Beyond the Hype of Frictionless Markets: Evidence of Heterogeneity in Price Rigidity on the Internet

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Journal of Management Information Systems / Fall 2005, Vol. 22, No. 2, pp. 57–89.

0742–1222 / 2005 $9.50 + 0.00.

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ABSTRACT: We explore daily patterns of Internet pricing for the two major retailers, Amazon.com and Barnes and Noble (BN), using data on 377 books collected over a 449-day period in 2003–4. We frame this investigation in terms of a key question: How rigid are prices on the Internet? Are there reasons to suggest that prior predictions of more flexible prices on the Internet may not have been founded on the appropriate theoretical knowledge? We find that Internet retailers, in contrast with traditional firms, adjust prices any day of the week throughout the year. Yet firms' price adjustments for books occur much less frequently than daily—every 90 days on average. For most observers of Internet-based selling, this is surprising, because most expect more frequent price adjustments—based on the quality of technological environment that supports price-setting. In fact, our results show that price-change activity appears to vary by book category, from a high of one change, on average, every 61 days for best sellers to a low of one change every 184 days, on average, for steady sellers. In addition, we learned that individual firms exhibited different patterns for their price changes: Amazon changed book prices every 222 days, whereas BN changed its book prices more frequently, every 56 days on average.

KEY WORDS AND PHRASES: bookselling, e-commerce, economic analysis, empirical research, empirical regularities, Internet retailing, price rigidity, strategic pricing.

PRICE RIGIDITY, THE INABILITY OF FIRMS TO ADJUST PRICES, has been a topic of long-standing interest for researchers studying firms, industries, and the economy as a whole. For example, it occupies a central stage in the research agenda of new Keynesian macroeconomics [14, 18, 54] and industrial organization [24, 57].[1] This is in stark contrast to the traditional assumption that firms flexibly adjust prices, which lies at the heart of classical economic models in microeconomics, and in many areas of business such as finance, marketing, and strategy.

Yet, as Carlton states, whether "price rigidity is efficient, one common conclusion emerging from models with price rigidity is that markets with rigid prices behave very differently than markets with flexible prices. Therefore, an important unanswered question is: Just how rigid are prices? Despite the great interest in this question, there have been virtually no attempts to answer it with data on individual transaction prices" [23, p. 637]. Many authors, such as Cecchetti [25], Dutta et al. [32], Kashyap [39], and Warner and Barsky [62], echo the need for more micro-level studies of price adjustment using actual retail transaction prices of firms. As Lach and Tsiddon suggest, retail transaction prices "most closely resemble the data envisioned by the cost of adjustment theory: price quotations at the level of the price-setter" [44, p. 351].

In traditional markets, there are a number of micro-level settings that have been of special interest to researchers, who have revealed rich and varied theoretical knowledge about price adjustment. Some of the contexts that have been studied in terms of price adjustment include product quality [1], inventory policies [3], crude oil price changes and gasoline prices at the service station pump [19], wholesaler contracts [22], banking and financial services [38], and grocery stores [52]. The weight of these studies suggests that there has been no single reason for either price adjustment or price rigidity, but rather a variety of useful theories to explain what has been observed.

The Internet offers opportunities to inform our understanding of *digital price rigidity* and the nature of price adjustment in three fundamental ways. First, the Internet provides a unique context for the micro-level study of price-setting behavior and strategies. As of the late 1990s, when the hype around electronic commerce crested, it was commonplace in discussions among academic researchers to hear observations about how information technology (IT) was changing industry practices in strategic pricing. In fact, some of the most influential papers of that time, including Bakos [12, 13] and Brynjolfsson and Smith [21], adopted this general perspective—that pricing is likely to be frictionless on the Internet. This suggested applying pricing models that were financial-market–like—the strategic pricing equivalent of Clemons et al.'s [31] "market technostructure"—providing the functionality of the stock markets in firms' ability to adjust prices. Others pointed to the technology-enabled practices associated with revenue yield management and financial risk management. Indeed, the inexorable trend toward the "financification" of the strategic pricing function in the firm was well under way.

But sometime in 2001 and 2002, the weight of the discussion and debate seemed to shift to *pricing frictions* in e-commerce—in spite of the revolutionary, powerful, and new capabilities of IT in support of the firm to adjust prices. Paralleling this new direction for the discussion of pricing on the Internet, we also saw another debate move in an unexpected direction: from disintermediation of traditional firms by Internet firms in e-commerce to reintermediation by traditional firms, ultimately leading to the demise of many Internet firms [42]. As a result of these developments, some observers of e-business and the changing digital economy have called for renewed efforts to discover useful theoretical knowledge and establish normative guidance for senior managers.

In this context, research on Internet markets has increasingly focused on micro-level price adjustments, and it has also sought theoretical explanations for what has been observed. Some of the settings that have been studied include Internet-based automobile retailing [50], mortgage markets [6], e-bookselling [27, 28, 29, 43], insurance markets [20], and electronics markets [15]. The primary tension that exists in the current literature involves how to provide theory-driven explanations to support the belief that prices on the Internet ought to be more flexible and more often adjusted, as opposed to the belief that there are underlying drivers of rigidity.[2]

Second, firms may adjust prices differently on the Internet than in traditional commercial settings, and being able to detect this kind of behavior may change our conventional wisdom about price rigidity. Many observers have commented that physical price-adjustment costs are almost entirely absent in e-commerce because they primarily consist of the costs of simple database updates, which may be easily programmed [9, 21]. This suggests that Internet-based retailers have the capability through the intensive use of technologies to adjust prices more flexibly than traditional retailers, almost as in financial markets (e.g., foreign exchange and equity trading), where pure supply-and-demand relationships rule.

More broadly, IT has changed the process by which strategic pricing decisions are made and implemented in business operations, so there is a need to develop substantial managerial understanding of these new firm pricing technologies. In the 1990s and earlier, technology-driven pricing was largely the domain of the airlines, which implemented powerful revenue yield management practices. Hotel chains and rental car companies did the same. The technologies of that pre-Internet era, combined with powerful underlying data capture and online real-time capabilities, took advantage of advanced knowledge in economic modeling and marginal value-based price discrimination approaches to effectively implement pricing structures (e.g., the number of consumer segments and advance purchase requirements), as well as to make day-to-day adjustments in "demand bucket" prices in response to shifting demand patterns and shocks. Today, we have the same kinds of technologies available in many other price-setting contexts. As a result, now it is possible for bricks-and-clicks firms—and even traditional retailers—to implement systems that permit significant adjustments to be made to prices in situations where menu costs previously made rapid price changes uneconomical [41].

Third, the ability to access transaction price data using software agents now allows researchers to explore pricing and price adjustment patterns quasi-experimentally at a previously unimaginable level of micro-economic detail [2]. Although this kind of data has been used to study other aspects of pricing, such as price dispersion [9, 27, 30], price levels [21, 28] and price-setting behavior [29, 43], there are still only a few studies that have focused on price adjustment and price rigidity in e-commerce [40, 41, 51].

In this research, we explore price rigidity and price adjustment patterns at a micro-level of analysis, by focusing on the daily patterns of Internet pricing for two major Internet book retailers: Amazon.com and Barnes and Noble (BN). We analyze data collected over a 449-day period in 2003 and 2004 for 377 books sold on the Internet.

We obtained a number of interesting findings: (1) unlike traditional retail outlets, prices are adjusted fluidly on any day of the week throughout the year; yet (2) price adjustment by firms occurs less frequently than daily, with prices changing for a book in our sample every 90 days on average; (3) price-change activity varies by category for books, from a high of one change every 61 days for best sellers to a low of one change every 184 days on average for steady sellers; and (4) Amazon changes prices significantly less frequently than BN. Specifically, we find that Amazon changes prices on a book every 222 days, whereas BN does so every 56 days on average. These findings suggest that the Internet changes the way firms adjust prices, providing new evidence to inform our understanding of how rigid prices are in electronic commerce. Moreover, there still seems to be a role for market forces to play in price adjustment—even for Internet retailers. This suggests a different basis for interpreting how price rigidity works from observations of price dispersion on the Internet.

