We have access to the 2003 and 2004 surveys. Survey responses reflect behavior in the year previous to the title year, because the survey is typically administered from prior-year December through title-year January. For example, when the 2004 survey asks respondents about their behavior over the past year, the answers reflect actions taken in 2003.

While the survey is primarily cross-sectional, conveniently for us there is a retrospective question asking when the respondent "start[ed] purchasing products or services online." The respondent can choose one of several time ranges: "less than 1 year ago," "1 year to less than 2 years ago," and so on up to "8 years ago or more." We construct from these responses the fraction of market consumers that had started purchasing products or services online for each year from 1994 through 2003.[9]

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[8]See Goolsbee (2000) for additional details about the survey.

[9]We used the 2003 survey to compute the fraction of online shoppers in 1994 and 1995, and the 2004 survey to compute the fractions from 1996 to 2003. The use of two surveys was necessary because the "8 years ago or more" responses in the 2004 survey correspond to any purchases occurring before 1996, not necessarily those in 1995 exclusively. We do see 1995 purchase patterns, however, in the 2003 survey (through the "7 years to less than 8 years ago" responses). We are still left with online activity in 1994 being measured with "8 years ago or more" responses from the earlier survey. However, given the small fractions of respondents reporting buying products online in 1995 (see below), as well as the fact that the Internet's commercial structure at that time was quite embryonic, it is unlikely that many of the purchases attributed to 1994 actually occurred before that year. The use of two separate surveys over the observation period does not seem to have created spurious increases in reported online purchases. There is no discernable trend break between 1995 and 1996, the surveys' point of contact.

3.3 Market Definition

We define markets using the U.S. Bureau of Economic Analysis' Component Economic Areas (CEAs). CEAs are collections of counties usually, but not always, centered on Metropolitan Statistical Areas (MSAs). Counties are selected for inclusion in a given CEA based upon their MSA status, commuting flows, and newspaper circulation patterns, subject to the condition that CEAs counties are contiguous. CEA boundaries need not coincide with state boundaries. The selection criteria ensure that counties in a given CEA are economically intertwined. The roughly 3200 U.S. counties are grouped this way into 348 markets that are mutually exclusive and exhaustive of the land mass of the United States. Since our Internet use data excludes Alaska and Hawaii, our empirical analysis uses data for the 345 CEAs in the continental U.S.[10]

Using CEAs offers a compromise between conflicting requirements of the analysis. The most constraining is that, with an Internet use sample of 55,000, using smaller market areas (like counties) would result in many markets having very thin samples. Aggregating the Technographics survey to the CEA level reduces the sampling error involved, though of course with the tradeoff of losing some variation in market structures. Further, counties may in some cases be too small to accurately capture market areas in the industries we investigate. This is particularly true in more rural areas, where cross-county commerce in travel agency and bookstores is likely to be commonplace. CEAs should be large enough to envelop businesses' catchment areas in most cases.

To give an idea of the size of markets in our data, Table 1 presents summary statistics of within-CEA establishment counts in our two industries. In order to highlight across-market differences, we first take the within-market average establishment counts over our sample period, and then report quantiles of the cross-sectional distribution of these averages. The table shows quantiles for the total number of establishments as well as for each of the employment size categories. We note, however, that our empirical specifications below include market fixed effects, so that the estimated relationships between market structure and consumers' online shopping behavior reflect within-market variation over time.

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[10]See U.S. Bureau of Economic Analysis (1995) for more detailed information about creation of CEAs and the super-regions that they comprise, Economic Areas.

4   Empirical Tests

We seek to test the model's implications regarding how a shift in the consumer search cost distribution impacts industry market structure, particularly with regard to the relative fortunes of high- and low-type producers. Our focus, as mentioned previously, is on two industries where a shift in consumer activity to e-commerce channels has been cited as having a noted impact on industry producers. While these two industries are in many ways suitable for our analysis, they do not present perfect matches to the stylized industry in the model. We do find it entirely plausible, as the model assumes, that there are significant and persistent differences in producers' types in these industries. The most relevant type dimension in these two industries is, it seems to us, the per-dollar cost to industry producers of delivering a bundle of goods and services at a given quality level. Where reality and the model depart, however, is with regard to horizontal product differentiation. This is not modeled in the above theory, but it almost surely exists to some extent in both industries. Just as with search costs, differentiation decreases consumers' abilities to substitute across industry producers. So product differentiation may dampen the quantitative impact of the substitutability-enhancing (via reduced search cost) features of e-commerce. (Efforts along these lines among online booksellers have been noted in the literature; see Clay (2002), for example.) To the extent that any changes did occur, our estimates offer guidance as to the magnitude of e-commerce's impact net of product differentiation shifts.

4.1   Travel Agencies

Much has been made about the demise of the travel agent due to consumers' shifting travel purchases to e-commerce sites like travel search engines (e.g., Orbitz or Expedia) or to travel service providers themselves (with particular regard to buying tickets directly from airlines' websites). However, we are unaware of any attempt to formally analyze whether or not this is happening, and if it is, its magnitude and the manner in which it works. The model offers guidance as to the likely mechanism and its impact: declining search costs (here, the ability directly access airlines' ticket sales service online or the several fare search engines or discount bidding sites) led to decline and exit among the low-type producers in the industry and a shift in market share to the highest-type operations.

