

Price competition and valuation online: Amazon and Barnes and Noble

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Abstract

Valuing Internet retail firms is made very difficult by the fact that the firms will have to raise margins in the future in order to survive. This raises the question: can these firms raise margins? How competitive are Internet retail markets? Despite the interest in measuring price sensitivity of online consumers, most academic work on Internet commerce is hindered by a lack of data on quantity. In this paper we use publicly available data on the sales ranks of about 20,000 books to derive quantity proxies at the two leading online booksellers. Matching this information to prices, we can directly estimate the elasticities of demand facing both merchants as well as create a price index for online books. The results show significant price sensitivity at both merchants but demand at Barnes and Noble is much more price-elastic than is demand at Amazon. We describe how these findings might impact an assessment of valuation.

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This paper examines publicly available data from Amazon.com and Barnesnoble.com to measure the elasticity of demand faced by these retailers and the potential ability of these retailers to raise prices in the future. While publicly available, the data that we use has not been incorporated into previous valuation methodologies and we show that measuring elasticities can provide important insights into each company's expected future profitability.

Many researchers and analysts have considered the question of how to value a company, such as Internet companies, for which current financials are likely to be a poor indicator of future prospects (see Damodaran [2000] and Schwartz and Moon [2000]). However, all of these methodologies run into the problem that it is very difficult to forecast whether a firm that is realizing low operating margins today will be positioned to earn higher operating margins in the future.

Unfortunately, from the earliest days of Internet commerce, observers have differed widely in their assessments of how profitable Internet retailers could possibly become. Many economists and media observers predicted that competition among Internet retailers would quickly resemble perfect competition.¹ After all, the Internet already reduces search costs relative to visiting physical stores and shopbots and comparison sites could be expected to lower search costs still further. Others suggested that the profitability of Internet retailers would eventually resemble the profitability of brick and mortar retailers (for example, Damodaran [2000] uses this assumption in his valuation model). Certainly, during the period of peak Internet stock prices, some investors must have been forecasting that Internet retailers would achieve levels of profitability far above those observed for brick and mortar retailers.

¹ See, for example, Kuttner (1998).

While these historical observations suggest different predictions for the future of Internet retailing *in general*, it is clear that market valuations must also reflect the particular prospects of specific companies. In this paper, we consider Amazon.com and Bn.com. Recall that BN.com is the online Barnes and Noble bookstore (ticker BNBN) and is partially owned by, but legally distinct from the brick and mortar Barnes and Noble stores (ticker BKS). Table 1 shows the 2002 accounting data for BN.com and Amazon.com, as well as their market valuations as of February, 2003. Total sales by Amazon.com equal 9 times the total sales of BN.com, while gross profits at Amazon equal 10 times the gross profits at BN.com. Thus, gross margins are very similar at the two sites. The accounting data do suggest that there might be economies of scale in this industry: Amazon's sales, general, and administrative expenses, as well as total operating expenses were only 5 times larger than BN.com's. However, while the accounting data might suggest that BN.com could be viewed as a roughly 10% of Amazon, BN.com's market valuation at this writing is only 2% of Amazon's.

This example raises several possibilities. First, the two securities could be mispriced relative to one another, perhaps because Amazon is more well-known and newsworthy. This is the hypothesis most frequently espoused by the "BNBN bulls" on Internet stock bulletin boards such as Ragingbull.com.

The second possibility is that the market rationally forecasts that Amazon will grow faster, and that economies of scale are important in this industry. Certainly, Amazon has achieved a faster growth rate of sales than BNBN. Amazon's 2002 sales represented a 26% increase over 2001 sales. BN.com's 2002 sales represented only a 4% increase over 2001 sales. As historical data show erratic relationships between SG&A and sales and between total operating expenses and sales, it is difficult to estimate the fixed and variable

components of those expenses. Furthermore, some of these expenses might represent one-time expenses that will not be repeated annually, such as expenses related to developing the user interface. Finally, it should be noted that BN.com shares some facilities (such as warehouse fulfillment facilities) with the brick and mortar Barnes and Noble, suggesting that BN.com may be able to leverage some of Barnes and Noble's scale advantages.

A third possibility is that the market is quite optimistic about Amazon's currently non-profitable ventures outside of core retailing. For example, Amazon effectively "rents" space on its site to small retailers through its z-shops, as well as to larger retailers such as Target and Eddie Bauer. While currently, only Amazon's Books, Music, and DVD and Video segment (BMDV) is profitable, the market could be very optimistic about these other segments.

Finally, it is possible that the market rationally forecasts that Amazon is well-positioned to raise margins on its core BMDV business in the future and that BN.com is poorly positioned to do so. In this paper, we explore this third possibility. To do this, we take up this question by detailing analytical tools for theoretically and empirically considering a firm's ability to raise margins in the future. The tools we describe are applicable for companies that are using low current prices as a means of investing in future market share. The "pricing for market share strategy" is often articulated as important in consumer industries, particularly for young firms. "Pricing for market share" may occur in any industry in which consumers who buy from a particular company today have an extra propensity to buy from that same company in the future. Klemperer (1987) provides several formal models of "pricing for market share". Our sketch of the theory of "pricing for market share" borrows heavily from Klemperer. In this paper, our main contribution is to attempt

to measure empirically the extent to which Amazon and/or BN.com may be engaging in a “pricing for market share” strategy.

To do this measure demand elasticities faced by each retailer. Measuring only current prices or margins do not inform us about the potential for retailers to raise price in the future. As we show below, if we measure that the elasticity of demand facing a retailer is inelastic, this suggests that the retailer may be able to raise prices in the future. Any measurement of demand elasticities, however, is made difficult by the fact that companies generally do not separately provide public data on their prices and quantities sold. Using the “sales rank” data provided by Amazon.com and BN.com on their shopping pages and some distributional assumptions, we are able to convert the sales rank data into information on quantities sold of some 20,000 books sampled from both sites. We use these data as inputs to measuring elasticities.

The paper proceeds as follows. Section I briefly surveys the literature on Internet competition. Section II reviews the theoretical literature on “pricing for market share”. Section III presents the methodology for translating sales ranks into sales quantities. Section IV presents price indices for Amazon and Barnes and Noble and assesses the impact of price movements at Amazon and BN.com. Section V provides evidence on the demand elasticities. Section VI briefly describes some robustness checks. Section VII concludes.