Data Collection and Data

WE USE PRICE-RELATED DATA COLLECTED from multiple Internet sites, including a price comparison site, BestWebBuy.com, and the two largest online book stores, Amazon and BN. Book specifications are represented by the International Standard Book Number (ISBN) of a book. Allen and Wu [2] offer useful guidance on various issues to be aware of to ensure that a representative sample is obtained when price comparison sites are used. They remind us that research designs involving software agent-based collection of data on the Internet may be subject to unexpected and systematic biases, insufficient data to support making specific comparisons, incomplete or incorrect data, and inconsistent updates and other irregularities that may diminish the reliability of empirical and model-based research findings.

In the present research, we used a combination of indirect observation, confirmatory observation, and collateral observation. *Indirect observation* in our context involved using a software agent to collect price and related data from a price comparison site, BestWebBuy.com. *Confirmatory observation* involved collecting similar price and other data from the Web sites of the Internet-based sellers, Amazon and BN, and then comparing them with the data obtained from indirect observation. *Collateral observation* involved obtaining different information from Amazon and BN that was not available to us based on indirect observation from BestWebBuy.com. This approach, we believe, helps to ensure that the reliability of this research is not materially harmed by some of issues with agent-based data collection that Allen and Wu [2] pointed out.

We are fortunate in that the bookselling market provides us with a setting where the products are identical. Such homogeneity rarely obtains for most other product categories. Thus, we were able to tailor our data collection approach so that the books in the price comparison samples are all identical. Books do not change in quality (i.e., they are nonperishable) and the market structure of bookselling was also stable during the time of our study. These characteristics are different from those in markets with perishable goods, such as the airlines, hotels, and rental car companies. The

latter involve supply and demand, so fare changes are dispersed and volatile to reflecting demand and capacity [55].

Since our focus is on issues related to price changes that occur at the product level, for the purposes of intragroup comparative analysis and sampling bias control, we grouped our price-change observations of 377 books into four broad subcategories: 89 *best sellers,* 79 *steady sellers* (e.g., famous literature, Nobel Prize or Pulitzer prize winners, the classics, etc.), 112 *new books,* and 97 *computer books.* The first three are standard classifications. We added computer books because they represent a popular category that is different than the other three, and an area in which we have some expertise. The total number of observations is 338,546.

Collecting the data involved different activities. From the list of books available at the price comparison site BestWebBuy.com, we generated a large sample of ISBNs belonging to the different subject categories using *stratified proportionate random sampling* [64]. With this list of ISBNs, we used a *price information gathering agent* to extract information for each book from BestWebBuy.com each day at 4:00 A.M. Our data cover March 31, 2003, to June 21, 2004, a 449-day period. For each book, we have panel data for *list price, selling price, publication date, book format* (hardback/paperback), and *total price* (including shipping costs) extending across stores and over time. We collected qualitative information, such as *consumer ratings* of the products and stores, the *number of reviews,* and *sales rank,* among others, from BestWebBuy.com, Amazon, and BN.[3] The price range of the book categories is $4.75 to $199.99, and mean values of different categories vary from $11.58 (steady sellers) to $37.70 (computer books). The Appendix provides an overview of the data: the overall sample (Table A1), data for the two retailers (Tables A2 and A3), and data for each product category (Tables A4–A7).

Results

WE NEXT ANALYZE THE PRICE-CHANGE DATA that we obtained as a means to establish the empirical regularities of observed price-adjustment behavior in the Internet bookselling market. This approach is common in economic studies involving very large data sets (e.g., financial market research, economic forecasting, and auction market performance) as a precursor to the exploration of existing theory and the development of new theory.[4] This analysis permits us to draw a number of conclusions about the price-adjustment behaviors of Internet-based booksellers, and the extent to which changing technological capabilities, the costs of price adjustment, and other considerations may affect what we observe.

Daily Price-Change Frequency Analysis

A natural starting point for our analysis is to examine the demographics of price-change activity for the books in our sample on a daily basis, as illustrated in Figure 1.

The total number of daily price changes was 3,778, for 8.41 price changes per day on average. With a total number of 377 books all carried by both Amazon and BN, on

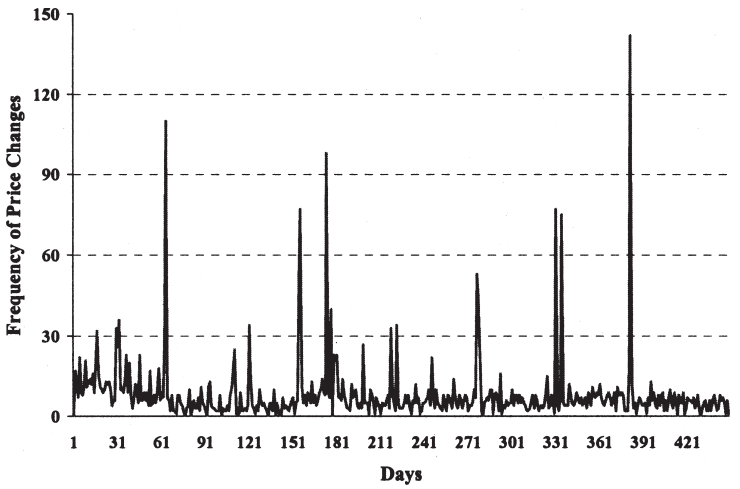

Figure 1. Frequency of Price Changes by Day.

Note: The data aggregate observations from Amazon and BN.

average, a book in a store in our sample changed price on the Internet about every 90 days (i.e., (377 * 2)/8.41).

We further note the days of the year (numbered according to the observation days in our data set) that represent the points in time for which the highest frequencies of price changes occur. April 15, 2004 (the income tax deadline), had the highest frequency of price changes, followed by June 2, 2003 (around the time that the summer reading season begins and schools let out). Five of the top ten dates with the highest frequencies of price changes occurred in the first couple days of January, February, June, and September, as shown in Table 1. None of the top ten price-change days occurred in the Christmas holiday shopping season, or around other holidays, except the New Year's holiday period of January 1 and 2, 2004, which ranked seventh and ninth in our price-change data.

Another question is related to the price changes that are observed in other industries (e.g., Sundays and Mondays for groceries). Do price changes in e-bookselling appear to be orchestrated to focus attention on different days of the week (similar to announcements of new music recording releases on Tuesdays by Apple iTunes)? The data in Table 2 suggest that neither Amazon nor BN targets specific days of the week for price changes to encourage shoppers to cluster their purchases or make them wait for specific price-change announcements. Also, unlike physical stores, which have consumer peak-purchase activity-level staffing adjustments and use weekly promotions in newspapers to draw traffic, it appears that the Internet retailers whose data we collected are largely unmotivated to make pricing moves on any day relative to any of the others.

The only day of the week with less than 10 percent of all price changes is Sunday, at 8.8 percent. Others have as few as 12.4 percent and as high as 18.8 percent of all changes—a narrow band for daily shares of price changes. Since the number of

Table 1. Price Change Frequencies: Top Ten Days

Rank	Day	Date	Number
1	382	April 15, 2004	142
2	64	June 2, 2003	110
3	174	September 20, 2003	98
4	156	September 2, 2003	77
4	331	February 24, 2004	77
6	335	February 28, 2004	75
7	277	January 1, 2004	53
8	155	September 1, 2003	52
9	278	January 2, 2004	45
10	177	September 23, 2003	40

Notes: All data are from Amazon and BN. The day number represents the sequential order of daily observations in our data set.

Table 2. Price Change Frequency by Day of the Week

Day	Changes	Increases	Decreases
Sunday	334 (8.8)	209 (11.4)	125 (6.4)
Monday	468 (12.4)	211 (11.5)	257 (13.2)
Tuesday	711 (18.8)	397 (21.6)	314 (16.2)
Wednesday	535 (14.2)	241 (13.1)	294 (15.1)
Thursday	664 (17.6)	275 (15.0)	389 (20.0)
Friday	499 (13.2)	233 (12.7)	266 (13.7)
Saturday	567 (15.0)	271 (14.8)	296 (15.2)
Total	3,778	1,837	1,941

Notes: All data are from Amazon and BN. Column percentages (shown in parentheses) total 100 percent with some rounding errors.

observations by day is very large, all observed levels are likely to be statistically different. Even the day-by-day price increases and decreases appear to be balanced.

