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Price Rigidity on the Internet: New Evidence from the Online Bookselling Industry

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PRICE RIGIDITY ON THE INTERNET: NEW EVIDENCE FROM THE ONLINE BOOKSELLING INDUSTRY

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Extended Abstract

Introduction

Price rigidity occurs when prices do not change with the regularity predicted by standard economic theory. This has been a topic of long-standing interest with respect to firms, industries, and the economy as a whole. Compared to traditional markets where significant costs associated with price adjustments occur, Internet-based retailers are able to more accurately control inventory and costs, sample demand at any given moment, and have significant price-changing capabilities.

Despite the growing number of theoretical and empirical studies on price dispersion (e.g., Clemons et al. 2002), price levels (e.g., Brynjolfsson and Smith 2000), and price-setting behavior (e.g., Kauffman and Wood 2004) to explain firm pricing strategies on the Internet, there are only a few studies on price-changing behaviors and price rigidities in e-commerce. Many observers have commented that 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 (Brynjolfsson and Smith 2000). This suggests that Internet-based retailers have the capability to make more frequent price changes than do traditional retailers, which actually may not be true. With the concern about the pervasive expectation of declining price rigidity on the Internet, we address the following research questions:

- Other than the menu cost explanation, what other factors determine Internet-based retailers' price-changing behaviors?
- From the product level, how differently do *price elements* (e.g., nine-ending price, relative price, and price discount) and *non-price elements* (e.g., product popularity, product information quality, and shipping cost) influence Internet-based retailers' decisions about price adjustments?

Theoretical Background

Price Rigidity, Marketing, and Economics

A wide range of partial equilibrium theories in economics, such as those based on price adjustment costs, market interactions, asymmetric information, and demand and contract-based explanations, have been proposed to explain why prices might be rigid (Blinder et al. 1998). Table 1 describes several of these price rigidity theories.

Price Rigidity in the E-Commerce Sector

Price Adjustment Costs. Bergen et al. (2003) report that the Internet does not necessarily reduce managerial costs associated with making price changes. This is due to the need to integrate the firm's efforts in the Internet channel with traditional channels by ensuring product, price, and promotion consistency. Chakrabarti and Scholnick (2001) analyze the pricing behavior of two leading e-bookstores and find that they exhibit *within-store synchronization* in price changes. They argue that price rigidities still exist in online environments, although they are largely free of menu costs.

Table 1. Theories of Price Rigidity

Theories	Description
Cost of Price Adjustment (Carlton 1986; Levy et al. 1997)	Changing prices is costly, prices remain unchanged even with changes in demand and supply. • **Menu Cost:** Firms face a lump sum cost whenever they change their prices. • **Convex Adjustment Cost:** The costs of changing prices rise at an increasing rate. • **Managerial Cost**: Time and attention required by managers slow price changes. • **Synchronization, Staggering:** Store products' prices change together, independently.
Mkt Structure (Carlton 1986; Stiglitz 1984**)**	Monopoly power and coordination failure in markets are primary sources of price rigidity. • **Industry Concentration:** A slow price change is an indicator of monopoly power. • **Coordination Failure:** Lack of effective mechanism for market clearing causes rigidity.
Asymmetric Information (Allen 1988; Stiglitz 1987)	Information asymmetries between buyers and sellers provide an explanation of price rigidity. • **Price as Quality Signal:** Firms are reluctant to lower prices for fear that consumers may misinterpret price cut as a reduction in quality. • **Search and Kinked Demand Curve:** Search costs lead to kinked demand curve.
Demand-Based (Blinder et al. 1998; Carlton and Perloff 2000)	Firms react to demand fluctuations beside price changes: inventories, non-price competition. • **Procyclical Demand Elasticity:** Demand less elastic to price changes as curves shift in. • **Psychological Pricing Point:** Prices tend to get stuck at certain ending prices (e.g., 9¢). • **Inventories:** Inventories are used by firms to buffer demand shocks. • **Non-Price Competition:** Firms use non-price elements instead of price changes.
Contract-Based (Bergen et al. 2003; Zbaracki et al. 2004)	Prices remain unchanged by nominal or implicit contracts. • **Explicit Contracts:** Prices are fixed for limited time periods under nominal contracts. • **Implicit Contracts and Customer Antagonization:** As price changes may antagonize customers, implicit agreements between firms and customers are used to stabilize prices.

Market Structure Effects. Knowing that competitors instantly learn about price cuts, Internet-based retailers have become cautious about changing prices, and increasingly adopt similar price structures (Daripa and Kapur 2001). Moreover, online prices may be higher than expected due to tacit collusion, for example. Online prices also may be rigid due to incentives to sustain them at a higher level through implicit interfirm agreements and market signaling.

