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The Law of One Price?
The Impact of IT-Enabled Markets on Consumer Search and Retailer Pricing

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ABSTRACT

Recent IT research has analyzed how the performance of IT-enabled markets may differ from conventional markets. This literature has made two unexpected empirical findings. First, IT-enabled markets for commodity goods exhibit significant price dispersion. Second, well-known retailers in these markets appear to cooperate to set high prices.

This paper presents an analytic model, and confirmatory empirical evidence, that explains this behavior as a response to the unique characteristics of consumer search in electronic markets. In conventional markets, consumer search costs are primarily a function of the consumer's physical proximity to retailer outlets — and physical proximity is distributed relatively equally across retailers. In electronic markets, consumer search costs are primarily a function of the consumer's mental awareness of different retailers — and this awareness is likely to be concentrated in the hands of a few retailers.

Based on this model of consumer search, IT-enabled markets for commodity goods exhibit high price dispersion in equilibrium and a few well-known retailers are able to cooperate to set high prices. The predictions of the model are shown to be consistent with empirical data for 23,744 books collected from 24 Internet retailers in late 1999. Viewing consumer search in this manner provides a useful starting point for understanding the likely development of IT-enabled markets, and for understanding the importance of advertising and first-mover advantage for electronic market participants.

(Internet Markets; Search; Collusion; Competition; Price Dispersion; shopbots)

1. Introduction

A growing body of the IT literature studies how the unique features of IT-enabled markets will impact market structure and firm competition. For example, IT research has examined the effect of IT-enabled markets on the relative performance of market making institutions (Malone *et al* 1987, Vakrat and Seidmann 1999), pricing behavior and market efficiency (Bakos 1997, Brynjolfsson and Smith 2000), market intermediation (Bakos 1991, Bailey and Bakos 1997), product customization (Bakos 1998), product entry (Nault and Vandenbosch 2000), customer expectations (Keeney 1999), customer switching costs (Chen and Hitt 2000), price discrimination (Clemons, Hann, and Hitt, Forthcoming), and financial market responses (Subramani and Walden 2001).

This paper contributes to this literature by examining how the unique characteristics of consumer search in IT-enabled markets impact market structure and firm-level strategy. Two recent empirical studies are particularly relevant for this question. First, Brynjolfsson and Smith (2000) find that, contrary to expectations, price dispersion in Internet markets for books and CDs is larger than the dispersion in conventional world markets for the same goods. Second, Kauffman and Wood (2000) find that retailers can use low search costs in Internet markets to match their competitors' prices, and that price matching may increase prices in Internet markets (c.f. Varian 2000). These findings — high price dispersion across all retailers and price cooperation among a set of retailers — are in stark contrast to early predictions that low search costs in electronic markets would drive prices for commodity goods toward marginal cost (e.g. Kuttner 1998).

This paper presents an analytic model showing it is possible for these characteristics to be an equilibrium response to the unique nature of consumer search in electronic markets. In

conventional markets, consumer search costs are primarily a function of the physical proximity of consumers to retailers. Furthermore, in conventional markets the physical proximity of consumers is distributed relatively equally across retailers (e.g., Salop 1979, Varian 1980). In contrast, consumer search costs in electronic markets are primarily a function of the consumer's mental awareness of different retailers' locations and site designs (Smith, Bailey, and Brynjolfsson 2000; Johnson, Bellman, and Lohse 2000). This awareness is sometimes referred to as "neural real-estate" and the nature of national advertising campaigns and consumer recall lead to awareness being concentrated in the hands of a few retailers.

In the resulting model, the focus of search on these well-known retailers creates strong interdependence in their pricing strategies. In a repeated game setting, this interdependence allows them to cooperate to set high prices. The remaining fringe retailers lack strong interdependence in their strategies and in equilibrium randomize over prices — sometimes they charge high prices to maximize profits from their fringe aware consumers and sometimes they charge low prices to gain sales from shopbot consumers.¹ The predictions of this model are consistent with prices set by 24 Internet book retailers for 23,744 book titles collected in late 1999.

This paper contributes to the IT literature in three ways. First, it provides one explanation why IT-enabled markets have not exhibited strong price competition as predicted by early market observers. Second, it provides a basis for understanding how consumer search in IT-enabled markets will impact long term market performance. Third, it provides insight into the importance

¹ Cooperation in the face of focal consumer search is just one reason why well-known retailers might be able to sustain high prices (c.f., Smith, Bailey, and Brynjolfsson 2000) and should not be seen as contradicting other explanations. However, this explanation also has the advantage of being consistent with empirically observed parallel pricing among well-known retailers (Section 4).

of advertising, brand development, and first mover advantage for electronic market retailers — even for retailers selling commodity goods.

The remainder of this paper proceeds as follows. Section 2 introduces the model and discusses how it differs from standard economic models of consumer search in conventional markets.

Section 3 derives the equilibrium behavior of the model for dominant and fringe retailers.

Section 4 compares the predictions of the model to data gathered from the book market in late 1999. Section 5 concludes, discusses implications of this research, and presents areas for future study.

2. Model

Typically, models in the economics literature conceptualize search costs as arising from a consumer's physical location relative to retailer outlets, distributing physical proximity evenly across consumers and retailers. For example, the well-known "Salop's Circle" model (Salop 1979) distributes consumers and retailers evenly around a circular city and has consumer search costs arising from the distance between a consumer and any retailer on the circle. Likewise, in "tourists-natives" models (e.g., Varian 1980), consumers pay a cost to draw prices at random from a distribution of retailer prices. Critically, in both models no single retailer dominates in terms of low search costs. This accords well with conventional markets where proximity is the primary driver of consumer search costs and where different consumers are in close proximity to different retailers. However these characteristics do not accord well with the characteristics of search in IT-enabled markets.²

² Note that this comment does not apply to Bakos (1997) who uses Salop's circle to model consumer-product fit, not consumer search costs *per se*.