Based on these observations of the different price-adjustment patterns, we also performed a chi-square test and a likelihood ratio test to see if the observed patterns were significantly different by day of the week. The chi-square test compares the frequencies that we observe in the sample distribution with the frequencies that we expect to observe if the null hypothesis is true. The likelihood ratio test is an alternative to examine the independence of the observed and expected frequencies, based on maximum likelihood estimation. Table 3's results show that the price-adjustment pattern is significantly different by day of the week.

Daily Price Changes by Product Category

Another aspect of these data that is appropriate to explore is the apparent differences in price-changing behavior that Amazon and BN exhibit with respect to the four dif-

Table 3. Results of the Chi-Square Test

		By day of the week	
Statistics	Value	Degrees of freedom	Asymmetric significance
Pearson χ^2	177.4	6	0.000
Likelihood ratio	183.4	6	0.000

ferent book categories: best sellers, steady sellers, computer books, and new books. Tables 4 and 5 summarize the category demographics, and the top ten days with frequent price changes for the categories.

Best Sellers

The data for 89 best sellers indicate that a total of 1,321 price changes occurred, leading to 2.94 price changes per day, on average. With daily prices for 89 books obtained, on average, a book in our sample changes its price on the Internet every 61 days (i.e., (89 * 2)/2.94). In addition, we note that there are only six days in the study period for which the frequency of price changes rose above 20 per day, as shown in Figure 2.

Steady Sellers

The total number of price changes was 387, leading to 0.86 price changes per day, on average. With 79 different books studied, on average, a book in our sample changes prices on the Internet every 184 days (i.e., (79 * 2)/0.86), a longer interval than best sellers. In addition to the basic category demographics, we also see that daily price changes for steady sellers (i.e., "classics," works of Nobel Prize–winning authors, etc.) were not clustered on any single day of the year. In fact, there were no days with more than 10 price adjustments for the 79 steady sellers, based on Figure 3.

Computer Books

We also observed 1,096 price changes for the 97 computer books in our sample, resulting in about 2.44 price changes per day, on average. So, on average, a computer book in our sample has a price change on the Internet each 90 days (i.e., (97 * 2)/ 2.44). Interestingly, however, we see from Figure 4 and Table 5 that there were five daily observations with 30 to 65 price changes. This was unexpected.

New Books

In this category, the total number of price changes was 974, leading to 2.17 price changes per day, on average. With 112 new books studied, on average, new books

Table 4. Price Changes by Day of Week: Four Categories

Day	Best sellers	Steady sellers	Computer books	New books	Total
Sunday	145 (11.0)	37 (9.6)	84 (7.7)	68 (7.0)	334 (8.8)
Monday	201 (15.2)	47 (12.1)	112 (10.2)	108 (11.1)	468 (12.4)
Tuesday	211 (16.0)	62 (16.0)	236 (21.5)	202 (20.7)	711 (18.8)
Wednesday	211 (16.0)	67 (17.3)	110 (10.0)	147 (15.1)	535 (14.2)
Thursday	222 (16.8)	60 (15.5)	202 (18.4)	180 (18.5)	664 (17.6)
Friday	156 (11.8)	68 (17.6)	154 (14.1)	121 (12.4)	499 (13.2)
Saturday	175 (13.2)	46 (11.9)	198 (18.1)	148 (15.2)	567 (15.0)
Total	1,321	387	1,096	974	3,778

Notes: All observations were obtained from Amazon and BN. Column percentages (shown in parentheses) total roughly to 100 percent with some rounding errors.

Table 5. Top Ten Days for Price Changes: Four Categories

	Best sellers		Steady sellers		Computer books		New books	
Rank	Date	Number	Date	Number	Date	Number	Date	Number
1	September 1, 2003	52	January 1, 2004	10	April 15, 2004	65	April 15, 2004	37
2	September 20, 2003	45	June 2, 2003	8	February 24, 2004	59	September 20, 2003	36
3	June 2, 2003	44	September 2, 2003	8	February 28, 2004	57	September 2, 2003	35
4	April 15, 2004	35	January 2, 2004	8	September 2, 2003	33	June 2, 2003	26
5	May 1, 2003	24	November 3, 2003	7	June 2, 2003	32	January 2, 2004	19
6	April 29, 2003	22	November 7, 2003	7	October 15, 2003	17	September 23, 2003	17
7	April 16, 2003	18	January 3, 2004	6	January 1, 2004	17	January 1, 2004	15
8	April 30, 2003	16	Seven different		November 7, 2003	14	June 1, 2003	12
9	May 6, 2003	15	dates had five		Three dates had 13		February 24, 2004	12
10	June 1, 2003	15	price changes.		price changes.		February 28, 2004	12

Notes: The number of books by category is 89 best sellers, 79 steady sellers, 97 computer books, and 112 new books.

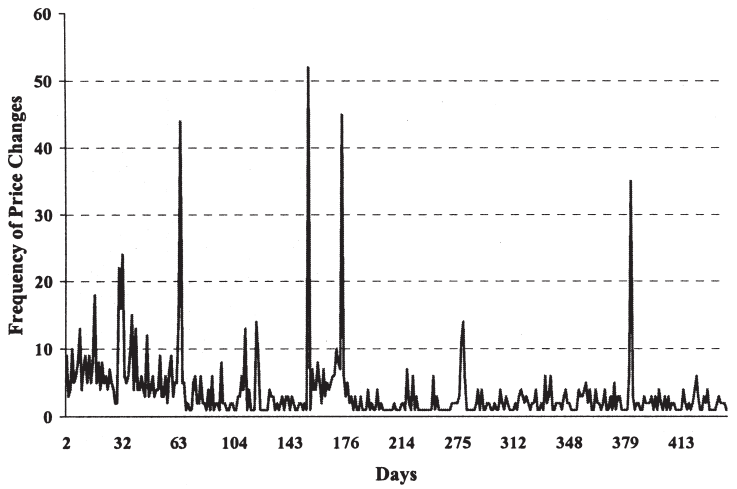

Figure 2. Daily Price Changes: Best Sellers.

Note: The data aggregate observations from Amazon and BN.

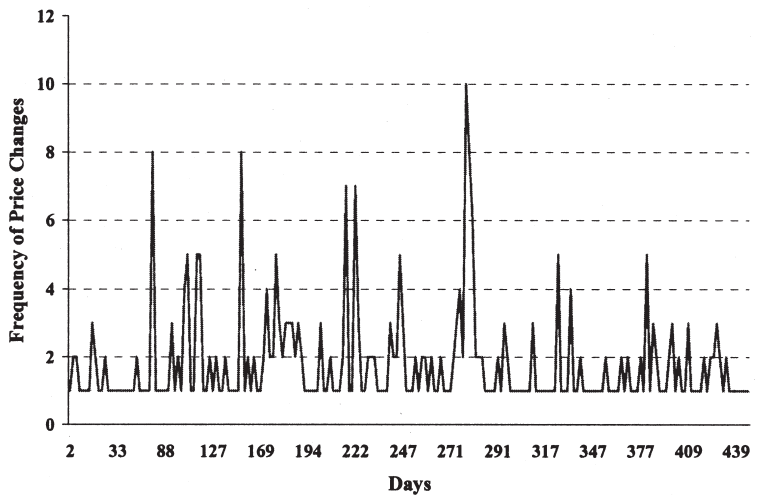

Figure 3. Daily Price Changes: Steady Sellers.

Note: The data aggregate observations from Amazon and BN.

changed prices on the Internet every 103 days (i.e., (112 * 2)/2.17). Similar to other categories, we see only a small number of dates where there is any significant concentration of price changes—between 12 and 37 price changes on no more than 10 different days of the study period. See Figure 5 and Table 5. We observe changes over many days of the year.