II. Related Literature

As described above, this paper is related to the short literature on valuing Internet companies. It is also related to a small, but growing literature estimating the degree of competition between retailers on the Internet. Two strands of research have addressed the question of price competition on the Internet. The first set of papers examines patterns of

prices for homogeneous goods. Using price dispersion to measure the extent of competition has been used extensively in traditional bricks and mortar retail settings (see Sorensen, 2000, for example). Researchers have examined the degree of price dispersion amongst Internet retailers, as well as between Internet retailers and bricks-and-mortar retailers. The general consensus of these papers is that price dispersion amongst Internet retailers is large, and that online retailers charge prices that are either modestly lower or actually higher than their offline counterparts.² These results seem incompatible with the idea that the Internet has completely eliminated consumer search costs. An important advantage of this strand of research is that these studies require only publicly available price data. However, a concern with these findings is that, while relatively high prices are posted at some Internet sites, few or no transactions may be taking place at those relatively high prices. Without quantity data, it is impossible to know.

A second strand of research attempts more direct measures of consumer price sensitivity. For example, Goolsbee (2000; 2001) finds a large cross-price elasticity of online retail and online computers with respect to physical retail prices. Ellison and Ellison (2001) find large elasticities for computer memory and motherboards from data on a private computer parts retailer. Brown and Goolsbee (2002) and Scott Morton et. al. (2001) examine the impact of Internet shop-bots on prices of life insurance and for cars respectively and find that the Internet leads to significantly lower prices. Smith and Brynjolfsson (2001) examine customer behavior at a book price comparison site but find that brand still matters a lot for consumers' click through probabilities.

² Work by Lee (1997) for cars and Bailey (1998) for books, CDs, and software suggest that prices were actually higher online than in retail stores. More recent work by Brynjolfsson and Smith (2000) for books and CDs and by Clay et al. (2000) for books has found prices the same or lower online but that online price dispersion is quite high, perhaps greater than in retail stores. Carlton and Chevalier (2001) show, among other things, the existence of price dispersion among online fragrance retailers.

The general consensus from this work seems to be that Internet markets do seem competitive in the sense that demand for a seller appears to be quite elastic to the seller's own price or to competitors prices. One important drawback of the research is that the papers using data on price and quantity rely on proprietary information on firm sales or consumer buying patterns. In particular, much of this work focuses on consumers who use Internet shopbots, a group that may not be representative of overall Internet shoppers.³ In general, there has been little overlap in the industries studied by the two approaches.

Our research attempts to combine the best features of these two approaches. We examine online books, in part because this is the most-studied Internet retail category, but also because it is one of the largest online sales categories. We develop a method to estimate directly the own- and cross-price elasticities of demand at Amazon and Barnes and Noble.com (hereafter, BN.com). By construction, we measure the elasticity of demand of all customers at the two web sites, including those using and not using shopbots to assist in their decision-making.

III. Pricing for Market Share

We measure elasticities in order to inform our hypothesis of pricing for market share. An example of pricing for market share will fix ideas.

Consider one possible model of supermarket shopping. When a new consumer moves to town, that consumer may evaluate which local supermarket has the best prices and selection. During that initial investigation, the consumer is price sensitive, but, following that initial investigation, the consumer may not shop across supermarkets very carefully. When setting prices, the supermarket has to consider the effect that its prices will have on

³ See White (2000) for a discussion of the usage of Internet shopbots.

the decisions of the “newcomer” shopper, as well as on the decisions of the “oldtimer” shopper. The supermarket might want to charge high prices in order to harvest profits from the less price-sensitive oldtimers, but has an incentive to charge low prices in order to capture the newcomer. The incentive to price low to attract newcomers will be more important in a town which is growing rapidly in size: that is, in a town in which the newcomers are important relative to the oldtimers. The supermarket may price low, even perhaps below marginal cost, because by doing so, they invest in locked-in oldtimers that can be harvested profitably in the future. A more formal model of this process for the supermarket context can be found in Chevalier and Scharfstein (1996).

Thus, in an industry in which “pricing for market share” is an important phenomenon, prices today can be lower than the prices dictated by static profit maximization. Amazon.com is an example of a company that articulates a “pricing for market share” strategy. During its October 2002 webcast of quarterly results, Amazon reports: We will continue \$25 free super saver shipper at least through the holidays,and will continue to offer the best value proposition for our customers through lower prices.... Each of these investments is expensive, and will negatively impact profits in the near term. However, unit growth is critical to driving significant increases in future cash flows and therefore, as we have been doing throughout the years, we are willing to forego some current profits to invest for the long term benefit of our shareholders.”

Notice that this strategy can be profitable even absent significant economies of scale. However, the strategy would be more profitable in the presence of scale economies. If there are scale economies, costs will fall as “newcomers” are added to the locked in customers. This may raise barriers to successful imitation.

Consider the difficulties inherent in assessing the financial data provided by a company pursuing an “investing in market share strategy”. In many respects such a strategy is an investment in future sales, just like any other investment expenditure. However, pricing for market share will not appear in accounting data as an investment expenditure. How will the accounting data for a “pricing for market share” firm appear relative to the same firm, pursuing a static profit maximization strategy. Reported investment expenditures should be the same in both cases. Cost of goods sold will be higher for the “pricing for market share” firm. In principle, total revenues for the “pricing for market share” firm could be higher or lower than total revenues for the static profit-maximizing firm. However, operating margins will be lower for the “pricing for market share firm”, due to the lower prices. Looked at differently, from the standpoint of the accounting data, this implies that two firms with identical revenues, costs of good sold, and operating margins could have extremely different future prospects.

How could one tell whether a firm is engaged in a pricing for market share strategy? One bit of evidence would come from an investigation of demand elasticities. Consider a normal, static profit-maximizing firm. We know that such a firm maximizes profits by pricing in the elastic region of the demand curve. That is, profits are maximized by choosing prices such that $\epsilon_D < -1$. If we measure the elasticity of demand and find that it is greater than -1 , then one possible explanation is pricing for market share. Given this possibility, we proceed to measuring the price elasticity of demand.

IV. Background and Data

Amazon began selling books online in 1995, one of the first electronic commerce firms. By 1999, books were the second largest retail segment (after computers) sold over the

Internet (BCG, 2000). Online book sales grew from essentially nothing in 1995 to more than \$2 billion in 2000 (Forrester, 2001). Today such sales make up between 7.5% and 10% of total book sales in the U.S (American Booksellers Association, 2002; Cader, 2001).

