ESSAYS IN COMPETITION BETWEEN PRICE COMPARISON SITES AND PRICING BEHAVIORS OF FIRMS ON THE INTERNET

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Abstract

My dissertation consists of three chapters. In the first two chapters, I study entry decisions and competition between price comparison sites on the Internet. In the third chapter, I empirically examine pricing behaviors of firms on two leading price comparison sites — Cnet.shopper.com and Nextag.com. My research is motivated by the fact that price comparison sites are widely used by consumers when they shop online. Moreover, in most online markets, there are multiple price comparison sites.

In my first chapter, I study under what kind of circumstance multiple price comparison sites coexist in the market, and under what kind of circumstance a monopoly site dominates the market. The Baye and Morgan (2001) (hereafter BM) model, in which the market is served by a single price comparison site (also called an “information gatekeeper”), is the basis of my research. I show that even if each consumer observes price quotations from all price comparison sites, potential entrants do not find it optimal to enter a market monopolized by an incumbent information gatekeeper. Thus, the BM equilibrium is robust when one allows entry into the information market. The result of this chapter has the interpretation that the more “bargain hunters” over the entire population, or the higher the value of the good, the less the number of price comparison sites the information market would be able to support.

The second chapter addresses the question of whether there exists equilibria in which multiple price comparison sites coexist in the market. I extend the BM model to accommodate more than one site. Here, all players’ strategies are endogenous. I identify two types of strategy profiles as symmetric equilibria. In both types of equilibria, the
two price comparison sites coexist in the market. In the first type of equilibrium, consumers subscribe to both sites, and the equilibrium is similar to the second stage Nash equilibrium identified in the first chapter. In the second type of equilibrium, as long as the sum of advertising fees falls within a certain range, then in the second stage there exist Nash equilibria in which each consumer subscribes to only one site, and each firm mixes between advertising on both sites and not advertising. In equilibrium, the ratio of advertising fees charged by each site has to be equal to the ratio of the fractions of consumers who subscribe to each site. Social welfare is lower with two sites than with only one site. Moreover, the main results extend to the case where there are more than two sites.

My third chapter examines pricing behaviors of firms on two leading price comparison sites — Cnet.shopper.com and Nextag.com, using data collected from these two sites in a four-month period. I find that (1) using the indicator whether a product is refurbished or open box or not as a proxy for quality, I find evidence supporting the hypothesis that firms on Cnet use price to signal their product quality; (2) prices on Cnet are about 5% higher than on Nextag after controlling for factors that may affect difference in price levels across sites; (3) after adjusting for rebate prices, less than 10 percent of the firms that advertise on both sites charge different prices.

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Chapter 1

When Consumers Compare All Prices, Can More Than One Price Comparison Website Survive?
1.1 Introduction

Price comparison sites, such as Cnet.shopper.com or Nextag.com, provide both firms and consumers with new trading opportunities. They allow consumers to obtain a list of prices for a single product from a variety of merchants with just a few mouse clicks, and firms to advertise their prices to consumers whom they would not otherwise be able to reach. Usually, online merchants have to pay advertising fees to be included in online price listings, while consumers can generally browse these listings for free.

Baye and Morgan (2001) (BM henceforth) are the first to explicitly take into account the specific shopping environment a consumer faces when using a price comparison site. They introduce a model in which a single price comparison site is available to consumers and firms in the information market on the Internet. They find that only dispersed price equilibria exist in such a model, if the price comparison site is utilized at all. They also show that in a dispersed price equilibrium the gatekeeper’s profits are maximized when all consumers subscribe to the gatekeeper’s services. Moreover, the gatekeeper has incentives to set “low” subscription fees for consumers, and “high” advertising fees for firms.

In their discussion of the effects of competition among multiple gatekeepers, Baye and Morgan (2001) argue that the monopoly equilibrium remains even if there is more than one information gatekeeper. They illustrate this by considering a situation in which there is an incumbent gatekeeper and a new potential entrant in the information market. The monopoly equilibrium holds if one of the two sites is completely ignored by consumers (or firms), because in that instance firms (or consumers) will have no

\footnote{In Baye and Morgan (2001), the price comparison site is referred to as the “information gatekeeper” as it charges fees to consumers who obtain price information from it as well as firms that advertise prices on its site.}
incentive to switch to the other site.

A natural question arise as to under what kind of circumstance multiple price comparison sites coexist in the market, and under what kind of circumstance a monopoly site dominates the market. We identify a condition under which the monopoly equilibrium is the only equilibrium even if consumers view multiple sites. In particular, we propose an entry game modified from Baye and Morgan (2001) in which there is an incumbent gatekeeper and a potential entrant.\textsuperscript{2} We demonstrate that even when all consumers look at price quotations from the two information gatekeepers, the new entrant does not find it optimal to enter the information market because its advertising revenues do not cover its setup costs. Furthermore, this result remains unchanged when we generalize the model to allow more than one potential entrant.

We give two examples under which each consumer visits all price comparison sites. First, all consumers are “bargain hunters” who visit all sites to find the lowest price available. Second, the value of the good is of relatively high value so the consumers visit all sites in order to “save more.” However, only one monopoly site can be supported in equilibrium when each consumer visits all sites.

Intuition might lead one to think that the higher the proportion of “bargain hunters,” or the higher the value of the good, the more price comparison sites there should be. This paper shows it is not the case. In fact, one may even conjecture that the higher the proportion of “bargain hunters” over the entire population, or the higher the value of the good, the less the number of price comparison sites the information market would be able to support.

\textsuperscript{2}See Caillaud and Jullien (2003) for an alternative model on intermediary competition.
The rest of this chapter is organized as follows. Section 1.2 describes the model. Section 2.4 characterizes the equilibrium when both firms coexist in the information market and every consumer subscribes to both sites. Section 2.6 discusses price comparison sites’ fee-setting and entry decisions. Section 1.5 generalize the model to allow more than one potential entrant. Finally, section 3.5 gives conclusions, discussions, and make suggestions for future research.

1.2 The Model

Consider an entry game among information gatekeepers (or price comparison sites). Suppose the information market is currently served by a single price comparison site, which we call price comparison site \(A\). A potential entrant, price comparison site \(B\), has the option of spending a fixed cost, \(K\), which could be interpreted as the cost of setting up a new price comparison site, and entering the market. If site \(B\) enters, then site \(A\) and site \(B\) play a simultaneous-move game by setting advertising fees to attract firms to advertise on their sites. The advertising fees set by sites \(A\) and \(B\) are referred to as \(\phi_A\) and \(\phi_B\) respectively. We assume that subscription is free for consumers.\(^3\) Moreover, we assume:

**Assumption 1.** *All consumers subscribe to both sites if the two sites coexist in the market.*

The timing of the game is as follows.

- **Stage 0:** Site \(B\) decides whether to spend \(K\) and enter the market. If site \(B\) enters,

\(^3\)This assumption simplifies the analysis, and seems to be a reasonable approximation of reality, as consumers usually pay nothing when they use a price comparison site.
the game moves on to stages 1 to 3. Otherwise, the game goes back to the original BM model.

• Stage 1: After site \(B\) enters, sites \(A\) and \(B\) announce advertising fees \((\phi_A\text{ and }\phi_B)\) simultaneously.

• Stage 2: Observing these fees, firms make pricing decisions and decide whether or not to advertise their prices on the price comparison sites, and if they do, on which site(s) to advertise. All consumers subscribe to both sites.

• Stage 3: Consumers shop. Consumers decide where to purchase the good and how much to purchase based on the prices they see. Also, once a (subscribing) consumer sees prices advertised on a price comparison site, she can always go back to the site to make a purchase even if she decides to visit her local firm.

The specifications for consumer demand and firms’ profit functions follow those of BM and are summarized as follows. A unit mass of consumers are evenly distributed across \(n\) geographic locations. Each location is assumed to be far from the other locations. Consumer preferences for the good in consideration are identical. Each consumer’s demand for the good is characterized by the function \(q(p)\), which is assumed to be continuous and non-increasing in the price level. Consumer surplus at price \(p\) is defined to be \(S(p) \equiv \int_p^{\infty} q(t)dt\).

The \(n\) markets are each served by a single firm \(i, i = 1, 2, ..., n\). Without the Internet, consumers will not travel to other locations to buy the good, as the cost of travelling is assumed to be prohibitively high. Thus, each firm enjoys monopoly power over its local market in the absence of price comparison sites. Each firm sets a single price to sell all units of the good it produces. All firms produce the good with the same technology.
with constant marginal cost $c$ ($c \geq 0$) and no fixed costs. Define the function $\pi$ as a firm’s expected profits when it sells to the whole market, that is $\pi(p) = (p - c)q(p)$.

Assume that there is a unique profit-maximizing price $r \in (c, \infty)$, and that $\pi$ is strictly increasing up to $r$. The cost for a consumer to physically visit her local store is $\varepsilon$, where $\varepsilon$ is sufficiently small such that $S(r) > \varepsilon$; i.e., a consumer finds it worthwhile to physically visit her local store even if she is sure that she will be charged the monopoly price.

Since consumers cannot travel to other locations, if no price comparison sites are present, each firm simply charges the monopoly price to all of its local customers to earn profits of $(r - c)q(r)/n$, or $\pi(r)/n$. On the other hand, when price comparison sites are available, firms can make their prices known to consumers from other locations, and consumers can access price information of firms from other locations and purchase from one of the firms who list their prices on the site(s), as long as firms choose to advertise on these sites. As shown in BM, when there is only one information gatekeeper, the economy can coordinate on an equilibrium in which firms do advertise with the information gatekeeper, and consumers do subscribe to the services.\footnote{As pointed out in BM, there is also an equilibrium in which firms and consumers simply ignore the information gatekeeper.}

Firms can choose to advertise on both sites, on just one of them, or not to advertise at all. We make the following assumption about firms’ advertising strategies.

**Assumption 2.** Firms cannot price discriminate among different consumers.

Assumption 2 implies that, regardless of whether a consumer contacts a firm through $A$, $B$, or with a local visit, the firm must charge the consumer the same price.\footnote{See Baye and Morgan (2002) and Nahm (2003) for discussions of the potential effects of price discrimination in the BM model.} If a consumer subscribes to a site, then she can either purchase the good from any firm
advertising on that site, or visit her local firm to purchase the good.

We will adopt the following notation for a firm’s expected profits. Firm \( i \)'s \((i = 1, 2, \ldots, n)\) expected profits when it advertises a price \( p \) on site \( I \) are \( E\pi_i(p, I) \), where \( I = A, B \). The expected profits of a firm when it advertises on both sites and when it does not advertise are denoted as \( E\pi_i(p, AB) \) and \( E\pi_i(p, N) \), respectively.