Aggregate statistics leave little doubt that the diffusion of the Internet coincided with considerable establishment exit in the travel agency industry. Figure 3 plots two time series: the total number of industry establishments, and the fraction of Technographics

survey respondents reporting that they had first purchased products or services online by a given year. The number of travel agency establishments was fairly steady, in fact slightly rising, until 1997, at which time it began to fall substantially. The number of establishments in the industry dropped by over 35 percent between 1997 and 2003. As can be seen, this exit coincided with a post-1997 acceleration in the fraction of surveyed consumers reporting online purchases.

This broad exit pattern was concentrated among the industry's smaller operations. Panel A of Table 2 contains establishment counts by establishment size category (size is measured by number of employees). Over the sample period, establishment counts fell in the four smallest employment categories, those including businesses with fewer than 50 employees. At the same time, though, the number of establishments with 50 or more employees actually rose. Proportionately, the 5-9 employment class saw the greatest decline, nearly one-half, while the numbers of the largest operations (those with 100 or more employees) grew 70 percent. The shakeout at the low end was therefore accompanied by growth among the largest industry businesses.[11]

These patterns are consistent with those seen in the model. A decline in search costs, made possible through the diffusion of the Internet and the advent and improvement of travel-shopping websites, shifted equilibrium production to the larger, higher-type producers in the industry. Indeed, some of these high-type producers may host the very portals that led to the decline of their smaller competitors.

To show the connection more formally, we regress the (logged) number of industry employees and establishments in a CEA market on the fraction of people in the market who reported making purchases online by that year. Because Internet use diffused sooner into urban areas for reasons likely unrelated to its use for purchasing travel services, there is an underlying positive correlation across markets in the number of travel agencies and the fraction of consumers using the Internet. If we did not control for these differences, we would

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[11]The CBP data does not allow one to track individual establishments through time. Therefore, it is conceptually possible that even a growing industry could exhibit net establishment losses at lower employment ranges due to formerly small businesses growing into larger size categories. However, this scenario would imply that the total number of establishments in the industry remained roughly unchanged. This is clearly not the case here. One possibility that cannot be ruled out, however, is that many small establishments were merged into larger ones. This would shrink establishment counts both at the low end of the distribution and in total. To the extent mergers played a role, though, we show shortly that the employment growth among large establishments did not fully make up for employment losses among the industry's small operators.

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spuriously conclude that greater Internet use led to increases in travel agency numbers. We therefore include CEA fixed effects in this and all of our empirical specifications. The estimates thus reflect the relationship between changes in online purchase frequencies and industry activity within CEA markets. We also control for employment across all industries in the market-year (also taken from the CBP data) to account the influence of overall market growth or decline on the industry.

The results, reported in Panel B of Table 2, reflect the aggregate patterns above.[12] Higher fractions of consumers buying goods and services online are associated with declines in the numbers of industry employees and establishments in the market. The impact of consumers' e-commerce activity is quite negative for the smallest establishments. For example, a 15 percentage point increase in the fraction of consumers making purchases online–a one standard deviation change–corresponds to a 13 percent (21 percent) drop in establishments with 1-4 employees (5-9 employees). Notice, however, that this negative impact lessens as one works up the establishment size distribution. Indeed, it eventually becomes insignificant with positive point estimates for establishments with 50-99 employees and those with 100 employees or more. The results in the first numerical column indicate that any employment gains in the larger size classes are swamped by employment losses due to the exit of smaller operations. Overall market employment, not shown here, enters positively and significantly in most of the specifications, as one might expect.

Greater e-commerce activity among consumers is therefore associated with losses among the smallest industry producers, but no noticeable negative impact and perhaps even a positive influence on the largest producers. Despite the inclusion of market fixed effects, however, the test above does not answer the question of whether the market structure impact of the shift to e-commerce acts locally or instead more broadly. It could be that the many within-market changes reflect aggregate shifts, and while the overall increase in Internet purchasing behavior shifts industry market shares in the direction predicted by the model, there is no sense in which this impact is noticeably stronger in markets that saw larger increases in consumers' Internet use than in those that experienced smaller gains.

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[12]The different sample sizes across establishment size categories result because not all market-year observations have a positive number of establishments in a particular category. Obviously, this is more likely to be the case for the counts of larger establishments. To see if these missing values were closely tied to the results, we reran the regressions using as the dependent variable the log of the number of establishments plus one. The magnitudes estimated coefficients were smaller in magnitude–as one might expect given this essentially adds a number of zeros to the dependent variables in the sample–but the qualitative features seen here remained.

To answer the question of the geographic scope of e-commerce's impact in the industry, we add a set of year dummies to the regression. This removes the impact of aggregate shifts in Internet use, leaving only the idiosyncratic within-market variation in the growth of online purchasing patterns and establishment counts to identify the coefficient. In essence, this regression tests if markets that had unusually high increases in Internet use also saw larger-than-average declines in small-establishment counts.