Within the online bookstore industry, the two dominant players are Amazon and Barnes and Noble (BN.com). According to Net Ratings, these two firms account for more than 85% of online book sales. Recent accounting data shows that Amazon's book, music and DVD sales are approximately four times that of bn.com.

More detail about the business operations of the online merchants can be found in Rayport (1998). For purposes of this paper, what is relevant is that online bookstores tend to have much larger selection of titles than even the largest physical bookstores. A large superstore might have as many as 150,000 titles whereas Amazon and BN.com claim to have millions of titles available (although for books outside of the top 200,000, this may involve waiting two weeks or more to actually receive the book).

A customer visiting one of the sites and looking for a book would typically face a screen giving the price of the book, the relative sales ranking at the site, information on the shipping time/availability, a brief description of the book, customer reviews of the book and a listing of other books and authors that are popular among people interested in the book, and the price for a used version of the book (if available).

We collected data during three different weeks in 2001 on about 18,000 different books from the websites of Amazon and BN.com. We did this by ISBN number. Since a tiny fraction of books in print account for most book sales, building a large and representative sample is not easy. To get books representative of different parts of the sales distribution, we combined ISBN numbers from three sources. First, we included all books that appeared on any Publishers' Weekly best-seller list from 1996 to March 2000 (predating

our sample). Second, we include all books that were searched for at Dealtime.com from August 25 to November 1, 1999 as compiled in Smith and Brynjolfsson (2001).⁴ Third, we took a random sample of about 3,000 books Book in Print (2000). In total, these three methodologies give us approximately 26,000 ISBN numbers of which typically about 18,000 had price and rank data at Amazon and about 13,000 had price and rank data at BN.com. The difference arises because BN.com does not report sales ranks for books with rankings greater than about 630,000 whereas Amazon's are not censored (and go to over 2,000,000). We will address this asymmetric censoring of rankings in our results below.

Our three samples were taken during the weeks of April, June and August of 2001. During this period there were major price changes by both sellers. We do not look at price changes over very short time horizons because of the way the ranks are updated at the sites. Amazon claims that for books in the top 10,000 ranks, the rankings are based on the last 24-hours and updated hourly. For books ranked 10,001-100,000, the ranks are updated once per day. For books ranked greater than 100,000, the sales ranks are updated once per month (Amazon, 2000). Many hundreds of thousands of books, however, have a rank but almost certainly have less than one sale per month. Italic (2001) claims that for these rarely purchased books, Amazon bases the rank the total sales since Amazon's inception. BN.com claims to update all the rankings daily (BN.com, 2000).⁵

In the first period of our sample, taken during the week of April 13, 2001, prices had been quite stable for some time. The general price structure at Amazon and BN.com was to discount hardback books at 20% off their retail price, paperback books at 10% off, New York Times bestsellers at 40% off and textbooks at no discount (some other types of books

⁴ We thank Michael Smith and Erik Brynjolfsson for providing this list to us.

⁵ Since BN.com provides rankings on tens of thousands of books that average far less than one sale per day, this statement cannot be completely accurate. They would not provide us any more detail in their ranking system (despite repeated requests).

were also sold with no discounts and there are periodic editor picks and the like that receive further discounts). The sites do differ in their classifications of some of the books and Amazon tends to use New York Times bestseller lists with a lag whereas BN.com does not.

Starting June 20th, 2001, Amazon conducted a two-week pricing experiment in which it raised the prices of many of its books. Our second data collection occurred during the week of June 23rd, 2001. Amazon announced the launch of free shipping for all buyers purchasing more than two books while simultaneously increasing overall prices rather significantly.⁶ During this period, they eliminated all discounts for most paperback books, maintained no discount for textbooks, and reduced the discount on hardback books to 10%. BN.com generally maintained their previous pricing structure.

The pricing regime of June did not last long. On July 3rd, BN.com launched free shipping with the purchase of two items. At that time, BN.com vice chairman Steve Riggio contrasted the BN.com strategy to Amazon's by noting "we're offering free shipping without changing our prices or making any fine-print exceptions." On July 4th, Amazon.com removed the free shipping offer and changed prices again. The company claimed that the two-week price change was merely an experiment and that it was intended to be short-lived.

In the third period of our sample (conducted during the week of August 3, 2001), Amazon had reinstated the 20% discount but now applied it only to books over \$20. Books under \$20 generally received no discount, nor did textbooks. In this new period, BN.com's policy was not explicitly stated but they appeared to move away from the standard discounts of 10 and 20 percent for paper and hardback books.

⁶ Amazon.com made the following statement during this time: "We've also changed our pricing on some books, CDs, DVDs, and videos: for some products prices have stayed the same, for some products prices are lower, and for some products we've reduced our discounts." (www.internetnews.com, July 2, 2001). However, our observation from the data is that prices mainly increased.

Importantly for our estimation, the pricing at these sites is set at a general level. That is, broad categories of books all receive the same discount off of the manufacturer's suggested retail price. Individual book pricing appears to be done only for a very small number of editor's picks. The sales of a particular book (relative to the book's broad category) does not seem to impact the book's pricing. During this time period, price differences between the sites mostly reflect differences in the prices charged for a particular category of book or differences in the categorization scheme (for example, whether or not the *Chicago Manual of Style* is classified as a textbook).

V. Computing Sales Quantities

Our basic approach is to translate the observed sales ranking of each book into a measure of quantity. To do so, we need to know the probability distribution of book sales. A standard distributional assumption for this type of rank data is a Pareto distribution (i.e., a power law).⁷ In the Pareto distribution, the probability that an observation, s , exceeds some level, S , is an exponential function

$$\Pr(s > S) = (k / S)^\theta \tag{1}$$

where k and θ are the parameters of the distribution. The most important parameter is θ , the shape parameter that indicates the relative frequency of large observations. If θ is 2, for example, the probability of an event decreases in the square of the size. With a value of 1, it decreases linearly.

⁷ For discussions on the use of power law distributions to describe rank data, see Pareto (1897), Quandt (1964), and Mandelbrot (1988). It should be noted that the well-known "Zipf's law" (Zipf, 1949) is a special case of Pareto's law. More details on the Pareto and its application can be found in Johnson and Kotz (1970) or Goolsbee (1999).