Another question is a comparative one: Which category appears to provide evidence of the greatest price rigidity? Table 6 compares the frequencies between the *observed price changes* and the *expected price changes* for the different book catego-

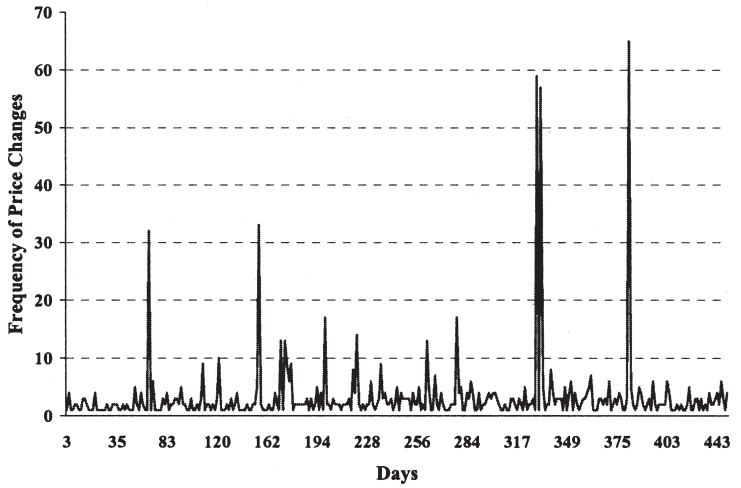

Figure 4. Daily Price Changes: Computer Books.

Note: The data aggregate observations from Amazon and BN.

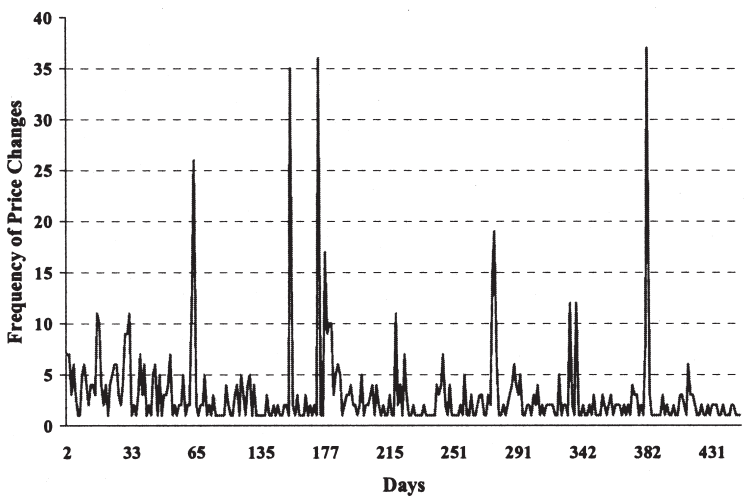

Figure 5. Daily Price Changes: New Books.

Note: The data aggregate observations from Amazon and BN.

ries. Expected price changes are defined as the total observed price-change frequency (i.e., 3,778) multiplied by the observed proportions of each category in total observations (e.g., 23.61 percent for best sellers). As expected, the difference between the observed frequency and the expected frequency in steady sellers (i.e., 387 – 791.7 = –404.7) is the lowest. This means that the prices of steady sellers are the most rigid. In contrast, the difference in best sellers is the highest (1,321 – 891.9 = 429.1). This means that the prices of best sellers are the most flexible.

Table 6. Observed/Expected Changes by Category

Category	Observations	Number	Price changes
Best sellers	79,744	Observed	1,321.0
(percentage)	(23.61)	Expected	891.9
Steady sellers	70,784	Observed	387.0
(percentage)	(20.95)	Expected	791.7
Computer books	86,912	Observed	1,096.0
(percentage)	(25.73)	Expected	972.1
New books	100,352	Observed	974.0
(percentage)	(29.71)	Expected	1,122.4
Total	337,792	Observed	3,778.0

Table 7. Results of Chi-Square Test by Book Category

		By book categories	
Statistics	Value	Degrees of freedom	Asymmetric significance
Pearson χ^2	453.8	3	0.000
Likelihood ratio	475.7	3	0.000

As before, we also performed chi-square and likelihood ratio tests to see if the price-adjustment patterns were different across the book categories. As reported in Table 7, the probabilities of the chi-square test statistic and likelihood ratio statistic are less than 0.001. Thus, there are different price-adjustment patterns that are statistically associated with different book categories.

Daily Price Changes by Retailer

We next consider the daily price changes of Amazon and BN separately, as shown in Figures 6 and 7.

Amazon

Amazon made 765 price changes overall, consistent with 1.70 price changes per day. With 377 books, a book at Amazon changes prices every 222 days, on average (i.e., 377/1.70). This is the greatest rigidity we observed in our sample—suggesting that Amazon changed book prices once every 7.5 months.

The observed range of the number of price changes peaked at about 137 price changes per day on April 15, 2004, as shown in Table 8, with the top 10 dates having from 14 to 137 price changes. The bulk of Amazon's price changes, based on Table 9, occurred on Wednesday, Thursday, and Friday (approximately 75 percent), whereas

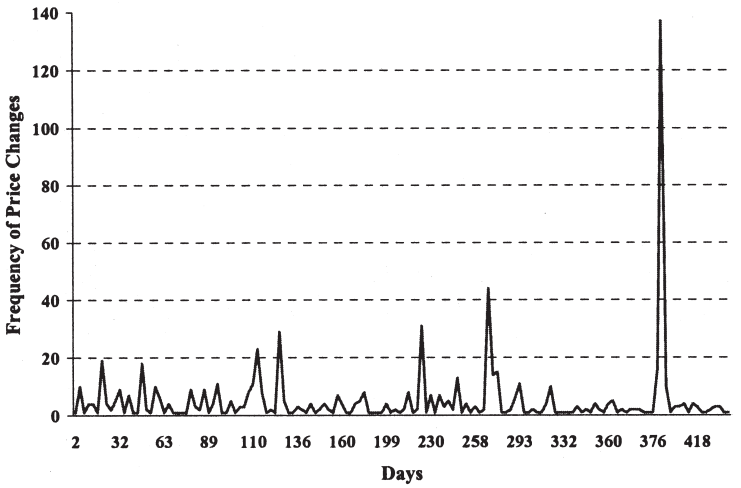

Figure 6. Daily Price Changes: Amazon

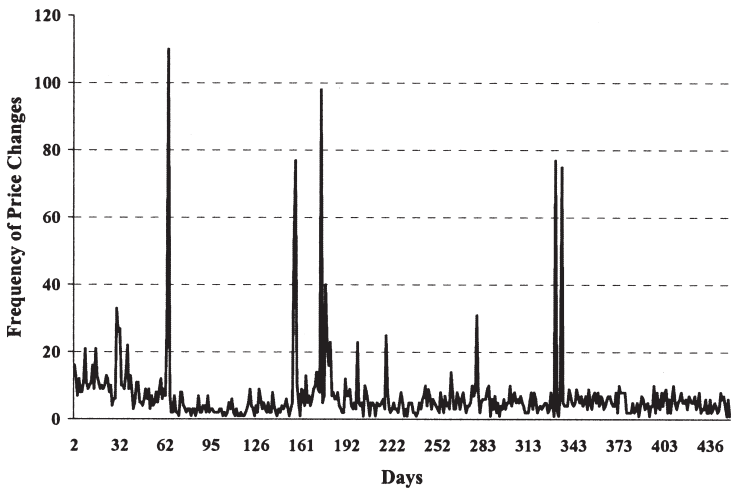

Figure 7. Daily Price Changes: BN

the remainder occurred on Sunday, Monday, Tuesday, and Saturday. This is in contrast to BN's price changes, which change by day of the week. BN has a more uniform distribution of price changes. All of the days, except Tuesday at 21.8 percent of all price changes, lie within a 10 percent to 15 percent band for changes.

Barnes and Noble

BN made 3,013 price changes overall, or 6.71 price changes per day on average. This suggests that, on average, a book at BN in our sample changes prices on the Internet every 56 days (i.e., 377/6.71), based on 377 books in the sample.

Table 8. Top Ten Dates for Price Changes in Study Sample: Amazon Only

Rank	Day	Date	Number
1	382	April 15, 2004	137
2	277	January 1, 2004	44
3	222	November 7, 2003	31
4	121	July 29, 2003	29
5	111	July 19, 2003	23
6	17	April 16, 2003	19
7	46	May 15, 2003	18
8	381	April 14, 2004	16
9	279	January 3, 2004	15
10	278	January 2, 2004	14

Table 9. Price Changes by Day of Week in Study Sample: Amazon and BN

Day	Amazon		BN	
Sunday	12	(1.6)	322	(10.7)
Monday	30	(3.9)	438	(14.5)
Tuesday	55	(7.2)	656	(21.8)
Wednesday	130	(17.0)	405	(13.4)
Thursday	303	(39.6)	361	(12.0)
Friday	137	(17.9)	362	(12.0)
Saturday	98	(12.8)	469	(15.6)
Total	765	(100)	3,013	(100)

Column percentages are shown in parentheses.

