Static and Dynamic Pricing in Online Markets: Evidence from Books*

Karen Clay[†], Michael Smith[‡], Eric Wolff[§]

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Abstract

Commentators have observed that the ease of monitoring competitors on the Internet may allow Internet retailers to engage in non-competitive pricing. Using data on the daily prices of 399 books at 26 online bookstores between August 1999 and January 2000, we investigate firm pricing behavior in the online book market. Although sales in the Internet channel were growing very rapidly at the time, we find that relative prices differed across the three categories of bookstores (big three, active fringe, and inactive fringe), and these differences were remarkably stable over time. We present a simple model in which cross-channel competition and differentially informed consumers lead to the observed (static) pricing patterns. Although relative prices were stable, prices did change and were on average increasing over time. We document the dynamic strategic interaction across firm categories and across individual firms. Ten pairs of firms involving seven individual firms changed prices in the same direction on the same book within three days in an (one standard deviation) above average number of cases and respond more than 25 percent of the time to competitors' price changes. Given the behavior of these firms and the large market shares held by the top three firms, we formally test a number of oligopoly and non-oligopoly explanations for the observed price changes. We find that the observed patterns were not consistent with the predictions of oligopoly pricing in the Haltiwanger and Harrington (1991) model or with other explanations such as customer loyalty, inventory considerations or changes in elasticity of demand associated with holidays. We conjecture that the observed cases of parallel pricing were largely attributable to experimentation on the part of the initiator and learning or competitive response on the part of the responder.

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[†]Heinz School, Carnegie Mellon University, kclay@andrew.cmu.edu

[‡]Heinz School, Carnegie Mellon University, mds@andrew.cmu.edu

[§]Tepper School of Business, Carnegie Mellon University, wolff@andrew.cmu.edu

1 Introduction

Several authors have observed that the unique characteristics of Internet markets enable firms to gather price information from their competitors more easily than in a traditional environment. This capability may also allow Internet retailers to engage in non-competitive pricing strategies. Given that the Internet is ubiquitous and the possibility that pricing in the Internet channel may be affecting pricing in the physical channel, this would appear to be an important area for research. There has, however, been little empirical work to analyze whether Internet retailers appear to be engaging in such strategies.

To explore this issue, we use data on daily prices 26 online bookstores for 399 books including New York Times bestsellers, computer bestsellers, and random books collected between August 1999 and January 2000. We divided firms into three categories — the big three, the active fringe, and the inactive fringe. The big three consists of the three largest players — Amazon and the online arms of Barnes and Noble and Borders. The active fringe consists of firms that offer discounts on most books. The inactive fringe consists of firms that offered high, usually static, prices. These firms tend to be the online arms of independent physical bookstores and may be offering books primarily for their physical customers' convenience. Although book sales in the Internet channel were growing at about 60 percent per year during this period, we find that relative prices across the three categories of bookstores (big three, active fringe, and inactive fringe) were remarkably stable over time, with the big three being cheaper on average than the active fringe for New York Times bestsellers and more expensive for random books.

We present a simple model in which cross-channel competition and differentially informed consumers lead to the observed (static) pricing patterns. The model is based on stylized facts from the book industry. The dominant player and the competitive fringe compete for Internet sales. Informed consumers compare prices among physical stores as well as the dominant player and the competitive fringe. Uninformed consumers compare only the physical stores and the dominant player. The model generates the prediction that the dominant player, in response to the constraint posed by the physical channel, will offer lower prices for bestsellers than the fringe, but higher prices for random books. Thus, the predictions of the model match the observed (static) pricing patterns.

Although relative prices were stable, we observe 8,269 price changes. Sixty percent were price increases, 40 percent were price decreases, and about 20 percent were associated with changes in bestseller status. We document the dynamic strategic interaction across firm categories and across individual firms. In regressions at the firm category level, we find that firms responded primarily to changes in prices within their category, usually within one or two days. Cross-category response occurred, typically with greater delay. Some of this is driven by movement on and off of bestseller lists. To pinpoint firm-level interaction, we restrict attention to changes that were not associated with changes in bestseller status and compute the number of times that pairs of firms changed prices on the same book in the same direction within three days of one another. We compare this with the number of times that they could have responded, i.e., the number of times that the other firm changed a price on a book that the firm carried. Ten pairs of firms involving seven individual firms responded to price changes by the other firm at least 25 percent of the time, and changed prices together one standard deviation more often than average. The average price change by eight of the nine pairs that increased prices together was substantial, ranging from 20 to 32 percent. The other pair made very small changes. The one pair that decreased prices together both lowered prices 24 percent on average.

Given the behavior of these seven firms and the large market shares held by the largest firm and the top three firms, we formally test a number of oligopoly and non-oligopoly explanations for price changes using ordinary least squares, vector autoregression and two-stage least squares techniques. We find that the observed patterns were not consistent with the predictions of oligopoly pricing in the Haltiwanger and Harrington (1991) model or with other explanations such as customer loyalty, inventory considerations or changes in elasticity of demand associated with holidays. As Athey, Bagwell and Sanchirico (2004) show, under some conditions, it can be optimal for colluding firms to offer rigid prices. Thus, the absence of oligopoly pricing along the lines of Haltiwanger and Harrington (1991) does not rule out oligopolistic behavior. We conjecture that the observed cases of parallel pricing were largely attributable to experimentation on the part of the initiator and learning or competitive response on the part of the responder.

The rest of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the data and provides evidence on the stability of relative prices over time across firm and book categories. Section 4 presents our model consumer and firm behavior that predicts the observed patterns of (static) relative price differences. Section 5 investigates dynamic pricing interactions at the firm and book category level and at the individual firm level. Section 6 presents the results of regressions that test predictions from the Haltiwanger and Harrington (1991) model of dynamic oligopoly pricing as well as prediction based on customer loyalty and cost considerations. In Section 7, we conclude.

2 Related Literature

Our paper is most closely related two literatures, the literature on different (static) pricing strategies across retail outlets and the literature on dynamic pricing. Although contributions to these two literatures might appear contradictory, the literatures are in fact complementary.

The literature on different (static) pricing strategies across retail outlets is primarily in marketing journals. This literature has tended to focus on grocery stores, were customers buy a basket of items and receive weekly circulars that advertise their prices for certain items. Theoretical models of pricing have compared every day low pricing (EDLP) and high low promotional pricing (PROMO) to understand the conditions under which one or the other is more profitable (see for example Lal and Rao 19997, Bell and Lattin 1998, Bell et al

1998, and Voss and Seiders 2003).

Those models do not fit this context particularly well because of some unique features of the online book market. Online bookstores are similar to grocery stores in that customers typically do purchase multiple items from a single store, whether to save on shipping, the customer's costs of shopping, or both. Bookstores typically only advertise pricing policies for bestsellers, rather than offering promotional prices on a changing assortment of products. One key feature of the online book market that is not present in grocery markets is the presence of strong cross-channel competition, with the physical channel using a PROMO pricing scheme.

In the dynamic pricing literature, price changes can be driven by a number of different causes including anticipated and unanticipated changes in cost and demand. Unanticipated changes may or may not be firm specific and may or may not be observable by some or all players. Following the seminal theoretical contributions by Green and Porter (1984) and Rotemberg and Saloner (1986) on the behavior of oligopolists in repeated games and important extensions of Rotemberg and Saloner by Haltiwanger and Harrington (1991) and others, a substantial empirical literature developed around testing the predictions of these models. Because the theoretical models are fully equilibrium models, there is no opportunity for firm learning or experimentation, although this may be important empirically, especially if firms have entered or exited or the market is relatively new.

