December 2000

Follow the Leader? Strategic Pricing in E-Commerce

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Extended Abstract

1. INTRODUCTION

Conventional wisdom and current research (e.g., Bakos 1997) suggest that the Internet will lower *electronic commerce* (EC) product prices by causing intense competition among EC firms. Surprisingly, the predicted intense competition has not materialized. Sager and Green (1998) ask, "So where are all the bargains?" and note that EC firms *match,* (not *beat*)*,* competitors' prices. Firms retrieve competitors' prices using the same EC *shopbot* technology that allows buyers to search for the best prices (Varian 2000). Thus, *information asymmetry* among EC firms is reduced, opening a new spectrum of competitive possibilities.

We examine the dynamics of EC product pricing using research from information systems (IS) (Bakos 1997; Brynjolfsson and Smith 1999), marketing (Alba et al. 1997; Bailey 1998; Lal and Sarvary 1999) and economics (Varian 2000) as a base. We conduct a multi-industry investigation of pricing behavior using a customized data-collecting Internet agent called *Time Series Agent Retriever* (TSAR). *Information asymmetry* and *tacit collusion* theories show how EC technology increases firms' ability to tacitly collude. Our results, analyzed using an econometric technique called *vector autoregression* (VAR) (Sims 1980, 1986), show that EC technology reduces *information asymmetry* among EC firms and allows rapid competitor response, allowing firms to avoid competition.

We address the following research questions:

- How can researchers empirically evaluate pricing strategy for EC firms with micro-level data from the Internet?
- What are the effects of reduced information asymmetry between EC firms on the price a consumer pays for goods? What factors can determine pricing strategies?
- What empirical evidence, if any, exists to indicate that EC firms are tacitly colluding on prices?

EC firms utilize pricing strategies that heretofore were infeasible. We develop and test a model of EC price competition for *different classes* of *identical goods* across *firms* and *industries* and find that EC technology increases firms' price responsiveness, but that pricing strategy is based on more than just competitor evaluation.

2. LITERATURE

We examine IS, economics, and marketing research on EC pricing dynamics (e.g., Bakos 1997; Brynjolfsson and Smith 1999; Lal and Sarvary 1999;), *tacit collusion* (Chamberlin 1929), and *price tiers* (Carpenter et al. 1988).

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[1]A longer version of this paper is available at http://misrc.umn.edu/wpaper/WorkingPapers/.

2..1 EC Product Pricing

Many IS researchers propose that EC technology increases competition because EC technology lowers search costs (e.g, Alba et al. 1997; Bakos 1997; Lynch and Ariely 2000). However, this price reduction has not materialized. The EC environment contains friction that can cause EC buyers to prefer certain sellers even if they are forced to pay more for an identical item sold by a discount seller (Bailey 1998; Brynjolfsson and Smith 1999; Choudhury et al. 1998; Lal and Sarvary 1999). There is also anecdotal evidence of collusion on prices among competitors (Dillard 1999; Varian 2000). In this research, we attempt to better understand the nature of EC competition and pricing.

2.2 Tacit Collusion

Economists note how identical commodities are often priced differently. Tirole (1998) describes Bertrand competition in a single-period game: If firms want to sell their products *only once*, then Bertrand competition may occur. In a repeated game, collusion works best for all parties. Chamberlin introduces *tacit collusion* to show how competitors tacitly cooperate with each other to avoid competition. The EC environment reduces *information asymmetry* among competitors and allows immediate evaluation of competitors' pricing through browsers and Internet agents, thus facilitating tacit collusion by reducing monitoring costs.

2.3 Price Tiers

Price tiers form as competitors compete with each other at a given price tier (Blattberg and Wisniewski 1989; Carpenter et al. 1989). These tiers *compete asymmetrically* in that price promotions of the market leaders adversely affect lower-tier companies, but lower-tier companies cannot affect the higher-tier (Corts 1997; Sethuraman et al. 1999). EC technology can be used to immediately respond to promotional pricing, and thus competitors settle into a tiered format and price tiers become the viable EC strategy.

3. THEORETICAL MODEL

Figure 1, Equation 1, and Table 1 describe the model used for this research that predicts price changes in the EC environment.