The regression results (with year dummy coefficients not reported for parsimony) are in Table 2, Panel C. In this case all coefficients on the measure of consumers' e-commerce activity are statistically insignificant. There is no measurable market-specific influence of online purchases on local travel agencies. This indicates, very interestingly, that the shifts in industry market structure seen above, while coincident with consumers' increasing use of online sites to conduct their travel purchases, did not arise from a set of coordinated market structure shifts in specific markets that produced the observed patterns once aggregated up. Instead, the influence of Internet use on market structure in the industry is a completely aggregate phenomenon.

A consideration of the industry's institutional details offers a likely explanation for this result. As Internet purchases of airline tickets became more common over our observation period, airlines gradually decreased the commissions they paid to travel agents. The first modest commission cut (imposing a $50 cap per domestic ticket, which given the standard 10 percent rate at the time meant it was only binding for tickets above $500) occurred in 1995.[13] This ended up being only the first cut of a series, however. By 2002, major carriers had ceased paying commissions altogether. Since airline tickets accounted for an estimated 58 percent of travel agencies' revenues in 1996, these commission declines resulted in a serious income loss for the industry (some lost commissions were replaced by fees charged directly to the consumer, though these did not cover the losses). Small operations, having high fixed costs relative to their sales volume, found it increasingly difficult to be profitable and began to exit, as seen in the data. Importantly, airlines' commission-cutting decisions were implemented nationwide, presumably in response to perceived changes in consumers' aggregate ticket purchasing patterns rather than market-

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[13]The facts on travel agent commissions discussed in this paragraph are from a 2002 report by the National Commission to Ensure Consumer Information and Choice in the Airline Industry (NCECICAI). The creation of the NCECICAI was a provision of the Aviation Investment and Reform Act for the 21st Century. The commission's congressionally mandated mission was to study the travel agent industry and, more generally, the airline services information available to consumers.

specific changes. We are aware of no evidence that airlines selectively reduced commissions more in those particular markets where online purchases were growing fastest. This would explain why the connection between Internet use and market structure changes is starkly evident in aggregate changes over time but not so across markets within a period. It is also consistent with the fact that any growth among the largest establishments was uncorrelated with local Internet use, because many of these establishments plausibly tapped into the new (and national) Internet market, and drew their business growth largely from customers outside their local area.

4.2 Bookstores

Another line of business that has by many accounts in the popular press been affected by the diffusion of Internet commerce is the retail bookstore industry. The first major Internet retailer, Amazon.com, began of course as a book-selling specialist. Many other online booksellers have since arisen, from e-commerce branches of large chain booksellers (e.g., bn.com) to dealers specializing in narrower markets like textbooks, used books, and rare books. Several brick-and-mortar booksellers have blamed their demise in large part on online competition (see, for example, Herman 2001, Weisman 2004, and Melo 2005). The process through which this competitive effect would take place is again that which is highlighted in our model: e-commerce induced reductions in consumers' search costs shift market share across the industry type distribution.

We investigate this possibility by repeating the empirical analyses above, this time using CBP data for the bookstores (SIC 5942/NAICS 451211) industry. We begin with the industry-wide establishment counts shown in Panel A of Table 3. They reflect similar patterns to those seen with the travel agency aggregates: declines in establishments in the smaller employment size categories with coincident expansion in the larger categories. For instance, while the number of bookstores with fewer than 20 employees fell by over one-fourth during the sample, those with more than 20 employees more than doubled. This growth was particularly pronounced among the 50-99 employee size category. So we again see the pattern of market share shifts from small (low-type) operations to large (high-type) ones.

Again the question arises of whether these effects reflect aggregate impacts or instead coincide with local Internet commerce patterns. No obvious institutional analogy exists in the bookstores industry to the airlines' commission reductions and their impact on

travel agencies. Therefore one might expect the impact of the Internet here to be more concentrated within particular markets. If this is the case, the overall shift from smaller to larger bookstores noted above reflects aggregated changes that occurred market-by-market.

We investigate this issue by estimating the above specification that includes year fixed effects, this time using bookstores CBP data. The results are reported in Panel B of Table 3. Again we have suppressed the estimated year effects and the coefficients on overall market employment.

In contrast to the market structure shifts in the travel agency industry, there is more evidence that local market effects matter in bookstores. Markets seeing faster growth in local consumers making online purchases had greater declines in bookstore employment and the total number of bookstores, with establishment exit being driven by losses among operations having fewer than 20 employees. This increased exit was statistically significant, excepting the case of establishments with less than five employees.

There is weaker evidence, on the other hand, that local online purchasing behavior impacted the growth seen among larger booksellers. None of the e-commerce activity ("fraction online") coefficients for the three largest size categories, while reflecting the positive comovement between online shopping and the numbers of larger bookstores, are statistically significant. This is likely due to the fact that the industry classification system includes an industry separate from bookstores, "Electronic Shopping and Mail-Order Houses" (NAICS 45411), into which the largest online booksellers are classified.[14] The expansion seen within the bookstores industry may instead reflect the ascendance of the new-format large-store chains like Barnes and Noble and Borders. Their growth is not strongly correlated with local online shopping habits because, while these sellers have extensive online operations (Barnes and Noble has its own website and Borders has teamed with Amazon), their online operations have industrial classifications that are separate in the CBP data from their brick-and-mortar locations.