The empirical literature on dynamics has a number of limitations. Most of these papers examine firms already known or suspected to be oligopolists in established markets where either price wars or cyclical pricing are observed.[1] For example, authors have studied Green and Porter's predictions with respect to price wars in railroads (Porter 1983 and Ellison 1994), airlines (Brander and Zhang 1993, Busse 2002), the bromine industry (Levenstein 1997), Ontario petroleum (Grant and Thille 2001), Australian coal (Fleming 2000), cigarettes (Elzinga and Mills 1998, 1999), British shipping (Scott-Morton 1997), gasoline (Slade 1992), among other industries, and across different types of legal cartels (Dick 1996). Authors have also studied Haltiwanger and Harrington's predictions about cyclical pricing in gasoline (Borenstein and Shepard 1996), Portland cement (Rosenbaum and Sukharomana 2001), food pricing (Chevlier et al. 2003), US and UK manufacturing industries (Galeotti and Schiantarelli 1998 and Machin and Van Reenan 1993), steel (Gallet 1997), and rayon (Gallet and Schroeter 1995), among other industries. Most of these were industries were already thought to be collusive. And with the exception of Chevalier et al. (2003), the findings of the papers support the relevant oligopoly models, occasionally with caveats.

With a few exceptions, there has been a tendency to ignore firm-specific strategies. Part of the issue is that in most oligopoly models, firms are identi-

[1] There has also been limited exploration of firm-level response to price shocks. On response to changes in gasoline prices, see Asplund, Eriksson, and Friberg (2000), Borenstein, Cameron, and Gilbert (1997). On menu costs and responses to cost changes in grocery stores, see Levy et al. (1997), and Slade (1998, 1999).

cal and the product is undifferentiated. The studies that have examined firm-specific strategies have shown, however, that heterogeneity is important in understanding why pricing behavior varies. For instance, Busse (2002) examines the role that firm financial condition plays in airline price wars. Scott-Morton (1997) investigates the conditions under which shipping cartels initiate price wars against entrants, finding that the financial status of the entrant is an important determinant. Elzinga and Mills (1999) evaluate incumbent and entrants pricing strategies in cigarette price wars. Gupta (2001) relates differences between incumbents and entrants to price wars in tea.

Much less attention has been paid to settings in which we observe pricing behavior not associated with oligopolies or pricing behavior that does not fit the standard oligopoly models. Warner and Barsky (1995) present a model and empirical evidence indicating that counter-cyclical markups in retailing are driven by changes in transactions costs and thus elasticity of demand. Borenstein and Shepard (1996) test – and reject – theoretical models that observed patterns of pricing may be driven by inventory considerations or customer loyalty. Chevalier et al. (2003) use grocery scanner data to evaluate pricing of seasonal holiday-related items. They reject models with cyclical elasticities due to search (Warner and Barsky 1995) and dynamic oligopoly models (Rotemberg and Saloner 1986) in favor of a loss-leader model due to Lal and Matutes (1994).

There is also typically no product differentiation in the models, although this will clearly affect the scope of competition (Ross 1992, Baye and Ueng 1999). One interesting exception on the empirical is the recent paper by Pinske, Slade, and Brett (2002) that looks at the nature of competition among gas stations that are differentiated by location. Although global competition is possible, they show that competition is in fact local.

This paper contributes to the foregoing literature in a number of dimensions. First, we look at a new market – Internet book sales – characterized by rapid growth, some entry and exit, and low costs of monitoring and implementing price changes. One firm in this market, Amazon, had more than a 50 percent market share during this period, although there were many other firms, including the online branches of two well-known physical chains. Internet bookstores also faced substantial competition from the physical channel. Second, we document that relative prices differed across the three categories of bookstores (big three, active fringe, and inactive fringe) and present a simple model in which cross-channel competition and differentially informed consumers lead to the observed (static) pricing patterns. Third, although relative prices were fairly stable, prices did change and were on average increasing over time. Thus, we add to the literature on firm-level dynamics by documenting the dynamic strategic interaction across firm categories and across individual firms. Fourth, given the large market shares held by the largest firm and the top three firms, we formally test – and reject – a number of oligopoly and nonoligopoly explanations to understand the pattern of price changes. We discuss possible reasons for the fact that a subset of small firms does respond systematically to one another's price changes and for the fact that the biggest online bookstores rarely respond to one another's price changes.

3 Data and Stable Relative Prices

3.1 Data

Our data include daily price observations for 399 books sold by 26 Internet retailers over 180 days from August 1999 to January 2000. Data were collected using automated agents (spiders). Stores were included if they were covered in one of two major comparison-shopping engines — DealTime or PriceScan.[2] These comparison-shopping engines did not cover the universe of all online stores, but the twenty-six stores in our sample cover the largest United States-based bookstores (i.e., Amazon, BarnesandNoble.com, Borders.com, Buy.com, and Booksamillion) and a representative sample of the smaller U.S.-based bookstores.[3]

Three categories of books appear in the sample: New York Times current and former bestsellers, computer current and former bestsellers, and a random sample of books listed in Books in Print. New York Times bestsellers were included, because they are widely carried, represent high aggregate sales, and are a focal point for discounts.[4] When New York Times bestsellers went off of the list, we continued to track them as former bestsellers. Although the New York Times does not maintain a bestseller list for computer books, Amazon does maintain such a list. We chose Amazon's bestseller list because of Amazon's high volume of book sales and the generalist (as opposed to specialist) orientation of the site.[5] Like the New York Times bestsellers, we continued to follow computer bestsellers when they went off of the list. Random books were included to provide a baseline against which to compare the price competition for bestsellers and former bestsellers and to understand price competition in online markets for the millions of books not covered by the bestseller lists.[6]

Summary statistics for the data set are presented in Table 1. Our book titles include 136 current and former New York Times bestsellers, 82 current and former computer bestsellers, and 181 books selected at random from Books in Print. The data set includes 933,002 individual price observations and 8,269 price changes. Price changes are defined as a difference in listed price on an ISBN from one date to the next date with a listed price in the same store. Dates with

[2] Data were also collected from some individual stores to confirm the accuracy of the information from DealTime and PriceScan.

[3] Thirty-two stores were originally collected. Six stores were removed from the sample because they only stocked specific genres of books — and thus, we were able to collect fewer than 1,000 book-day observations from these stores. In contrast, we collected more than 30,000 book-day observations from stores such as Amazon and Barnes and Noble. A complete list of all stores is provided in Table 3.

[4] We included all books appearing in the New York Times bestsellers lists for paperback fiction, paperback nonfiction, hardcover fiction and hardcover nonfiction for the weeks of of August 8, October 3, and November 28, 1999. The number is approximately 60, because there are often ties for the #15 spot.

[5] Use of any store's bestseller list raises unavoidable issues of endogeneity.

[6] The random sample was created by generating random strings of letters of random length and then checking the result against the online Books in Print database until approximately 200 in-print titles were found. Some, although technically in print, were not available in any bookstores. After eliminating these, the data set includes 181 random books.

missing prices are not considered as price changes.[7] Prices are collected once per day. To the extent that price changes several times during a single day, this methodology will undercount the true number of price changes.[8]

Because book prices are variable and discounts are often quoted as a percentage of publishers suggested price, we have normalized price as follows:

$$NPRICE_{ijt} = UNIT\ PRICE_{ijt}/PUB.SUG.PRICE_i$$

where i is the book, j is the store, and t is time (day).

We examine both endogenous and exogenous prices changes. We define exogenous price changes as those driven by movement onto and off of bestseller lists. To allow for lags in the response by individual firms, we consider all price changes (and baseline observations) that occurred within one week of a book changing its bestseller status as exogenous.[9] This window is conservative in the sense that it will err on the side of removing some endogenous changes along with the exogenous changes. The corrected price changes in Table 1 are all remaining (endogenous) price changes.