The top 10 dates for price adjustments ranged from a high of 110 changes on June 2, 2003, to a low of 27 price changes on May 1, 2003. According to Table 10, the price changes appear to occur at the ends or the middle of the month for about 70 percent of the observations. The remainder occur in the final two weeks of the month.

The most striking finding is how different the price-adjustment levels are between these two competitors. BN makes over four times as many price changes as Amazon (3,013 versus 765), suggesting that Amazon's prices are nearly four times more rigid than BN's (222 versus 56). As before, we also performed chi-square and likelihood ratio tests to see if the price-adjustment patterns are different across retailers. Table 11 shows that the probabilities of the chi-square test statistic and likelihood ratio test statistic are less than 0.001. Thus, there are different price-adjustment patterns that are statistically associated with these retailers.

Discussion

DUE TO THE DIFFICULTY ASSOCIATED WITH GETTING cost and demand data from firms, a number of previous studies measured price rigidity indirectly using price-change

Table 10. Top Ten Dates for Price Changes in Study Sample: BN Only

Rank	Day	Date	Number
1	64	June 2, 2003	110
2	174	September 20, 2003	98
3	156	September 2, 2003	77
4	331	February 24, 2004	77
5	335	February 28, 2004	75
6	155	September 1, 2003	52
7	177	September 23, 2003	40
8	30	April 29, 2003	33
9	278	January 2, 2004	31
10	32	May 1, 2003	27

Table 11. Results of Chi-Square Test by Retailer

		By retailer	
Statistics	Value	Degrees of freedom	Asymmetric significance
Pearson χ^2	1,352.74	1	0.000
Likelihood ratio	1,445.59	1	0.000

frequencies or magnitudes. The studies that reflect this measurement tradition in price-rigidity research include Carlton's [23] study on cross-industrial heterogeneity in price adjustments using the transaction-price data of Stigler and Kindahl [56], and Kashyap's [39] analysis of retail catalog-price rigidity. Warner and Barsky [62] similarly used survey data on retail in their study on the thick market effects. This phenomenon involves the counterintuitive tendency of firms to charge lower prices during periods of peak demand. This contradicts the rule of charging high prices when demand is high. Another related approach was used by Levy et al. [45], who measured the amount of time between price changes. Finally, Bils and Klenow [17] have argued in favor of using count and frequency data from the Bureau of Labor Statistics to gauge price rigidity. Thus, *price-adjustment frequency,* in general, has been shown to be a very useful proxy for the measurement of price rigidity: infrequent price adjustments tend to imply greater price rigidity.

We next discuss our results in terms of price changes by day of the week, our overall findings for price rigidity on the Internet related to this data set, the variations that we observe by book category, and price adjustments that Amazon and BN made during the study period. Both retailers faced similar underlying conditions of demand and supply in the periods that we studied in this research, even though consumer demand for books, especially best sellers, was changing during this period. Observed

variations in price-adjustment frequencies across the different book categories is evidence to indicate the extent of price rigidity. The same is true across the different retailers.

Price Changes by Day of the Week

Our results suggest that price changes are dispersed by day of the week over the entire sample. We saw just about equal rates of price changes each day of the week made by the leading Internet-based sellers. Our analysis of the top ten days with price-change activity shows that leading Internet booksellers have the ability to change prices any day. The top ten days of the week for price changes by both Amazon and BN appear to occur almost at random on Monday, Tuesday, Wednesday, Thursday, Friday, and Sunday; only Saturday is not represented. This is interesting in comparison to price-change activity in grocery chains. There, Sunday and Monday price changes made up nearly all of the planned price-change activity—96 percent of it—based on results for a supermarket chain studied by Dutta et al. [33]. (See Table 12.)

Also, grocery store owners who were able to obtain electronic shelf-pricing technology for their stores would use this technology to concentrate price changes all in one day of the week. This view is at odds with what we see with the leading Internet booksellers, who have similar technology. They use it to change prices throughout the week rather than to concentrate price changes on a single day or two days.

Clearly, changes in the underlying technologies that support the production of price changes at the level of the firms lead to changes in costs of adjustment. The daily price-adjustment flexibility that we report is consistent with the suggestion that physical price-adjustment costs are almost entirely absent in e-commerce [9, 21]. This flexibility also suggests that Internet markets have the capacity to be more fluid, with price changes more spread out over time to match market demand. So, we also expect that the new technologies will offer firms the possibility to be more flexible and efficient in the application of pricing strategy.

Price Rigidity on the Internet

Bailey [9] found that Internet retailers make significantly more frequent changes than traditional retailers for homogeneous products, such as books and CDs. Brynjolfsson and Smith [21] also observed that online retailers make price changes that are up to 100 times smaller than those made by bricks-and-mortars sellers. Given the reduced physical costs of adjustment on the Internet, and our results on daily price flexibility in this paper, we also expected to find less price rigidity for Internet booksellers in comparison with traditional bricks-and-mortar stores. But this is not what we found.

Overall, we noticed that price adjustment is not being done on a daily or weekly basis at the individual book level. For the 377 books in our sample, and given the average number of price changes per day, it appears that Internet-based booksellers change book prices on the order of every 90 days. Apparently, these booksellers are somewhat reluctant to change more than a few prices on any given day, despite the

Table 12. Daily Price Changes: Grocery Industry

Day	Price changes	Percent of total	Product categories
Saturday	72	2	General merchandise, advertisements
Sunday	2,271	53	Groceries, market
Monday	1,853	43	General merchandise
Tuesday	82	2	Groceries, advertisements

Notes: Data are from "Supermarket Chain A" in Dutta et al. [33, p. 697, table 4]. No price changes occurred on Wednesday, Thursday, and Friday.

fact that they have the available technological capability, and would not incur exorbitant operational costs to do it.

Further, based on the findings of Dutta et al. [33] related to price changes in supermarket chains, we observe that the level of price-change activity there is about twice as frequent compared to what we observed for Amazon and BN. In addition, Levy et al. [47] reported on the analysis of similar kinds of data from drugstore chains. Our estimates for the Internet booksellers are more consistent with what these authors observed for drugstore chains, which change prices about every 93 or 94 days. Amazon's prices appear to be somewhat more rigid than this, though. Still, our expectation is for heterogeneity in price-adjustment behavior across different Internet retailers, similar to bricks-and-mortar supermarket chains and drugstore chains.

Examining the monthly frequency of price changes for 350 categories of consumer goods and services from the Bureau of Labor Statistics for 1995 to 1997, Bils and Klenow [17] reported that the mean duration between price changes was less than five months. They also found that the duration between price changes for book categories was 5.1 months for books that were purchased through book clubs and 7.5 months for books that were not.

Thus, there appears to be more going on with price adjustment than just menu costs associated with making the price changes—even on the Internet. The Internet apparently does not necessarily reduce the related managerial costs for price changes. This may be due to integration efforts that firms make to get their operations in the Internet channel in sync with their efforts to sell in traditional channels [16]. Zbaracki et al. [65] presented evidence from industrial markets showing that the managerial costs are more than six times greater than the menu costs associated with price changes. A preliminary conclusion based on our results is that the Internet will change *some* of the observed patterns of price adjustment, but the technology may not affect other factors that are central to pricing decisions by firms. Blinder et al. [18], for example, point to a number of other theories that may explain why we see price rigidity continuing to occur in Internet-based bookselling. They include theories that are based on the nature of contracts, consumer demand, implicit contracts, underlying costs, market interactions, and imperfect and asymmetric information [41]. Thus, in spite of the new technologies that are available for e-commerce and the Internet, we still be-

lieve that there may be other theoretical explanations that will help to explain how firms actually approach making price adjustments on the Internet.

Price-Adjustment Variations by Book Category

Our results point out that the level of price adjustment varies by book category. Based on our results, the category with the most rigid prices is steady sellers, with a price-change rate of just 0.86 per day. This is followed by new books at 2.17 price changes per day and computer books at 2.44 price changes per day. The most flexible category for price changes is best sellers at 2.94 price changes per day. Yet the physical costs of price adjustment do not vary across these book categories. Again, this suggests that there is more to price adjustment than the menu costs of making the changes—even on the Internet.