For IT-enabled markets, search costs are primarily a function of consumer awareness of retailers, and awareness is likely to be concentrated among a small set of retailers. While some analysts have argued that on the Internet all retailers are “just a click away,” this is only the case when consumers know the right click to make. When consumers can recall a domain name from memory, or can use a web browser’s bookmark, search costs will be relatively low. However, search costs may be quite high to locate suitable retailers from online directories or search engines.

Given this conceptualization, the model proceeds as follows. A large number of retailers compete in a market for an entirely homogeneous good. A subset k of these retailers are “dominant” in the sense that they possess higher awareness levels among consumers. Without loss of generality, I employ three dominant retailers; two or more dominant retailers could also be used subject to the constraints derived below. The remaining N retailers make up a competitive fringe.

The three types of consumers are used to capture the unique characteristics of search in IT-enabled markets discussed above. The first are “dominant aware.” These consumers search costlessly for prices among the three dominant retailers and can search for additional prices at a cost s . Consumers in the second category are aware of prices at the three dominant retailers in addition to one of the “fringe retailers,” and these consumers can search for additional prices at a cost s . Following Greenwald and Kephart (1999), the third consumer type uses “shopbots” to search all prices in the market. The assumption that not all consumers use shopbots is supported by recent research showing that only 6% of Internet shoppers use shopbots (Montgomery et al 2001). However, in section 3 I discuss the comparative statics of the model with respect to shopbot use. Dominant aware, fringe aware, and shopbot consumers make up proportions α , ξ ,

and β respectively of the total number of consumers. All consumers have unit demand up to a reservation price (R). All consumers purchase at the lowest price within their search set.³

Consumer demand is given by a demand function that is applicable to a wide variety of consumer products: products are released to an initial period of popularity, but over time demand decline to a steady state. Without loss of generality, demand is specified as follows:⁴

$$q = \begin{cases} \mu^{\hat{t}} D & \forall 0 \leq \hat{t} < T \\ \mu^T D & \hat{t} \geq T \end{cases} \quad (1)$$

where \hat{t} is the number of time periods since the introduction of the product and $\mu \leq 1$. These products are produced at a marginal cost c giving retailers a profit function of

$$\Pi_t(P_t) = q(P_t - c)\theta(P_t) \quad (2)$$

where $\theta(P_t)$ is the fraction of consumers who purchase at price P_t .

The order of the game is as follows. In the first period all retailers observe the demand characteristics for the product and in the second period they simultaneously set prices. Retailers do not observe consumer types before setting prices and thus must charge the same price to each consumer.⁵ This game is repeated an infinite number of times where all retailers can observe the history of strategies played up to the present time and where retailers discount future profits by a constant δ . This discount factor is typically interpreted in terms of interest rates (where $\delta = 1/(1+i)$) or in terms of uncertainty regarding future outcomes.

³ Where retailers set the same minimum price, I assume that demand is divided equally among the low priced retailers.

⁴ This demand specification is adapted from an example in Tirole (1995), p. 250.

⁵ If consumer types are observable prior to price setting, this restriction may be enforced by “community norms.” For example, Amazon.com was criticized in the press for charging multiple different prices to purchasers of an MP3 player (“MP3 player ‘sale’ exposes Amazon’s flexible prices,” Troy Wolverton, CNET News.com, May 17, 2000.)

3. Results

3.1. Dominant Retailer Competition

In the dominant retailer segment, because production costs are equal and the retailers are a focal point of search, the unique Nash equilibrium of the stage game is for price to equal marginal cost. However, in an infinite horizon game, Subgame Perfect Equilibria can develop where retailers set price above marginal cost (e.g., Rotemberg and Saloner 1986). A strategy in a Subgame Perfect Equilibrium is a course of action that maximizes the present discounted value of each retailer's profits given their information regarding the history of the game to date. A candidate set of prices $\{P_t\}$ form a Subgame Perfect Equilibrium in an infinitely repeated game if two conditions are met. First, each retailer charges P_t in time period t . Second, no retailer finds it profitable to deviate from the pricing schedule in any period. To satisfy these conditions, retailers must find the cooperative schedule of prices more profitable than single period deviations from this schedule.

There are two relevant regions of demand for this equilibrium. In the region of steady state demand ($\hat{t} \geq T$), each retailer's expected payoff from charging the cooperative set of prices is:⁶

$$V_c = \sum_{t=0}^{\infty} \frac{\alpha}{3} \delta^t \mu^T D(P_t - c) = \frac{\alpha}{3} \left(\frac{1}{1-\delta} \right) \mu^T D(P_t - c) \quad (3)$$

In a single period, a retailer could deviate from this strategy by lowering its price slightly to capture 100% of sales from the dominant aware consumers. However, to sustain the cooperative equilibrium this deviation will result in a punishment from the competitors in future periods.