3.2 Relative Prices

When we plot prices over time by store type for current NYT bestsellers and random books (Figures 1 and 2), two features of the data are striking. First, although prices trend up slightly over time, prices appear to be very stable. For example, there is no evidence of price wars or other dramatic events. The most noticeable change — the fall in prices for the inactive fringe in January — was the result of inventory clearance as three of the eight firms went out of business. Plots not presented here that include only inactive firms in existence at the end of our period show exceptional stability. The blip in prices for bestsellers at the big three in late September was driven by a brief increase in bestseller prices by Amazon. We were unable to determine whether this was the result of experimentation or a data collection error. Second, the relationship among prices for the three store categories appears to have fairly stable.

Table 2a presents results of regressions on price that further explore these patterns. The three columns are the results of OLS estimation of the following equation by book category:

$$\begin{aligned} NPRICE_{ijt} &= \alpha_0 + \alpha_1 TIME_t + \alpha_2 BESTSELLER_{it} + \sum \beta_j TYPE_j + \\ &\sum_j \delta_{jt}(TYPE_j * BESTSELLER_{it}) + \sum \gamma_{jt} TYPE_j * TIME_t \end{aligned}$$

[7]We assume there is no price change during data missing period. When calculating the total changes, we use the next available reported price at the same store as a proxy for the missing price.

[8]Anecdotal evidence suggests that this happens only very rarely for books sold on the Internet.

[9]Because industry sources suggested that the new list is often available prior to its official release, a week starts — 1 day before the official change and continues to +5 days after the change in bestseller status.

$$+\sum \delta_m MONTH_m + \sum \kappa_i ISBN_i + \epsilon_{ijt}$$

where TIME is a number that indicates the month (it ranges from 1 for August to 6 for January); BESTSELLER is a dummy variable that indicates whether a book is a bestseller; TYPE are dummy variables that indicate whether a store is a member of the big three, the active fringe, or the inactive fringe; TYPE*BESTSELLER is the interaction of the TYPE and bestseller dummy variables; TYPE*TIME is the interaction of the TYPE and the TIME dummy variables; MONTH are monthly dummies for September, October, November, and December; and ISBN are dummy variables for each book.

Prices for the big three are significantly lower than for the active fringe for current NYT bestsellers and somewhat higher than the active fringe for random books. Prices are also trending up over time. These relationships are summarized in Table 2b. In the next section, we present a simple stylized model that captures the main institutional features of this market and generates this pattern of relative pricing.[10]

4 A Model of (Static) Relative Price Differences

Assume that there are two sales channels, physical stores and Internet, and two types of firms in the Internet channel (dominant and fringe). Assume that firms carry two types of books. These books are bestsellers with probability b, and random books with probability $1-b$. Assume that there are two types of customers, naïve with probability a and experienced with probability $1-a$, and that consumers buy either a 1-book bundle with probability c or a 2-book bundle with probability $1-c$. Thus, there are five possible bundle compositions: $(1B, 1R, 2B, 2R, 1B+1R)$, where B denotes bestsellers and R denotes random books.

Assume the marginal cost for the dominant firm in the Internet channel is constant across books and without loss of generality zero. Assume the marginal cost for the physical firms and the fringe firms in the Internet channel is constant. In general, the marginal costs for both types of firms may be higher than for the dominant firm in the Internet channel — the physical channel because of inventory and store costs and the fringe because the discounts they receive from wholesalers may be slightly lower than for the dominant firm. Further allow firms to obtain an unlimited number of books at this constant marginal cost. Reported prices for all firms will be net of the marginal cost for the *dominant firm* in the Internet channel. Finally, assume that firms in the Internet channel take the prices offered by stores in the physical channel as given.

Consumers differ in their sophistication (or willingness to search) such that naïve customers only consider the prices in the physical channel and at the dom-

[10] There are many possible extensions to this model including: modeling the behavior of the physical channel, having consumers purchase multiple bundles over their 'lives', modeling the fixed costs and the entry costs for the fringe, allowing different customers types to had different mixes of bundles, modeling the linkage between the pricing behavior of Barnes and Noble and Borders in the two channels.

inant firm. Experienced customers consider the prices offered by the fringe as well as the dominant player and physical stores. Consumers maximize utility for any given bundle X, by choosing the lowest price, where ph, d, and f denote the physical channel, the dominant firm and the fringe firm. Assume that consumers buy their bundle from a single vendor, i.e. they do not buy individual books from different vendors. Also assume that consumers weakly prefer the physical channel to the dominant firm and weakly prefer the dominant firm to the fringe. Naïve consumers minimize $\{p(X)_{ph}, p(X)_d\}$. Experienced consumers minimize $\{p(X)_{ph}, p(X)_d, p(X)_f\}$.

Given the assumption that consumers weakly prefer the dominant firm to the fringe, the fringe firms can only attract experienced customers if they are cheaper than the dominant firm for at least one of the two types of books. Depending on the relative prices of the fringe and the dominant firm, the fringe will sell to i) all experienced customers; ii) only those experienced customers buying either a single type of book $(1R, 2R, 1B, 2B)$; or iii) those experienced customers buying a single type and those buying one of each type (mixed bundles).

Maximization problem for the fringe:

$$\max_{p_{rf}, p_{bf}} (1-a)[A_f, B_f, C_f, D_f, E_f]$$

where $A_f - E_f$ are defined below

$$\begin{aligned}
A_f &= \max_{p_{rf}, p_{bf}} [cb + 2(1-c)b^2]p_{bf} + [c(1-b) + 2(1-c)(1-b)^2]p_{rf} + \\
&\quad [(1-c)(1-b)b][p_{bf} + p_{rf}] \\
for\ p_{bf} &< p_{bd}, p_{bf} < p_{bph}, p_{rf} < p_{rd}, p_{rf} < p_{rph} \\
B_f &= \max_{p_{rf}, p_{bf}} [cb + 2(1-c)b^2]p_{bf} \\
for\ p_{bf} &< p_{bd}, p_{bf} < p_{bph}, p_{rf} \geq p_{rd}, p_{rf} + p_{bf} \geq p_{rd} + p_{bd}, p_{rf} + p_{bf} \geq p_{rph} + p_{bph} \\
C_f &= \max_{p_{rf}, p_{bf}} [cb + 2(1-c)b^2]p_{bf} + [(1-c)(1-b)b][p_{bf} + p_{rf}] \\
for\ p_{bf} &< p_{bd}, p_{bf} < p_{bph}, p_{rf} \geq p_{rd}, p_{rf} + p_{bf} < p_{rd} + p_{bd}, p_{rf} + p_{bf} < p_{rph} + p_{bph} \\
D_f &= \max_{p_{rf}, p_{bf}} [c(1-b) + 2(1-c)(1-b)^2]p_{rf} \\
for\ p_{rf} &< p_{rd}, p_{rf} < p_{rph}, p_{bf} \geq p_{bd}, p_{rf} + p_{bf} \geq p_{rd} + p_{bd}, p_{rf} + p_{bf} \geq p_{rph} + p_{bph} \\
E_f &= \max_{p_{rf}, p_{bf}} [c(1-b) + 2(1-c)(1-b)^2]p_{rf} + [(1-c)(1-b)b][p_{bf} + p_{rf}] \\
for\ p_{rf} &< p_{rd}, p_{rf} < p_{rph}, p_{bf} \geq p_{bd}, p_{rf} + p_{bf} < p_{rd} + p_{bd}, p_{rf} + p_{bf} < p_{rph} + p_{bph}
\end{aligned}$$

Lemma 1 *For any book type for which the dominant firm charges a price greater than marginal cost, the fringe firm will undercut the dominant firm's price(s) of these books by ϵ. If the dominant firm charges a price equal to marginal cost for both types of books, the fringe firm will not sell books.*

In particular, in our case it appears that the dominant firm is pricing bestsellers at or below the marginal cost of the fringe, so the fringe cannot compete with the fringe on bundles composed only of bestsellers. The price set for bestsellers in the model will be $p_{bf} = p_{bd} = 0$, or in the case of differences in costs, $p_{bf} > p_{bd} = 0$.