For any given book, the number of books that have greater sales than that book is just the book's rank-1. Therefore, the fraction of all books that have sales greater than a particular book is just (Rank-1)/(Total Number of books). If there are a sufficient number of books to eliminate discreteness problems, then we can replace Eq. 1 with:

$$(\text{Rank}-1)/\text{Total number of books} = (k/S)^\theta \quad (2)$$

Taking logs, we can translate sales into ranks according to

$$\ln(\text{Rank} - 1) = c - \theta \ln(\text{Sales}) . \quad (3)$$

The constant c is a function of θ , k , and the total number of books for sale. In what follows, we will constrain θ to be the same for both Amazon and bn.com, but we will not constrain c to be the same across sites.

Evidence that the Pareto distribution fits well for books can be found using the weekly Wall Street Journal book sales index which, unlike other bestseller lists, gives an index of the actual quantity sold. This index is constructed by surveying Amazon.com, BN.com, and several large brick and mortar book chains. Using the data from April to August 2001, we regress $\log(\text{rank} - 1)$ on \log sales for each book-week observation in the data set, as well as weekly dummies. The regression specification fits very well. The R-squared of this regression is 0.94. The estimated value of θ is 1.49.

We could use this estimate of θ to translate sales ranks into quantities in our main sample, but sales online may have a different distribution than sales in stores. We are able to get several independent estimates of θ strictly for online books (as described below) and they are all quite close.

The first estimate of θ comes from a single publisher who was monitoring the sales of their own books and competitor's books on Amazon. We discovered that this publisher

was using a methodology very similar to our own. This publisher had performed a non-linear least squares regression of the form $\text{Rank} = A \times (\text{Sales})^\theta$ using their own proprietary data on the sales of their own books at Amazon. Of course, this methodology should produce the same results as a linear regression of $\ln(\text{Rank})$ on $\ln(\text{Sales})$. Given that most of this publisher's books had ranks of 100 or greater, we are not particularly concerned that the publisher's methodology did not subtract one from the ranks, as the Pareto formula requires. This was done for the subsample of this publisher's books that had sales ranks at Amazon in the top 15,000 over the course of one week. They conducted two regressions giving estimates of θ of 0.9 and 1.3. They did not provide us with standard errors on either estimate.⁸

For the second estimate, we conducted our own experiment. A publisher who would not give us direct information on rankings and sales of their books did tell us of a title they had with steady sales at Amazon.com of 14 copies per week (i.e., about two copies per day). We observed this book to be ranked 14,468. We then purchased 6 copies of the book in a 10-minute period and observed its rank rise to 2,854. Assuming 2 sales in a day corresponded to the first ranking and 8 sales in a day corresponded to the second ranking, we can solve for the implied Pareto shape parameter, θ . In this case it is equal to 1.17.

Third, an author, Gene Weingarten did a similar experiment to ours with his own book (see Weingarten, 2001). According to the author, his new book's ranking was 1,484,129. Purchases of 20 copies in an hour sent the book to rank 1,297. Purchases of another 5 copies moved the book to rank 1,025. Assuming that the daily sales at a rank of 1,484,129 is very close to zero, this implies a θ of 1.05.

⁸ See Schnapp and Allwine (2001), for a description of the methodology.

Finally, Poynter (2000), gives an estimate of actual sales in seven different rank ranges (e.g., ranks 450 to 750 average 90 sales per week). Taking the mid-point of his ranges and regressing the log rank on the log sales yields an estimate of θ of 1.199 (with a standard error of .102 and an R^2 of .97).

Thus all of these experiments suggest fairly consistent estimates of θ in the relatively tight range of 0.9 to 1.3 and can be used to translate ranks into sales. We will use 1.2 as the basic estimate.

VI. Price Indices and Price Dispersion

Given this estimate of the shape parameter, we can compute the implied sales for any book that has a sales rank. Using these sales weights, we can also compute a price index to compare prices across sites within a time period or across time within a site. Since the BN.com books are censored at ranks of approximately 600,000, we restrict the sample here to books with data on ranks in all periods at both sites.⁹ The price indices will allow us to determine, with proper weighting, the rate of inflation at the online book stores as well as to know which of the sites is more expensive.

We start, in Table 2, by showing that it can be somewhat misleading to use unweighted prices. Previous work has, by necessity, not had sales weights and thus has calculated equally weighted price indices. The first two panels show that the unweighted prices are notably different from the weighted (where the sales weights here are just the actual sales of the given book in the period as estimated using a Pareto shape parameter θ of 1.2 and normalizing the sales of the highest selling book to 1). Sales of inexpensive books

⁹ Given that the previous section demonstrated that sales are dropping almost linearly with the sales rank, there is little impact of the cutoff rule on the results.

are much greater than the sales of expensive books, leading the sales-weighted average prices to be less than half of the raw averages.¹⁰ The percent discount from the manufacturer's list price is given in parentheses and shows the same major difference between the weighted and unweighted data.

To construct a proper price index we use the sales quantities at the two sites and compute a Fisher ideal index in each of the three periods (with BN.com providing the base of 100.0 in each). This is reported in the middle panel of Table 2. In the first period, Amazon has lower prices than BN.com. In the second period, with Amazon's price increase experiment, Amazon's prices are about 3.4% higher than BN.com's. In the week of August 3rd, Amazon's prices are again lower than at BN.com (note that these indices show only prices at Amazon relative to BN.com at each point in time, not the prices within Amazon across time).

In addition to a price index, we can also compute the degree of price dispersion across sites. Sorenson(2000), Brynjolfsson and Smith (2000), and Clay et al. (2000) use the dispersion across Internet retailers as a measure of the imperfection of market competition. In Table 3, we calculate the degree of price dispersion across the sites for the three time periods. This measure is calculated as:

$$\text{Price dispersion} = \frac{1}{N} \sum_{i=1}^N \frac{| \text{Price}_{i,AMZN} - \text{Price}_{i,BN} |}{(\text{Price}_{i,AMZN} + \text{Price}_{i,BN})/2} \quad (4)$$

¹⁰ These prices do not include shipping charges. As we discuss later, it is not obvious how to best include shipping prices since the shipping charge schedule is non-linear and there are multiple shipping options available at each site. Here, the inclusion of any shipping charges would raise BN.com and Amazon.com's prices symmetrically in period 1, as the two sites had identical shipping price schedules at that time. In period 2, Amazon's price would fall relative to BN.com's price, as Amazon was offering free standard shipping with the purchase of two items. For a benchmark, the marginal price of shipping a third book at Amazon would be zero, versus 0.99 cents at BN.com. In period 3, BN.com's relative price would be lower it was offering free standard shipping with the purchase of two items, while Amazon.com had reverted to its previous shipping schedule.