These observed cross-category variations seem consistent with consumer demand-based and firm information-based arguments about the drivers of price adjustment, such as demand volatility. Steady sellers seem likely to have more stable, and better understood, demand structures than either new books or best sellers. Both new books and best sellers face markets with more unstable, changing demand, because best sellers are more affected by announcements and the "buzz" in the media (e.g., *New York Times* best-seller list, the many columns of leading book critics, and so on). Kauffman and Wood [43], in their study of the online bookselling industry, also found that the price of best-selling books may depend on booksellers' business rules for selling books. Moreover, new books have no sales history with which to baseline forecasts. Even computer books face more demand uncertainty because of technological changes and rapid technology obsolescence.

These cross-category results may also be related to other demand-based theories, such as the *thick market effect* reported by Warner and Barsky [62], or others reported in Blinder et al. [18] and Chevalier et al. [26]. Warner and Barsky [62] find strong empirical evidence of procyclical elasticity of demand just prior to the Christmas holidays and also on three-day holiday weekends. These thick market effects occur when consumers are engaged in more intense shopping or search activities, and when "missing the market" could be very costly for the seller in terms of overall annual revenue. This illustrates the will of firms to compete more aggressively on the basis of prices in markets with high demand, when there are also significant opportunities to generate revenues and earn a profit based on a high volume of sales. Chevalier et al. [26] provide contradictory evidence that prices do not fall during Thanksgiving or Christmas holiday seasons, however. Instead, they find significant procyclical pricing patterns over seasonal cycles due to retail margin changes. This is consistent with another approach that retailers are frequently seen to adopt: loss-leader strategies to ensure a position in the marketplace. *Loss-leader advertising,* for example, is a strategy in which retailers offer big discounts in order to attract customers for future profits once a market equilibrium involving fewer competing firms is achieved.

These results may also be related to other forms of costs of price adjustment beyond the physical costs, such as managerial and customer costs [16, 65]. These di-

mensions of the price-adjustment process have not been well recognized in the early papers on Internet price dispersion.

Variations in Price Adjustments by Amazon and BN

Perhaps our most interesting finding lies in the substantial differences that we observe for Amazon and BN in terms of their price-adjustment patterns. We learned that Amazon made 1.70 price changes per day, on average, for its books, consistent with any individual book's changing prices with a 222-day interval. In contrast, BN made 6.71 price changes per day on average, which is consistent with a much shorter 56-day interval.

This finding is hard to explain with the reduced physical costs of price adjustment that have been the primary focus in the literature to date. For example, do the costs of price adjustment vary between the two firms? If BN was held up by legacy systems that support its physical stores, then the price-change interval for this firm ought to have been the shorter of the two.

Still, what is not as clear is why this particular competitive pricing pattern has emerged between Amazon and BN. Our first reaction is that it will be necessary to understand what we observe in terms of explanatory theories that emphasize the competitive dynamics that are at play on the Internet. Clay et al. [28] cite price and nonprice factors that affect retailing strategy for online books. Kauffman and Wood [43] suggest possible follow-the-leader strategic pricing dynamics, where one of the players adopts a deliberately aggressive price-change leadership style, and others mimic their changes over time. Still others may ignore the price changes of competitors, such as BestBuy in consumer electronics for their bricks-and-mortar stores and on the Internet.[5]

There might also be an explanation based on managerial capabilities and costs. BN, as a later entrant to Internet-based selling, may have more strategic pricing expertise from its traditional store operations. This may allow BN to pursue a strategy of changing prices more frequently. Another explanation may lie in the negative media reports that resulted from Amazon's brief foray into computer-based price discrimination for its existing customers [53, 63]. The firestorm that erupted around that incident may have caused management to temper its approach to strategic pricing, to ensure that frequent price changes would not create impressions that the firm was shifting prices for its own advantage.

Another interpretation is due to Stiving and Winer [58], who argue that *image effects* transmit signals that enable consumers to infer something (in terms of "images") about a store based on price. So, a favorable impression of a store's quality might occur as a result of *high-price image* [49]. Blinder et al. [18] argue that firms are reluctant to decrease prices even in economic downturns for fear that customers may misinterpret the lowering of prices as a signal for a reduction in the quality of the product. So, prices are less flexible for high-priced, high-quality stores to sustain and signal their high-quality images.

Notice that the Internet gives consumers access to different information about products and firms than has ever been available before. Moreover, it has changed the

composition of firms in the marketplace, and the ways customers interact with Internet-based firms as well. In general, higher-quality firms tend to have higher product quality, higher service levels, more product assortment and support. But they may face higher costs and seek to achieve higher margins for their products, too. This leads to higher prices for higher-quality firms. Varian [60] predicted that Internet-based firms would be grouped into two types along these lines: those with low service levels and low prices, and those with high service levels and high prices. High-quality firms that signal the market with their higher prices are more sensitive to consumers' responses to the unexpected price changes. Baylis and Perloff [15] found evidence that the price-ranking of Internet-based firms selling electronics products (e.g., digital cameras and scanners) does not change frequently: high-price firms usually keep their prices high over long periods of time.

Conclusion

IN CONCLUSION, WE PRESENT THE OVERALL CONTRIBUTIONS of this research, consider some of its limitations, and identify a number of future directions for valuable interdisciplinary research on this topic that will yield new managerial knowledge about price rigidity and price adjustment in Internet-based selling.

Contributions

We found evidence that daily price adjustment on the Internet is more flexible than daily price-adjustment processes of traditional bricks-and-mortar retailers. The daily price flexibility that we observed is consistent with the reduced physical costs of price adjustment on the Internet, and so we view it as a logical consequence of the inclusion of more technology in the price-production process. This is similar, of course, to what we see in markets that involve revenue yield management for perishable goods, such as airline tickets, rental cars, hotel rooms, and the disposal of excess inventory and product supplies. Although this flexible pricing imperative is not nearly as operative in Internet bookselling—where the low physical costs of price adjustment make flexible pricing possible—the reader nevertheless should recognize that flexible pricing truly is an "upper bound." It will apply to the kind of behavior that we might observe in other contexts where the value of products that are sold via the Internet is not totally extinguished with the passage of a short amount of time.

Nevertheless, we still found pervasive patterns of price adjustment that cannot be explained by reduced physical costs of price adjustment—from levels of price rigidity better described in months than in days, to variations in price rigidity across product categories and retailers. These patterns appear to be driven in part by demand considerations, as suggested by the differences in average times to change book prices in different categories, though we have not been able to observe them directly. As well, they may be driven by other competitive considerations, including organizational capabilities, the sophistication of the competition, a firm's chosen price/qual-

ity/service profile in the market, among other possible considerations—all of which may provide a basis for a *variance theory of Internet-based price rigidity.*

If there is a key takeaway for the reader from this research, it is that the prices on the Internet appear to be more rigid than we ever might have guessed. Our results should "break the hype" that surrounds expectation of what Internet technology has done in strategic pricing. This single statement captures the "human-bites-dog" surprise value of our findings. In this research, we have posited at a high level that it seems likely that as long as the costs of price adjustments go beyond the bounds of the technologies that produce prices, the fluidity of daily price adjustments will hold across product categories, retailers, and industries. If, however, the costs of price adjustment are *more* managerial for certain sectors, markets, and firms—as Zbaracki et al. [65] have warned us—then the results that we obtained in this research are likely to provide an interesting basis for comparison across more sellers, more product categories, and more channels.

Indeed, we expect to see price rigidity and heterogeneous variations in this rigidity across products and retailers on the Internet. This is because current theories of price rigidity are unlikely to be *exclusively* cost-based, as we hinted earlier relative to Blinder et al.'s [18] work. Instead, we expect to see a number of theories that will be helpful in developing a sound understanding of price adjustment and price rigidity on the Internet. They include theories of competition, customer psychology, incomplete contracts, and systemic interconnectedness, for example. We believe that the forces that these theories posit will be operative on the Internet, just as they shape strategic pricing behavior in traditional retailing environments.

What should change, however, are the observed levels of rigidity, and the extent to which observations of price-adjustment variations will occur across firms and products. This is where a variance theory becomes important. We expect price-adjustment levels and variations to change and differ based on observable differences in competitor, customer, and firm characteristics in other markets that we have not studied in this research.