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[14]Note that online airline ticket sales operations are not included in this industry. According to the U.S. Census Bureau, businesses in NAICS 45411 sold $4.16 billion of books and magazines in 2003, $2.14 billion of which was exchanged via "e-commerce" channels (these are defined as transactions over open networks like the Internet or proprietary networks running systems like Electronic Data Interchange). These book and magazine sales accounted for 3.2 percent and 5.3 percent of the industry's total and e-commerce product sales, respectively. See U.S. Census Bureau (2005) for details.

5 Conclusions

This paper has investigated the equilibrium market structure changes spurred by the introduction of e-commerce tools that reduce consumers' search costs. We specified a general industry model involving consumers with differing search costs buying products from heterogeneous-type producers. Solving for the equilibrium in the general case, we showed how shifts in the consumer search cost distribution impact equilibrium prices and market shares. Specifically, downward shifts in search costs lead to lower prices and shift market share from low-type producers to the industry's high-type businesses.

While there is an empirical literature investigating the advent and diffusion of e-commerce on prices, little has been done regarding the market structure impacts–specifically, the shifts in market share from low- to high-type businesses that our model predicts. We test these predictions in two industries for which the introduction of e-commerce has arguably decreased consumers' search costs considerably: travel agencies and bookstores.

We found evidence of the market share shifts predicted by the model. As consumers' use of the Internet to make purchases rose, smaller establishments (where size reflects firm "type") declined in number and larger establishments became more dominant. The net impact of these opposing changes on the total number of industry employees and establishments was negative in both industries, indicating that the shifts were not merely reflecting the shifting of establishments into larger size categories as the grew, but instead truly reflected exit of the industries' smaller operations.

Interestingly, while the nature of the market share shifts were similar in both industries, the specific mechanisms through which the declining search costs created them were different. For travel agencies, the shifts reflected aggregate changes, common across markets, driven in large part by airlines' reductions in agent commissions in response to consumers' increasing use of online sources to buy tickets. This is evidenced by the fact that once these aggregate changes in Internet purchasing patterns were controlled for, there was no indication that the magnitude of the market share changes were any larger (smaller) in markets experiencing idiosyncratically high (low) growth in consumers' online purchases. For bookstores, on the other hand, there was evidence that more exit occurred among smaller stores in those markets where Internet use grew fastest. This suggests that the industry-wide declines in small book stores reflect aggregated market-specific impacts. However, the observed growth in the number of large bookstores appeared to reflect instead an aggregate reshuffling of the way business is conducted in the industry.

5.1 Appendix

Derivation of equilibrium distribution of prices:

$$F(p) = \Gamma\left(h^{-1}(p)\right)$$

This equality can be obtained from the relationship between the pdf's of marginal cost distribution $\gamma(c)$ and price distribution $f(p)$:

$$f(p) = \gamma(c)\left|\frac{dc}{dp}\right| = \gamma(c)\frac{1}{h'(c)} = \gamma\left(h^{-1}(p)\right)\frac{1}{h'(h^{-1}(p))}$$

and

$$F(p) = \int_{-\infty}^{p} f(z)\,dz = \int_{-\infty}^{p} \gamma\left(h^{-1}(z)\right)\frac{1}{h'(h^{-1}(z))}dz = \int_{-\infty}^{h^{-1}(p)} \gamma(w)\,dw = \Gamma\left(h^{-1}(p)\right)$$

If there is a price $\bar{p}$ charged by the highest-cost firm in the industry $\bar{c}$, the relationship becomes

$$F(p) = \begin{cases} \Gamma\left(h^{-1}(p)\right) & \text{for } p < \bar{p} \\ \Gamma\left(h^{-1}(\bar{p})\right) = \Gamma(\bar{c}) & \text{for } p \geq \bar{p} \end{cases}$$

Derivations of Properties 1-3:

From the SOC (11), we know that

$$(h(c) - c)\,q'\left(\int_{h^{-1}(0)}^{c} \Gamma(y)\,h'(y)\,dy\right)\Gamma(c) > -2q\left(\int_{h^{-1}(0)}^{c} \Gamma(y)\,h'(y)\,dy\right)$$

If $h'(c) > 0$, using the differential equation (13), that also means

$$-(2h'(c) - 1)\,q\left(\int_{h^{-1}(0)}^{c} \Gamma(y)\,h'(y)\,dy\right) > -2h'(c)\,q\left(\int_{h^{-1}(0)}^{c} \Gamma(y)\,h'(y)\,dy\right) \tag{18}$$

If $h'(c) < 0$, then

$$-(2h'(c) - 1)\,q\left(\int_{h^{-1}(0)}^{c} \Gamma(y)\,h'(y)\,dy\right) < -2h'(c)\,q\left(\int_{h^{-1}(0)}^{c} \Gamma(y)\,h'(y)\,dy\right) \tag{19}$$