Throughout this paper, we consider symmetric equilibria only, i.e., equilibria in which each firm adopts the same pricing strategy.

1.3 Nash Equilibria Between Firms and Consumers

In this section, we characterize the Nash equilibria between firms and consumers under the assumption that each consumer subscribes to both sites. We first describe the optimal shopping decisions by consumers.

**Lemma 1.1.** Consumers (a) first visit both sites and (b) purchase at the lowest price listed on these sites. (c) If neither site has price listings, they visit and purchase from their local firm.

Lemma 1.1 is obtained by using the same type of argument as in Proposition 1 of Baye and Morgan (2001). The reason for part (a) is that for a consumer who subscribes to both sites, the marginal cost of obtaining a price observation from the sites is zero while that of visiting the local firm is \( \varepsilon \). The reason for part (b) is as follows. It can be shown that a consumer’s behavior must be characterized by a threshold level \( p_{AB}^* \) if she does visit her local firm some of the time.\(^6\) That is, the consumer visits her local firm if and only if the lowest price available on both sites, \( p_{AB}^{min} \), exceeds \( p_{AB}^* \). But knowing

\(^6\)See Appendix A for a more detailed description.
this, the local firm will never charge a price that is lower than $p^*_{AB}$ when it does not advertise. This eliminates the reason for the consumer to visit her local firm. Finally, the reason for part (c) is because $S(p) \geq S(r) > \varepsilon$ for all $p \leq r$ and because firms never find it optimal to charge any price greater than $r$.

Now given advertising fees ($\phi_A$ and $\phi_B$) set by price comparison sites in the first stage, and the assumption that consumers subscribe to both sites, we would like to find Nash equilibria between firms and consumers in the second stage.

Next, we describe firms’ pricing behavior when they do not advertise.

**Lemma 1.2.** Given that every consumer subscribes to both sites, a firm charges the monopoly price when it does not advertise.

*Proof.* Suppose firm $i$ does not advertise. Given Lemma 1.1, it can have positive sales only when its local consumers do not observe any price listings on either of the two sites, i.e., when no firms advertise on either of the two sites. Since this probability does not depend on the price level charged by firm $i$, it charges the monopoly price $r$ to maximize expected profits when it does not advertise.

The next lemma characterizes firms’ advertising decisions.

**Lemma 1.3.** Suppose $\phi_i > 0$ for some $i = A, B$. Then a firm advertises on, at most, one site.

*Proof.* Since every consumer looks at price quotations from both sites, no matter whether a firm advertises on one site or both sites, it attracts the same pool of consumers but it saves on the advertising fee if it advertises on only one site, as long as at least one of the advertising fees is strictly positive.
To further characterize firms’ equilibrium advertising strategies, notice that when both advertising fees are positive, it is not possible that each firm advertises (on one site) with probability one. The reason is that in this instance Bertrand competition arises and profits (gross of advertising fees) are driven down to zero. Given positive advertising fees, firms would rather not advertise.

Now we characterize four types of Nash equilibria given different values of advertising fees set by the price comparison sites in the first stage. Let $\alpha_A$ be the probability a firm advertises on site $A$ only, and $\alpha_B$ be the probability a firm advertises on site $B$ only. Denote $\alpha \equiv \alpha_A + \alpha_B$ as the probability of advertising on one site, and $1 - \alpha$ as the probability of not advertising. Also denote $F$ as the distribution function of advertising on one site. We then have the following proposition.

**Proposition 1.4.** Given advertising fees ($\phi_A$ and $\phi_B$) set by price comparison sites, four types of symmetric Nash equilibria exist in the second stage depending on different values of advertising fees. Furthermore, there is only one type of equilibrium given each fee combination.

- The first type of equilibrium exists iff $\phi_A = \phi_B = \phi$, $0 < \phi < \frac{n-1}{n} \pi(r)$, and can be characterized as follows.

  (1) Each firm advertises on one site with probability

  $$\alpha \equiv \alpha_A + \alpha_B = 1 - \left[ \frac{n\phi}{(n-1)\pi(r)} \right]^{\frac{1}{n-1}}, \alpha \in (0, 1).$$

  (2) The distribution function of a firm’s advertised price is given by the c.d.f.

  $$F(p) = \frac{1}{\alpha} \left[ 1 - \left( \frac{(1 - \alpha)^{n-1}\pi(r) + n\phi}{n\pi(p)} \right)^{\frac{1}{n-1}} \right]$$

---

7See Lemma 1.3.
8Appendix B provides a more detailed proof.
9See Appendix C for the details of the proof.
with support \([p, r]\), where
\[
p = \pi^{-1}\left(\frac{n\phi}{n-1}\right).
\]

(3) Each firm earns expected profits of
\[
E\pi_i = \frac{\phi}{n-1}.
\]

- The second type of equilibrium exists iff \(\phi_A \neq \phi_B\), \(\phi_A > 0\), \(\phi_B > 0\), and the lower of the two advertising fees is less than \(\frac{n-1}{n}\pi(r)\). Each firm advertises on the site with a lower advertising fee with probability
\[
\alpha = \begin{cases} 
\alpha_A & \text{if } \phi_A < \phi_B; \\
\alpha_B & \text{if } \phi_A > \phi_B.
\end{cases}
\]

The distribution function of a firm’s advertised price and each firm’s expected profits are the same as those in the first type of equilibrium, with \(\phi\) replaced by the lower of the advertising fees. The site charging the higher advertising fee is completely ignored by firms.

- The third type of equilibrium exists iff \(\phi_A\) and \(\phi_B\) are both larger than \(\frac{n-1}{n}\pi(r)\). In this type of equilibrium, no firm advertises on any site.

- The fourth type of equilibrium exists iff at least one of the two advertising fees is zero. In this type of equilibrium, at least two firms price at marginal cost as a result of Bertrand competition. Each firm earns zero expected profits.

In the second and third types of equilibrium, one or both sites are completely ignored by firms. Both sites are completely ignored in the third type because the advertising fees are both too high for firms to have incentives to advertise on either site. In the
second type of equilibrium, the site charging a higher advertising fee is completely ignored because advertising on the site with a lower advertising fee dominates. Thus, the “inactive market” equilibrium (in which no firms advertise) does not exist if at least one of the two advertising fees is less than $\frac{n-1}{n} \pi(r)$. The fourth type of equilibrium arises as a result of Bertrand competition.

Now we look at the first type. In this type of equilibrium, sites $A$ and $B$ charge the same advertising fees. Since from a firm’s perspective, the effect of advertising on $A$ is exactly the same as that of advertising on $B$, there is no reason for a firm to advertise more intensively on one site than on the other. Thus, two strategy profiles with different combinations of $\alpha_A$ and $\alpha_B$ have exactly the same advertising effects as long as the values of $\alpha_A$ and $\alpha_B$ add up to the same value of $\alpha$. No matter whether firms advertise on site $A$ with a higher probability or with a lower probability, the final transaction price is generated by the same distribution function, $F$. Hence, in equilibrium, if a consumer observes that the best price listed on one site, say site $A$, is lower than on the other site, site $B$, it is not because firms advertise more intensively on site $A$ but because the consumer observes more price listings on site $A$.

1.4 Fee-Setting and Entry Decisions

In the first stage, price comparison sites set advertising fees simultaneously in order to maximize their own expected profits. We would like to find all Nash equilibria between the two sites. Notice first it is not a Nash equilibrium for both sites to set advertising fees that are above $\frac{n-1}{n} \pi(r)$. The reason is that any site would have an incentive to deviate to set an advertising fee that is slightly lower than $\frac{n-1}{n} \pi(r)$ given the other site’s
strategy. It is also not a Nash equilibrium for both sites to set advertising fees above zero because one site would have an incentive to undercut the other. Thus, in equilibrium, at least one of the two sites must set advertising fee(s) to be zero. Each site earns zero expected profits whether firms advertise on it or not, by Proposition 2.1.

Now consider the entry stage of the game. It is never optimal for the entrant, site B, to enter the information market since if it enters, it earns zero expected profits, which is strictly lower than its setup cost, \( K \).

### 1.5 Multiple Entrants

The four types of equilibria identified in Proposition 2.1 continue to hold when we generalize the model to allow more than one potential entrant. Suppose there are now \( k \) potential entrants, where \( k \geq 2 \). Also suppose consumers look at price quotations from all sites in the market. As in Proposition 2.1, four types of Nash equilibria between firms and consumers can be identified. First, when all of the advertising fees are too high, firms have no incentive to advertise. Second, when at least one of the advertising fees is zero, Bertrand competition occurs, and in equilibrium at least two firms price at marginal cost, and all firms earn zero expected profits. Third, when all of the advertising fees are equal and fall within the positive range \( (0, \frac{n-1}{n} \pi(r)) \), each firm simply mixes between advertising on each of the price comparison sites and not advertising. Finally, when the advertising fees are not all equal, and the lowest fee falls within the positive range \( (0, \frac{n-1}{n} \pi(r)) \), only the site(s) with the lowest advertising fee get(s) traffic from firms. Thus, using the same argument as when there is only one potential entrant, when we go back to the entry and fee-setting decisions of the game, the entrants would not find
it optimal to enter the information market because the potential advertising revenues, which are zero, do not cover the setup costs.

1.6 Conclusions, Discussions, and Future Research

This chapter considers a situation in which there is an incumbent price comparison site and a potential entrant in the information market. We show that even if all consumers look at price quotations from both sites, the potential entrant does not find it optimal to enter the information market. Thus, the monopoly equilibrium identified in Baye and Morgan (2001) is the only equilibrium given this assumption on consumers’ subscription decisions. Moreover, similar results hold when we generalize the model to allow more than one potential entrant.

We give two examples under which each consumer visits all price comparison sites. First, all consumers are “bargain hunters” who visit all sites in order to find the lowest price available. Second, the value of the good is of relatively high value, i.e., costs more, so a consumer would be able to “save more” by visiting all price comparison sites. However, only one monopoly site can be supported in equilibrium when each consumer visits all sites.