That is, price dispersion measures the extent to which BN.com and Amazon.com are charging different prices from one another in each period. In the framework of the existing literature, which interprets price dispersion as evidence of market power, the results in Table 3 would be interpreted as suggesting that the level of competition between the two sites has been diminishing over time, as price dispersion is steadily rising. Using our measures of elasticities, we will be able to estimate the amount of competition in the different periods and thus check the validity of the existing approach. Previewing the results, we do not find any evidence that consumer price sensitivity has fallen over time.

The data on price differences across sites and across time also motivates such empirical analysis since it means there is likely to be considerable variation across sites for price of the same books. Another way to think about the price variation is to note that, pooling all the periods together, about 36 percent of the books have identical prices across the two sites. Amazon's prices are higher for about 28 percent of the books and lower for about 35 percent. Of the two-thirds of books where prices differ across site, about nine out of ten of them have price differences of more than 5 percent.

VII. Estimating the Demand System

A. Empirical Approaches

Given the price variation across sites and across time and the measures of quantity each period coming from the sales ranks, we can consider the price sensitivity of online book sales. We start with each cross-section separately, and ask, essentially, whether relative sales across sites are lower when the relative price is higher.

Calling the total sales of book b at site s during week t , Q_{bt}^s , and log sales q_{bt}^s , we assume that the log sales of a book depends on book and site dummies, the characteristics of

the book at a site, denoted x , including things like the shipping time and the customer reviews, and the log of the price at the site, p_{bt}^s , and at the competitor site, p_{bt}^{-s} according to

$$q_{bt}^s = f_b + f^s + \beta^s p_{bt}^s + \alpha^s p_{bt}^{-s} + \Gamma' x_{bt}^s + \varepsilon_{bt}^s . \quad (5)$$

With cross-sectional book data across sites, we can estimate a relative elasticity of substitution by estimating the relative demand as a function of relative prices

$$(q_{bt}^s - q_{bt}^{-s}) = (f^s - f^{-s}) + (\beta^s - \alpha^{-s})(p_{bt}^s) + (\beta^{-s} - \alpha^s)p_{bt}^{-s} + \Gamma'(x_{bt}^s - x_{bt}^{-s}) + \eta_{bt} . \quad (6)$$

As the equation makes clear, the coefficients on log price are not the true elasticities but rather a combination of the own and cross-price elasticities of demand because a change in the price at one site affects relative demand in two ways. One is by reducing demand via the negative own price elasticity. The other is by raising the demand at the other site via the cross-price elasticity. Notice that, in this estimation, the estimated constant term is equal to the difference in the constant terms across the two sites. Thus, we are implicitly allowing the Pareto k parameter and the total number of books to differ across the two sites. However, we are constraining the Pareto k parameter and the total number of books to be the same within site, across time.

With more than one time period and with price changes over time, we can estimate the own- and cross-price elasticities directly. Differencing the data across time, we see that

$$(q_{bt}^s - q_{bt-1}^s) = (f_t - f_{t-1}) + (\beta^s)(p_{bt}^s - p_{bt-1}^s) - (\alpha^s)(p_{bt}^{-s} - p_{bt-1}^{-s}) + \Gamma'(x_{bt}^s - x_{bt-1}^s) + \omega_{bt} . \quad (7)$$

which gives the demand coefficients α and β separately.¹¹

To translate this model into one that we can use rank data for requires us only to substitute the log sales rank for the log quantity in equation (4) according to the Pareto

¹¹ Of course, it is equivalent here or in (3) to include book and time period or book and site (respectively) fixed effects rather than differencing the data.

relationship in Equation 1:¹²

$$(r_{bt}^s - r_{bt-1}^s) = \theta(f_t - f_{t-1}) + \theta(\beta^s)(p_{bt}^s - p_{bt-1}^s) - \theta(\alpha^s)(p_{bt}^{-s} - p_{bt-1}^{-s}) + \theta\Gamma'(x_{bt}^s - x_{bt-1}^s) + \theta\omega_{bt}. \quad (8)$$

In other words, estimating the equations using log ranks, r , rather than actual quantities, yields the correct elasticity but scaled up by the Pareto shape parameter, θ , which we estimated above.

B. Results: Cross-Sectional Results

Before estimating the parametric model, we present suggestive evidence about price sensitivity that does not rely on the Pareto assumption. Table 4 presents the mean difference in log ranks for books where the prices are lower at Amazon than at BN.com, the same as at BN.com, and greater than at BN.com. In the pooled sample and in every period individually, when the relative price is lower at Amazon, the sales ranks also tend to be lower (meaning greater sales). In August of 2001, for example, among books whose prices were higher at Amazon than at BN.com, Amazon's sales ranks averaged about 31 percent higher than at BN.com. For books whose prices were the same at the two sites, Amazon ranks were less than 1 percent lower than BN.com's. Among books whose prices were lower at Amazon, the sales ranks at Amazon were about 61 percent lower than at BN.com.

The analysis relies on the assumption that the universe of available books is the same at both sites. If one site had many fewer books, ranks would tend to be higher at that site (that is, rank numbers would be lower). However, we do find that our results are robust to restricting the sample to books which rank above 75,000 at both sites. As both sites purport to have relatively comprehensive catalogs, it seems unlikely that, in the range of relatively popular books, the sites differ much in their selection.

¹² For simplicity we refer to the dependent variable as the log rank rather than being more precise and calling it the log of the sales rank minus one which we use in the empirical work.

In column 1 of Table 5, we present a probit specification. The dependent variable takes the value of one if the sales rank at Amazon is higher than the sales rank at BN.com (note: higher ranks correspond to lower sales). The independent variables are the relative price at Amazon (P^A/P^B) and time dummies. The coefficient on the relative price shows a large and statistically significant positive coefficient. That is, when Amazon.com has relatively higher prices, it has relatively higher ranks (lower sales).