Abreau's (1986) maximal punishment principle states that to show a price schedule is sustainable

in equilibrium it is sufficient to show that it is sustainable under the strongest possible equilibrium punishment. In this setting the strongest sustainable punishment is the single period Nash equilibrium in perpetuity: price equals marginal cost.⁷ Thus, the discounted sum of a retailer's expected payoff to deviating from the cooperative pricing in the current period is

$$V_D = \alpha\mu^T D(P_t - c) + \sum_{t=1}^{\infty} \delta^t \cdot 0 \quad (4)$$

Adding these two criteria to the standard refinement that any equilibrium be Pareto optimal, retailers solve the following maximization problem in each period to determine a sustainable cooperative price schedule:

$$\max_{\{P_t\}} \sum_{t=0}^{\infty} \delta^t \alpha\mu^T D(P_t - c) \quad (5)$$

$$\text{subject to } \alpha\mu^T D(P_t - c) \leq \frac{\alpha}{3} \left(\frac{1}{1-\delta} \right) \mu^T D(P_t - c) \quad (6)$$

The solution to this maximization problem is that if $\delta \geq 2/3$ then $\{P_t\}=R$ for all $\hat{t} \geq T$. Thus, for sufficiently large discount factors, cooperation is possible at the consumer's reservation price during periods of steady demand. For discount factors below this value, no cooperation is possible and retailers set price equal to marginal cost. Note also that the criteria $\delta > 2/3$ only holds for $k=3$. In general, in the period of steady state demand, $\delta > (k-1)/k$ is necessary for cooperation to be sustainable. Thus for $\delta = 0.7$ cooperation is possible for 3 retailers, but not for 4. Because of this, the number of retailers who would be willing to invest in the necessary

⁶ As shown below, the fringe retailers are constrained by the dominant retailers' prices in such a way that α is the appropriate proportion of consumers for these calculations.

⁷ As shown below, no deviations from the cooperative price schedule occur on the equilibrium path. Thus, it does not matter whether one imagines the punishments occurring on individual books, categories of books, or the entire shared catalog of titles.

advertising to become dominant retailers is constrained by the knowledge that for large enough k , the collusion among the dominant retailers will break down.

In periods of product popularity ($\hat{t} < T$), cooperation is harder to maintain because larger demand in the current periods gives retailers larger incentive to deviate from the cooperative schedule of prices. To see this, consider the problem facing retailers in the first period after a product is released ($\hat{t} = 0$). Here the profit to charging the reservation price in all time periods is

$$V_C = \sum_{t=0}^{T-1} \frac{\alpha}{3} \delta^t \mu^t D(R-c) + \sum_{t=T}^{\infty} \frac{\alpha}{3} \delta^t \mu^T D(R-c) \quad (7)$$

and the profit to deviating from the cooperative price schedule in the first time period is

$$V_D = \alpha D(R-c) \quad (8)$$

Following the calculations in equation (5), cooperation is possible at the reservation price if

$$\frac{1 - (\delta^* \mu)^T}{1 - \delta^* \mu} + \frac{(\delta^* \mu)^T}{1 - \delta^*} \geq 3 \quad (9)$$

Thus, for $T \geq 1$ there exists a $\delta^* > 2/3$ such that if $\delta \geq \delta^*$, $P=R$ in all demand states in the equilibrium price schedule. Furthermore, equation (9) shows that δ^* is increasing in T and decreasing in μ — longer periods of popularity and higher initial demand relative to steady state demand make cooperation more difficult to sustain.

For $2/3 < \delta < \delta^*$, cooperation is possible, but only at prices less than the reservation value.

Consider the problem facing retailers in period $T-1$ after the product is released. Here the profit to following the cooperative price schedule is

$$V_C^{T-1} = \frac{\alpha}{3} \mu^{T-1} D(P_{T-1} - c) + \sum_{t=0}^{\infty} \frac{\alpha}{3} \delta^t \mu^T D(R-c) = \frac{\alpha}{3} \mu^{T-1} D(P_{T-1} - c) + \frac{\alpha}{3} \left(\frac{1}{1-\delta} \right) \mu^T D(R-c) \quad (10)$$

and the profit to deviating from this schedule is

$$V_D^{T-1} = \alpha\mu^{T-1}D(P_{T-1} - c) \quad (11)$$

Under these conditions, $P_{T-1} = R$ if $\delta \geq 2/(\mu + 2)$. However, for $2/3 < \delta < 2/(\mu + 2)$

cooperation is still possible if the dominant retailers lower their prices to

$$P_{T-1} = c + \frac{1}{2} \left(\frac{\delta\mu}{1-\delta} \right) (R - c) \quad (12)$$

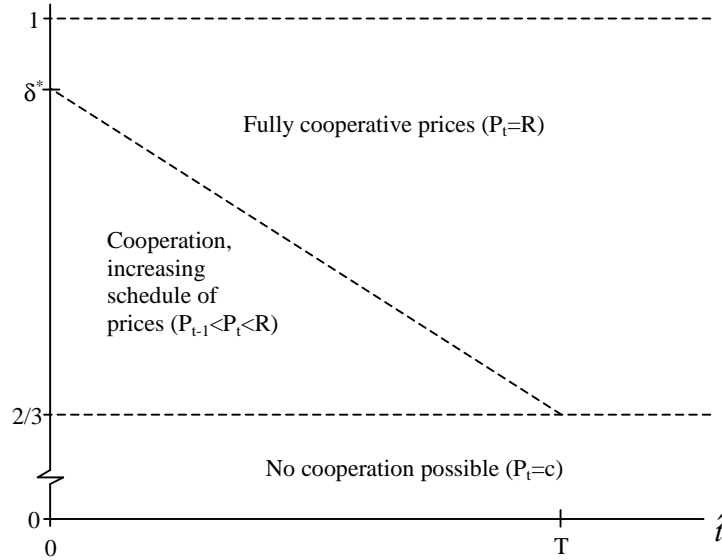
More importantly, lowering the price in period T-1 lowers the benefit to maintaining cooperation in the earlier periods. Thus, to sustain cooperation the dominant retailers will adopt an increasing schedule of prices defined as follows:

$$P_{T-k} = \begin{cases} c + \left(\frac{3}{2}\right)^{k-1} \frac{1}{2} \frac{(\delta\mu)^k}{1-\delta} (R - c) & 1 \leq k \leq T \\ R & \text{otherwise} \end{cases} \quad (13)$$