Intuition might lead one to think that the higher the proportion of “bargain hunters,” or the higher the value of the good, the more price comparison sites there should be. This paper shows it is not the case. In fact, we may even have the following conjectures. First, the more consumers who are “bargain hunters” over the entire population, the less price comparison sites the information market would be able to support. Second, we should observe more price comparison sites for products of relatively low value than
of relatively high value since consumers tend to visit more sites to find the best price deal when they shop for high value goods than for low value ones. Observations of price comparison sites in the real world seem to support our second conjecture. For example, the number of price comparison sites who specialize in products of low value such as books and CDs are a lot more than price comparison sites who specialize in products of high value such as loose diamonds, although this observation has to be interpreted with caution since this may also arise from the fact that the market size is smaller for products of high value than for products of low value.\footnote{We know of only two price comparison sites who specialize in loose diamonds — pricescope.com and diamondse.info. On the other hand, the following price comparison sites all specialize in books — AddAll.com, AllBookStores.com, ISBN.nu, BookFinder4u.com, BookWormer.com, BestBookDeal.com, BookBrain.co.uk, AAABooksearch.com, BestBookBuys.com, Bublos.com, and bookHQ.com. See Google.com directory for more examples. For price comparison sites that specialize in CDs, see the directory of musicmoz.com for information. The link is as follows, http://musicmoz.org/Shopping/Directories_and_Comparison_Services/.
}

In this chapter, we identify a condition under which the Baye and Morgan (2001) equilibrium is the only equilibrium. This condition is equivalent to making the assumption that each consumer subscribes to all sites. It would be of interest for future research to explore possible types of equilibria if we relax this assumption — for example, by assuming that a proportion of consumers subscribe to one site while the rest subscribe to both sites or by assuming that each consumer subscribes to only one site.
Chapter 2

Competing Gatekeepers
2.1 Introduction

In today’s e-commerce, price comparison sites enhance transaction opportunities between firms and consumers by directing consumers to different firms who advertise their products on the sites.\footnote{In August 2003, more than 21 million customers visited price comparison sites, according to Nielsen/Net-Ratings. The most popular sites have millions of visits. For example, Shopping.com (formerly DealTime.com) had nearly 12 million unique visits, BizRate.com had 6 million, NexTag.com had 4.6 million, and PriceGrabber.com had 3.9 million. Source: Clickz.com on Shopping Search Engines by Sherman (2003).} Usually free of charge, consumers can easily get a list of prices for a product from multiple firms while firms usually pay advertising fees to be included in online price listings.

Products on price comparison sites include books, CDs, electronics, mortgages, to software, etc. Moreover, in many product categories, consumers have multiple options to choose from. For example, to find the best price for *Harry Potter and the Order of the Phoenix*, consumers may use price comparison sites such as AddAll.com, AllBookStores.com, or isbn.nu. To find the best mortgage rates, consumers can use BestRate.com, LendingTree.com, or MoneyNest.com. To find the cheapest prescription drugs, consumers can use DestinationRx.com or PharmacyChecker.com. While these price comparison sites specialize in products, other sites, such as Nextag.com, PriceGrabber.com, or priceSCAN.com, provide price information for a wide range of products.

We look at competition between price comparison sites in the information market on the internet. Baye and Morgan (2001) (BM henceforth), the basis for this research, introduce a model in which a *single* price comparison site, the “information gatekeeper,” interacts with consumers and firms in this information market.\footnote{Baye and Morgan (2001) term the price comparison site an “information gatekeeper” as it charges consumers and firms fees for obtaining from it price information.} They find that only...
dispersed price equilibria exist in such a model. Moreover, the gatekeeper’s profits are maximized in a dispersed price equilibrium where all consumers subscribe to the gatekeeper’s services. Finally, the gatekeeper has incentives to set “high” advertising fees to firms while “low” subscription fees for consumers.

In the BM model, only one price comparison site is allowed because the focus is on the interaction between information markets and the associated product markets. However, as discussed, the coexistence of multiple price comparison sites seems more common than dominance by a monopoly site.

We study competition in the information market by extending the BM model to allow multiple price comparison sites. We find equilibria in which both sites coexist in the market and make positive profits. Social welfare is lower with competing price comparison sites as it reduces the effectiveness of the information market. Moreover, joint profits of price comparison sites are lower than the profits of one monopoly site.

We start out with a three-stage game model in which there are two price comparison sites. In stage 1, price comparison sites simultaneously set advertising fees. In stage 2, consumers and firms simultaneously make subscription and advertising decisions. Finally, in stage 3, consumers make shopping decisions. Restricting subscription fees to zero, price comparison sites compete on advertising fees to attract firms to advertise on their sites. Two types of strategy profiles are identified as symmetric equilibria for the second stage.

In the first type of equilibria, as long as price comparison sites set the same non-prohibitive advertising fees, then Nash equilibria exist in the second stage with each consumer subscribing to both sites, and each firm mixing between advertising on one site and not advertising. This is similar to the first type of Nash equilibrium identified
by ?).

In the second type of equilibria, as long as the sum of advertising fees falls within a certain range, then in the second stage there exist Nash equilibria in which each consumer subscribes to only one site, and each firm mixes between advertising on both sites and not advertising. The second type of equilibria is more reasonable than the first type in the sense that there exists an equilibrium close to the original one even if there is a slight deviation from the original advertising fee by any site.

We require consumers and firms to play according to the second type of equilibrium as long as this type of equilibrium exists. There is only one symmetric subgame perfect Nash equilibrium (SPNE) for the whole game. In the unique SPNE, both sites coexist in the market and make positive profits.

Compared with the model when there is only one price comparison site, allowing for one more reduces social welfare in the information market. The joint profits of price comparison sites are lower than the profits of one monopoly site, but each firm earns higher expected profits when there are two sites than when there is only one monopoly site. Moreover, the main results we derive when there are two price comparison sites hold when we generalize to multiple sites.

2.2 Literature and Stylized Facts

This chapter is related to models on “temporal price dispersion.” That is, a firm constantly changes its posted price so consumers and rival firms are not able to predict its pricing strategies. Papers by Rothensal (1980), Varian (1980), and Narasimhan (1988)

\footnote{Stigler (1961) is the first on modelling price dispersion.}
fit into this category. Rothensal (1980) prevents firms from charging different prices to captive consumers versus non-captive consumers, leading to price dispersion. Varian (1980) has two types of consumers – informed and uninformed. Uninformed consumers purchase from a randomly selected store as long as the price charged is less than the reservation price. Informed consumers, on the other hand, purchase from the store charging the lowest price. Price dispersion arises when firms price discriminate. Narasimhan (1988) has the total mass of consumers segmented into brand loyal consumers and brand switchers. Price dispersion arises because “firms fluctuate their prices to induce brand switchers to buy their products while at the same time minimizing the loss of profits from their loyal consumers (Narasimhan (1988), p. 428).”

While these papers have examined price dispersion in conventional retail markets, others have examined price dispersion in online market. Janssen and Moraga (2000), for example, adopt a search model to model price dispersion in online markets. Two consumer types differ in search costs – informed consumers have zero search costs while less-informed consumers have positive search costs. Three types of equilibria for consumers’ search intensity emerge. Baye and Morgan (2001) model price dispersion as a single price comparison site interacting with consumers and firms in the internet information market. The main reason for a dispersed price equilibrium is that firms have to pay advertising fees to use the price comparison site’s services. By randomizing advertised prices, firms avoid marginal cost pricing and hence sustains the value of the information market.

Two main features distinguish the BM model from the other models. First, all players’ strategies are endogenous. Thus, firms decide whether to advertise on the site, consumers decide whether to subscribe to the price comparison site’s services, and
the price comparison site decides on the fees it charges. Second, the model explicitly considers online market characteristics, especially the shopping tool that is becoming more and more popular among consumers – price comparison sites. By using price comparison sites, consumers obtain various prices for the same product. Thus, the search cost is basically zero for consumers.

In the first chapter, we demonstrate that the equilibrium identified in BM is the only equilibrium even if entry is allowed and if consumers all look at price quotations from each of the price comparison sites. Thus, the BM equilibrium is robust to entry. While we point out that there may be multiple price comparison sites in the information market in the first chapter, in equilibrium only one monopoly site exists because potential entrants have no incentives to enter the market.

**Some Stylized Facts:** The results of some searches for the same product on different price comparison sites provide a picture of how firms actually price on different price comparison sites as well as a background for the model in Section 2.3. First, price dispersion is prevalent, as is documented by recent empirical studies. Second, some firms advertise on multiple sites at the same time. Third, when a firm advertises on multiple sites, it usually charges the same price on each site. For example, to search for the lowest price deal for Canon PowerShot S500 digital camera, we consult price listings of two sites — cnet.shopper.com and NexTag.com. The search result on October 22, 2004

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4Empirical evidence suggests price dispersion exists in online markets. For example, Bailey (1998) finds that price dispersion is higher online than in traditional outlets, while Brynjolfsson and Smith (2000a) find mixed results for the level of price dispersion in online markets versus conventional markets for books and CDs, depending on whether prices are weighted by market share. Clemons, Hann, and Hitt (2002) and Clay, Krishnan, and Wolff (2001) find substantial price dispersion for online bookstores and airplane tickets offered by online travel agents respectively. Scholten and Smith (2002) find that price dispersion persists over 24 years periods for both retail and e-tail markets. Recently, a series of papers by Baye, Morgan, and Scholten(2001, 2003a, 2003b) also provide evidence of persistent price dispersion on the internet.

5Since shipping costs are sometimes not shown, we refer to the base price here.
is as follows. First, price dispersion is prevalent on both sites. On NexTag.com, prices range from $304.83 to $409.00, while on cnet.shopper.com, prices range from $299.95 to $355.99. Second, some firms advertise on both sites. Among those 61 firms who advertise on cnet.shopper.com, and those 64 who advertise on NexTag.com, there are 15 firms who advertise on both sites. Moreover, a more careful examination shows that when a firm advertises on both sites, it advertises the same price. There is no exception among those 15 firms in this example, and no exception among our casual searches. We do not intend to explain why a firm charges the same price on different price comparison sites in this chapter. However, based on the observations, later in our model we will make the assumption that when a firm advertises on both sites, it advertises the same price.

The rest of the chapter is organized as follows. Section 2.3 describes the model with two price comparison sites. Section 2.4 considers the situation when each consumer subscribes to both sites. Section 2.5 considers the situation when each consumer subscribes to only one site. Section 2.6 discusses price comparison sites’ fee setting decisions. Section 2.7 compares social welfare of two price comparison sites with that of a monopoly site. Section 2.8 shows that the results we derive in the above sections continue to hold with more than two price comparison sites. Section 3.5 concludes.