To compute a price elasticity, however, we invoke the Pareto assumption. Because the sales rank data are censored at BN.com, we estimate equation (3) using the trimmed least absolute deviations (LAD) panel estimator of Honore (1992). The Trimmed LAD is used due to the difficulty with and inconsistency of a Tobit estimator with a large number of unit fixed effects (but a small number of time periods). Because we don't know the exact censoring point, we used the largest observed rank at BN.com in the sample. We treat Amazon.com observations as uncensored.

The results are reported in columns (2)-(4) of the table. The dependent variable is the sales rank. The explanatory variables included in the regression are the price, a site dummy, availability dummies (i.e., ships in 24 hours, 2-3 days, and so on) and dummies for each individual book title. Including dummies for individual book titles is crucial. This ensures that our identification derives from the differences in prices of the same book across sites.

The top panel uses prices without shipping charges. As there are numerous shipping choices (ground, air, priority, FedEx) and the prices depend on how many books one orders according to a two-part tariff, it isn't clear what shipping price to use. The lower panel uses prices that include the incremental shipping charge if a person was adding this as a second book to their order. This was 99 cents at both sites in period 1, zero at Amazon and 99

cents and BN.com in period 2, and then zero at BN.com and 99 cents at Amazon in period 3. The results do not differ much between the two (nor with other choices of the shipping price), so we will not include shipping in the subsequent regressions.

All price coefficients are highly significant and in the range of 2.1 to 2.5. With our mean estimate of the Pareto shape parameter, this indicates an elasticity -2.5 and -3. In words, this says that a one percent increase in the price of a book at site A relative to site B reduces sales at A by 2.5 to 3 percent relative to sales of that book at site B.

C. Empirical Results: Panel Results

The relative price elasticity above is notably large, suggesting the importance of competition. To break out the own- and cross-price components of this number, however, requires variation in prices across time. To get such variation, we use pairs of time periods for each site. One reason to do this is that we can then use trimmed LAD estimation to allow for the censoring problem with the Barnes and Noble data.¹³ A second reason to do this is that it gives us a closer look at Amazon's pricing changes the summer of 2001. We present these results for three cases—the change in log ranks between periods 1 and 2, the change in log ranks between periods 2 and 3 and the “long-difference” estimator comparing the change in log ranks between periods 1 and 3. The BN.com results use the trimmed LAD.

Table 6 presents the results. Interestingly, the sum of the own price elasticity at each site plus the cross-price elasticity at the other site do approximately equal the same value (as assumed in our specification of equation (3)). However, this conceals an extreme difference in the source of the relative price sensitivity across the two sites. BN.com has a

¹³ Trimmed LAD estimation panel procedures for data sets with more than two time periods are not well-developed. The survey of Chay and Powell (2001), for example, present trimmed LAD results only for pairs of time periods rather than for the entire panel.

large own price elasticity with a small cross-price from Amazon. Amazon has the reverse. With the Pareto parameter of 1.2, BN.com's own-price elasticity of demand is around -3.5. At Amazon, on the other hand, it is actually less than one in absolute value, at -0.45.

The low price elasticity of demand at Amazon is important and puzzling. Of course, standard calculations for static imperfectly competitive markets suggest that a firm should choose prices such that the elasticity of demand exceeds 1 in absolute value. However, we are not the first to obtain results estimates of relatively inelastic demand for retail establishments. For example, Hoch et. al. (1995) estimate store-level price elasticities of demand of less than 1 in absolute value for many stores in the Dominick's supermarket chain. Note, however, that a firm maximizing dynamic profits might choose a price below this static profit-maximizing level.¹⁴ Prices below the single-period profit-maximizing level would be attractive in a growing market with consumer switching costs, for example. This possibility has been raised in the popular press, where speculation abounds as to whether Amazon's prices are sustainable or are artificially low (see, for example, Hansell, 2001). When Amazon's growth stops, we may see prices rise substantially.

A second factor to consider is that a one percent increase in the price at Amazon reduces quantity by about 0.5 percent at Amazon but raises quantity at BN.com by 3.5 percent. Given that Amazon sells somewhere between 3 and 10 times as many books as BN.com, this is very close to the same number of books, implying that every customer lost by Amazon instead buys the book at BN.com. This is likely to be an unrealistically high degree of switching but the data, at the least, seem to suggest that the cross-price effect is important. The reverse is not true, however. Raising prices by one percent at BN.com reduces sales about 4 percent but increases sales at Amazon by only about 0.2 percent.

¹⁴ See Klemperer (1987) and Chevalier and Scharfstein (1996) for discussion.

Many of the lost customers from BN.com evidently do not just go buy the book from Amazon.

Recall that previous research on Internet bookselling has used price dispersion as a proxy for market power. Recalling Table 3, we showed that price dispersion between sellers is quite volatile over the three time periods. Using the price dispersion data to infer market power would lead one to have differing conclusions about the degree of market power for each of the three periods. However, when we use our “quantity” data to estimate price elasticities, we observe very little change in the price sensitivity/market power of the two merchants across the different time periods, despite large shifts in the measured dispersion.

We checked the robustness of the trimmed LAD estimator in Table 7. There, we rerun the specifications for BN.com, using OLS in place of the trimmed LAD. We drop observations for which the sales rank is unobserved. These estimates echo the large own price elasticities for BN.com, but show much smaller cross price elasticities of BN.com with Amazon.com.

We also checked the robustness of our results across books of different types and found little difference in the panel specifications of including category-price interaction terms. Table 8 shows the “long difference” panel specifications for both Amazon and BN.com, allowing fiction and non-fiction books to have different own- and cross-price elasticities of demand. While fiction books appear slightly more own- and cross-price elastic in both sites’ specifications, differences in the coefficients for fiction and non-fiction books are not statistically different from one another. Across our specifications, there was little evidence that the price elasticity of demand varied systematically by type of book. We tried many categories of books as well as formats. All showed the same basic results.

VIII. Impact on Valuation

While the elasticity data do provide insights into valuation, we cannot, unfortunately, directly translate the elasticity estimates into projections for future margins. Our results, however, suggest that future margin growth for Amazon may be higher than future margin growth for Bn.com, assuming customer behavior does not change. It may be instructive to consider valuing Amazon and Bn.com using different assumptions about future margins, to illustrate the importance of their future margin prospects being different. Consider the valuation model proposed by Damodaran (2000). Damodaran provides a web site in which users can input current accounting data, projections about future growth rates of revenues, and projections about the steady-state margins that the firm will enjoy. For illustration, we input Compustat end-of-year 2001 accounting data for Amazon.com and Barnesandnoble.com into Damodaran's spreadsheets. Table 9 reports reports per-share values of Amazon.com and Barnesandnoble.com on March 1, 2002, around the time the annual financial figures for Amazon.com and Barnesandnoble.com for 2001 would be fully available.