We have assumed that consumers weakly prefer the dominant firm, so the fringe must undercut the dominant firm by ϵ. In reality, the fringe must choose prices such that actual consumers are indifferent, so this number may not be small. For instance, Smith and Brynjolfsson (2001) using data from the comparison shopping engine Dealtime found that the average Dealtime consumer appeared to be willing to pay a premium of \$1.72 on an average item price of \$38.06 to buy that book from a well-known Internet retailer (Amazon, Barnes and Noble, or Borders). The premium specifically for Amazon — by far the dominant player — was \$2.49.

With respect to the maximization problem for the dominant firm, assume $p_{bph} > 0$ and $p_{rph} > 0$, since this is the most interesting case. Thus, the dominant firm's maximization problem is:

$$\max_{p_{rd}, p_{bd}} (1-a)[A_d, B_d, C_d, D_d, E_d, 0] + a[F_d, G_d, H_d, I_d, J_d]$$

where $A_d - J_d$ are defined below and 0 represents the profits of setting both prices higher than the fringe and not selling to any experienced customers.

$$\begin{aligned}
A_d &= \max_{p_{rd}, p_{bd}} [cb + 2(1-c)b^2]p_{bd} + [c(1-b) + 2(1-c)(1-b)^2]p_{rd} \\
&\quad +[(1-c)(1-b)b][p_{bd} + p_{rd}] \\
for\ p_{bd} &\leq p_{bf}, p_{bd} < p_{bph}, p_{rd} \leq p_{rf}, p_{rd} < p_{rph} \\
B_d &= \max_{p_{rd}, p_{bd}} [cb + 2(1-c)b^2]p_{bd} \\
for\ p_{bd} &\leq p_{bf}, p_{bd} < p_{bph}, p_{rd} > p_{rf}, p_{rd} + p_{bd} > p_{rf} + p_{bf}, p_{rd} + p_{bd} \geq p_{rph} + p_{bph} \\
C_d &= \max_{p_{rd}, p_{bd}} [cb + 2(1-c)b^2]p_{bd} + [(1-c)(1-b)b][p_{bd} + p_{rd}] \\
for\ p_{bd} &\leq p_{bf}, p_{bd} < p_{bph}, p_{rd} > p_{rf}, p_{rd} + p_{bd} \leq p_{rf} + p_{bf}, p_{rd} + p_{bd} < p_{rph} + p_{bph} \\
D_d &= \max_{p_{rd}, p_{bd}} [c(1-b) + 2(1-c)(1-b)^2]p_{rd} \\
for\ p_{rd} &\leq p_{rf}, p_{rd} < p_{rph}, p_{bd} > p_{bf}, p_{rd} + p_{bd} > p_{rf} + p_{bf}, p_{rd} + p_{bd} \geq p_{rph} + p_{bph} \\
E_d &= \max_{p_{rd}, p_{bd}} [c(1-b) + 2(1-c)(1-b)^2]p_{rd} + [(1-c)(1-b)b][p_{bd} + p_{rd}] \\
for\ p_{rd} &\leq p_{rf}, p_{rd} < p_{rph}, p_{bd} > p_{bf}, p_{rd} + p_{bd} \leq p_{rf} + p_{bf}, p_{rd} + p_{bd} < p_{rph} + p_{bph} \\
F_d &= \max_{p_{rd}, p_{bd}} [cb + 2(1-c)b^2]p_{bd} + [c(1-b) + 2(1-c)(1-b)^2]p_{rd} + \\
&\quad [(1-c)(1-b)b][p_{bd} + p_{rd}] \\
for\ p_{bd} &< p_{bph}, p_{rd} < p_{rph} \\
G_d &= \max_{p_{rd}, p_{bd}} [cb + 2(1-c)b^2]p_{bd} \\
for\ p_{bd} &< p_{bph}, p_{rd} + p_{bd} \geq p_{rph} + p_{bph}
\end{aligned}$$

$$
\begin{aligned}
H_d &= \max_{p_{rd},p_{bd}} [cb + 2(1-c)b^2]p_{bd} + [(1-c)(1-b)b][p_{bd} + p_{rd}] \\
for\ p_{bd} &< p_{bph}, p_{rd} + p_{bd} < p_{rph} + p_{bph} \\
I_d &= \max_{p_{rd},p_{bd}} [c(1-b) + 2(1-c)(1-b)^2]p_{rd} \\
for\ p_{rd} &< p_{rph}, p_{rd} + p_{bd} \geq p_{rph} + p_{bph} \\
J_d &= \max_{p_{rd},p_{bd}} [c(1-b) + 2(1-c)(1-b)^2]p_{rd} + [(1-c)(1-b)b][p_{bd} + p_{rd}] \\
for\ p_{rd} &< p_{rph}, p_{rd} + p_{bd} < p_{rph} + p_{bph}
\end{aligned}
$$

Note that the presence of the fringe makes it impossible for the dominant firm to make positive profits from the experienced customers because the fringe will always undercut the dominant firm if the dominant firm charges a price above marginal cost. Thus, the dominant firm may sell to some experienced customers but at zero markup. This reduces the problem to

$$\max_{p_{rd},p_{bd}} a[F_d, G_d, H_d, I_d, J_d]$$

Lemma 2 *The dominant firm will undercut the physical channel firm on both prices by ϵ, since selling units of these books is profitable.*

In this simple model, the equilibrium price is determined by the price in the physical channel and the difference in prices between (1) the physical channel and the dominant firm and (2) the dominant firm and the fringe firm such that consumers are indifferent. Thus in this simple model, the fringe should be a constant amount cheaper than the dominant firm for at least one of the two types of books. For the other book type, the prices should be equal to the fringe's marginal cost.[11] Thus, the predictions of the model match the observed (static) pricing patterns.

5 Dynamic Interaction

5.1 Macro-level Interaction

A first step in understanding the dynamic interaction is to understand how the three categories of stores react to price changes by stores in their own and other categories. Table 3 presents the results of exploratory regressions on average normalized price of a given book category and store category where the independent variables are the lagged average normalized prices for that book category for all three store categories for the past seven days. Table 3 includes both exogenous and endogenous price changes. To correct for heteroskedasticity and serial correlation, we use Newey-West standard errors with lags of up to 7 periods.

[11] Because the firms engage in Bertrand-type competition, the relative prices are not affected by the share of naive consumers, the percentage of books that are bestsellers, or the percentage of one-book bundles.

For all three categories of books, the dynamics are clearly complex. In all nine cases the largest responses are to changes by other members of the same store category and occur the next day. In seven out of the nine cases, stores in one category also respond, usually with some delay, to price changes by stores in at least one other category. For example, the big three respond to price changes by the other two categories of stores for both New York Times bestsellers and computer bestsellers. For random books, however, the big three only respond to changes by other stores in the big three. The active fringe responds to changes in prices by the big three and the inactive fringe for New York Times bestsellers, only to other members of the active fringe for computer bestsellers, and to the big three for random books. The inactive fringe responds to changes by the big three for New York Times bestsellers and computer bestsellers, but only to other members of the inactive fringe for random books.