2.3 The Model

Consider an information market served by two price comparison sites, which we call (sites) A and B. These two sites interact with other players – a unit mass of consumers

\footnote{This may be justified by the following reasons. First, by advertising the same price on two different sites, firms establish goodwill based on their pricing strategies. Second, charging the same price prevents the possibility of arbitrage by consumers if they see different prices posted on different sites.}
and $n$ firms in the information market. Price comparison sites charge firms “advertising fees” for posting their prices, but do not charge consumers for browsing price information.\textsuperscript{7} The advertising fees charged by sites $A$ and $B$ are $\phi_A$ and $\phi_B$. The cost of setting up one price comparison site is $K$.\textsuperscript{8}

A unit mass of consumers are evenly distributed across $n$ geographic locations. Each location is assumed to be far from the other locations. The demand function $q(p)$ characterizes consumer preferences for the good. It is assumed to be continuous and non-increasing in the price level, and is identical for each consumer. Consumer surplus at price $p$ is defined to be $S(p) \equiv \int_p^\infty q(t)dt$.

Each location is served by a single firm $i$, $i = 1, 2, ..., n$. Without the internet, consumers will not travel to other locations to buy the good, as the cost of travelling is assumed prohibitive. Thus, each firm enjoys monopoly power over its local market without price comparison sites. All firms produce the good with the same technology with constant marginal cost $c$ ($c \geq 0$) and no fixed costs. Define a firm’s expected profits when it sells to the whole market as $\pi(p) = (p - c)q(p)$. Assume that there is a unique profit-maximizing price $r \in (c, \infty)$, and that $\pi$ is strictly increasing up to $r$. The costs for a consumer to physically visit her local store is $\varepsilon$, where $\varepsilon$ is sufficiently small such that $S(r) > \varepsilon$; i.e., it is worthwhile to physically visit the local store even if a consumer is sure that she will be charged the monopoly price.

Since consumers cannot travel to other locations, if no price comparison sites are present, each firm simply charges the monopoly price, sells to its local customers, and earns profits of $(r - c)q(r)/n$, or $\pi(r)/n$. On the other hand, with price comparison

\textsuperscript{7}This assumption – subscription is free for consumers – simplifies the analysis. Moreover, this is reasonable approximation as consumers usually pay nothing when browsing a price comparison site.

\textsuperscript{8}See Caillaud and Jullien (2003) for an alternative model on intermediary competition.
sites, firms can make their prices known to non-local consumers, and consumers can access price information of non-local firms and purchase from one of the firms who list their prices on the site(s). In fact, BM show that with one information gatekeeper, the economy can coordinate on an equilibrium in which firms do advertise with the information gatekeeper, and consumers do subscribe to the services.\(^9\)

Firms may advertise with one or both sites, or not advertise at all. We make the following assumption about a firm’s advertising strategies:

**Assumption 3.** Firms cannot price discriminate among different consumers.

In other words, no matter whether a consumer reaches a firm through A, B, or a local visit, the firm must charge the consumer the same price.\(^10\)

Throughout this paper, we will adopt the following notation: Firm \(i\)'s \((i = 1, 2, \ldots, n)\) expected profits when it advertises a price \(p\) on site \(I\) are \(E\pi_i(p, I)\), where \(I = A, B\). The expected profits of a firm when it advertises on both sites and when it does not advertise are denoted as \(E\pi_i(p, AB)\) and \(E\pi_i(p, N)\), respectively. Moreover, we consider symmetric equilibria only, i.e., each firm adopts the same pricing strategy.

Consumers can choose to subscribe to both sites, just one of them, or neither. We consider only pure consumer strategies. Furthermore, we make the following assumption.

**Assumption 4.** Each consumer subscribes to the same number of site(s).

Assumption 4 simplifies the analysis by ruling out the possibility that a fraction of the consumers subscribe to one site while the rest subscribe to both sites.\(^11\)

\(^9\)As pointed out in BM, there is also an equilibrium in which firms and consumers simply ignore the information gatekeeper.


\(^11\)Alternatively, we can specify that a consumer’s preference is lexicographic with two criteria: (1)
The timing of the game is summarized as follows.

- **Stage 1:** Sites A and B announce advertising fees ($\phi_A$ and $\phi_B$) simultaneously.

- **Stage 2:** Learning these fees, consumers decide whether or not to subscribe, and if they do, which site(s) to subscribe to; firms make pricing decisions and decide whether or not to advertise their prices on the sites, and if they do, which site(s) to advertise on.

- **Stage 3:** Consumers shop. Consumers decide where to purchase the good and how much to purchase. Also, once a subscribing consumer sees prices advertised on a price comparison site, she can always go back to the site to make a purchase even if she visits her local firm.

Before characterizing the equilibria, notice that for any advertising fees, there always exists an equilibrium in which firms do not advertise and consumers do not subscribe (inactive market). One of the two sites may be completely ignored by firms and consumers, and the equilibrium collapses into that of the original BM model. Also, to see how subscribers and firms are affected by price comparison sites’ fees, we ignore the possibility that a fraction of consumers do not subscribe to any site. Moreover, we ignore cases in which at least one site sets zero advertising fees. If we allowed an entry expected surplus, (2) number of sites subscribed. Thus, when a consumer decides whether to subscribe to one or both sites, she first uses the first criterion by comparing the net expected surplus from subscribing to one site versus that from subscribing to both sites. She subscribes to both sites (one site) if she gets strictly higher expected surplus from subscribing to both sites (one site). If the expected surpluses are the same, then the consumer uses the second criterion, subscribing to one site. We can think of the second criterion in a sense that there is a small cost of visiting a site. However, this cost is so small that it plays a role only when the expected surplus from subscribing to one site is the same as that from subscribing to both sites. Lexicographic preferences rule out the possibility that a fraction of consumers subscribe to one site while the rest subscribe to both sites. In addition, it prevents subscribing to one site being weakly dominated by subscribing to both sites.

The BM model predicts that in the equilibrium that maximizes the gatekeeper’s profits, all consumers subscribe to the gatekeeper’s services.
stage at the beginning of the game, then a rational price comparison site would not have an incentive to enter the market if it anticipates earning nothing from advertising revenues.

2.4 Nash Equilibria When Each Consumer Subscribes to Both Sites

The equilibria when each consumer subscribes to both sites are similar to the first type of equilibrium in Proposition 1 of (?). The set of equilibria are summarized as follows.

**Proposition 2.1.** Given advertising fees set by the price comparison sites($\phi_A$ and $\phi_B$), a symmetric Nash equilibrium exists if and only if $\phi_A = \phi_B \equiv \phi$, $0 < \phi < \frac{n-1}{n} \pi(r)$, and can be characterized as follows:

1. Every consumer subscribes to both sites;

2. Each firm advertises on one site with probability

\[ \alpha \equiv \alpha_A + \alpha_B = 1 - \left[ \frac{n\phi}{(n-1)\pi(r)} \right]^{\frac{1}{n-1}}, \alpha \in (0, 1); \]

3. The distribution function of a firm’s advertised price is given by the following c.d.f.

\[ F(p) = \frac{1}{\alpha} [1 - \left( \frac{(1 - \alpha)^{n-1} \pi(r) + n\phi}{n\pi(p)} \right)^{\frac{1}{n-1}}] \]

with support $[p_1, r]$, where

\[ p_1 = \pi^{-1}(\frac{n\phi}{n-1}); \text{ and} \]

\[ r = \pi^{-1}(\frac{n\phi}{n-1}); \text{ and} \]
(4) Each firm earns expected profits of

\[ E\pi_i = \frac{\phi}{n-1}. \]

Thus, as long as the price comparison sites set equal non-prohibitive advertising fees, then in the second stage a Nash equilibrium exists in which each consumer subscribes to both sites, and each firm mixes between advertising on one site and not advertising. According to Proposition 2.1, the differences in the best price deals across sites are not driven by differences in firms’ pricing aggressiveness as perceived by common notion, but by the fact that a consumer observes more price listings on one site than on the other site.

2.5 Nash Equilibria When Each Consumer Subscribes to One Site

We now consider the situation when each consumer subscribes to only one site. We divide the total mass of consumers into two fractions — \( \mu_A \) and \( \mu_B \), where \( \mu_A + \mu_B = 1 \), \( \mu_A \neq 0 \), and \( \mu_B \neq 0 \). Fractions \( \mu_A \) and \( \mu_B \) consist of consumers subscribing to site \( A \) only and site \( B \) only, respectively. Throughout Section 2.5, we shall assume the following:

**Assumption 5.** A consumer’s subscription decision is independent of her location.

Without assumption 5, different firms may have different incentives when choosing their advertising strategies. For example, all else equal, a firm with more of its local consumers subscribing to site \( A \) tends to have less incentives to advertise on \( A \) than a firm with less of its local consumers subscribing to site \( A \), since the main purpose of
advertising is to attract consumers from other locations. Assumption 5 avoids this type of complication by requiring consumers’ subscription decision to be independent of their locations.

Specifically, we assume that for each firm \(i, i = 1, 2, ..., n\), the fraction \(\mu_A\) of its local consumers subscribe to site \(A\) while the fraction \(\mu_B\) of its local consumers subscribe to site \(B\).

Let \(\alpha_A\) (\(\alpha_B\)) be the probability a firm advertises on site \(A\) (site \(B\)) only. We first establish the following Lemma.

Lemma 2.2. When each consumer subscribes to only one site, and no site is ignored by consumers completely, firms must advertise on both sites if they advertise. That is, \(\alpha_A = \alpha_B = 0\).

Appendix A proves Lemma 2.2. Intuitively, notice that consumer subscriptions are free. Thus, for a consumer subscribing to only one site, if she perceives that there is a positive probability that she could get different price information from the other site, she will strictly prefer subscribing to both sites to subscribing to the current site only. For example, consider a consumer subscribing to site \(A\) only. Suppose now \(\alpha_B > 0\). This implies that the consumer has a positive probability of getting different price information if she is to subscribe to site \(B\). She thus strictly prefers subscribing to both sites to subscribing to site \(A\) only. Thus, when each consumer subscribes to only one site, and no site is completely ignored by consumers, firms must advertise on both sites if they advertise.

Using Lemma 2.2, we rule out the following advertising strategies as equilibrium strategy candidates: every firm advertises on one site with probability one, every firm mixes between advertising on one site and not advertising, every firm mixes between
advertising on one site and both sites, and every firm mixes between advertising on one site, both sites and not advertising. We are left with two cases to consider: every firm advertises on both sites with probability one, and every firm mixes between advertising on both sites and not advertising. Before discussing these two cases, we first describe the optimal shopping decisions by consumers.

**Lemma 2.3.** A consumer who subscribes to one site (a) first visits the site that she subscribes to and (b) purchases at the lowest price on the site. (c) If there are no price listings on the site, she visits and purchases from her local firm.