Information Asymmetry. On the Internet, buyers and sellers are geographically separated and do not interact face-to-face as they transact. Thus, it is difficult for buyers to inspect product quality. Further, it is doubtful that the firm with a low online price will be the most reliable. So advertising, consumer search, and digital intermediaries (e.g., trusted third parties, online reputation mechanisms) will play a significant role in building trust between buyers and sellers.

Consumer Demand. Compared to traditional channels requiring firms to keep higher inventories, in e-commerce operations it is possible for firms to obtain more efficient supply chain benefits. So, e-commerce firms can accurately control inventory and send products to market faster. Clay et al. (2002) point out that the Internet facilitates price competition and non-price competition. Online consumers care about other non-price aspects like seller reputation, delivery locations and times, contract lengths, etc. Thus, we expect that strategic use of non-price elements will be a cause of price rigidity on the Internet.

Contracts. Unexpected changes in the terms of implicit contracts, in contrast, may antagonize customers and diminish the firm's reputation—even on the Internet. With reduced search and switching costs for the consumer, firms may lose more of their customers when they violate consumer expectations about pricing patterns.

Research Framework

Compared to traditional retailing, we can observe price or non-price competition more frequently in Internet-based retailing since online consumers and sellers can easily access more information about products, as well as different competitors' prices. So with these ideas in mind, we develop a framework to explain firms' price-changing behaviors at the product level. Specifically, we propose six research hypotheses to predict how *price elements* (e.g., nine-ending price, relative price, and price discount) and *non-price elements* (e.g., product popularity, product information quality, and shipping cost) of the product have effects on Internet-based retailers' decision making for price adjustments (see Figure 1).

Price-Elements and Price Changes

- **Hypothesis 1: Nine-Ending Price Hypothesis**. Similar to traditional retailing, Internet-based retailers do not change prices frequently because they have an incentive to make the price ending equal to $9 or 9¢.
- **Hypothesis 2: Relative Price Hypothesis**. Internet-based sellers change the prices of low-priced products more frequently than those of high-priced products.
- **Hypothesis 3: Product Discount Hypothesis**. Product discounting by Internet-based sellers' positively affects the frequency of observed price adjustments.

Non-Price Elements and Price Changes

- **Hypothesis 4: Information Quality Hypothesis**. If consumers have more information on the quality of a product sold on the Internet, the price of the product will be less rigid.
- **Hypothesis 5: Product Popularity Hypothesis**. Internet-based sellers have an incentive to frequently change the prices of popular products.
- **Hypothesis 6: Shipping Costs Hypothesis**. Internet-based sellers make use of shipping costs instead of price changes for competition.

Figure 1. Research Hypotheses for Price Changes Among Internet-Based Sellers

Research Methods

Data Collection

From the list of books available at a price comparison site, BestWebBuy.com, we generated a large sample of book ISBNs belonging to different subject categories using *proportionate random sampling*. With this list of ISBNs, we employed a *price information-gathering agent* to automatically extract the necessary information for each book in our sample from the appropriate Web site each day at 4:00 a.m. With each daily run of the data extraction process, we added price observations for 11 stores. Our daily data cover the period from March 31, 2003, to February 2, 2004, a 309-day period. We also collected some qualitative information, such as consumers' ratings of the products and stores, the number of reviews, and sales rank, from BizRate.com, Amazon.com, and BN.com.

Data Aggregation

To measure the explanatory variables as well as a dependent variable (i.e., the frequencies of price changes) at the *product level*, we averaged each observation over a *group* of original panel data observations to result in a proportion. This enabled us to conduct a cross-sectional data analysis at an aggregated level. A description of the aggregated variables used in our empirical model is shown in Table 3. Table 4 gives summary statistics for the variables used in this study.

Table 3. Description of Key Aggregated Variables

Variable	Definition
Obs (Number Observations)	Total price observations of a book in a given time period (i.e., 309 days).
NineEnding (Nine-Ending)	How often price ending of a book has been set to nine in a given time period.
PriceLevel (Price Level)	Mean of the actual sale prices of a book in a given time period.
Discount (Price Discount)	Discount on a book from list price on average in a given time period.
Quality (Information Quality)	How easily consumers perceive book quality before purchase. Measured by number of reviews on book collected weekly from two Amazon and BN.com.
Popularity (Book Popularity)	Book popularity, based on weekly sales rank from Amazon and BN.com.
Shipping (Shipping Cost Changes)	How often shipping cost charged to a book changes in a given time period.
Δ (Price Changes)	How frequently price of a book changes in a given time period.