While statistically significant changes occur as many as seven days after the first change, the rapidity of the initial response to a change suggests that some members of every category are using web-enabled technology to monitor competitors' prices. In the next subsection, we restrict attention to these more rapid changes (within 3 days) and examine the response of individual stores to other stores' price changes.

5.2 Micro-level Interaction

We examined the behavior of the 650 pairs of stores in our sample. Specifically, we computed for each pair for each book whether a price change was made in a three-day window.[12] A new window was started every day, so that the windows overlap. This ensures that we correctly capture all associated changes. Here, we ignore changes associated with changes in bestseller status to focus on endogenous changes.

Forty-five (19) pairs increased (decreased) prices on the same book during a three-day window one standard deviation more often than average (in 27 or more windows). Given that movements by a pair of firms ranged from 0 to 145 windows, behavior involving movements in fewer than 27 instances appeared not to be economically significant.[13] For ease of presentation, Table 4a reports the 9 pairs of stores where a) the pair increased (decreased) price together in at least 27 windows and b) one of the firms was responding to the other firm's price changes at least 25 percent of the time. These interactions involve 7 total stores, with 5 of the 7 responding to changes by more than one other store. The

[12]For an N-day window, changes on the same day or on N consecutive days would be considered related. A three-day window allows for the possibility that some stores do not respond to price changes over the weekends. In regressions not reported here of the probability of a change on the day of the week, we found that stores were statistically significantly less likely to change their prices on Sunday than on any other day of the week.

[13]There were a maximum of 71,022 windows in which pairs of firms could possibly change prices (399 books x 178 windows/book if both stores carried all of the books). Since the probability of a change in the price of a book at a given store on a given day is less than 1 percent on average, the number of windows in which pairs of firms change prices is likely to be small relative to this maximum.

first two columns list the store names. The middle column shows the number of windows in which the two stores move together. The percentages in the last two columns represent the observed number of windows divided by the number of windows in which the stores could have moved (i.e., windows in which at least one store changed a price on a book the other store also carried).

The most striking case involves Amazon and Bookbuyer's Outlet which moved together in 145 windows, and this represented 83 and 82 percent of the possible instances in which one store changed its price and the other store could have responded. The numbers are high for both stores, because nearly all of the changes and responses occurred within a single day, so we cannot observe which firm moved first (although we suspect that Amazon moved first). Classbook and BCY Bookloft are also striking. BCY Bookloft responded to price increases by Classbook 80 percent of the time. The remaining pairs had substantial response rates, ranging between 27 percent and 48 percent for one of the firms in each pair.

To better understand what happened when both members of a pair made changes, Table 4b examines relative prices before and after price changes and the magnitudes of the change. Four pairs — involving Amazon, Barnes and Noble, Borders, and Bookbuyer's Outlet — had nearly identical prices before the price increase and the responses led to nearly identical prices after the change. The average magnitudes of the changes for these four were substantial, ranging from 20 percent to 32 percent. The remaining five cases for price increases are intriguing, because the stores had significantly different prices both before and after. Four of the five cases involved 1Bookstreet, which had higher prices on average before the change, and the four stores mentioned above. Although 1Bookstreet predominantly responded to price increases rather than initiating them, on average it did not take the opportunity to match the other stores' prices. The remaining pair — Classbook and BCY Bookloft — had quite different average prices, but made relatively small price changes. For price decreases, Amazon and Bookbuyer's Outlet had nearly identical average prices before and after the change. The average change was -24 percent. Overall, the big three — Amazon, Barnes and Noble, and Borders — were represented in 8 of the 10 total pairs. Among the three, Amazon and Barnes and Noble tended to initiate price changes, and Borders tended to respond.

6 Potential Explanations

The preceding section documented that certain pairs of stores frequently raised or lowered prices together on a given book within a short time frame (3 days). This raises the question of why we see these changes. On the demand side, two factors could generate this pattern. First, firms could be reacting to cyclical changes in elasticity of demand. Using data on eight products collected over a four month period at seventeen stores, Warner and Barsky (1995) show that prices were lowest during periods of high exogenous demand (weekends and the period between Thanksgiving and Christmas). They argue that prices are typically counter-cyclical because economies of scale in search during periods of high demand lead to greater elasticity. Second, firms could be learning about book-level elasticity from their own or other's pricing experiments. Unless there are systematic changes in underlying elasticity, this implies that price changes should be roughly random.

On the supply side, there are several possible effects, two cost-based and two strategic. If price changes are driven by strategic considerations, it may be because firms are engaged in are playing a dynamic oligopoly game or because firms are concerned about customer loyalty. Rotemberg and Saloner (1986) model a dynamic oligopoly game in which firm's prices are a reflection of the incentives for collusion. If current demand is lower than expected future demand, collusion is easier to sustain because future profits are relatively more valuable than if current demand is higher than expected future demand. In the Haltiwanger and Harrington (1991) extension of this model to incorporate deterministic demand cycles, they show that holding current demand and cost constant collusion is more difficult to sustain if demand is declining. Klemperer's (1987) model of customer loyalty gives the opposite prediction. Firms want to attract customers in the current period in order to sell to them in the next period. This effect is stronger if demand is increasing than if demand is decreasing, thus margins are lower if demand is increasing and higher if demand is decreasing.

One the cost side, firms could be reacting to changes in the wholesale price of books. Industry sources indicate, however, that the wholesale price of books is constant over time. It is possible that some firms may be reacting to changes in fulfillment costs and possibly inventory effects associated primarily with the first few weeks of December, when demand is at its peak. Borenstein and Shepard extend the Haltiwanger and Harrington (1991) dynamic oligopoly model to anticipated changes in costs. Borenstein and Shephard (1996) show that controlling for both demand and cost in the current period that current margins decrease with expected next-month cost.[14] We cannot separately identify this effect, which is caused by very high demand.[15]

6.1 Seasonal Patterns of Prices and Demand

Given that a number of models involve firms changing prices in response to seasonal changes in demand, we begin by documenting these patterns. Figure 3 shows the dollar value of sales in the physical channel over time between 1997 and 2000. Book sales are highly seasonal; December, January, and August are the months of peak demand. Although data on the seasonal patterns of demand are not available for the Internet channel, they are available from multiple

[14]In standard inventory models, if increased inventory costs are not passed through to consumers this implies that higher demand in the next period will lead to lower prices and margins today (Pindyck 1994 and Thurman 1988). Thus changes in costs in a dynamic oligopoly model yields the opposite prediction to changes in cost in a standard inventory model.

[15]In unreported regressions, we found that controlling for changes in future costs by adding a dummy variable for the first two weeks of December to the regressions below did not change the results.

sources for physical channel sales as described below, and we will assume that the Internet channel exhibits the same basic seasonal pattern.

Recall that Table 2 presented evidence on pricing in the Internet channel between August 1999 and January 2000. The coefficients on time, time interacted with the store categories, and the month dummies indicate that the prices for all book and store categories were trending upward over time, reaching their peak in January. The data on prices and demand in Table 2 and Figure 3 indicate that firms are not on average offering lower prices during periods of peak demand (i.e., Christmas), as was the case in Warner and Barsky (1986). This may be because Internet search costs are so low that there are no additional economies of scale.

Table 5 reports the results of exploratory regressions on the timing of price changes:

$$PCHANGE_{ijt} = \alpha_0 + \sum \delta_m MONTH_m + \beta_1 NFIRMS_{it} + \beta_2 NFIRMS_{it}^2 + \epsilon_{ijt}$$

where $PCHANGE$ is the probability of a price change and $NFIRMS$ is the number of firms offering a book. The first column reports results for all price changes and the next two columns separately consider the probability of positive and negative price changes. Across all three regressions, if we look at when price changes occur, the greatest number occur in December followed by August. If we compare the up and down changes, the most notable difference is in December, which has a much larger absolute and relative increase in down price changes than in up price changes.