Similar results obtain when one considers the periods before T-1. For example, for some δ such that $2/(\mu + 2) < \delta < \delta^*$, the fully cooperative outcome is possible at T-1, but not at T-2. For this and prior time periods, the dominant retailers will adopt an increasing schedule of prices similar to that shown in (13).

Thus, different discount factors lead to different cooperative price schedules. For discount factors less than $2/3$, cooperation is not possible in any time period. For discount factors above δ^* (equation (9)) cooperation at the reservation value is possible in all time periods. For discount factors between these two values, the fully cooperative outcome is possible during steady state demand, and in the initial period of popularity, cooperation is only possible with an increasing schedule of prices that are below the fully cooperative outcome. This is summarized in Figure 1.

Figure 1: Dominant Retailer Pricing Regions by Discount Factor



Given popular predictions that the Internet is “a nearly perfect market,” (Kuttner 1998) it may be surprising that retailer cooperation is possible in any situation. However, cooperation in an Internet setting could be fostered by two factors. First, retailers in IT-enabled markets are able to easily observe their rivals’ prices (Varian 2000) making punishment for cheating easier than in an environment where only noisy signals of cheating can be observed (Green and Porter 1983, Ellison 1994). Second, cooperation is easier in expanding industries such as online sales because the retailer’s future profits from maintaining the cooperative price are increased by the increasing demand from the inflow of market participants.⁸

3.2. Fringe Retailer Competition

The existence of fringe aware consumers precludes fringe retailers from participating in the Subgame Perfect Equilibrium described above. If dominant firms are cooperating ($P_D > 0$) all fringe retailers charging marginal cost in the punishment stage is not a credible threat. Fringe

retailers would receive a larger single period profit by charging the same price charged by the dominant retailers and receiving sales from their share of the fringe aware consumers. Likewise, all retailers charging the dominant retailers' price cannot be a pure strategy equilibrium since some retailers could benefit by pricing below this price and receiving sales from both their fringe aware consumers and the shopbot consumers.

While there are no pure strategy Nash equilibria of this game, there are mixed strategy equilibria where retailers randomize over prices by choosing prices from a distribution $F(p)$. A variety of models have been proposed bearing this characteristic of price randomization (and thus price dispersion) in settings of positive consumer search costs.⁹ However, in this setting Stahl's (1989) model is particularly useful because it allows for sequential search with recall, constant marginal costs, and no capacity constraints — assumptions that accord well with the characteristics of Internet markets. For this reason, I follow the exposition of Stahl and Sorensen (1999, 2000), but adapt the model to a setting where consumers may be aware of multiple prices from dominant retailers, constraining the feasible mixed strategy price distribution.

As noted above, fringe aware consumers are aware of a set of prices $\{x\}$, which includes the prices for all dominant retailers and at least one fringe retailer price. Letting $\hat{x} = \min(\{x\})$, the consumer's benefit to finding a lower price is $(\hat{x} - p)$. Given a cumulative distribution function $F(p)$ for the mixed strategy price distribution, the expected value to a consumer of obtaining an additional quote is

⁸ To see this, note that if market demand increases by λ each period ($\lambda > 1$) then for $k=3$, cooperation is sustainable for any $\delta > 2/3\lambda$.

⁹ E.g., Salop and Stiglitz (1977), Reinganum (1979), Varian (1980), Salop and Stiglitz (1982), Burdett and Judd (1983), Carlson and McAfee (1983), Stiglitz (1987), Burdett, Shi, and Wright (2000).

$$E[\hat{x} - \min(p, \hat{x})] = \int_{\underline{p}}^{\hat{x}} (\hat{x} - p) dF(p) \quad (14)$$

where \underline{p} is the minimum value in the support of $F(p)$.

Integrating the right hand side of (14) by parts, the first (non-integration) term is zero, and the resulting equation shows that consumers will search if

$$E[\hat{x} - \min(p, \hat{x})] \equiv \int_{\underline{p}}^{\hat{x}} F(p) dp > s \quad (15)$$

Two important results follow from this equation. First, this equation captures the intuition that $\beta \in (0,1)$ and $\xi \in (0,1)$ are necessary and sufficient conditions for retailers playing mixed strategies in equilibrium. With regard to sufficiency, by (15) if all retailers charged the same price, then $F(p)=0$ for all p under the integral and consumers would never benefit from searching. If no consumers search, retailers benefit by raising their price to the monopoly price. However, this cannot be an equilibrium since individual retailers could gain sales from the costless consumers by deviating to a slightly lower price. With regard to necessity, if $\xi = 0$ then $s=0$ for all fringe consumers and by (15) consumers will search all stores resulting in the Bertrand equilibrium. Likewise, if $\beta = 0$, all consumers have positive search costs and all retailers charge the reservation price in equilibrium (Diamond 1971).