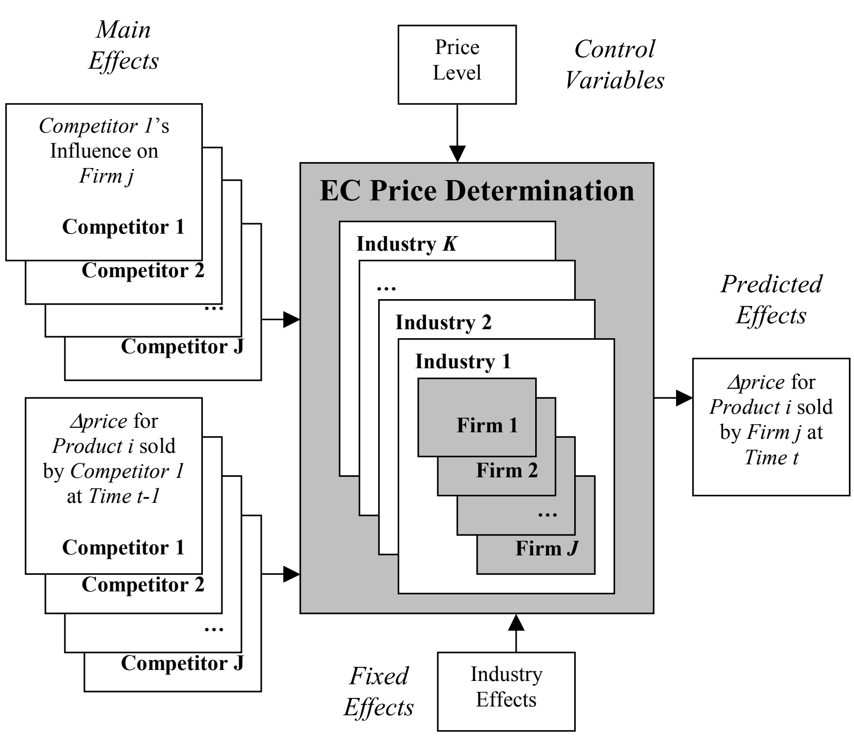

Figure 1. A Conceptual Model for Price Changes in EC Competition

$$\Delta price_{11t} = f\left(\begin{array}{l} \Delta price_{11,t-1}, \Delta price_{12,t-1}, \ldots, \Delta price_{1J,t-1}, \\ CompetitorInfluence_{12}, CompetitorInfluence_{13}, \ldots, CompetitorInfluence_{1J}, \\ Averageprice_{1}, Industry_{1} \end{array}\right)$$

$$\Delta price_{12t} = f\left(\begin{array}{l} \Delta price_{11,t-1}, \Delta price_{12,t-1}, \ldots, \Delta price_{1J,t-1}, \\ CompetitorInfluence_{21}, CompetitorInfluence_{23}, \ldots, CompetitorInfluence_{2J}, \\ Averageprice_{1}, Industry_{1} \end{array}\right)$$

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$$\Delta price_{1Jt} = f\left(\begin{array}{l} \Delta price_{11,t-1}, \Delta price_{12,t-1}, \ldots, \Delta price_{1J,t-1}, \\ CompetitorInfluence_{J1}, CompetitorInfluence_{J3}, \ldots, CompetitorInfluence_{J,J-1}, \\ Averageprice_{1}, Industry_{1} \end{array}\right) \quad (1)$$

$$\Delta price_{21t} = f\left(\begin{array}{l} \Delta price_{21,t-1}, \Delta price_{22,t-1}, \ldots, \Delta price_{2J,t-1}, \\ CompetitorInfluence_{12}, CompetitorInfluence_{13}, \ldots, CompetitorInfluence_{1J} \\ Averageprice_{2}, Industry_{2} \end{array}\right)$$

::

$$\Delta price_{IJt} = f\left(\begin{array}{l} \Delta price_{I1,t-1}, \Delta price_{I2,t-1}, \ldots, \Delta price_{IJ,t-1}, \\ CompetitorInfluence_{J2}, CompetitorInfluence_{J3}, \ldots, CompetitorInfluence_{J,J-1}, \\ Averageprice_{I}, Industry_{I} \end{array}\right)$$

Table 1. Variables Used in Equation 1

Variables	Description
$\Delta price_{ijt}$	Percentage change in price for *Product i* {*i* =1 to *I*) sold by *Firm j* (*j* =1 to *J*) at *Time t* (*t* =1 to *T*). Shaanan and Feinberg (1995) advocate using percentage change in price rather than nominal price to measure price changes
$Averageprice_{i}$	Average price level for *Products* {*i* =1 to I)
$CompetitorInfluence_{jc}$	The influence on *Firm j* of *Competitor c* {*c =1* to *J for c* $\neq$ *j*}. Note that the number of competitors is the same as the number of firms (J).
$Industry_{i}$	Industry effects for the *Industry* where *Product i* is sold. Different EC industries have different characteristics, such as product demand, age, competition, etc.