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It can easily be seen that if $h'(c) > 0$, (18) is always satisfied and if $h'(c) < 0$, (19) is never satisfied. Further, $h'(c) = 0$ cannot be a solution since it does not satisfy (??). Hence, $h'(c) > 0$. This completes the proof of Property 1.■

The market share is equal to

$$x(p) = \frac{1}{L} \int_p^\infty q\left(\int_0^r F(u)\,du\right) dr$$

where $p = h(c)$. Taking the derivative with respect to c:

$$\frac{dx}{dc} = -\frac{1}{L} h'(c) q\left(\int_0^{h(c)} F(u)\,du\right)$$

Since $h'(c) > 0$, by Property 1, and $q(\cdot)$ is a pdf and cannot be equal to zero for a firm operating in the industry (see (FOC)), $dx/dc < 0$.■

The profits of a firm with marginal cost c is equal to

$$\pi(p) = (p - c)\frac{1}{L} \int_p^\infty q\left(\int_0^r F(u)\,du\right) dr - \nu \tag{20}$$

where $p = h(c)$. Taking the derivative with respect to c:

$$\frac{d\pi}{dc} = \frac{1}{L}(h'(c) - 1) \int_{h(c)}^\infty q\left(\int_0^{h(r)} F(u)\,du\right) dr - (h(c) - c)h'(c)\frac{1}{L} q\left(\int_0^{h(c)} F(u)\,du\right)$$

Using the FOC (12), this is equivalent to

$$\frac{d\pi}{dc} = \frac{-1}{L} \int_{h(c)}^\infty q\left(\int_0^{h(r)} F(u)\,du\right) dr$$

Since the integral on the right hand side is always positive for a firm operating in the industry, $d\pi/dc < 0$.■

Proof of Proposition 1:

FOSD implies the following relationship between pdfs $\widehat{q}(s)$ and $q(s)$; for any $s_1 \geq s_0$,

$$\frac{\widehat{q}(s_1)}{\widehat{q}(s_0)} \leq \frac{q(s_1)}{q(s_0)} \tag{21}$$

Let s_0 and s_1 be defined as

$$s_0 = \int_0^{h(c)} \Gamma\left(h^{-1}(u)\right) du$$

$$s_1 = \int_0^r \Gamma\left(h^{-1}(u)\right) du$$

Also, for $r \geq h(c)$, $s_1 \geq s_0$. Thus, (21) becomes

$$\frac{\widehat{q}\left(\int_0^r \Gamma\left(h^{-1}(u)\right) du\right)}{\widehat{q}\left(\int_0^{h(c)} \Gamma\left(h^{-1}(u)\right) du\right)} \leq \frac{q\left(\int_0^r \Gamma\left(h^{-1}(u)\right) du\right)}{q\left(\int_0^{h(c)} \Gamma\left(h^{-1}(u)\right) du\right)}$$

Taking the integral over r and using (12),

$$\int_{h(c)}^\infty \frac{\widehat{q}\left(\int_0^r \Gamma\left(h^{-1}(u)\right) du\right)}{\widehat{q}\left(\int_0^{h(c)} \Gamma\left(h^{-1}(u)\right) du\right)} dr \leq \int_{h(c)}^\infty \frac{q\left(\int_0^r \Gamma\left(h^{-1}(u)\right) du\right)}{q\left(\int_0^{h(c)} \Gamma\left(h^{-1}(u)\right) du\right)} dr = (h(c) - c)$$

Therefore $h(c)$ can no longer be the equilibrium price of a firm with marginal cost c. In order to maximize its profits, the firm with marginal cost c needs to reduce the price so that the integral on the left hand side rises and the right hand side $(p - c)$ declines. The new equilibrium is achieved at price $\widehat{p} = \widehat{h}(c)$ where $\widehat{h}(c) \leq h(c)$. $\blacksquare$

Proof of Proposition 2:

Only the proof of (ii) is provided, as (i) can easily derived from it. The condition $\widehat{Q}(s) > Q(s)$ for $s \geq \bar{s}$ implies that

$$\int_s^\infty \widehat{q}(s)\, ds < \int_s^\infty q(s)\, ds$$

for all $s \geq \bar{s}$. Using the definition of s in (2), this condition can be re-written as

$$\int_{\widehat{h}(c)}^\infty \widehat{q}\left(\int_0^r \widehat{F}(u)\, du\right) \widehat{F}(r)\, dr < \int_{h(c)}^\infty q\left(\int_0^r F(u)\, du\right) F(r)\, dr$$

for $h(c) \geq h(\bar{c})$, where $\widehat{F}(p)$ is the new equilibrium price distribution. Note that $h(\bar{c})$ (or $\widehat{h}(\bar{c})$) is the highest price in the market (Property 1), so for

$r \geq h(\overline{c})$ (or $\widehat{h}(\overline{c})$), $F(r) = 1$ (or $\widehat{F}(r) = 1$). Therefore, this inequality is equivalent to

$$\int\limits_{\widehat{h}(c)}^{\infty} \widehat{q}\left(\int\limits_0^r \widehat{F}(u)\,du\right)dr < \int\limits_{h(c)}^{\infty} q\left(\int\limits_0^r F(u)\,du\right)dr$$