The second result pertains to consumer search rules. Equation (15) shows that shopbot consumers will search until they exhaust all retailers or they find \underline{p} . For fringe aware consumers, this equation suggests that there exists a price where the consumer will not benefit by engaging in additional search. This is true because in equilibrium $F(p)$ is continuous and

increasing on its support. Discontinuities cannot exist in equilibrium because if $F(p)$ were discontinuous, a retailer could benefit by infinitesimally undercutting at the point of discontinuity.

To establish equilibrium the shape and support of the mixed strategy price distribution, note that when dominant retailers are cooperating ($P_D > 0$) the expected profit to retailer i from charging price p_i is

$$E(\Pi(p_i)) = \mu^t D_s(p_i - c) \left[\beta [1 - F(p)]^{N-1} + \left(\frac{\xi}{N} \right) \right] \quad (16)$$

where the first term is the marginal profit of the sale, and the second term is the sum of the probability that a consumer is a shopbot user times the probability that the retailer's price is the lowest price in the market plus the retailer's share of the fringe aware consumers.

In a mixed strategy Nash equilibrium, no participant can increase its profit by deviating from its strategy. Thus, each retailer earns the same expected profit for each p in the support of $F(p)$:

$$E(\Pi(p_i)) = E(\Pi(P_D)) \quad (17)$$

where P_D is the price charged by the dominant firms.

Combining (16) and (17) and noting that $F(P_D) = 1$ (since no sales result if $p > P_D$) one can solve for the cumulative distribution function for equilibrium prices as

$$F(p; P_D) = 1 - \left[\left(\frac{\xi}{N\beta} \right) \left(\frac{P_D - c}{p - c} - 1 \right) \right]^{\frac{1}{N-1}} \quad (18)$$

The pdf of this distribution is U-shaped —retailers tend to charge either a relatively low price to gain sales from both their fringe aware consumers and the shopbot consumers or they charge relatively high prices to maximize profits from the fringe aware consumers alone.

To establish bounds on the support of this distribution, note that the dominant retailer price forms the upper bound on the support of $F(p)$ (since fringe aware consumers are also aware of the dominant retailers' prices) and from (18) the lower bound in the support is given by solving for $F(\underline{p}; P_D) = 0$, which is:

$$\underline{p}(P_D) = c + \left[\frac{\xi}{\xi + N\beta} \right] (P_D - c) \quad (19)$$

Analyzing the comparative statics in the competitive fringe with regard to search cost (s) and the relative proportion of shopbot to website consumers ($\gamma = \beta / \xi$) it can be shown (Appendix A) that larger search costs lead to larger price ranges and higher average prices. Similarly, more shopbot consumers will result in lower and potentially less dispersed prices (depending on the specific model parameters).

4. Empirical Evidence

I analyze the predictions of the model using data gathered from DealTime.com, an Internet shopbot for books. These data were gathered over 69 days in late 1999 for 23,744 titles sold by 24 Internet retailers operating in the United States. The data include the date of the search, the ISBN number of the book, and the item price from each retailer offering the book.¹⁰ ISBN numbers were used to determine the publication date for and general topic of each book along with dummy variables for whether the book was a current or former New York Times bestseller.

With regard to the dominant retailer segment, the first and most notable prediction of the model is that dominant retailers will be able to effectively cooperate on prices over a wide variety of titles. This prediction is confirmed in this data in that for 42% of the 23,744 titles where all three retailers provide price quotes, their prices are exactly the same and for 49.8% of these titles they are within \$0.05 of each other. Further, the titles where similar prices are observed range in price from \$0.79 to \$748.75, have discounts as large as 85% off list price, and represent both current releases and some of the oldest products in the sample.

A second prediction of the model is that it will be harder for the retailers to cooperate on popular books and, as a result, they will set lower cooperative prices on books where demand is high and these prices will increase as demand falls over time. This prediction is confirmed by comparing the normalized prices of current and recent New York Times bestsellers and recent releases to older titles. Table 1 makes this comparison by regressing normalized price (item price / list price) onto dummy variables for the New York Times bestsellers and release date. The results follow the predictions of the model as described above. Current bestsellers have higher discounts than recent bestsellers, and discounts for recently published books are higher than for older books and appear to decline over time.

Table 1: Cooperative Pricing Characteristics as a Function of Popularity

<i>Dependent Variable</i>	<i>Discount off List</i>
Current New York Times Bestseller	29.389 (.500)
Recent New York Times Bestseller	7.064 (.654)
Published in 1999	4.988 (.273)
Published in 1998	2.690 (.304)
Published in 1997	2.183 (.371)

N=11,829. Standard error listed in parenthesis. All results are significant at $p < .05$.

¹⁰ The results reported below are the same whether one uses item price or transaction price (item price plus the price for standard shipping offered by each retailer). For simplicity, only results using item price are reported here.

A third prediction of the model is that, because of their large numbers, fringe retailers will not be able to cooperate to set high prices. This is also supported by the data, with three exceptions.