4. ECONOMETRIC MODEL

Vector autoregression (VAR) treats residuals as *shocks* to a system of variables rather than as measuring or sampling errors (Anderson 1979; Kennedy 1998; Sims 1986). *We model the shock as a competitor price change that is not predicted.* Based on our conceptual model, we begin with the linear autoregression model described in Equation 2 and Table 2.

$$\Delta price_{ijt} = \alpha_{j} + \sum_{c=1}^{J} \gamma_{jc} \Delta price_{ic,t-1} + \sum_{k=1}^{K} \omega_{k} Industry_{k} + \varepsilon_{ijt} \quad (2)$$

VAR is appropriate for our research for several reasons. EC technology allows firms to respond immediately to competitor actions, resulting in *probable* endogeneity. VAR allows for endogenous predictors, thus making VAR models more predictive (since endogenous relationships are considered) and coefficient estimates more reliable (Kennedy 1998). In addition, VAR analysis is less susceptible to theoretical bias found in traditional econometric models (Pindyck and Rubinfeld 1998; Sims 1980).

Table 2. Linear Autoregression Model

Variable	Description
$\Delta price_{ijt}$	Percentage change in *Price* for *Product i* {*i* = *1* to *I*} sold by *Firm j* {*j* = *1* to *J*} at *Time t* {t = 1 to T}.
a_j	Intercept that captures individual firm effects for *Firm j*. This vector of intercepts describes price changes made by a firm that are not attributable to a change in competitor's price.
g_{jc}	Coefficient indicating the effect on *Firm j*'s price change in the current period of *Competitor c*'s price change in the previous period {*c* = *1* to *J*}.
w_k	The coefficient of the fixed industry effects for the Industries *k* studied {*k* = 1 to *K*}. It represents industry-wide effects that affect every product selling in an industry. The book selling industry is the base case and is omitted to eliminate perfect collinearity among the explanatory variables.
$Industry_k$	A dummy variable to capture industry fixed effects for the industries studied. It is equal to 1 if *Firm j* sells *Product i* in *Industry k* and 0 otherwise. The book selling industry is the base case.
e_{ijt}	The random error in the price for *Product i* sold by *Firm j's* price for at *Time t.*

Heteroskedasticity. Equation 3 shows a logarithmic transformation used to adjust our linear model for non-linearity, to preserve stable prices, and to lead to greater predictive power.

$$\Delta price'_{ijt} = \ln(\Delta price_{ijt} + 1) \tag{3}$$

Equation 4 shows the transformed linear model.

$$\sum_{c=1}^{J} \Delta price'_{ijt} = \alpha_j + \sum_{c=1}^{J} \gamma_{jc} \Delta price'_{ij,t-1} + \sum_{k=1}^{K} \omega_k Industry_k + \varepsilon_{ijt} \tag{4}$$

Endogeneity. Price change variables may be endogenous, or dependent upon competitor price changes in the current period. VAR adjusts the dependent variable by a coefficient, β, derived from endogenous effects other variables have on the dependent variable in the same time period (Enders 1995), as shown in Equation 5.

$$\sum_{c=1}^{J} \Delta price'_{ijt} = \alpha_j + \sum_{c=1}^{J} \gamma_{jc} \Delta price'_{ij,t-1} + \sum_{k=1}^{K} \omega_k Industry_k + \varepsilon_{ijt} \tag{5}$$

VAR β coefficients are underidentified. *Cholesky decomposition* (Press et al. 1993; Enders 1995) resolves this by restricting the β's so a solution can be found to Equations 5. This requires ranking firms by market power in accordance with price tier theory. For this, we use data provided by *PCData Online* (www.pcdataonline.com).

Correlation. We removed any Δ*price* correlation between two firms above 60%. Thus, NoWalking.com (100% correlated with 10base.com) and BookBuyers Outlet (83% correlated with Amazon.com) were removed from our study. No other deletions were required. These deletions make our tests more conservative.

5. HYPOTHESES AND DATA COLLECTION

We test two hypotheses:

- ***Competitor Reaction Hypothesis*:** Firms will exhibit significant reactions to competitors' price increases and decreases within a single day.

- ***Price Effect Hypothesis***: Firms will exhibit a greater tendency to respond to competitor prices with more expensive items.

We recorded 165,875 prices from 341 products and 53 firms via daily execution of TSAR from February 21 to March 29. Figure 2 shows how TSAR retrieves the top-selling items from various websites and data from shopbots.