**Proof.** Parts (a) and (c) are obtained using the same reasoning as those in Proposition 1 of BM. The reason for part (a) is that, for a consumer subscribing to one site, the marginal cost of obtaining a price observation from the site is zero while that of visiting the local firm is $\varepsilon$. The reason for part (c) is that $S(p) \geq S(r) > \varepsilon$ for all $p \leq r$ and that firms never find it optimal to charge any price greater than $r$. Next we sketch the proof of part (b). Consider a consumer who subscribes to site $A$ only. Clearly, if she observes her local firm’s price on site $A$, she purchases at the lowest price available on the site. If she does not observe her local firm’s price on site $A$, she knows that her local firm does not advertise (by Lemma 2.2), and she must decide whether to incur $\varepsilon$ to visit her local firm. It can be shown that the consumer’s behavior must be characterized by a threshold level $p_A^*$ if she does visit her local firm some of the time. That is, she visits her local firm if and only if the lowest price available on site $A$, $p_A^{min}$, exceeds $p_A^*$. But knowing this, the local firm will never charge a price below $p_A^*$ when it does not advertise, which makes it never optimal for the consumer to visit her local firm.

\[13\text{See also Lemma 1 of } \text{?).}\]
Now treating advertising fees set by price comparison sites in the first stage as exogenous, we would like to find Nash equilibria for the second stage simultaneous move game between firms and consumers. We first fix consumers’ subscription decisions and check for the optimality of firms’ advertising strategies. Then given firms’ advertising strategies, we check for the optimality of consumers’ subscription decisions. First, we describe firms’ pricing decisions when they do not advertise.

**Lemma 2.4.** Given that every consumer subscribes to only one site, and no site is ignored by consumers completely, a firm charges the monopoly price when it does not advertise.

*Proof.* Consider a firm that does not advertise. Given that each consumer subscribes to only one site, and no site is ignored by consumers completely, a firm that does not advertise can have positive sales only if its local consumers do not observe any price listings on any of the two sites, and hence come back to visit the firm. Since this probability does not depend on the price charged by the firm, the firm charges the monopoly price $r$ to maximize its expected profits when it does not advertise. 

We consider the following two cases and establish a class of equilibrium under Case 2.

**CASE 1:** Suppose that every firm advertises on both sites with probability one. This cannot be an equilibrium because Bertrand competition arises and profits (gross of advertising fees) will be driven to zero. Since the advertising fees ($\phi_A$ and $\phi_B$) are positive, a firm would rather not advertise because if it does, it earns negative net profits, while if it does not, its profits are at least zero.

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14If there are no price listings on one site, it must be that there are also no price listings on the other site since a firm advertises on both sites when it advertises.
CASE 2: Suppose that every firm mixes between advertising on both sites and not advertising. We first establish the following Lemma.

**Lemma 2.5.** When every consumer subscribes to only one site, and no site is ignored by consumers completely, in an equilibrium with every firm mixing between advertising on both sites and not advertising, the ratio between advertising fees for the two sites equals the ratio between fractions of consumers who subscribe to these sites. That is,

\[
\frac{\mu_B}{\mu_A} = \frac{\phi_B}{\phi_A}.
\]

Lemma 2.5 ensures that, in equilibrium, a firm advertising on both sites will not have incentives to deviate to advertise on one site only. For example, suppose the right hand side is greater than the left hand side. This means that site B charges an advertising fee that is too high compared to the fraction of subscribing consumers. Then a firm would rather advertise on site A only because it is not profitable to spend an extra advertising fee \((\phi_B)\) and advertise on an additional site.

Let \(\beta\) be the probability that a firm advertises on both sites; \(1 - \beta\) be the probability that it does not advertise. Let \(H\) be the distribution function of a firm who advertises on both sites. We are able to establish the following proposition.

**Proposition 2.6.** Suppose price comparison sites A and B set advertising fees \(\phi_A\) and \(\phi_B\), then a symmetric Nash Equilibrium exists if and only if \(0 < \phi_A + \phi_B < \frac{n-1}{n} \pi(r)\), and can be characterized as follows:

(1) A fraction \(\mu_A\) of consumers subscribe to site A while the fraction \(\mu_B\) of consumers subscribe to site B, \(\mu_A + \mu_B = 1, \mu_A \neq 0, \mu_B \neq 0, \) and \(\frac{\mu_A}{\mu_B} = \frac{\phi_A}{\phi_B}\);
(2) Each firm advertises on both sites with probability

\[ \beta = 1 - \left[ \frac{n(\phi_A + \phi_B)}{(n - 1)\pi(r)} \right]^{\frac{1}{n-1}}, \beta \in (0, 1); \]

(3) The distribution function of a firm’s advertised price is given by the following c.d.f.

\[ H(p) = \frac{1}{\beta} \left\{ 1 - \left[ (1 - \beta)^{n-1}\pi(r) + n(\phi_A + \phi_B) \right]^{\frac{1}{n-1}} \right\} \]

with support \([p_2, r]\), where

\[ p_2 = \pi^{-1}\left[ \frac{n}{n-1}(\phi_A + \phi_B) \right]; \text{and} \]

(4) Each firm earns expected profits of

\[ E\pi_i = \frac{\phi_A + \phi_B}{n - 1}. \]

Notice that consumers’ strategies are optimal. Since subscription is free for consumers, subscribing is always better than not subscribing. Moreover, the expected surplus for a consumer from subscribing to one site is the same as that from subscribing to both sites. This is because once firms advertise, they advertise on both sites. By subscribing to one site only, consumers get the same benefits as they would if they subscribed to both sites.\(^{15}\)

2.6 Fee Setting Decisions by Price Comparison Sites

In the first stage, price comparison sites set advertising fees simultaneously to maximize expected profits. First, notice that, as long as we specify the off equilibrium path to be

\(^{15}\)Alternatively, we can consider a perturbed model in which there is a small cost of visiting a site. In the limit, a consumer will subscribe to only one site. Thus, the equilibrium in which each consumer subscribe to only one site is the “right” equilibrium we should be focusing on.
the inactive market Nash equilibrium, then any equilibrium path with $\phi_A = \phi_B = \phi$, 
$0 < \phi < \frac{n-1}{n} \pi(r)$, and consumers and firms playing according to Proposition 2.1, or with 
$0 < \phi_A + \phi_B < \frac{n-1}{n} \pi(r)$, and consumers and firms playing according to Proposition 2.6, could be supported as subgame perfect Nash equilibrium (SPNE).

However, if either site deviates from the equilibrium advertising fee, then in the second stage there does not exist an equilibrium that is close to the original Nash equilibrium as in Proposition 2.1. Thus, the second type of equilibrium is more reasonable than the first type in the sense that there exists an equilibrium close to the original one even if there is a slight deviation from the equilibrium advertising fee by either site.

Now, given any pair of advertising fees set by price comparison sites in the first stage, in the second stage we require consumers and firms to play according to the second type of equilibrium as long as this type of equilibrium exists. Given this restriction, there is only one symmetric SPNE. This SPNE could be obtained by solving the two price comparison sites’ maximization problems simultaneously.

Notice that price comparison sites derive revenues entirely from advertising fees. Thus, site $A$’s problem is to set $\phi_A$ to maximize $\pi_A = n \beta \phi_A$, and similarly for site $B$. Substituting $\beta = 1 - \left[ \frac{n(\phi_A + \phi_B)}{(n-1) \pi(r)} \right]^{\frac{1}{n-1}}$ into sites $A$ and $B$’s profit functions and solving their maximization problems simultaneously gives the equilibrium advertising fees

$$
\phi_A^* = \phi_B^* = \left[ \frac{2(n-1)}{2n-1} \right]^{n-1} \cdot \frac{(n-1) \pi(r)}{2n}.
$$

By Lemma 2.5 and the assumption that $\mu_A + \mu_B = 1$, we get the equilibrium fractions of consumers who subscribe to sites $A$ and $B$ respectively to be $\mu_A^* = \mu_B^* = \frac{1}{2}$. We have the following proposition.

**Proposition 2.7.** Suppose in the second stage we require firms and consumers to play
according to the equilibrium in Proposition 2.6 as long as this type of equilibrium exists. Then there is only one SPNE for the whole game. This SPNE could be characterized as follows.

(1) In stage 1, sites A and B set \( \phi_A^* = \phi_B^* = \left[ \frac{2(n-1)}{2n-1} \right]^{n-1} \cdot \frac{(n-1)\pi(r)}{2n} \) simultaneously.

(2) In stage 2, consumers and firms play according to the Nash equilibrium in Proposition 2.6 after they learn advertising fees set in stage 1; The proportions of consumers subscribing to sites A and B satisfy \( \mu_A^* = \mu_B^* = \frac{1}{2} \).

(3) In stage 3, consumers shop in accordance with Lemma 2.3.

2.7 Welfare Analysis

Now we compare social welfare of the second type of equilibrium (with price comparison sites setting \( \phi_A^* = \phi_B^* = \left[ \frac{2(n-1)}{2n-1} \right]^{n-1} \cdot \frac{(n-1)\pi(r)}{2n} \), and consumers and firms playing the Nash equilibrium as in Proposition 2.6) with that when there is only one monopoly site, i.e., the BM equilibrium. Setting \( \mu \), the fraction of consumers subscribing to the gatekeeper’s services, equal to one in Proposition 3 of BM and comparing the BM equilibrium with that of Proposition 2.6 in this paper, we see that, when \( \phi \), the advertising fee in the BM model, is equal to \( 2\phi_A \), the respective probability of advertising and the distribution functions are the same. Thus, we need to compare the equilibrium advertising fee, \( \phi^* \), in the BM model with \( 2\phi_A^* \) in Proposition 2.6 in order to know the changes in social welfare since the social welfare depends on the probability of advertising and the associated distribution function, which in turn depends on the advertising fee.

Setting the subscription fee to be zero in the BM model and solving for the monopoly
site’s maximization problem gives the equilibrium advertising fee:

\[ \phi^* = \left(\frac{n-1}{n}\right)^n \pi(r). \]

Comparing \(2\phi_A^*\) with \(\phi^*\), we see that \(2\phi_A^* > \phi^*\) since \(\frac{n-1}{n} < \frac{2(n-1)}{2n-1}\). This further implies that the lower bound of \(H\) is higher than the lower bound of \(F\) for the BM model.

Moreover, \(2\phi_A^* > \phi^*\) implies that \(\beta < \alpha\), where \(\alpha\) is the probability of advertising in the BM model. That is, in the second type of equilibrium, firms advertise less intensively than in the equilibrium when there is only one price comparison site. Thus, they are more likely to advertise a price that is higher than in the monopoly case.