This implies that from (14)

$$\left(\widehat{h}(\overline{c}) - \overline{c}\right)\frac{1}{L^*}\int\limits_{\widehat{h}(c)}^{\infty} \widehat{q}\left(\int\limits_0^r \widehat{F}(u)\,du\right)dr - \nu < (h(\overline{c}) - \overline{c})\frac{1}{L^*}\int\limits_{h(\overline{c})}^{\infty} q\left(\int\limits_0^r F(u)\,du\right)dr - \nu = 0$$

as $\widehat{h}(\overline{c}) < h(\overline{c})$ from Proposition 1. Thus the firm with marginal cost $\overline{c}$ will exit the market, reducing the equilibrium number of firms in the market.∎

Derivations for the Uniform Cost Distribution:

From the differential equation (13), we can easily find that $h'(c) = 1/2$; i.e.,

$$h(c) = \frac{1}{2}c + h(0)$$

In order to find the initial condition $h(0)$, we can use the FOC. Note that the marginal condition for a consumer with s is

$$s = \int\limits_{h(0)}^{r} F(u)\,du \tag{22}$$

and $F(p) = \Gamma(h^{-1}(p)) = 2(p - h(0))$. For a consumer with the highest level of search cost s, i.e., $a - 1$, () implies that the reservation price is $r(a) = \sqrt{a - 1} + h(0)$. Going back to the FOC (10), and replacing ∞ with $r(a - 1)$, the highest reservation price, we can find that $h(0) = \sqrt{a - 1}$. Therefore,

$$h(c) = \frac{1}{2}c + \sqrt{a - 1} \tag{23}$$

The firm with the highest marginal cost $\overline{c}$ that chooses to stay in the industry will just break even; $\pi(\overline{c}) = 0$. Using the price function (23) and the profit function (20), zero-profit condition becomes

$$\frac{1}{aL^*}\left(\sqrt{a - 1} - \frac{1}{2}\overline{c}\right)^2 = \nu \tag{24}$$

Note that the price markup $p - c$ should be positive for firms operating in the industry. That is, $p - c = \sqrt{a - 1} - c/2 > 0$.

For an market initially in equilibrium, if there is a decline in consumers' search costs; in particular, if the new search cost distribution $\widehat{Q}(s)$ is defined by (17), then the first firm

to consider staying in the market or not is the firm with the highest search cost $\bar{c}$. This is because profits are decreasing with c. Using the zero-profit (24) and positive markup $\sqrt{a-1} - c/2 > 0$ conditions, we can find that $\bar{c} = 2\left(\sqrt{a-1} - \sqrt{aL^*\nu}\right)$. By taking the derivative of $\bar{c}$ with respect to a,

$$
\begin{aligned}
\frac{d\bar{c}}{da} &= \frac{1}{\sqrt{a-1}} - \frac{\sqrt{L^*\nu}}{\sqrt{a}} \\
&= \frac{1}{a\sqrt{a-1}} + \frac{\bar{c}}{2a} > 0
\end{aligned}
$$

where the second line uses the zero-profit condition (24). Therefore, with a decrease in a, the cutoff value of marginal cost $\bar{c}$ declines, reducing the total number of firms L^* in the industry.

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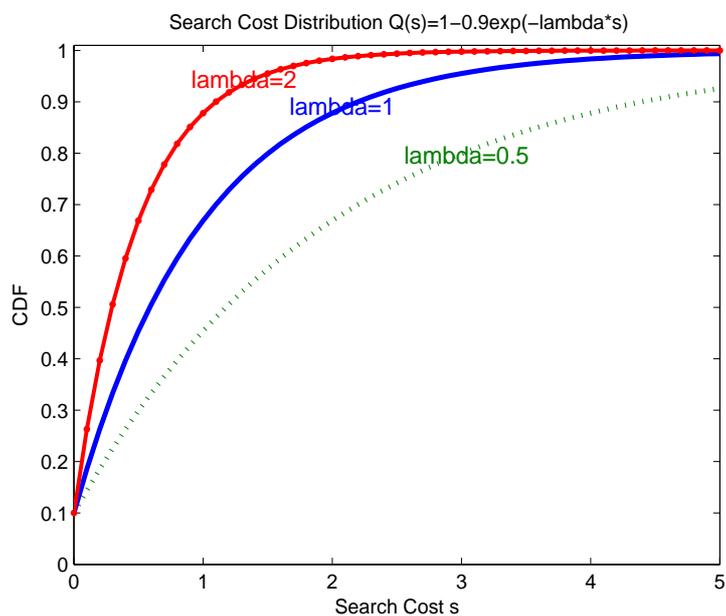Figure 1: Search cost distributions

Search Cost Distribution Q(s)=1−0.9exp(−lambda*s)