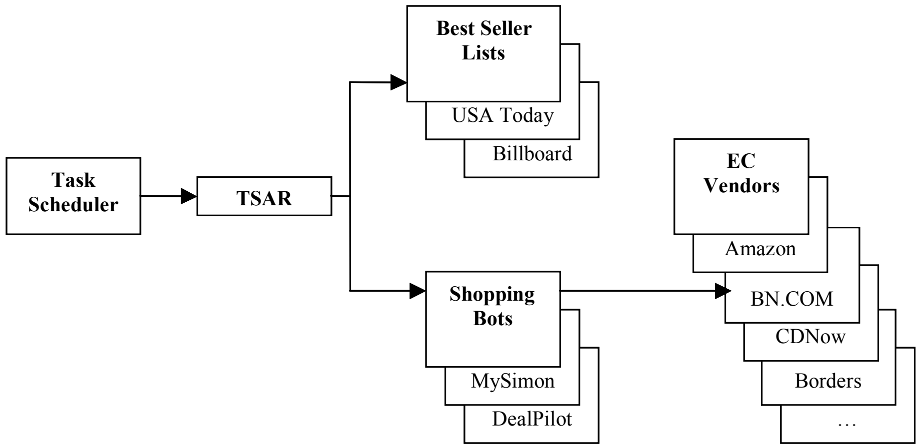

Figure 2. TSAR Data Collection Functionality

6. RESULTS

We detected 1,615 price changes: 806 price increases and 807 price decreases. Firms generally matched *both* positive and negative competitor price changes, as illustrated by Figure 3.

Table 3 shows the results of the analyses for the *Competitor Reaction Hypothesis* and the *Price Effect Hypothesis*.

Table 3. Results for the Linear and Transformed, and VAR Models

7. CONCLUSION

This research is one of the first multi-industry empirical studies of EC firms' pricing behavior. It incorporates tacit collusion theory and empirical tests to explain how it is irrational to start a price war that will lead to diminished profits for all market participants. Our first hypothesis was supported in that we showed significant response to competitor actions within a day, thus facilitating collusive responses from competitors. We found it interesting that our second hypothesis was not supported. Firms tend to be more reactive within a shorter period with inexpensive items. We feel this is due to a firm's desire to give more consideration to price changes when the larger revenue generated by the sale of expensive items is at stake. The insights generated from this paper can lead researchers to seek other means, in addition to intense competition, to explain pricing strategy.

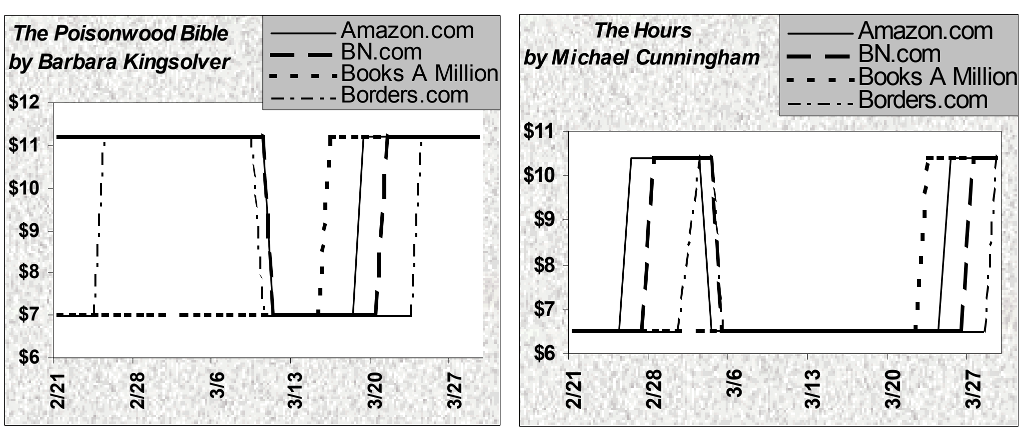

Figure 3. Following-the-Leader Example in the Book Selling Industry, February-March, 2000

Table 3. Results for the Linear, Transformed, and VAR Models

Sample Set	# of Obs.	Price Changes	Followers	Non-Followers	F-Stat.	R^2
Competitor Reaction Hypothesis – Transformed Linear Model (Equation 4)						
Books	41,699	352	11	14	7.6***	8.9%
Music CDs	120,176	1,263	15	13	21.9***	12.6%
Both Industries	165,875	1,615	26	42	15.7***	11.3%
Competitor Reaction Hypothesis – VAR Model (Equation 5)						
Books	41,699	352	13	12	10.5***	16.8%
Music CDs	120,176	1,263	24	4	31.5***	23.5%
Both Industries	165,875	1,615	37	16	27.5***	18.4%
Price Effect Hypothesis – Transformed Linear Model (Equation 4)						
Inexpensive Books	34,040	302	10	12	8.0***	8.7%
Inexpensive CDs	118,104	1229	14	14	20.0***	11.8%
Expensive Books	4,092	50	2	7	1.5***	5.3%
Expensive CDs	2,205	34	1	8	.02	0.0%
Price Effect Hypothesis –VAR Model (Equation 5)						
Inexpensive Books	34,040	302	11	11	11.0***	16.3%
Inexpensive CDs	118,104	1229	25	3	32.2***	24.3%
Expensive Books	4,092	50	2	7	1.8***	8.7%
Expensive CDs	2,205	34	1	8	.09	.1%

Note: * means $p < .01$. F-statistics are the measurement of the statistical significance of the hypothesis for the sample set.**

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