In order to obtain valuation figures, we have to make a number of assumptions. First, for both firms, we assume a variety of growth rates in revenues over the next 10 years, with revenues reaching a steady-state growth rate of 5% per year beginning in the 11th year. We assume that each firm will maintain a constant level of sales to capital of 3. This choice is rather arbitrary, and could be quite important, as pointed out in Damodaran (2000). If the Amazon can economize on capital relative to bn.com, or Bn.com can share assets with the brick and mortar Barnes and Noble stores, this assumption will be flawed, and will affect the relative valuations of the two firms. For assumptions other than the growth rate of revenues and the level of margins, we adopt the default assumptions in Damodaran (2000). In order to highlight the role of margins, we use the actual 2001 accounting data for each of

the two firms, and make common assumptions for the two firms about the equity premium, firm beta, expected cost of debt, etc. We ignore the effects on valuation of any outstanding options. Inputs are available from the authors on request.

The results are reported in Table 9. The first thing to note is how wildly sensitive valuation estimates are to the sales margin input. At the time these accounting data were released, on March 1, 2002, Amazon.com had a per-share price of \$15.39, while bn.com has a per share price of \$1.44. Assuming growth rates of revenues of 10% per year for the first 10 years, one cannot achieve the \$1.44 BN.com share price without pushing the steady-state margins to below 5%. Of course, as the assumed margin gets lower, the valuation estimate becomes increasingly insensitive to the revenue growth rate chosen. For Amazon.com, assuming growth rates in revenues compounding 10% per year for the first 10 years, Amazon's per-share value of \$15.39 can only be reached by assuming that profit margins approach 15%.

IX. Conclusion

This paper has used publicly available data on the prices and sales ranks of more than 18,000 different books at Amazon and BN.com to estimate price indices and the amount of price competition online. To do this, we develop a method of converting sales ranks into actual quantity measures for every book. The results show that there is significant price sensitivity of online customers both to a site's own price as well as to leading rival's price. This is much more true at BN.com, however, where the own price elasticity of demand is close to -4 and the cross-price elasticity very high, than at Amazon where the price elasticity is around -0.6, and the cross-price elasticity is relatively small. The results also show that using price dispersion as a proxy for market power is not appropriate in our data.

Taken together, our results point to Amazon as a clear market leader in the online book business with BN.com serving as more of a price-taking fringe. The usefulness of the sales rank data in allowing us to actually estimate the degree of market power in markets with little publicly available quantity data raises the question of whether similar information could be gathered for other industries. Of course, our particular technique for turning ranks into sales is specifically applicable only in situations in which sales rank data are available while quantity data are not. However, more generally, one could use very similar distributional assumptions and data-gathering techniques to transform other web-gathered measures, such as page view data, web counter data, or site visit data into sales proxies.

Using a borrowed rough and ready valuation technique from Damodaran (2000), we illustrate that differing assumptions about the future margins to be earned by Amazon.com and barnesandnoble.com are likely factors in the widely different valuations of the two firms implied in the market.

Table 1: Valuation and accounting data

	12-Feb-2003	2002			
	Market cap	Net sales	Gross profit	SG&A	Total Op Ex
AMZN	7,683,000	3,932,936	992,618	812,516	928,494
BMDV		1,873,291	527,542		
Non-BMDV		2,059,645	465,076		
BNBN	172,727	422,827	95,569	167,304	170,841
(‘000 omitted)					
AMZN/BNBN	44.48	9.30	10.39	4.86	5.43

Notes: SG&A are sales, general and administrative expenses. BNBN is barnesandnoble.com, AMZN is Amazon.com. BMDV denotes the books, music, DVD and video segment of Amazon.com. The last row shows the Amazon data divided by the barnesandnoble.com data.

Table 2: Prices and Price Indices

	BN.com Price	Amazon Price
Books Equally Weighted (% discount)		
April 14, 2001	\$24.23 (11.3%)	\$23.58 (15.4%)
June 23rd, 2001	\$24.39 (10.9%)	\$26.75 (2.1%)
August 3rd, 2001	\$24.51 (10.6%)	\$22.26 (19.2%)
Books Equally weighted, including shipping		
April 14, 2001	\$25.22	\$24.57
June 23rd, 2001	\$25.38	\$26.75
August 3rd, 2001	\$24.51	\$23.25
Books Weighted by Sales (% discount)		
April 14, 2001	\$13.09 (34.9%)	\$14.32 (26.1%)
June 23rd, 2001	\$13.24 (34.0%)	\$15.72 (18.4%)
August 3rd, 2001	\$13.12 (33.4%)	\$15.25 (29.7%)
Books Weighted by Sales, including shipping		
April 14, 2001	\$14.08	\$15.31
June 23rd, 2001	\$14.23	\$15.72
August 3rd, 2001	\$13.12	\$16.24
Price Index within Period, Across Site		
April 14, 2001	100.0	96.7
June 23rd, 2001	100.0	103.4
August 3rd, 2001	100.0	95.3
Price Index within Site, Over Time		
April 14, 2001	100.0	100.0
June 23rd, 2001	100.7	109.5
August 3rd, 2001	98.6	105.3

Notes: Authors' calculations as described in the text. When shipping is included, it is marginal shipping assuming the customer is buying this as their second book. Sales weights in the second panel are current period sales estimated using a Pareto shape parameter of 1.2 as described in the text.

Table 3: Price dispersion between Amazon and BN.com

	Price dispersion
April 14th, 2001	0.081 (0.104)
June 23rd, 2001	0.095 (0.108)
August 3rd, 2001	0.123 (0.130)

Notes: Authors' calculations. Price dispersion calculated as $2(|\text{Price}_{\text{AMZN}} - \text{Price}_{\text{BN}}|)/(\text{Price}_{\text{AMZN}} + \text{Price}_{\text{BN}})$. Standard deviation in parentheses.