Figure 2: Changes in search costs and firm sizes
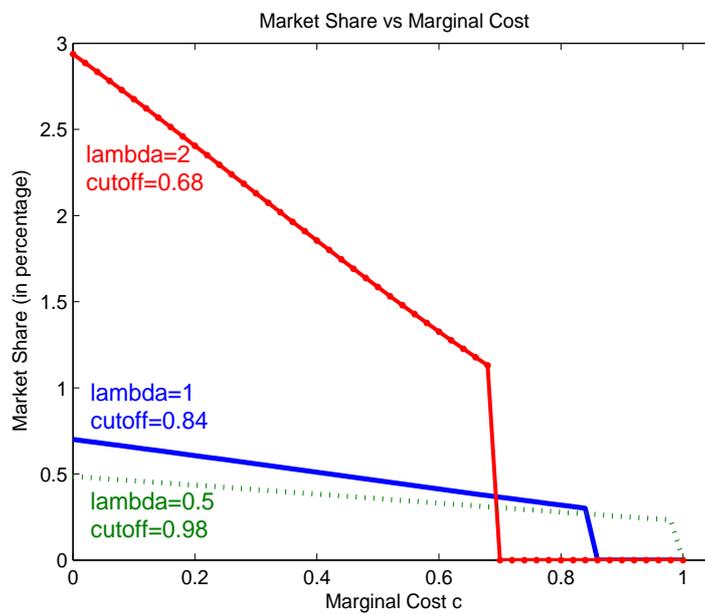

Market Share vs Marginal Cost

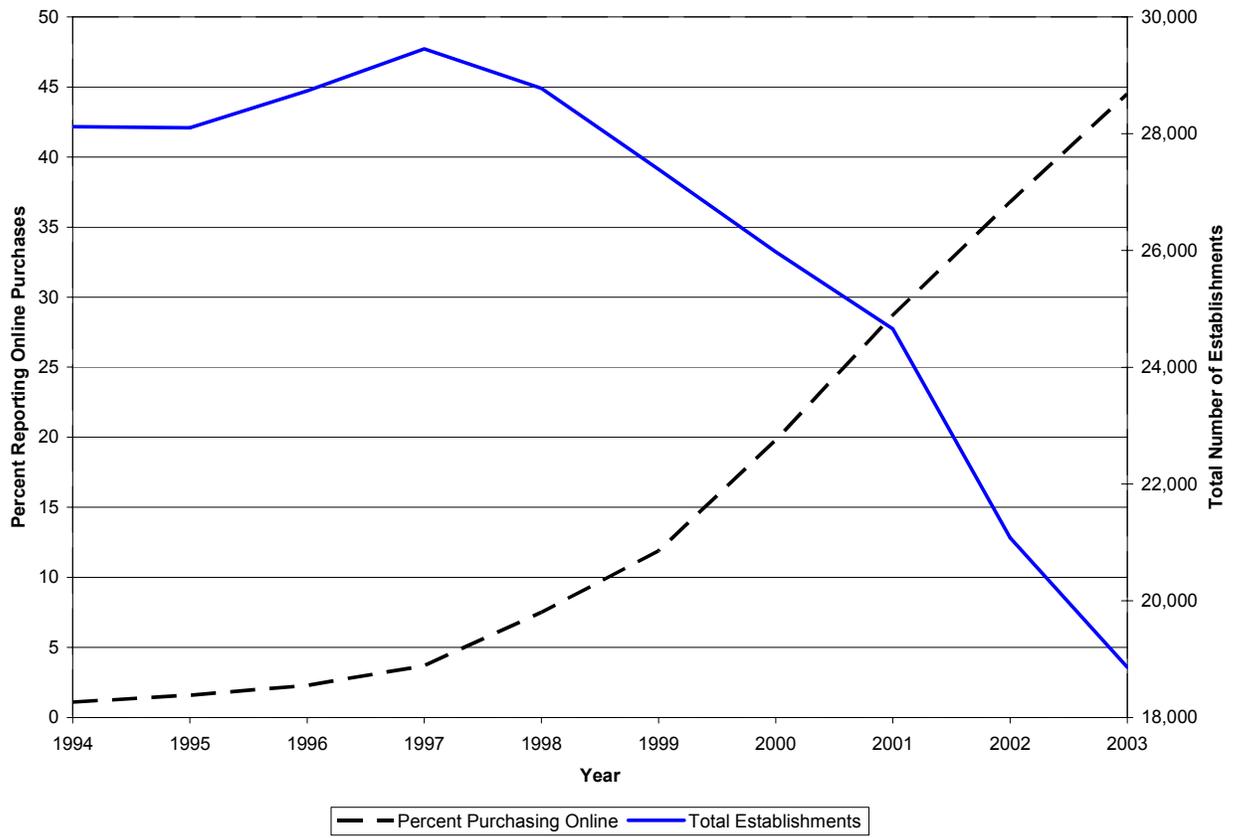Figure 3. Total Travel Agency Establishments and Consumers' Internet Purchases