The social welfare when there are two price comparison sites could be written as follows:

\[
SW^{D2} = \int_{p_2}^{r} [S(p) + \pi(p)]d[1 - (1 - \beta H(p))^n] + (1 - \beta)^n[S(r) - \varepsilon + \pi(r)] - 2K, \tag{2.1}
\]

where \(p_2\) is the lower-bound of \(H\) as defined previously.

On the other hand, the social welfare with one monopoly site is:

\[
SW^M = \int_{p_1}^{r} [S(p) + \pi(p)]d[1 - (1 - \alpha F(p))^n] + (1 - \alpha)^n[S(r) - \varepsilon + \pi(r)] - K, \tag{2.2}
\]

where \(p_1\) is the lower-bound of \(F\) in the BM model.

Define a new variable \(p^M\) as the final transaction price for the consumer when there is only one price comparison site, and similarly for the variable \(p^D\) when there are two price comparison sites. Then the c.d.f. of \(p^M\) has mass \((1 - \alpha)^n\) at the monopoly price \(r\), and similarly the c.d.f. of \(p^D\) has mass \((1 - \beta)^n\) at the monopoly price \(r\). Since we know that the lower-bound of \(H\) is higher than the lower-bound of \(F\), that \(1 - (1 - \alpha F(p))^n\) decreases with \(\phi\) (by differentiating \(1 - (1 - \alpha F(p))^n\) with respect to \(\phi\)), and that \(2\phi_A^* > \phi^*\), we know the distribution function of \(p^D\) first order stochastically dominates the distribution
function of $p^M$. Since $S(p) + \pi(p)$ is decreasing in $p$, we know $SW^{D2} < SW^M$. We have the following proposition.

**Proposition 2.8.** Social welfare is lower with two price comparison sites than with one monopoly site.

That social welfare is lower with two sites than with one monopoly site is explained by changes in the advertising fee. With two price comparison sites, the total amount of advertising fees firms pay is higher than that paid with one monopoly site. Higher advertising fees induce firms to advertise less intensively. As a result, consumers are less likely to find a lower price deal on the price comparison sites than with one monopoly site. Since total surplus is decreasing in the price level, social welfare is lower with two sites than with one monopoly site.

It can also be shown that the joint profits of price comparison sites are lower than the profits of one monopoly site.\(^{16}\) This driven by the fact that $2\phi^*_A > \phi^*$, i.e., the joint advertising fees charged by the two sites are larger than the advertising fee charged by a monopoly site. Notice that joint expected profits of price comparison sites are maximized when site $A$ and $B$ both set advertising fees to be $\phi^*/2$. However, given that one site sets advertising fee to be $\phi^*/2$, it is not optimal for the other site to also set advertising fee to be $\phi^*/2$. Instead, it has an incentive to set an advertising fee that is

\(^{16}\)The equilibrium joint profits of price comparison sites $A$ and $B$ can be written as

$$\pi^*_A + \pi^*_B = 2^{n-1}(\frac{n-1}{2n-1})^n\pi(r) - 2K,$$

while the total profits of one monopoly site can be written as

$$\pi^*_M = (\frac{n-1}{n})^n\pi(r) - K.$$

It can be shown that the first term of $\pi^*_A + \pi^*_B$ over the first term of $\pi^*_M$ is equal to $\frac{1}{2}(1 + \frac{1}{2n-1})^n$, which is less than one for all $n \geq 2$. 
higher than $\phi^*/2$.\textsuperscript{17} This is because when site $A$ maximizes its expected profits, it takes into account only the changes in revenue from firms who advertise on its site rather than on both sites. Thus, the joint profits of price comparison sites are lower than the profits of one monopoly site.

### 2.8 Multiple Price Comparison Sites

Propositions 2.1 and 2.6 may be easily generalized to more than two price comparison sites. Now suppose that there are $k$ ($k > 2$) price comparison sites in the information market. Let $\phi_s, s = 1, 2, ..., k$, be the advertising fees charged by each site. Let $\alpha_s, s = 1, 2, ..., k$, be the probability a firm advertises on site $s$ only. We have the following proposition as a generalization of Proposition 2.1.

**Proposition 2.9.** Given advertising fees ($\phi_s, s = 1, 2, ..., k$) set by price comparison sites, a symmetric Nash Equilibrium exists if and only if $\phi_1 = \phi_2 = ... = \phi_k \equiv \phi$, $\phi \in (0, \frac{n-1}{n}\pi(r))$, and can be characterized as follows:

1. Every consumer subscribes to $k$ sites;

\textsuperscript{17}This can be seen by looking at the following two equations. Differentiating the monopoly gatekeeper’s expected profits with respect to $\phi$ gives

$$n[1 - \left(\frac{n\phi^*}{(n-1)\pi(r)}\right)^{\frac{1}{n-1}}] + n\phi^*(-\frac{1}{n-1})\left(\frac{n\phi^*}{(n-1)\pi(r)}\right)^{\frac{1}{n-1}-1} \cdot \frac{n}{(n-1)\pi(r)} = 0.$$  

The first term is the monopoly site’s increased profits because of an increase in the advertising fee while the second term is its loss in profits because of decreased intensity of advertising by firms induced by the higher advertising fee.

Similarly, differentiating site $A$’s expected profits with respect to $\phi_A$ gives

$$n[1 - \left(\frac{n(\phi_A + \phi_B)}{(n-1)\pi(r)}\right)^{\frac{1}{n-1}}] + n\phi_A(-\frac{1}{n-1})\left(\frac{n(\phi_A + \phi_B)}{(n-1)\pi(r)}\right)^{\frac{1}{n-1}-1} \cdot \frac{n}{(n-1)\pi(r)} = 0.$$  

Substituting $\phi_A = \phi_B = \phi^*/2$ into the first order condition of site $A$, and comparing it with the first order condition of the monopoly site, we see that it is not optimal for site $A$ to set its advertising fee to be $\phi^*/2$. Instead, it has incentives to set an advertising fee that is larger than $\phi^*/2$. 

(2) Each firm advertises on one site with probability

$$\alpha \equiv \sum_{s=1}^{k} \alpha_s = 1 - \left[ \frac{n\phi}{(n-1)^2} \right]^{n-1}, \alpha \in (0,1);$$

(3) The distribution function of a firm’s advertised price is given by the following c.d.f.

$$F(p) = \frac{1}{\alpha} \left\{ 1 - \left[ \frac{(1-\alpha)^{n-1} \pi(r) + n\phi}{n\pi(p)} \right]^{n-1} \right\}$$

with support \([p^{(k)}_1, r]\), where

$$p^{(k)}_1 = \pi^{-1} \left( \frac{n\phi}{n-1} \right);$$

and

(4) The expected profits of each firm are

$$E\pi_i = \frac{\phi}{n-1}.$$

Similarly, proposition 2.6 could be generalized to \(k\) price comparison sites. Let \(\beta^{(k)}\) be the probability a firm advertises on all of those \(k\) sites, \(1 - \beta^{(k)}\) be the probability a firm does not advertise, and let \(H_k\) be the distribution function of a firm when it advertises on all \(k\) sites simultaneously.¹⁸ We have the following proposition as a generalization of Proposition 2.6.

**Proposition 2.10.** Given advertising fees \((\phi_s, s = 1, 2, ..., k)\) set by price comparison sites, a symmetric Nash Equilibrium exists if and only if \(0 < \sum_{s=1}^{k} \phi_s < \frac{n-1}{n} \pi(r)\) and can be characterized as follows:

(1) A fraction \(\mu_s, s = 1, 2, ..., k,\) of consumers subscribe to site \(s, \sum_{s=1}^{k} \mu_s = 1, \mu_s \neq 0,\)

and \(\frac{\mu_1}{\mu_1} = \frac{\mu_2}{\mu_2} = ... = \frac{\mu_k}{\mu_k}.\)

¹⁸The distribution function \(H\) in Proposition 2.6 is here \(H_2.\)
(2) Each firm advertises on all sites with probability

\[ \beta^{(k)} = 1 - \left[ \frac{\sum_{s=1}^{k} \phi_s}{(n-1)\pi(r)} \right]^{\frac{1}{n-1}}, \beta^{(k)} \in (0, 1); \]

(3) The distribution function of a firm’s advertised price is given by the following c.d.f.

\[ H_k(p) = \frac{1}{\beta^{(k)}} \{ 1 - \left[ \frac{(1 - \beta^{(k)})^{n-1}\pi(r) + n \sum_{s=1}^{k} \phi_s}{n\pi(p)} \right]^{\frac{1}{n-1}} \} \]

with support \([p_2^{(k)}, r] \), where

\[ p_2^{(k)} = \pi^{-1} \left[ \frac{n}{n-1} \sum_{s=1}^{k} \phi_s \right]; \text{and} \]

(4) Each firm earns expected profits of

\[ E\pi_i = \frac{\sum_{s=1}^{k} \phi_s}{n-1}. \]

However, using the same reasoning as in Section 2.6, we see that the equilibrium in Proposition 2.10 is more reasonable than that in Proposition 2.9 because latter hinges upon equalized advertising fees charged by the price comparison sites in the first stage.

Thus, if we require firms and consumers to play according to the equilibrium as in Proposition 2.10 as long as this type of equilibrium exists, then there is only one symmetric SPNE, which can be obtained by solving the price comparison sites’ maximization problems simultaneously. The equilibrium advertising fees for each site are

\[ \phi_1^* = \phi_2^* = \ldots = \phi_k^* = \frac{(n-1)\pi(r)}{nk} \left[ \frac{k(n-1)}{k(n-1) + 1} \right]^{n-1}. \]

We can also solve for the equilibrium fractions of consumers who subscribe to each site to be

\[ \mu_1^* = \mu_2^* = \ldots = \mu_k^* = \frac{1}{k}. \]
To see how the lower bound of $H_k$ and the probability of advertising change when the number of price comparison sites increases, we need to know how $k\phi^*_1$ changes with respect to $k$. Since $k\phi^*_1 = \left(\frac{n-1}{n}\right)\pi(r)\left(\frac{k(n-1)}{k(n-1)+1}\right)^{n-1}$, and $\frac{k(n-1)}{k(n-1)+1}$ increases with respect to $k$, we know $k\phi^*_1$ increases with respect to $k$. This implies that $p_2^{(k)}$ increases as the number of price comparison sites increases. This also implies that the probability of advertising $\beta^{(k)}$ decreases as $k$ increases. Moreover, we know that $p_2^{(k)}$ tends to the monopoly price $r$ as $k$ tends to infinity. This is because $p_2^{(k)} = \pi^{-1}\left(\frac{n}{n-1}k\phi^*_1\right)$ and $\lim_{k\to\infty}\{k\phi^*_1\} = \left(\frac{n-1}{n}\right)\pi(r)$.