6.2 Margin and Aggregate Demand

Margin represents the difference between price and marginal cost. For books, by far the largest component of marginal cost is the wholesale price of the book. The wholesale price is typically 50-60 percent of the publisher's recommended price and is nearly always constant over time (see Clay et al 2001). The remainder of marginal cost is order fulfillment. Industry estimates suggest that the average cost of order fulfillment is typically 8-12 percent of the publisher's recommended price. Industry estimates also suggest that other than at peak capacity (the middle two weeks of December), the cost of order fulfillment is constant for each store over time. Across stores, wholesale price, and to a lesser extent fulfillment cost, is fairly close to constant. Because we observe the wholesale price for a book, but not differences in fulfillment costs, we use wholesale price as a proxy for marginal cost. Any unobserved differences across stores are controlled for in reported regressions by store-book fixed effects and store-bestseller fixed effects.[16]

We construct margin as follows:

$$MARGIN_{ijt} = (UNITPRICE_{ijt} - WHOLESALE_i)/(PUB.SUG.PRICE_i)$$

[16]This would be a problem if we were interested in accurately estimating firm-level margins, but this is not the focus of the analysis.

where i is the book, j is the store, and t is time (day). We were able to obtain wholesale prices and thus margins from an industry source for 300 of the 399 books in our sample. There does not appear to be any bias in the books for which we have or do not have wholesale prices. We explicitly test for this below by running both price and margin regressions. If wholesale price is constant over time and we include a full set of book-store fixed effects the estimates should be two should be equivalent.

After numerous discussions with industry sources, it became clear that data on aggregate units sold in the Internet channel is not available. As a proxy for this, we use unadjusted monthly retail sales in physical bookstores from the U.S. Census Monthly Retail Trade Survey (SIC based) adjusted for changes in Consumer Price Index for recreational books and the rate of growth of Internet book sales. The average rate of increase in Internet book sales between 1998 and 2000 was 4.5 percent per month. We then interpolate quantity to get a daily measure of aggregate demand.[17]

Although using a proxy for aggregate demand is less than ideal, the numbers match well with other measures of units sold in the physical and Internet channels. We compared our measure to data from five other sources: i) American Association of Publishers reported monthly units sold for Adult Hardback and Paperback, Juvenile Hardback and Paperback, and Mass Market into the retail channel (all outlets); ii) Forrester's average monthly expenditure and total sales for a panel of 5000 Internet users; iii) reported quarterly retail sales for electronic commerce from the U. S. Census Monthly retail trade survey; and iv) Amazon.com and Barnes and Noble.com quarterly domestic sales for 3Q1999 to 1Q2000 as reported in their 10K and 10Q filings with the Securities and Exchange Commission, respectively.[18] The physical retail sales data is weakly correlated (0.25) with the American Association of Publishers units sold two months earlier. The two-month lag accounts for the fact that units sold to retailers sit in warehouses and then on shelves before they are sold to consumers. The physical retail sales data are also highly correlated (0.53) with Forrester's measure of total e-commerce book sales by its panel of consumers. While the correlation between physical sales and online sales might initially appear puzzling, Forrester's panel represents a fixed number of individuals who already purchase over the Internet, so these sales do not capture the enormous growth

[17]For online book sales, see Table 1035 in http://www.census.gov/prod/2002pubs/01statab/domtrade.pdf If q_m is the average daily sales in month m, which has n_m days and price is observed on d_m, then the interpolated q_t is given by:

$$\begin{aligned} q_t^{'} &= q_t(0.5 + d_m/n_m) + q_{t-1}(0.5 - d_m/n_m)\ if\ d_m \leq n_m/2 \\ q_t^{'} &= q_t(1.5 - d_m/n_m) + q_{t+1}(-0.5 + d_m/n_m)\ if\ d_m \geq n_m/2 \end{aligned}$$

[18]We thank Al Greco of the Book Industry Study Group for providing us with American Association of Publishers data and Forrester Research for providing their data. The Census quarterly retail sales through electronic commerce is available from http://www.census.gov/mrts/www/current.html. See also Tables 1035-1040 in http://www.census.gov/prod/2002pubs/01statab/domtrade.pdf

in the number of individuals using the Internet to buy books. The quarterly shares of sales implied by our measure of aggregate demand for online books, perhaps not surprisingly, closely match the shares implied by Amazon, Barnes and Noble.com, and electronic commerce overall retail sales.

The forecast of next month's quantity sold is constructed based on the following prediction equation:

$$\begin{aligned} QUANTITY_t &= \alpha_0 + \alpha_1 QUANTITY_{t-1} + \sum \beta_m MONTH_m \\ &\quad + \alpha_2 TIME_t + \alpha_3 TIME_t^2 + \epsilon_t \end{aligned}$$

Expected quantity sold is the interpolated fitted values from this equation. To improve the estimates, this construction uses data starting in 1997, which predates the price period. It also uses future information, which managers would not have, to estimate quantity. To test the importance of this, we constructed estimates that only include information up to the current period. The patterns of demand are quite stable over time, so the two yielded nearly identical estimates.

6.3 Testing Predictions

The main prediction that we test is Haltiwanger and Harrington's (1991) prediction that all else equal, margin will fall if demand is declining. Thus, if firms were acting as dynamic oligopolists, we would expect a negative coefficient on next period's quantity. As we noted above, Klemperer's (1987) model of customer loyalty gives the opposite prediction.

Our basic estimation approach is similar to the approach taken by Borenstein and Shepard (1996). We begin by using OLS to estimate the effect of next period's quantity on current margin, controlling for current quantity. Because each book represents to some degree a distinct market, we include store-book and store-bestseller fixed effects and control for the number of stores that sell the book at any given time. We then instrument for quantity to control for potential endogeneity issues. Finally, we estimate a vector autoregression to capture responses to other firms' price changes.

The first two columns of Table 7 present the results of the following OLS regressions.

$$\begin{aligned} NMARGIN_{ijt} &= \gamma_0 + \gamma_1 QUANTITY_t + \gamma_2 EXPQUANTITY_{t+1} \\ &\quad + \beta_1 NFIRMS_{it} + \beta_2 NFIRMS_{it}^2 + \epsilon_{ijt} \\ NPRICE_{ijt} &= \gamma_0 + \gamma_1 QUANTITY_t + \gamma_2 EXPQUANTITY_{t+1} \\ &\quad + \beta_1 NFIRMS_{it} + \beta_2 NFIRMS_{it}^2 + \epsilon_{ijt} \end{aligned}$$

The coefficients for the two regressions are essentially identical, suggesting that sample selection bias is not a problem for the 300 books (of 399 total) for which we have margin data. $EXPQUANTITY$ and $NFIRMS$ are significant and both have the expected signs. The coefficients are, however, small. For instance, the effect of one more firm than average is to lower prices by 0.001, which is about 0.40 percent of average margin. Future demand is at its lowest in mid-September with a value of 37 and highest in mid-November with a value of 70. The effect of a change of 30 (the difference between mid-October and mid-November) is 0.0006, or about 0.25 percent of average margin. We find this pattern in unreported category-level regressions, in unreported regressions that only include Amazon, Barnes and Noble, and Borders, and in category-level regressions that only include Amazon, Barnes and Noble, and Borders.