Table 1. Cross-Sectional Comparison of CEA Markets

A. Average Establishment Counts: Travel Agencies

	Mean	25%ile	Median	75%ile
Total Establishments	74.3	10.8	22.4	58.3
Estabs. w/ 1-4 employees	48.4	6.6	13.6	35.7
Estabs. w/ 5-9 employees	16.8	3	6	13.7
Estabs. w/ 10-19 employees	5.9	0.7	1.9	4.5
Estabs. w/ 20-49 employees	2.3	0	0.6	1.8
Estabs. w/ 50-99 employees	0.6	0	0	0.4
Estabs. w/ over 100 employees	0.4	0	0	0.1

B. Average Establishment Counts: Bookstores

	Mean	25%ile	Median	75%ile
Total Establishments	35.4	9.8	17.8	36.6
Estabs. w/ 1-4 employees	15.3	4.3	8.3	17.8
Estabs. w/ 5-9 employees	9.9	2.8	5	10.5
Estabs. w/ 10-19 employees	6.0	1.4	2.8	6.2
Estabs. w/ 20-49 employees	3.1	0.6	1.4	3.5
Estabs. w/ 50-99 employees	1.0	0	0.3	1.1
Estabs. w/ over 100 employees	0.2	0	0	0.1

Notes: Table reports moments of within-CEA average establishment counts over the sample. There are a total of 345 CEA markets in the sample.

Table 2. Market Structure Patterns: Travel Agencies

A. Establishment Counts: U.S. Aggregates

Year	Total	Employment Category					
		1-4	5-9	10-19	20-49	50-99	100+
1994	28,118	18,186	6,774	2,121	759	169	109
1995	28,099	18,089	6,710	2,212	802	176	110
1996	28,735	18,654	6,724	2,181	859	200	117
1997	29,452	19,183	6,758	2,332	834	206	139
1998	28,776	18,460	6,755	2,325	861	212	163
1999	27,390	17,611	6,281	2,276	821	225	176
2000	25,975	16,783	5,836	2,091	845	234	186
2001	24,654	16,050	5,306	2,000	853	243	202
2002	21,079	14,281	4,151	1,581	681	201	184
2003	18,860	12,865	3,556	1,430	653	182	174

B. Local Market Structure and Fraction Purchasing Online in Market

	ln(total emp.)	ln(total estabs.)	ln(establishments) by Employment Category					
			1-4	5-9	10-19	20-49	50-99	100+
N	3449	3449	3426	3306	2548	1740	783	538
R^2	0.96	0.98	0.97	0.94	0.91	0.89	0.83	0.84
Fraction	-0.932*	-1.117*	-0.906*	-1.538*	-0.870*	-0.357*	0.072	0.161
Online	(0.047)	(0.026)	(0.036)	(0.047)	(0.065)	(0.070)	(0.106)	(0.137)

C. Local Market Structure and Fraction Purchasing Online in Market, with Year Fixed Effects

	ln(total emp.)	ln(total estabs.)	ln(establishments) by Employment Category					
			1-4	5-9	10-19	20-49	50-99	100+
N	3449	3449	3426	3306	2548	1740	783	538
R^2	0.96	0.99	0.97	0.94	0.91	0.89	0.84	0.84
Fraction	0.278	0.033	0.029	-0.075	-0.178	0.180	-0.218	-0.195
Online	(0.165)	(0.084)	(0.138)	(0.161)	(0.226)	(0.251)	(0.509)	(0.592)

Notes: All regression specifications include CEA market fixed effects and control for (logged) overall employment in the market-year. Robust standard errors in parentheses. An asterisk denotes significance at the five percent level.

Table 3. Market Structure Patterns: Bookstores

A. Establishment Counts: U.S. Aggregates

Year	Total	1-4	5-9	Employment Category 10-19	20-49	50-99	100+
1994	13,520	6,625	3,840	2,198	708	102	47
1995	13,403	6,234	3,985	2,165	806	154	59
1996	13,134	5,916	4,039	1,940	966	211	62
1997	12,301	5,254	3,753	2,021	933	286	54
1998	12,151	5,031	3,588	2,025	1,088	357	62
1999	11,957	4,878	3,467	2,063	1,076	410	63
2000	11,662	4,641	2,953	2,349	1,163	485	71
2001	11,559	4,678	3,100	2,023	1,276	411	71
2002	12,178	5,494	2,777	2,089	1,275	475	68
2003	11,036	4,493	2,900	1,909	1,237	428	69

B. Local Market Structure and Fraction Purchasing Online in Market, with Year Fixed Effects

	ln(total emp.)	ln(total estabs.)	1-4	ln(establishments) by Employment Category 5-9	10-19	20-49	50-99	100+
N	3448	3448	3386	3338	3031	2400	1275	423
R^2	0.94	0.96	0.91	0.89	0.86	0.86	0.81	0.74
Fraction	-0.307*	-0.316*	-0.161	-0.398*	-0.817*	0.220	0.485	0.003
Online	(0.148)	(0.115)	(0.172)	(0.187)	(0.210)	(0.208)	(0.357)	(0.377)

Notes: All regression specifications include CEA market fixed effects and control for (logged) overall employment in the market-year. Robust standard errors in parentheses. An asterisk denotes significance at the five percent level.