The social welfare with $k$ price comparison sites is:

$$SW^k = \int_{p_2^{(k)}}^r [S(p) + \pi(p)]d[1 - (1 - \beta^{(k)}H_k(p))^n] + (1 - \beta^{(k)}n[S(r) - \epsilon + \pi(r)] - kK,$$

where $p_2^{(k)}$ is the lower bound of $H_k$.

Define $p^k$ as the final transaction price of a consumer with $k$ price comparison sites. Then the c.d.f. of $p^k$ has mass $(1 - \beta^{(k)})^n$ at the monopoly price $r$. Since the function $1 - (1 - \beta^{(k)}H_k(p))^n$ decreases with $\phi$, and we know $p_2^{(k)}$ is close to $r$ as $k$ goes to $\infty$, social welfare with $k$ price comparison sites, $SW^k$, decreases with $k$.

Like the discussions in the previous section, the changes in social welfare are driven by changes in the total amount of advertising fees. Higher advertising fees reduce the probability of advertising by firms, which in turn affects total surplus (or social welfare) through the overall increase in the price level advertised by firms.

It can be shown that as $k \to \infty$, the joint profits of price comparison sites tend to zero. This can be easily verified because price comparison sites’ joint profits are $n\beta^{(k)}k\phi^*_1$, which goes to zero as $k$ goes to infinity because $\beta^{(k)}$ goes to zero and $k\phi^*_1$ goes to $\frac{n-1}{n}\pi(r)$ as $k$ goes to infinity. Lizzeri (1999) studies a model in which a certification intermediary can charge the seller a fee for testing its product and then decide on how much information to reveal to uninformed buyers. The role of the intermediary...
in Lizzeri’s model is somewhat similar to the price comparison site (or information gatekeeper) in our model. Our finding, that when the number of price comparison sites gets large, the joint profits of these sites tend to zero echoes with the result of Lizzeri (1999).\footnote{Lizzeri (1999) shows that when there are multiple intermediaries, there is always an equilibrium in which information is fully revealed and intermediaries make zero profits. As the number of intermediaries goes to infinity, this is the only equilibrium.}

It can also be shown that in the second type of equilibrium, each firm’s expected profits increase as the number of price comparison sites, $k$, increases. This is consistent with the welfare analysis above. As the number of price comparison sites increases, each firm’s probability of advertising becomes lower as a result of increased advertising fees. As $k$ goes to infinity, the information market functions close to the situation without price comparison services and each firm simply charges the monopoly price and sells to its local consumers only.

The main results of this section is summarized as follows:

**Proposition 2.11.** When there are more than two price comparison sites,

(1) the two types of Nash equilibria between consumers and firms identified in Proposition 2.1 and 2.6 still exist.

(2) the entire game has a unique SPNE if we require that consumers and firms play according to the second type of equilibrium. In the unique SPNE, as the number of price comparison sites increases to infinity, social welfare decreases to its lowest, joint profits of price comparison sites decrease to zero, and each firm’s expected profits increase to the profit level without the information market.
2.9 Conclusions

We consider a model in which two sites offer consumers free access to their price comparison services, and charge firms fees for advertising. We show that in the symmetric subgame perfect equilibrium, (1) price comparison sites set the same advertising fees; (2) half of the consumers subscribe to one site and the other half subscribe to the other; (3) each firm mixes between advertising on both sites and not advertising; (4) advertised prices are dispersed. Contrary to the first chapter, two sites coexist in the market and make positive profits. Social welfare with two sites is lower than that with one monopoly site. Moreover, joint profits of price comparison sites are lower than the profits of one monopoly site while each firm earns higher expected profits with two sites than with one monopoly site.

The main results we derive when there are two sites remain true when we generalize the model to allow more than two sites. As the number of price comparison sites goes to infinity, social welfare decreases to its the smallest, joint profits of price comparison sites tend to zero, and each firm simply charges the monopoly price and sells to its local consumers only.

Some limitations of this model are discussed as follows and may be left for future research. First, we assume in our model that firms can not price discriminate among different consumers. Although our observations support this assumption, it would be interesting to empirically document how firms price on different price comparison sites. Second, price comparison sites charge firms a fixed advertising fee in our model. In reality, however, a large proportion of price comparison sites charge advertising fees on a
cost-per-click basis or a combination of fixed and cost-per-click basis. Future research may explore equilibria based on different fee structures of price comparison sites. Third, the two types of equilibria identified with two price comparison sites still hold in a model with more than two sites. Completely solving the model with more than two sites is beyond the scope of this paper. There may exist other “reasonable” equilibria in a model with more than two sites.

\footnote{For example, Nextag.com, PriceGrabber.com and Kelkoo.com charge advertising fees on a cost-per-click basis while cnet.shopper.com charges advertising fees on a fixed fee plus cost-per-click basis.}
Chapter 3

Pricing Behaviors of Firms on the Internet — Evidence From Price Comparison Sites Cnet and Nextag
3.1 Introduction

Price comparison sites such as pricegrabber.com, Nextag.com, cnet.shopper.com, or kelkoo.com, each attracts millions of visitors each month. They allow consumers to “shop wisely.” With a few mouse clicks, consumers get a list of firms as well as their price information for a particular product before they make their purchasing decisions.

The list of firms provided by a price comparison site based on each consumer inquiry represent firms who carry an “identical” product with the same product name, product feature, and even part number or ISBN number. However, product qualities may differ across firms who carry this particular product and are not readily observable from the search result list of a price comparison site. For example, a consumer usually has to click through firms’ websites in order to find out whether some firms offer faster shipping and handling, better return policy, more customization options, or other services than other firms.

In particular, recent observations show that some price comparison sites, such as Kelkoo.com, PriceGrabber.com, and Nextag.com, allow firms to advertise refurbished or open box products. For example, we used Nextag.com to search for the best price for Roxio Easy CD & DVD Creator on March 02, 2004. The search result list shows that two firms — HMcomputer.com and A2Z computers.com are labelled as selling open box products. Similarly, we searched for Nikon Coolpix 8700 8MP Digital Camera on May 08, 2005. The search result list shows that two firms — RefurbDepot.com and Amazon.com are labelled as selling refurbished products. While some firms on a price comparison site clearly label themselves as selling refurbished or open box products,

\footnote{While this type of product feature (the existence of refurbished or open box products) is not present on older price comparison site data, it is present as more price comparison sites emerge.}
there are times when consumers need to click through a firm’s website in order to find out the true quality of its product.

Thus, given the incompleteness of information on the consumer side when they use a price comparison site, would firms who sell products of high quality price differently than if consumers have complete information about the product qualities? We study pricing behaviors of firms on two leading price comparison sites — Cnet.shopper.com and Nextag.com (referred to as Cnet and Nextag henceforth). In particular, we use the indicator of whether a firm sells refurbished or open box products as a proxy of firm quality and study if firms who sell products of high quality use price as a signalling device.

The signalling story is briefly described as follows. In an environment with incomplete information, consumers are not able to distinguish between firm qualities while they observe only firm prices. In our current setting, consumers are not always able to tell whether a firm sells brand new or refurbished or open box products simply by looking at the search result list of a price comparison site. In a separating equilibrium, firms who sell new products (or high quality firms) will have to price higher in order to signal their quality.

We use the Fluet and Garella (2002) model as our basis of analyzing signalling behaviors of firms. Fluet and Garella (2002) provide a model in which firms can use price to signal their product qualities. They predict that in a separating equilibrium (under certain parameter values), both high quality and low quality firms will price higher than their respective price levels under complete information. Using our data set, we identify some Cnet product-dates whose environments are closest to that of incomplete
information in which high quality firms may use price to signal their quality.\textsuperscript{2} Our regression results indicate that the pricing behaviors of firms on those Cnet product-dates are consistent with the predictions of Fluet and Garella (2002).

Our approach is as follows. We assemble a four-month data set for 20 electronic products from Cnet and nextag. On Cnet, none of the firms are labelled as selling refurbished or open box products, while on Nextag, some firms are labelled as such.\textsuperscript{3} Given the specific product feature of our data set, i.e., the coexistence of refurbished and open box products versus brand new products, and the fact that some firms on Nextag are clearly labelled as selling refurbished or open box products, we are able to identify firms on Cnet whom we suspect are selling refurbished or open box products but are not labelled as such. These “identified low quality firms on Cnet” are firms on Cnet whom we believe conceal the fact that they sell refurbished or open box products. We examine whether price is used as a signalling device for those Cnet firms.

After identifying those “low quality firms” on Cnet, we compare those Cnet product-dates in which there exists at least one “identified low quality firm” with Nextag product-dates in which at least one firm is labelled as selling refurbished or open box products. We find that the price level for the former (after adjusting for rebates) is about 2.65\% higher than the latter after controlling for banner, the number of firms, popularity rankings, product and week specific effects, and product life cycle effects. This provides

\textsuperscript{2}Each price observation in our data set represents a price charged by a particular firm for a particular product on a particular date on either Cnet or Nextag. Thus, for each Cnet and Nextag “product-date,” or simply “site-product-date” we have a list of price observations posted by different firms who advertise on the price comparison sites.

\textsuperscript{3}Both cnet.shopper.com and Nextag.com allow firms to advertise refurbished or open box products. According to our email correspondences with the two sites, both say that it is the firms’ responsibility to indicate their product qualities when they advertise. However, it is not clear whether a firm gets any penalty (from price comparison sites) if it conceals the fact that it is selling refurbished or open box products. Moreover, Nextag.com advised us to take caution before ordering if we suspect a price is too low.
some support for price being used as a signal of quality on Cnet product-dates with “identified low quality firms.”

The idea of quality signalling has been widely studied. Earlier work mostly discuss the issue under a monopoly market structure. Milgrom and Roberts (1986) show that a high introductory price and a dissipative advertising expenditure can be used to signal high quality by a monopoly firm. Price-only signals prevail when there is no repeat purchase. Bagwell and Riordan (1991) analyze high introductory prices as signals of high quality products.4

The environment for firms on a price comparison site, however, is more close to a duopoly or oligopoly market structure. In addition to Fluet and Garella (2002), Hertzendorf and Overgaard (2001) provide a similar model with price and dissipative advertising signals in a duopoly market setting. They predict that in a separating equilibrium under incomplete information, the price levels for both high and low quality firms are distorted upwards if only price is used to signal quality. Simo (2003) considers a duopoly market in which the product quality of one of the firms is unknown. When a high quality firm sets a higher price to signal its quality it has strategic effect on the price level of its rival. Hence, a firm can benefit from using price to signal its quality.