Because quantity may be endogenous, we also run two-stage least squares. The third and fourth columns of Table 7 present the results of the 2SLS estimation. The instruments for quantity are monthly dummies, time, time squared, and current unemployment. The primary difference between the OLS and 2SLS estimation is that the coefficient on $EXPQUANTITY$ remains small and is now insignificant.

The last two columns of Table 7 present the results of vector autoregression estimation, where now we have added positive and negative changes in the average selling price of the book over the last three days and price in the previous two days as error correction terms to equations. In both cases, the coefficient on expected quantity is small and insignificant. Not surprisingly, the coefficients on $DPRICE$ are of the right sign and are significant, indicating that firms do respond to changes in prices by other firms.

7 Discussion and Conclusions

We examine both static and dynamic pricing by online bookstores between August 1999 and January 2000. We find static price differences across categories of bookstores — the big three (Amazon, Barnes and Noble and Borders), the active fringe, and the inactive fringe. The big three offer lower prices on best-sellers and higher prices on random books than the active fringe. In a simple model, we show that these static price differences can be driven by competition with the physical channel and differentially informed consumers.

Overall, prices are trending up slightly over this period, and firms are changing prices. We show that firms respond to price changes by other firms in the same category and secondarily to changes by firms in other categories. We also show that 7 of the 26 firms frequently respond to price changes by particular firms, notably to price increases. These 7 firms include each of the largest firms in our sample (i.e., Amazon, BN, Borders) along with some of the smaller firms in the sample (Bookbuyer's Outlet, 1Bookstreet, Classbook, BCY Bookloft).

We investigate a number of hypotheses with respect to this dynamic pricing, including that pricing was driven by tacit collusion, customer loyalty, inventory considerations, or cyclical variations in elasticity caused by economies of scale in search during periods of high aggregate demand. We find that pricing is not consistent with dynamic oligopoly pricing in the Haltiwanger and Harrington (1991) model. The evidence on prices is consistent with firms learning about their own demand from other firm's pricing experiments. This is not entirely surprising given the relatively early stage of development of this market and the fact that each of the largest firms in the market are present in these responding pairs. Whether the largest three firms have acted as an oligopoly remains an open question. It is worth noting that Amazon and Barnes and Noble simultaneously introduced new and nearly identical pricing policies in the summer of 2000.

8 References

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ftbpFO5.0444in5.5443in0ptRelative Price of BestsellersFigure 1a ftbpFO5.0444in5.5434in0ptRelative Price of Random BooksFigure 1b ftbpFOX5.7199in3.9202in0ptAggregate Demand Over TimeFigure

Table 1: Summary Statistics

	All	NYT	Computer	Random
Number of books	399	136	82	181
Normalized price	0.80	0.73	0.79	0.86
Avg. weeks on list	–	15	15.6	–
Total changes	8,269	3,778	1,881	2,610
Total observations	933,002	294,759	206,426	431,817
P(change)%, book-store-day	0.886	1.282	0.911	0.604
	Corrected Price Changes (All)			
Total changes	6,725	2,622	1,493	2,610
Total observations	857,553	253,563	172,173	431,817
P(change)%, book-store-day	0.784	1.034	0.867	0.604
	Corrected Price Changes (Positive)			
Total changes	4,023	1,517	881	1,625
Avg. magnitude of change	0.242	0.281	0.199	0.229
P(change)%, book-store-day	0.469	0.598	0.512	0.379
	Corrected Price Changes (Negatives)			
Total changes	2,702	1,105	612	985
Avg. magnitude of change	-0.179	-0.195	-0.159	-0.175
P(change)%, book-store-day	0.315	0.436	0.355	0.228

Notes: Normalized price is the unit price divided by the publisher's suggested price. P(change) is the average probability of a price change for a given book on a given day. Corrected changes remove changes and the underlying observations that occur within one week [t-1, t+5] of a change in bestseller status.

Table 2a: Price Differences Over Time

	NYT	Computer	Random
Time	0.0083***	0.0022***	0.0049***
Big 3	0.0262***	-0.0038	0.0182***
Inactive Fringe	0.1253***	0.0656***	0.0811***
Bestseller	-0.0479***	-0.0043***	
Bestseller x Big 3	-0.1563***	-0.0072***	
Bestseller x Inactive Fringe	0.0314***	-0.0078***	
Time x Big 3	-0.0067***	0.0052***	0.0012***
Time x Inactive Fringe	0.0042***	0.0003	-0.0013***
September	0.0017	0.0024**	0.0024***
October	-0.0018	0.0043***	-0.0003
November	0.0045***	0.0115***	0.0008
December	0.0070***	0.0102***	-0.0020***
Constant	0.6804***	0.7514***	0.8100***
ISBN fixed effects	Yes	Yes	Yes
Observations	294,759	206,426	431,817
R-squared (within)	0.337	0.085	0.087
Fraction of variance due to fixed effects	0.187	0.325	0.532

Note: Time is measured in months. * significant at 10%; ** significant at 5%, *** significant at 1%.

Table 2b: Summary of Price Differences Relative to Active Fringe in August 1999 and January 2000

	Current NYT	Former NYT	Current Computer	Former Computer	Random Books
Big 3 August	-0.1496	0.0195	-0.0020	0.0052	0.0194
Big 3 January	-0.1831	-0.0140	0.0188	0.0260	0.0254
Inactive Fringe August	0.0356	0.1295	0.0078	0.0656	0.0798
Inactive Fringe January	0.0566	0.1505	0.0078	0.0656	0.0733

Table 3a: Interaction at the Store Type-Category Level

NYT Bestsellers	Big Three	Active Fringe	Inactive Fringe
Big Three, t-1	0.752***	-0.008	-0.019
Big Three, t-2	0.005	-0.074	-0.111*
Big Three, t-3	-0.456**	0.006	0.119
Big Three, t-4	0.293*	0.085	0.100
Big Three, t-5	0.014	-0.247**	-0.298***
Big Three, t-6	-0.273*	0.201**	0.235
Big Three, t-7	0.248**	0.155***	-0.054
Active Fringe, t-1	-0.163	0.836***	0.287
Active Fringe, t-2	0.158*	0.080	-0.334
Active Fringe, t-3	-0.020	0.145*	0.059
Active Fringe, t-4	-0.049	-0.048	0.022
Active Fringe, t-5	0.088	-0.060	0.001
Active Fringe, t-6	-0.091	0.020	0.007
Active Fringe, t-7	-0.021	0.047	0.014
Inactive Fringe, t-1	-0.014	-0.047	0.942***
Inactive Fringe, t-2	0.081	0.105	0.123
Inactive Fringe, t-3	0.175**	-0.039	-0.123
Inactive Fringe, t-4	-0.060	-0.126	-0.136
Inactive Fringe, t-5	-0.036	0.429	0.246
Inactive Fringe, t-6	0.040	-0.321***	-0.263
Inactive Fringe, t-7	-0.031	0.007	0.164
Constant	0.281**	-0.058	0.017

Note: * significant at 10%; ** significant at 5%, *** significant at 1%.