Table 2 displays the proportion of times pairs of retailers set the same prices on books.¹¹

Table 2: Proportion of Times Prices are The Same for Largest Retailers

	Amazon	Borders	BarnesandNoble	BookBuyersOutlet	Fat Brain	Shopping.com	Books.com	1Bookstreet	Kingbooks	AlphaCraze	ChaptersGLOBE	AIBooks
Borders	60%											
BarnesandNoble	54%	48%										
BookBuyersOutlet	99%	61%	54%									
Fat Brain	32%	27%	23%	32%								
Shopping.com	15%	16%	14%	15%	17%							
Books.com	0%	0%	0%	0%	0%	0%						
1Bookstreet	3%	3%	2%	3%	3%	3%	0%					
Kingbooks	0%	0%	0%	0%	0%	0%	0%	0%				
AlphaCraze	8%	5%	5%	8%	6%	3%	0%	1%	1%			
ChaptersGLOBE	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
AIBooks	4%	3%	3%	3%	4%	4%	0%	0%	0%	4%	0%	
Classbook	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

These results suggest the presence of coordination on the part of the dominant retailers and also demonstrate that most fringe retailers do not follow these prices or establish separate coordinated pricing strategies. However, three retailers — BookBuyersOutlet, Fat Brain, and Shopping.com — do set prices that are similar to those set by the dominant retailers. While it is possible that these retailers are part of the group of dominant retailers coordinating on prices, this seems unlikely because of the low market share and low prominence of these retailers. Rather, these retailers may be adopting a “follow-the-leader” strategy using Amazon.com as their reference point. This strategy is particularly prominent for BookBuyersOutlet who charges *the same price as Amazon.com 99% of the time*.

¹¹ For simplicity, only retailers who return quotes on more than half the books in the sample are included in this

With regard to fringe retailers, the model predicts that books with higher search costs should have higher dispersion statistics and higher prices, and books where more consumers use shopbots should have lower prices and may also have lower dispersion statistics depending on the parameters of the model.

Unfortunately, no perfect measures of search costs and shopbot use exist across different book titles. However, older books should, *ceteris paribus*, have higher search costs by virtue of being carried by fewer retailers. Further, consumers who purchase computer books may be more inclined to use shopbots as a result of increased technical sophistication. Table 3 displays results for regressions of measures of price dispersion and average price onto these and other relevant characteristics of the books in this sample for fringe retailers.

Table 3: Dispersion in Transaction Price as a Function of Product Characteristics and Popularity Among Fringe Retailers

<i>Dependent Variable</i>	<i>Range</i>	<i>Std. Dev.</i>	<i>Avg. Price</i>
List Price	.356 (.002)	.138 (.001)	.936 (.001)
Hardcover	-3.087 (.479)	-1.279 (.187)	-.068 (.181)
Other Media (Cassette, CD, CD-ROM)	2.825 (.996)	.752 (.389)	-2.822 (.377)
Paperback	0	0	0
Year (2000- Publication Year)	.160 (.047)	.078 (.019)	.026 (.018)
No Year	-4.899 (1.391)	-.991 (.544)	1.108 (.526)
Current Bestseller	5.496 (1.901)	2.264 (.743)	-4.656 (.719)
Recent Bestseller	1.908 (1.865)	.872 (.729)	-2.403 (.706)
Computer Book	-1.981 (.683)	-1.095 (.267)	-1.528 (.259)

N=34,801. Standard error listed in parenthesis. Italicized results are insignificant at $p < .05$.

The results in this table are generally consistent with the predictions of the model. Computer books have lower measures of dispersion and lower prices than other book types¹² and older books have higher measures of dispersion and (insignificantly) higher prices than more recently released books.

comparison chart. The results including all retailers are the same as those shown here.

¹² Similar results are found for books in the science and technology categories, categories where the purchasers are also potentially more likely to use shopbots.

5. Discussion

A growing literature within the IT community examines the nature of structure and competition in IT-enabled markets. Two recent papers in this literature have made findings at odds with the conventional wisdom that IT-enabled markets will exhibit strong price competition. Brynjolfsson and Smith (2000) find high price dispersion in IT-enabled markets for commodity goods.

Kauffman and Wood (2000) find leader-follower behavior in IT-enabled markets, which may lead to increased prices (c.f. Varian 2000).

This paper presents an analytic model explaining these pricing characteristics as an equilibrium response to the unique nature of consumer search in IT-enabled markets. In conventional markets, search costs are primarily a function of a consumer's physical proximity to retailers, and physical proximity is distributed relatively evenly across retailers. However, in IT-enabled markets search costs are primarily a function of a consumer's mental awareness of retailer sites, and mental awareness is likely to be concentrated among a few retailers. The focus of search on these retailers creates interdependence among their pricing strategies, and this interdependence allows for cooperation as a subgame perfect equilibrium response in a repeated game environment. Well-known retailers cooperate to set prices which are just low enough that their consumers will not find it optimal to search for additional prices. Fringe retailers randomize over prices in a mixed strategy equilibrium that is constrained by the dominant retailers' prices. This pricing behavior is consistent with the studies mentioned above and with empirical data collected for 23,744 books sold by 24 Internet retailers in late 1999.

These results have applicability to managers, government regulators, and academics. For managers, these results identify one source of advantage from heavy advertising in IT-enabled

markets: decreasing competition through cooperation. These results also identify a source of first-mover advantage in IT-enabled markets since the number of cooperating firms, and thus the number of firms who will be willing to invest in heavy advertising, is limited by market conditions. The existence of high dispersion among fringe firms also suggests an opportunity for entrepreneurs to simplify price search for mass-market audiences, a promise that current shopbots have yet to fulfill (Montgomery *et al* 2000). For regulators, these results suggest the importance of tracking and monitoring potential anticompetitive price matching strategies by retailers operating in IT-enabled markets (Bloom, Milne, and Adler 1994; Foer 2001). Lastly, for researchers, it will be important for future work to confirm these results empirically in additional product markets and with data samples covering longer time periods.