Table 4. Summary Statistics of the Aggregated Variables

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
PriceLevel	387	22.27	17.02	4.13	150.36
Discount	387	0.20	0.06	0.00	0.45
Shipping	387	3.30	0.52	1.09	4.08
Quality	387	95.79	320.73	0.00	3,809.50
Popularity	387	-9.25	1.88	-13.25	-0.35
NineEnding	387	0.22	0.30	0.00	1.00
Δ	387	40.82	19.08	0.00	112.00
Obs	387	3,019.85	317.24	927.00	3,399.00

The Grouped Logit Model

We use a discrete choice model called *grouped logit* as a means to represent firms' binary decisions of whether to make a price change. Instead of using *ordinary least squares* (**OLS**), we use *weighted least squares* (**WLS**) to correct for this defect to produce the minimum χ^2 estimator of β (Greene 2003). We define the probability that a firm changes the price of a particular product i as $P(\Delta = 1) = \frac{e^Z}{1+e^Z}$, where Z is a linear equation of the variables that may affect the firm's decision. Applying the natural log results in the logit, L_i:

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = Z_i$$
$$= \beta_0 + \beta_{NineEnding} NineEnding_i + \beta_{PriceLevel} PriceLevel_i + \beta_{Discount} Discount_i + \beta_{Quality} Quality_i$$
$$+ \beta_{Popularity} Popularity_i + \beta_{Shipping} Shipping_i + u_i$$

Estimation and Results

We fitted a grouped logit model with the R^2, which is the squared correlation coefficient between actual and estimated L_i^*. Since our grouped logit model uses WLS regression, and the dependent variable is continuous and contains almost non-zero values, it is appropriate to use R^2 to assess goodness-of-fit for our model (Hosmer and Lemeshow 2000). The estimated model shows a reasonable fit with the data (R^2 = 0.610) (see Table 5).

Based on the calculated odds ratios, we are able to measure the relationship between price changes, Δ, and three price elements: *NineEnding*, *PriceLevel*, and *Discount*. The effect of a *NineEnding* on the price change is negative and significant ($\beta_{NineEnding}$ = -0.3507; p = 0.000, odds ratio = 0.704). This is consistent with the nine-ending hypothesis (H1), which states that an Internet-based seller is likely to change prices less frequently to make the price ending equal to 9. *PriceLevel* ($\beta_{PriceLevel}$ = -0.0038; p = 0.008, odds ratio=0.996) shows significant negative effects on the price change while *Discount*, ($\beta_{Discount}$= 0.8357; p = 0.011, odds ratio = 2.306) illustrates significant positive effects on the price change. These results also support the relative price hypotheses (H2) and product discount hypothesis (H3).

We also assessed the relationship between price changes and three non-price elements: *Quality*, *Popularity*, and *Shipping*. There is no effect of *Quality* ($\beta_{Quality}$ = -0.0001; p = 0.249, odds ratio = 1.000) on price changes, so we reject the information quality hypothesis (H4). The odds ratios of *Popularity* ($\beta_{Popularity}$ = 0.0585; p = 0.000, odds ratio = 1.060) indicates that there are positive and significant effects on price changes, so the product popularity hypothesis (H5) is well-supported. *Shipping* ($\beta_{Shipping}$ = 0.0188; p = 0.000, odds ratio = 1.029) shows significant positive effects on the price change, which is just opposite to what we expected (i.e., shipping costs hypothesis (H6)).

Table 5. Results of Grouped Logit Model

Variables	Coeff.	Standard Error	t-Stat.	p-Value	Odds Ratio
Constant	-3.8589***	0.1268	-30.442	0.000	NAx
NineEnding	-0.3507***	0.0724	-4.844	0.000	0.704
PriceLevel	-0.0038***	0.0014	-2.674	0.008	0.996
Discount	0.8357**	0.3252	2.570	0.011	2.306
Quality	-0.0001	0.0001	-1.153	0.249	1.000
Popularity	0.0585***	0.0108	5.408	0.000	1.060
Shipping	0.0188***	0.0051	3.676	0.000	1.029

Note: WLS estimation; dependent variable = Δ (price change). Model fit: F (6, 379) = 18.38; R^2 = 0.610; 387 observations with 1 skipped. Significance levels: *** = 0.01, ** = 0.05, * = 0.10.

Conclusion

We proposed and examined a product-level price rigidity model to explain how price and non-price elements of a product affect Internet-based retailers' decisions to make price changes. We provided a number of interesting findings using a grouped logit discrete choice model, which was appropriate based on the manner in which we aggregated price change data for books from among millions of observations of individual book prices. In addition, we found some unique empirical evidence on non-price elements that economics and marketing studies have not yet reported. Further, to the best of our knowledge, this research is the first to empirically assess price ending and price rigidity patterns in Internet-based retailing. So, we believe that our findings offer rich opportunities for new theory-building and empirical research in e-commerce settings, as well as in traditional retailing settings.

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