Limitations

Consistent with our idea of a variance theory of Internet-based price rigidity, the reader should consider a natural next question in this line of research: Will these results generalize to other product categories, and other retailers on the Internet? The present research was initially designed to identify a variety of high-level empirical regularities that characterize price changes and adjustments in Internet-based bookselling. So, due to the limitations of external validity associated with our chosen research design, at this point, we can only speculate on which aspects of our results will generalize across categories and retailers. We might guess, for example, that more established Internet-based sellers, or those that have greater brand recognition for their capabilities with order fulfillment and on-time delivery, will be able to sustain higher prices and be less responsive to the price changes of other firms that would lead to a Bertrand-style "one low price" market. Our results are consistent with this

kind of observation: Amazon, the first-mover firm among Internet booksellers, makes fewer price adjustments than its archrival, BN. However, we have no specific evidence that senior managers at either firm view their price-adjustment actions in the same competitive light. It may also be possible for some Internet-based sellers of electronic products (e.g., DVD players, digital cameras, PDAs, etc.) to adopt a similar approach. However, there, we would expect to see somewhat different pricing dynamics, due to the likelihood of nonstationary prices and to the rapid obsolescence of electronics goods [40].

A number of other limitations with the current study deserve discussion. First, we only examined data from a particular window of time, rather than a longer time line of price changes with even more data behind them. This may cause our results to be "pinned" by the specific competitive dynamics that were in operation during the time frame that we studied. Second, we also did not examine any issues associated with the possibility of nonstationary price trends over time [7], and their potential effect on price-change behaviors and price rigidity [32]. Nonstationary prices may occur, for example, during holiday seasons (when prices may either go up or down, depending on the competitive dynamics) or in the presence of products that tend to become obsolete or diminish in value over time (e.g., popular best sellers or computer books that cover the "last generation" of a software tool or operating system) [43].

A third limitation that may occur to some readers comes with our choice in this research of the Internet-based bookselling sector. Nevertheless, over the past seven or eight years, marketing and information systems (IS) researchers have learned a tremendous amount from empirical research in this context. The topics and coverage include strategic pricing and price adjustment on the Internet [4, 27, 28], the operation of the secondhand and used book market [35, 36], the application of collaborative filtering and customer personalization tools [48, 61], economies of scope for selling via branded and trusted Web sites [8], and so on.

A fourth limitation of this work is our lack of data on the underlying costs of the goods whose prices we have tracked in the marketplace. Since we have neither cost data nor demand data, the reader should recognize that it has not been possible for us to test price rigidity directly in terms of retailer and consumer reactions to these. However, in defense of the methodological approach that we have taken here, we note that the literature in marketing and economics reports similar limitations. This was the case with the research that explored the early data sets on price rigidity—for example, the first work on catalog retailing [39] and the first work on price rigidity in industrial markets [23]. Over time, an increasing effort has been made to achieve more degrees of freedom for analysis with other data sets that permit the exploration of other pricing contexts. The present research is another step in that direction.

We have only just begun to develop a sound managerial understanding of the range of managerially controllable factors that lead to high performance and market-leading profitability in the e-bookselling sector. The paper by Ghose et al. [36], also in this Special Issue of *JMIS,* analyzes the relationship between the new and used goods markets in the Internet channel, and offers some preliminary new evidence to suggest the extent to which increasingly available used goods tend to create pressure for

falling prices in the new goods market. Similar to what we see with that work, colleagues in marketing, economics, and IS to whom we have presented our work tell us that revealing the empirical regularities associated with new business phenomena often provides useful information and directional guidance for the development of new theory. Leading examples come with the work of Bajari and Hortacsu [10, 11] with respect to the empirical regularities associated with eBay auctions, as well as Clemons et al.'s [30] work on empirical regularities in strategic pricing for Internet-based travel services.

Future Research

In closing, it is important for us to properly position this research relative to other works in the area of price adjustment and price rigidity in a way that is suggestive of a fruitful agenda for future research. The primary thrust of the present research has been to discover patterns in strategic pricing at the *most* micro-level possible: the level of the product within the firm aggregated to the level of the firm. Many of the other papers that treat pricing in e-commerce that we have mentioned earlier are similarly positioned. We note, however, that the opportunity exists to grow this stream of research so that it will contribute to our understanding of *systemic issues of price adjustment and price rigidity in e-commerce.*

Some of the dimensions that can be explored systemically include price rigidity differences between Internet-based sellers and traditional bricks-and-mortar sellers. We can compare this to traditional retail markets, where significant costs associated with price adjustments occur. Internet-based retailers are able to more accurately control inventory and costs, and to sample demand at any given moment. They possess significant price-changing capabilities. The new technologies associated with the Internet also provide traditional bricks-and-mortar retailers with opportunities to adopt bricks-and-clicks retail capabilities, such as leveraging logistical and operational expertise with traditional distribution channels, as well as connecting their traditional technological infrastructures with the Internet. As a result, it is now possible to integrate a firm's Internet channel with traditional distribution channels while ensuring product, price, and promotion consistency [37]. And, with new information goods, retail businesses can be designed with virtually no physical inventory. Therefore, price changes are more likely to be driven by demand considerations than inventory levels and other systemic drivers in the overall marketplace (e.g., a new and used goods market, competition and industry concentration, products whose prices are likely to be stationary over time versus those that may experience *systemic drift* due to product obsolescence and other competitive factors at work, etc.).

Other systemic investigations of price rigidity are also possible. They might include, for example, the study of the connection between wholesale costs and retail price rigidity in e-commerce in settings beyond the mortgage markets [6]. Another possible direction might involve the study of price rigidity in online markets when firms manipulate the level of "market transparency" by holding back different details about a product or its prices, thus making it more difficult for consumers to compare

them, in spite of the fact that the underlying products ought to be about the same. This occurs on the Internet with the sale of airline tickets by firms such as Hotwire (www.hotwire.com), Travelocity (www.travelocity.com), Orbitz (www.orbitz.com), Northwest Airlines (www.nwa.com), and Priceline (www.priceline.com). Finally, it may also be useful to make comparative evaluations of relative price rigidity in the online "full-price" channel in product settings where a second online "discount-price" channel is simultaneously used versus when only the online full-price channel is used. A current example of this is BestBuy's (www.bestbuy.com) unbranded regional Internet outlet stores. These were announced in March 2004 as a strategic alliance involving eBay (www.ebay.com) and BestBuy. Francisco quotes Scot Wingo, president and CEO of ChannelAdvisor (www.channeladvisor.com), which helps companies sell excess inventory on eBay and other online sites: "It started with manufacturers (IBM, Motorola, Nokia, etc.) and now [this accelerating trend] is moving to retailers more and more" [34]. Our expectation is that by maintaining separate channels, firms such as BestBuy will protect their capability to hold the line on prices and avoid sales cannibalization, which ought to result in somewhat greater price rigidity in the online stores.

At the time we wrote this paper, little was known—both in academic research terms and also in industry-based anecdotal terms—about the "interconnectedness" of the various elements that can lead us to assert new systemic truths about strategic pricing on the Internet. Perhaps a next step beyond the "all Internet" focus of data collection that we have seen with many e-commerce pricing studies is to begin building *hybrid data sets.* This will involve the Internet with matched sources of data from the non-electronic channel (e.g., newspapers, in-store prices, etc.). Indeed, as a next step, work that involves this kind of data collection would be helpful in establishing a more systemic and a more holistic understanding of the inner workings of strategic pricing in competitive markets.

Finally, and perhaps most importantly for the managerial audience, our results also suggest an interesting and unexpected dimension of price competition between Amazon and BN on the Internet. Internet retailers may compete not only on the basis of prices but also on the basis of *price-adjustment frequency.* Why might this be? Does it map into consumer expectations? Or are there some underlying profit-maximization principles that can be taken advantage of this way? Is the use of such strategy intentional on the part of firms? Will it be value-maximizing for the firm?

To further explore issues such as this, the research agenda that we advocate is deliberately interdisciplinary. It will be best informed by a blend of new thinking and new theory from fields as diverse as economics, marketing, IS, psychology, and sociology. So, for example, exploring the implications of Amazon's greater price rigidity for price leadership, competition, and price synchronization—and other firms' capabilities in other industry sectors with different competitive conditions and different degrees of success in use of the Internet channel—will also be promising directions for future research. Observational studies that aim at finding the psychological and sociological correlates of observed patterns of price adjustment and price rigidity on the Internet also will be especially welcome. We expect they will open up new av-

enues for collaborative inquiry and innovations in research design that will take scientific inquiry in this area to the next level.