Table 3b: Interaction at the Store Type-Category Level

Computer Bestsellers	Big Three	Active Fringe	Inactive Fringe
Big Three, t-1	0.794****	-0.016	0.056
Big Three, t-2	0.011	-0.068	-0.225**
Big Three, t-3	-0.112	0.078	0.079
Big Three, t-4	0.094	-0.030	0.065
Big Three, t-5	0.218**	0.086	0.181
Big Three, t-6	-0.155**	-0.084	-0.198
Big Three, t-7	0.202***	0.121	0.099
Active Fringe, t-1	0.020	0.784***	-0.048
Active Fringe, t-2	-0.032	0.066	-0.020
Active Fringe, t-3	0.111	0.102	-0.074
Active Fringe, t-4	-0.039	-0.105	0.098
Active Fringe, t-5	-0.119	0.061	-0.094
Active Fringe, t-6	0.156	0.041	0.122
Active Fringe, t-7	-0.233***	-0.086	-0.108
Inactive Fringe, t-1	-0.061*	-0.018	0.902***
Inactive Fringe, t-2	-0.041	0.085	0.417**
Inactive Fringe, t-3	0.207**	-0.055	-0.264
Inactive Fringe, t-4	-0.123	-0.091	-0.125
Inactive Fringe, t-5	-0.026	0.041	0.053
Inactive Fringe, t-6	-0.002	-0.034	-0.133
Inactive Fringe, t-7	0.034	0.061	0.134
Constant	0.072***	0.046*	0.063***

Note: * significant at 10%; ** significant at 5%, *** significant at 1%.

Table 3c: Interaction at the Store Type-Category Level

Random	Big Three	Active Fringe	Inactive Fringe
Big Three, t-1	0.903***	-0.096*	0.050
Big Three, t-2	-0.056	0.219**	-0.128
Big Three, t-3	-0.136	0.144	0.117
Big Three, t-4	0.205	-0.307	-0.075
Big Three, t-5	0.048	0.143	0.137
Big Three, t-6	0.017	0.382**	0.319
Big Three, t-7	0.040	-0.397	-0.277
Active Fringe, t-1	-0.048	0.782***	-0.311*
Active Fringe, t-2	-0.069	0.124	0.113
Active Fringe, t-3	0.128	-0.133	0.111
Active Fringe, t-4	-0.013	0.070	-0.427
Active Fringe, t-5	0.083	0.148**	0.122
Active Fringe, t-6	-0.038	-0.155	0.057
Active Fringe, t-7	-0.056	0.013	0.069
Inactive Fringe, t-1	-0.002	-0.013	0.912***
Inactive Fringe, t-2	0.012	0.002	-0.051
Inactive Fringe, t-3	0.002	-0.034	0.191
Inactive Fringe, t-4	-0.026	0.021	-0.159*
Inactive Fringe, t-5	-0.002	-0.017	-0.024
Inactive Fringe, t-6	-0.023	0.035	0.048
Inactive Fringe, t-7	0.036	-0.023	-0.083*
Constant	0.006	0.072*	0.247*

Note: * significant at 10%; ** significant at 5%, *** significant at 1%.

Table 4a: Responses to Price Changes

Store	*Store*	*Wind-*	*X then Y*	*Y then X*
X	*Y*	*ows*	*or simult.*	*or simult.*
Price Increases			*Observed/Possible Windows %*	
Amazon	Bookbuyer's Outlet	145	83	82
Amazon	BN	112	32	13
BN	Borders	103	38	5
BN	1Bookstreet	96	37	26
Amazon	1Bookstreet	89	27	14
1Bookstreet	Borders	82	43	4
Bookbuyer's Outlet	BN	75	48	8
Bookbuyer's Outlet	1Bookstreet	60	38	9
Classbook	BCY Bookloft	33	80	1
Price Decreases				
Bookbuyer's Outlet	Amazon	47	79	63

Table 4b: Magnitude of Price Changes

Store	*Store*	*Wind-*	% Diff	% Diff	% chg	% chg
X	*Y*	ows	Before	After	Leader	Follower
Price Increases						
Amazon	Bookbuyer's Outlet	145	0	0	20	20
Amazon	BN	112	0	-1	31	32
BN	Borders	103	0	1	31	31
BN	1Bookstreet	96	-24	-15	32	27
Amazon	1Bookstreet	89	-27	-21	30	27
1Bookstreet	Borders	82	22	17	27	31
Bookbuyer's Outlet	BN	75	0	-1	31	32
Bookbuyer's Outlet	1Bookstreet	60	-27	-22	31	28
Classbook	BCY Bookloft	33	25	23	0	3
Price Decreases						
Bookbuyer's Outlet	Amazon	47	0	0	-24	-24

Table 5: Timing of Price Changes

	1	2	3
Dependent Variable	Pchange	Upchange	Downchg
Constant	0.022	0.015	0.006
	(27.80)***	(24.43)***	(13.30)***
September	-0.007	-0.006	-0.001
	(9.27)***	(9.55)***	(2.64)***
October	-0.008	-0.004	-0.004
	(9.92)***	(6.61)***	(7.44)***
November	-0.008	-0.006	-0.003
	(10.88)***	(9.11)***	(5.77)***
December	0.006	0.001	0.006
	(6.98)***	(0.72)	(10.27)***
January	-0.003	-0.002	-0.001
	(2.93)***	(2.18)**	-1.91
NFirms	-0.00048	-0.00040	-0.00008
	(4.94)***	(5.14)***	(1.35)
NFirmsˆ2	-0.00002	-0.00005	0.00002
	(0.96)	(2.70)***	(1.92)
Store-bestseller	Yes	Yes	Yes
Store-ISBN	Yes	Yes	Yes
Number of ISBNs	399	399	399

Notes: Absolute value of t statistics in parentheses. * significant at 5%; ** significant at 1%.

Table 6a: Dynamic Pricing

	1	2	3	4
	OLS	OLS	2SLS	2SLS
Dependent Variable	Nmargin	Nprice	Nmargin	Nprice
Constant	0.246	0.807	0.244	0.805
	(572.51)**	(1916.64)**	(536.87)**	(1811.68)**
Quantity	0.00040	0.00039	0.00047	0.00045
	(57.94)**	(59.52)**	(60.97)**	(62.06)**
Expected Quantity	0.00002	0.00002	0.00000	0.00000
	(3.78)**	(3.31)**	(1.58)	(1.74)
NFirms	-0.00083	-0.00082	-0.00081	-0.00079
	(23.69)**	(24.55)**	(22.81)**	(23.39)**
NFirmsˆ2	-0.00017	-0.00016	-0.00016	-0.00015
	(18.43)**	(18.61)**	(17.77)**	(17.82)**
Store-bestseller	Yes	Yes	Yes	Yes
Store-ISBN	Yes	Yes	Yes	Yes
Number of ISBNs	300	399	300	399
Observations				
R-squared (between)	0.07	0.11	0.07	0.11

Notes: Absolute value of t statistics in parentheses. * significant at 5%; ** significant at 1%.

Table 6b: Dynamic Pricing

	5	6
	VAR	VAR
Dependent Variable	Nmargin	Nprice
Constant	-0.470	0.100
	(630.27)**	(140.00)**
Quantity	0.00004	0.00000
	(11.37)**	(13.18)**
Expected Quantity	0.00000	0.00000
	(1.17)	(0.59)
NFirms	-0.00010	-0.00011
	(5.50)**	(6.24)**
NFirmsˆ2	-0.00002	-0.00001
	(3.48)**	(3.86)**
Dprice_{t-1} plus	0.956	0.938
	(143.98)**	(157.92)**
Dprice_{t-1} minus	-0.973	-0.97
	(122.04)**	(127.15)**
Dprice_{t-2} plus	0.277	0.256
	(40.99)**	(42.37)**
Dprice_{t-2} minus	-0.284	-0.274
	(32.29)**	(32.83)**
Nprice_{t-1}	0.655	0.657
	(410.93)**	(432.90)**
Nprice_{t-2}	0.227	0.218
	(142.64)**	(144.34)**
Store-bestseller	Yes	Yes
Store-ISBN	Yes	Yes
Number of ISBNs	300	399
Observations		
R-squared (between)	0.76	0.76

Notes: Absolute value of t statistics in parentheses. * significant at 5%; ** significant at 1%.