Table 4: Relative Sales Ranks Across Sites as a Function of Relative Prices Compares ranks as a function of the relative prices of observations at Amazon.com and BN.com.

	$P_{AMZN} > P_{BN}$	$P_{AMZN} = P_{BN}$	$P_{AMZN} < P_{BN}$
Number of Books	10,089	13,297	12,602
Avg. $\ln(\text{Rank}_{AMZN}) - \ln(\text{Rank}_{BN})$			
<u>Pooled:</u>	-0.017	-0.225	-0.627
<u>By Week:</u>			
April 14th, 2001	0.232	-0.142	-0.662
June 23rd, 2001	-0.151	-0.569	-0.580
August 3 rd , 2001	0.313	-0.008	-0.607

Notes: Authors' calculations. Negative values indicate lower ranks (i.e., higher sales) at Amazon.

Table 5: Cross-Sectional Evidence on Price Sensitivity of Demand.

	(1) Probit of $\text{Rank}_{AMZN} > \text{Rank}_{BN}$ Pooled	(2) Trimmed LAD April 14, 2001	(3) Trimmed LAD June 23, 2001	(4) Trimmed LAD August 3, 2001
$\ln(P_{AMZN}/P_{BN})$	2.573 (.055)			
$\ln(P)$		2.135 (0.080)	2.550 (0.105)	2.124 (.068)
Shipping Dums	No	Yes	Yes	Yes
Amazon Dum.	No	Yes	Yes	Yes
Time Dummies	Yes	No	No	No
ISBN Dummies	No	Yes	Yes	Yes
n	34,156	33,650	27,094	30,638
$\ln(P + \text{Shipping})$		2.276 (0.085)	1.919 (0.095)	2.458 (.069)
Shipping Dums		Yes	Yes	Yes
Amazon Dum.		Yes	Yes	Yes
Time Dummies		No	No	No
ISBN Dummies		Yes	Yes	Yes
n		33,650	27,094	30,638

Notes: Dependent variable in column 1 is the {0,1} variable of whether the rank is higher at Amazon than at BN.com. Dependent variable in columns 2-4 is the log of the rank. This is censored as described in the text. Standard errors are in parentheses.

Table 6: Two period panel estimates of online book demand system

Dep Var.: ln(Rank)	(1) t_2, t_1	(2) t_3, t_2	(3) t_3, t_1
<u>BN.COM (trimmed LAD)</u>			
ln (P_{own})	4.396 (0.182)	2.985 (0.128)	2.894 (0.128)
ln (P_{cross})	-3.825 (0.181)	-2.403 (0.128)	-2.696 (0.114)
n	24738	24738	24738
Shipping dummies	Yes	Yes	Yes
Time x age dummies	Yes	Yes	Yes
ISBN dummies	Yes	Yes	Yes
<u>AMAZON (OLS)</u>			
ln (P_{own})	0.262 (0.032)	0.256 (0.048)	0.371 (0.050)
ln (P_{cross})	-0.047 (0.090)	-0.131 (0.081)	-0.189 (0.073)
n	24738	24738	24738
R-squared	0.97	0.97	0.96
Shipping dummies	Yes	Yes	Yes
Time x age dummies	Yes	Yes	Yes
ISBN dummies	Yes	Yes	Yes

Notes: The dependent variable is the log of the sales rank. This is censored as described in the text. Standard errors are in parentheses. The cross price is the price for the same book at the competitor's site. t_1 denotes April 14, 2001. t_2 denotes June 23, 2001. t_3 denotes August 3, 2001.

Table 7: OLS Robustness estimates for BN.com results.

Dep Var.: ln(Rank)	(1) t_2, t_1	(2) t_3, t_2	(3) t_3, t_1
<u>BN.COM (OLS)</u>			
ln (P_{own})	2.399 (0.076)	2.813 (0.074)	2.693 (0.080)
ln (P_{cross})	0.232 (0.045)	-0.222 (0.029)	-0.774 (0.054)
n	19126	20106	19142
Shipping dummies	Yes	Yes	Yes
Time x age dummies	Yes	Yes	Yes
ISBN dummies	Yes	Yes	Yes

Notes: The dependent variable is the log of the sales rank. The data include only those observations in which the BN.com sales ranks are available. Standard errors are in parentheses. The cross price is the price for the same book at the competitor's site. t_1 denotes April 14, 2001. t_2 denotes June 23, 2001. t_3 denotes August 3, 2001.

Table 8: Two period panel estimates of online book demand system by book type

Dep Var.: ln(Rank)	(1) Amazon	(2) BN.com
<u>Time periods t_3, t_1</u>		
ln (P_{own}) Fiction	0.491 (0.129)	3.732 (0.471)
ln(P_{own}) Nonfiction	0.3469 (0.054)	3.142 (0.150)
ln (P_{cross}) Fiction	-0.419 (0.232)	-2.982 (0.489)
ln(P_{cross}) Nonfiction	-0.160 (0.078)	-2.482 (0.145)

Notes: The dependent variable is the log of the sales rank. This is censored as described in the text. Standard errors are in parentheses. The cross price is the price for the same book at the competitor's site. t_1 denotes April 14, 2001. t_2 denotes June 23, 2001. t_3 denotes August 3, 2001.

Table 9: Valuation estimates for Amazon.com and barnesnoble.com as of FY ending 2001 accounting data.

AMZN per share valuation

	Growth rate of revenues for first 10 years		
Steady state margin	10%	15%	20%
5%	\$2.32	\$3.53	\$5.29
10%	\$9.44	\$13.87	\$20.31
15%	\$16.49	\$24.20	\$35.85
20%	\$23.54	\$34.52	\$50.42

AMAZON ACTUAL SHARE PRICE 3/1/02: \$15.39

BNBN per share valuation

	Growth rate of revenues for first 10 years		
Steady state margin	10%	15%	20%
5%	\$1.55	\$1.81	\$2.20
10%	\$3.40	\$4.50	\$6.00
15%	\$5.22	\$7.15	\$9.96
20%	\$7.03	\$9.80	\$13.82

BN.COM ACTUAL SHARE PRICE 3/1/02: \$1.44

Note: Valuation methodology uses FY 2001 accounting data and spreadsheets from Damodaran (2000). Assumptions inputting the valuation are described in the text. The margin is the profit margin on goods sold that the firm will eventually earn. The growth rate in revenues describes how fast the company is assumed to grow per year for the next ten years.

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