Acknowledgments: An earlier version of this paper appeared in R.H. Sprague Jr. (ed.), *Proceedings of the Thirty-Eighth Hawaii International Conference on System Sciences* (Los Alamitos, CA: IEEE Computer Society Press, 2005). The authors thank Eric Clemons, Rajiv Dewan, Marshall Van Alstyne, Alok Gupta, Chris Forman, Vernon Richardson, the anonymous reviewers for HICSS-38, and the participants in our presentation at the conference in January 2005. Finally, the authors thank Steve Loyola, CEO of BestWebBuy.com, for his assistance with access to data for this study. All errors of fact and interpretation are the authors' sole responsibility.

NOTES

1. A wide range of theories, such as those based on price adjustment costs, market interactions, asymmetric information, and demand- and contract-based explanations, have been proposed to obtain a reading on why price changes might be sluggish. They provide a basis for the macroeconomic assumptions of rigid prices. The interested reader should see Andersen [5] and Blinder et al. [18] for foundational coverage of the issues.

2. There are a number of representative references that point out the new thinking. Morton et al. [50] and Tang and Xing [59] reported lower prices and less price dispersion online, for example. Kauffman and Wood [43] and Clay et al. [29] reported price leading and price following behavior. None of these works provides definitive answers, so we are left with a key research question: Are the price frictions that prior authors have written about still operative today in the Internet context?

3. Following up our earlier comments regarding our data collection approach and the concerns of Allen and Wu [2], we conducted preliminary *consistency sampling* to ensure the quality and consistency of our price data before implementing the larger analysis. This involved the collection of 100 random samples of data from the overall data, and then comparing them in terms of consistency of price information. We found that there were only six inconsistent price-pairs across either Amazon or BN, on one hand, and BestWebBuy.com, on the other hand. The results of our consistency sampling provide additional confidence in the quality of our data, and that our approach to its collection did not introduce other unexpected biases. We made no effort to adjust or correct the inconsistent price-pairs or other data, based on our view that we can reasonably expect errors in data that are reported by both the original producers of the prices and the secondary reporters of prices. This is similar to what is observed in the production of trade prices in the equity markets such as NASDAQ and the New York Stock Exchange, and their subsequent reporting via Bloomberg, Reuters, and other digital quote vendors—in spite of the fact that digital feeds of data are exclusively used.

4. It is important for us to point out to IS research readers that this view of methodology is not only common in other fields, such as marketing and economics, but also much better accepted. The reason is that progress in research with respect to some of the leading problems (how wholesale and consumer prices move, how well advertising works, how price discriminated is best achieved, etc.) in these fields involves the application of multiple competing *and* complementary theories that are individually well accepted. The accompanying empirical research efforts, as a result, are not always intended to isolate one theory as "the one and only truth," but instead to gauge the extent of the application of multiple theories as "a collection of truths" that support a much richer, fuller understanding of the phenomenon. Examples of such work include Bils and Klenow [17], Carlton [23], Kashyap [39], Levy et al. [46], and Warner and Barsky [62].

5. This was suggested to one of the coauthors of this article in a phone discussion with a senior manager at BestBuy during October 2004, and reiterated by Brian Hungerford, Director, BestBuy–eBay Alliance, in a presentation at the MIS Research Center, University of Minnesota, April 2005.

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Appendix. Descriptive Statistics

Table A1. Descriptive Statistics: Amazon and BN

Variables	Minimum	Maximum	Mean	Standard deviation
ListPrice (dollars)	4.75	199.99	28.59	22.29
SellingPrice (dollars)	3.32	199.99	22.16	17.35
DiscountRate (percent)	0.00	61.54	20.81	12.50
ShippingCost (dollars)	0.00	3.99	2.97	1.74
Duration (months)	16	578	52.21	62.01
PriceChanges (dollars)	–64.00	64.00	0.0004	0.62
%*PriceChanges*	–60.00	77.48	0.03	2.20

Notes: 338,546 observations for all variables (except *PriceChanges* and *%PriceChanges,* 337,792 observations); 449 days from March 31, 2003, to June 21, 2004; 377 books.

Table A2. Descriptive Statistics: Amazon Only

Variables	Minimum	Maximum	Mean	Standard deviation
SellingPrice (dollars)	4.19	199.99	20.870	16.29
DiscountRate (percent)	0.00	61.54	24.950	11.10
ShippingCost (dollars)	0.00	3.99	3.04	1.70
PriceChanges (dollars)	–64.00	64.00	0.0002	0.48
%*PriceChanges*	–60.00	77.48	0.01	1.38

Notes: 169,273 observations (except *PriceChanges* and *%PriceChanges,* 168,896 observations); same period; 377 books.

Table A3. Descriptive Statistics: BN Only

Variables	Minimum	Maximum	Mean	Standard deviation
SellingPrice (dollars)	3.32	159.99	23.44	18.26
DiscountRate (percent)	0.00	57.66	16.67	12.44
ShippingCost (dollars)	0.00	3.99	2.90	1.78
PriceChanges (dollars)	–33.00	33.00	0.0006	0.73
%*PriceChanges*	–40.06	66.83	0.04	2.79

Notes: 169,273 observations (except *PriceChanges* and *%PriceChanges,* 168,896 observations); same period; 337 books.

Table A4. Descriptive Statistics: Best Sellers

Variables	Minimum	Maximum	Mean	Standard deviation
ListPrice (dollars)	7.50	199.99	26.61	27.77
SellingPrice (dollars)	4.50	199.99	19.74	20.39
DiscountRate (percent)	0.00	61.54	23.67	12.17
ShippingCost (dollars)	0.00	3.99	3.64	1.13
Duration (months)	19	420	46.66	58.15
PriceChanges (dollars)	–64.00	64.00	0.0019	0.73
%*PriceChanges*	–42.87	75.00	0.05	2.80

Notes: 79,922 observations (except *PriceChanges* and *%PriceChanges,* 79,744 observations); same period; 89 books.

Table A5. Descriptive Statistics: Steady Sellers

Variables	Minimum	Maximum	Mean	Standard deviation
ListPrice (dollars)	6.00	35.00	13.84	5.06
SellingPrice (dollars)	4.19	35.00	11.58	3.59
DiscountRate (percent)	0.00	59.98	13.72	12.27
ShippingCost (dollars)	0.00	3.99	3.98	0.23
Duration (months)	30	578	123.22	87.05
PriceChanges (dollars)	–10.50	10.50	0.0001	0.19
%*PriceChanges*	–42.81	66.83	0.01	1.51

Notes: 70,942 observations (except *PriceChanges* and *%PriceChanges,* 70,784 observations); same period; 79 books.

Table A6. Descriptive Statistics: Computer Books

Variables	Minimum	Maximum	Mean	Standard deviation
ListPrice (dollars)	12.95	149.96	47.62	17.92
SellingPrice (dollars)	6.96	149.96	37.70	15.90
DiscountRate (percent)	0.00	60.00	21.10	11.87
ShippingCost (dollars)	0.00	3.99	0.72	1.53
Duration (months)	21	74	35.59	10.98
PriceChanges (dollars)	–33.00	33.00	0.00	0.90
%*PriceChanges*	–60.00	77.48	0.02	2.31

Notes: 87,106 observations (except *PriceChanges* and *%PriceChanges,* 86,912 observations); same period; 97 books.

Table A7. Descriptive Statistics: New Books

Variables	Minimum	Maximum	Mean	Standard deviation
ListPrice (dollars)	12.95	149.96	47.62	17.92
SellingPrice (dollars)	6.96	149.96	37.70	15.90
DiscountRate (percent)	0.00	60.00	21.10	11.87
ShippingCost (dollars)	0.00	3.99	0.72	1.53
Duration (months)	21	74	35.59	10.98
PriceChanges (dollars)	–33.00	33.00	0.00	0.90
%*PriceChanges*	–60.00	77.48	0.02	2.31

Notes: 100,576 observations (except *PriceChanges* and *%PriceChanges,* 100,352 observations); same period; 112 books.