References

- Abreu, Dilip. 1986. Extremal equilibria of oligopolistic supergames. *Journal of Economic Theory* **39**(1) 191-225.
- Bailey, Joseph P., Yannis Bakos. 1997. An Exploratory Study of the Emerging Role of Electronic Intermediaries. *International Journal of Electronic Commerce* **1**(3) 7-20.
- Bakos, Yannis. 1991. A Strategic Analysis of Electronic Marketplaces. *MIS Quarterly* **15**(3) 295-310.
- Bakos, J. Yannis. 1997. Reducing buyer search costs: Implications for electronic marketplaces. *Management Science* **43**(12) 1613-1630.
- Bakos, J. Yannis. 1998. The Emerging Role of Electronic Marketplaces on the Internet. *Communications of the ACM* **41**(8) 35-42.
- Bloom, Paul N., George R. Milne, Robert Adler. 1994. Avoiding misuse of new information technologies: Legal and societal considerations. *Journal of Marketing* **58**(1) 98-110.
- Brynjolfsson, Erik, Michael Smith. 2000. Frictionless commerce? A comparison of Internet and conventional retailers. *Management Science* **46**(4) 563-585.
- Burdett, Kenneth, Kenneth Judd. 1983. Equilibrium price dispersion. *Econometrica* **51**(4) 955-969.
- Burdett, Kenneth, Shouyong Shi, Randall Wright. 2000. Pricing and matching with frictions. Working Paper, Department of Economics, University of Essex, Colchester, UK.
- Carlson, John A., R. Preston McAfee. 1983. Discrete equilibrium price dispersion. *Journal of Political Economy* **91**(3) 480-493.
- Chen, Pei-Yu, Lorin M. Hitt. 2000. Switching Cost and Brand Loyalty in Electronic Markets: Evidence From On-line Retail Brokers. *Proceedings of The 21st Annual International Conference on Information Systems*, Brisbane, Australia, December 10-13, pp. 134-144.
- Clemons, Eric K., Il-Horn Hann, Lorin M. Hitt. Forthcoming. Price Dispersion and Differentiation in On-Line Travel: An Empirical Investigation. *Management Science*.
- Diamond, Peter A. 1971. A model of price adjustment. *Journal of Economic Theory* **3** 156-168.
- Ellison, Glen. 1994. Theories of cartel stability and the JEC. *RAND Journal of Economics* **25**(1) 37-56.
- Foer, Albert A. 2001. E-Commerce Meets Antitrust: A Primer. *Journal of Public Policy and Marketing* **20**(1) 51-63.

- Green, Edward J., Robert H. Porter. 1984. Noncooperative collusion under imperfect price information. *Econometrica* **52**(1) 87-100.
- Greenwald, Amy R., Jeffrey O. Kephart. 1999. Shopbots and pricebots. *The Proceedings of International Joint Conference on Artificial Intelligence*.
- Johnson, Eric J., Steven Bellman, Gerald L. Lohse. 2000. What makes a web site “sticky”? Cognitive lock in and the power law of practice. Working Paper, Columbia School of Business, Columbia University, New York, NY.
- Kauffman, Robert J., Chuck A. Wood. 2000. Follow the leader? Strategic pricing in e-commerce, *Proceedings of The 21st Annual International Conference on Information Systems*, Brisbane, Australia, December 10-13, pp. 145-151.
- Keeny, Ralph L. 1999. The Value of Internet Commerce to the Consumer. *Management Science* **45**(4) 533-542.
- Kuttner, Robert. 1998 “The Net: A Market Too Perfect for Profits?” *Business Week*, May 11, p. 20.
- Malone, Thomas, JoAnne Yates and Robert Benjamin. 1987. Electronic Markets and Electronic Hierarchies. *Communications of the ACM* **30**(6) 484-497.
- Montgomery, Alan L., Kartik Hosanagar, Ramayya Krishnan, Karen B. Clay. 2001. Designing a better shopbot. Working Paper, Carnegie Mellon University, Pittsburgh, PA.
- Nault, Barrie R., Mark B. Vandenbosch. 2000. Research Report: Disruptive Technologies Explaining Entry in Next Generation Information Technology Markets. *Information Systems Research* **11**(3) 304-319.
- Reinganum, Jennifer F. 1979. A simple model of equilibrium price dispersion. *Journal of Political Economy* **87**(4) 851-858.
- Rotemberg, Julio J., Garth Saloner. 1986. A supergame-theoretic model of price wars during booms. *American Economic Review* **76**(3) 390-407.
- Salop, S., J. E. Stiglitz. 1977. Bargains and ripoffs: A model of monopolistically competitive price dispersion. *Review of Economic Studies* **44**(October) 493-510.
- Salop, S. 1979. Monopolistic competition with outside goods. *Bell Journal of Economics* **10** 141-156.
- Salop, S., J. E. Stiglitz. 1982. The theory of sales: A simple model of equilibrium price dispersion with identical agents. *The American Economic Review* **72**(5) 1121-1130.
- Smith, Michael, Joseph Bailey, Erik Brynjolfsson. 2000. Understanding digital markets. E. Brynjolfsson, B. Kahin, eds. *Understanding the Digital Economy* MIT Press, Cambridge, MA, 99-136.

- Sorensen, Alan T. 1999. Empirical studies of oligopolistic pricing and heterogeneous consumer search. Ph.D. Thesis, Economics, Massachusetts Institute of Technology, Cambridge, MA.
- Sorensen, Alan T. 2000. Equilibrium price dispersion for prescription drugs. *Journal of Political Economy* forthcoming, August.
- Stahl, Dale O. 1989. Oligopolistic pricing with sequential consumer search. *The American Economic Review* **79**(4) 700-712.
- Stiglitz, Joseph E. 1987. Competition and the number of retailers in a market: Are duopolies more competitive than atomistic markets? *Journal of Political Economy* **95**(5) 1041-1061.
- Subramani, Mani, Eric Walden. 2001. The Impact of E-Commerce Announcements on the Market Value of Firms. *Information Systems Research* **12**(2) 135-154.
- Tirole, Jean. 1995. *The Theory of Industrial Organization*. MIT Press, Cambridge, MA.
- Vakrat, Yaniv, Abraham Seidmann. 1999. Can Online Auctions Beat Online Catalogs. *Proceedings of The 20th Annual International Conference on Information Systems*, Charlotte, North Carolina, December 13-15, pp. 132-143.
- Varian, Hal R. 1980. A model of sales. *The American Economic Review*. **70**(4) 651-659.
- Varian, Hal R. 2000. Market structure in the network age, Brynjolfsson and Kahin, eds. *Understanding the Digital Economy*. MIT Press, Cambridge, MA, 137-150.

Appendix A: Comparative Statics for Competition among Fringe Retailers

The following appendix follows the presentations of Stahl (1989) and Sorensen (1999, 2000), applying their derivations to the model.

A.1 Comparative Statics With Respect to Changes in Search Cost

Consider $\partial R^* / \partial s$. Following Stahl, equation (15) can be rewritten as:

$$\int_{\underline{p}(R^*)}^{R^*} F(p; R) dp = s \quad (\text{A1})$$

Expressing the ratio of shopbot to fringe aware consumer as $\gamma = \beta / \xi$ one can write (A1) as

$$G(R^*; N, \gamma, c, s) = \int_{\underline{p}(R^*)}^{R^*} F(p; R^*, N, \gamma, c) dp - s = 0 \quad (\text{A2})$$

such that R^* is as an implicit function of s . Note that $\partial G / \partial s = -1$ and

$$\partial G / \partial R = 1 - \int_{\underline{p}(R)}^R \frac{1}{N\gamma(N-1)(p-c)} \left[\frac{1}{N\gamma} \left(\frac{R-c}{p-c} - 1 \right) \right]^{\frac{2-N}{N-1}} \quad (\text{A3})$$

Since the integrand of (A3) is positive and decreasing for all $p \in (\underline{p}, R)$ the resulting equation is

$$\partial G / \partial R > 1 - \frac{(R - \underline{p})}{N\gamma(N-1)(\underline{p} - c)} \left[\frac{1}{N\gamma} \left(\frac{R-c}{\underline{p}-c} - 1 \right) \right]^{\frac{2-N}{N-1}} = \frac{N-2}{N-1} > 0 \text{ for all } N > 2 \quad (\text{A4})$$

Thus, by the implicit function theorem, $\partial R^* / \partial s > 0$.

Consider $\partial F^* / \partial s$. By the chain rule $\partial F^* / \partial s = \partial F / \partial R \cdot \partial R^* / \partial s + \partial F / \partial s$. From (18),

$\partial F / \partial s = 0$ and

$$\partial F / \partial R = - \frac{1}{N\gamma(N-1)(p-c)} \left[\frac{1}{N\gamma} \left(\frac{R-c}{p-c} - 1 \right) \right]^{\frac{2-N}{N-1}} < 0 \quad (\text{A5})$$

Thus, $\partial F^* / \partial s < 0$

Consider $\partial \underline{p}^* / \partial s = \partial \underline{p} / \partial R \cdot \partial R^* / \partial s + \partial \underline{p} / \partial s$. By (19), $\partial \underline{p} / \partial s = 0$ and $\partial \underline{p} / \partial R = (1 + N\gamma)^{-1}$

such that $\partial \underline{p}^* / \partial s = \phi \cdot \partial R^* / \partial s > 0$ where $\phi \in (0,1)$.

Consider $\partial R^* / \partial \gamma$. By (A2), the result is

$$\partial G / \partial \gamma = \int_{\underline{p}(R)}^R \frac{1}{N(N-1)} \left(\frac{R-c}{p-c} - 1 \right) \left[\frac{1}{\gamma} \left(\frac{R-c}{p-c} - 1 \right) \right]^{\frac{2-N}{N-1}} dp \quad (\text{A6})$$

Since the integrand of (A6) is positive for all $p \in (\underline{p}, R)$, $\partial G / \partial \gamma > 0$ and by the implicit function theorem $\partial R^* / \partial \gamma < 0$.

Consider $\partial F^* / \partial \gamma = \partial F / \partial R \cdot \partial R^* / \partial \gamma + \partial F / \partial \gamma$. By (A1),

$$\partial F / \partial \gamma = \frac{1}{N(N-1)} \left(\frac{R-c}{p-c} - 1 \right) \left[\frac{1}{\gamma} \left(\frac{R-c}{p-c} - 1 \right) \right]^{\frac{2-N}{N-1}} > 0 \quad (\text{A7})$$

Thus, $\partial F^* / \partial \gamma > 0$.

Finally, consider $\partial \underline{p}^* / \partial \gamma = \partial \underline{p} / \partial R \cdot \partial R^* / \partial \gamma + \partial \underline{p} / \partial \gamma$. By (19),

$$\partial \underline{p} / \partial \gamma = \frac{-(R-c)N}{(1+N\gamma)^2} < 0 \quad (\text{A8})$$

Thus, $\partial \underline{p}^* / \partial \gamma < 0$.