Two empirical works related to price signalling are summarized as follows. Kalita, Jagpal, and Lehmann (2004) use data from consumer reports for several durable and nondurable goods and provide evidence that firms use price to signal their quality. Caves and Greene (1996) find conflicting correlations between price and quality for different groups of products. Their evidence which is consistent with price as a quality signal is confined to “convenience goods,” i.e., goods unimportant but frequently purchased.

4See also Bagwell (1992), Hertzendorf (1993), and Overgaard (1993) for quality signalling in the monopoly case.
While “clearing house models” are typically used to study interactions of firms and consumers on price comparison sites, these models are usually based on the assumption that firms who list prices on a price comparison sites sell homogeneous products. Hence, these models (under complete information) give no predictions in an incomplete information setting.5

Our data set also allows us to address the following issues. First, we address the question of whether firms on one site persistently charge higher prices than on the other site. We find that, after controlling for refurbished and open box products, banner, number of firms, popularity ranking, product and week specific effects, and product life cycle effects, price level on Cnet is about 5.5% higher than that on Nextag. Second, we examine if firms charge different prices when they advertise on both sites. We find that, after adjusting for rebate prices, less than 10 percent of the firms that advertise on both sites in the same product-date list different prices.

This chapter is organized as follows. Section 3.2 describes the similarities and differences of price comparison sites Cnet and Nextag and summarizes the data set used in our research. Section 3.3 examines whether price is used as a signalling device on Cnet product-dates with “identified low quality firms.” In this section, we describe the Fluet and Garella (2002) model, and show our regression results based on this model. We also test the robustness of a separating equilibrium using a different specification and discuss a possible identification problem. Section 3.4 discuss two issues. First, we

5Clearing house models are first due to Varian (1980), Rothensal (1980), Shilony (1977), and Narasimhan (1988), but fully developed by Baye and Morgan (2001). Baye and Morgan (2001) term a price comparison site an “information gatekeeper” as it charges fees to firms and consumers for posting and acquiring information. They find that only dispersed price equilibria exist in such a model. Moreover, price comparison site has incentives to lower its subscription fee and induce maximum consumer subscription. Lin (2004) extends Baye and Morgan (2001) model to study competition of price comparison sites and shows that social welfare is lower with two sites than with only one site.
discuss whether the price level on Cnet is persistently higher or lower than that on Nextag. Second, we examine whether a firm list the same price on Cnet and Nextag when it advertise on both sites. Finally, section 3.5 concludes. Tables and graphs are collected at the end of this paper.

3.2 Data

Our data set comes from two leading price comparison sites — Cnet and Nextag. Cnet (or cnet.shopper.com because it is owned and operated by cnet.com) is a leading price comparison site that specializes in consumer electronics products. Products listed on Cnet include digital cameras, notebooks, handhelds, monitors, networking devices, camcorders, etc. Nextag.com, or simply Nextag, who first launched its business in May, 1999, is another price comparison site commonly used by consumers. It provides price listings for a wider range of products, not necessarily restricted to consumer electronics, than shopper.com. Products are divided into 18 major categories ranging from “Automotive,” “Electronics,” “Jewelry and Watches,” “Books, CDs & DVDs,” to “Video Games and Toys.” The part of our data collected from nextag.com comes exclusively from two categories: “Electronics” and “Computers and Software.”

The environment a consumer faces on Nextag is similar to that on Cnet for the following reasons. First, both sites are leading price comparison sites. Both Cnet and Nextag have millions of unique consumer accesses each month.⁶ According to 100hot.com’s ratings on March 04, 2004, Cnet ranks number 12 while Nextag ranks number 9 among the “hottest 100 electronics sites.” Second, both sites are genuine price comparison sites

⁶Each month over 9 million unique consumers access the site of Cnet (See Baye, Morgan, and Scholten (2001)). On the other hand, nextag.com claims that it has 7.7 million unique visitors in December 2003 and 10.6 million in September 2004.
instead of shopbots that search over the internet for prices. Thus, firms have to pay Cnet or Nextag for listing their prices on the sites. Moreover, they are charged depending on the number of qualified consumer leads. For this reason, we tend to believe that price listings on Cnet as well as Nextag represent true prices of merchants rather than fake prices aimed at directing potential consumers to the merchants’ websites. Third, the interfaces a consumer faces on both sites for the same searched product are similar. A consumer can either type the product name or the unique product part number to search for a product. Once the page on the search result is opened, a consumer can sort the sellers by listed price levels, total price levels (including tax and shipping costs), merchant names, etc. Moreover, both sites also provide consumers with information on seller ratings.

We assemble a data set consisting of a total of 20 electronic products from Cnet and Nextag respectively. The part numbers of the products on Cnet are the same as those on Nextag. Table 1 lists the names of the products as well as their part numbers used in our sample. Price observations are downloaded once per day by using a program written in PERL. Since the program downloads only the most popular 50 products from Cnet and the most popular 25 products from Nextag, we have some “unmatched product-dates” across sites in the assembled data set. Later in our analysis, we refer to the data set with unmatched product-dates eliminated as the “matched data set.” Table 2 gives summary statistics for the whole data set as well as for the matched data set.

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7Nextag provides two types of fee programs for sellers-Self-Serve Program and Merchant Partner Program. The first program is for merchants who have only a few items to sell. The second program is for merchants who would like to list more than 100 products. Merchants who want to list less than 100 products can set up an account with Nextag and list their products for free, but still pay for qualified consumer leads. Merchants who want to list more than 100 products also pay according to the number of consumer leads. (We are not sure how much are the extra fees charged for these larger merchants.)

8In unmatched product-dates, we have price observations on one site but not the other.
As we see from Table 2, average price for the 20 products is higher on Cnet than on Nextag if we give each product the same weight, while it is higher on Nextag than on Cnet if we average across all price observations. Notice that “price” here refers to the price level before taxes and shipping costs.\(^9\) Also, since prices listed on Cnet and Nextag may differ because of rebate offers, we adjust prices accordingly. In our later analysis, rebate adjusted price refers to the price level before rebate offers.\(^10\) We also report the number of observations labelled as refurbished or open box on both sites. Some of the observations on Nextag are labelled as refurbished or open box, while none of the observations on Cnet are labelled as such.\(^11\)

For the matched data set, average minimum and maximum prices are both higher on Cnet than on Nextag while the average range is higher on Nextag than on Cnet. Average proportion of firms who advertise on both sites is slightly higher on Nextag than on Cnet since the average number of sellers is slightly higher on Cnet. Following the traditional definition on the measures of price dispersion, we also report average percentage gap, average percentage range and average coefficient of variation for all products.\(^12\)

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\(^9\)Some firms do not list taxes or shipping charges directly on the price comparison site. Consumers have to click through the firm’s website to find out taxes or shipping charges.

\(^10\)For example, firms may put “price after $50 rebate”, “price before $100 rebate”, “Special $250 rebate offer”, or simply “price after rebate” by the prices they list on Cnet and Nextag. We adjust the corresponding dollar amount of rebate offers to obtain the price level before rebate offers for each observation.

\(^11\)We had the program to capture this information had an observation been labelled as refurbished or open box on Cnet, but did not get any such observation for the 20 products in our sample.

\(^12\)For each site-product-date, percentage gap is defined as the percentage change between the lowest two prices, percentage range is defined as the percentage change between the highest price and the lowest price, and coefficient of variation is defined as the standard deviation divided by the mean price times 100. Average percentage gap, percentage range, and coefficient of variation are obtained by averaging the above three measures over all products. See Baye, Morgan, and Scholten (2001) for discussions on changes in price dispersion measures with respect to the number of firms.
3.3 Price As a Signalling Device?

3.3.1 The Model

Fluet and Garella (2002) provide a model in which two firms produce a product of different quality. Consumers do not observe firm qualities while they observe only firm prices. In a separating equilibrium, a high quality firm can use price to signal its quality. Their model sets a basis for our current research and is described shortly as follows.

Two firms, 1 and 2, sell a good of different quality in a market. The quality of their products can be high \((H)\) or low \((L)\). The high quality firm sells goods of quality \(H\) while the low quality firm sells goods of quality \(L\). Unit production costs for a high quality or low quality firm are \(c\) or zero respectively. There are no fixed costs of production. Denote a firm’s strategy as \(p_i, i = 1, 2\), which is the price level charged by firm \(i\). The combination of quality can be \((H, L)\), \((L, H)\), and \((L, L)\), where the quality of firm 1 is the first element in each pair.\(^{13}\)

Each consumer buys at most one unit of the good. If the product sells at price \(p\), a consumer gets utility \(u_L = 1 - p\) if the quality is low, and \(u_H = 1 + \delta m - p\) if the quality is high. Parameter \(\delta\), which is greater than zero, measures quality differential between the two types of goods, while \(m\) is a taste parameter. There is a continuum of consumers, whose \(m\) is uniformly distributed in the interval [0, 1]. The higher \(m\) is, the more a consumer cares about quality.

Under full information, consumers observe firms’ quality. A consumer is indifferent between the two quality levels if \(u_H = u_L\), which implies \(m = (p_H - p_L)/\delta\). Thus,

\(^{13}\)Fluet and Garella (2002) discuss the situation when there are only three possible states of nature: \((H, L)\), \((L, H)\), and \((L, L)\). They show in the appendix that their results still hold if they allow for the additional state \((H, H)\).
demand for the low-quality firm is \( d_L(p_H, p_L) = \min \{ (p_H - p_L)/\delta, 1 \} \) if \( p_L \leq p_H \) and zero otherwise. Similarly, demand for the high-quality firm is \( d_H(p_H, p_L) = \min \{ 1 - (p_H - p_L)/\delta, 1 \} \) if \( p_H \leq \delta + p_L \) and zero otherwise. Solving for best reply functions of firm \( L \) and firm \( H \), we can obtain the full information equilibrium prices \( p^*_L \) and \( p^*_H \) to be \( p^*_L = \frac{1}{3}(\delta + c) \) and \( p^*_H = \frac{2}{3}(\delta + c) \), where \( \delta \leq 1 \) and \( c < 2\delta \).\(^{14}\)

Under asymmetric information, consumers do not observe firms’ types before they make the purchase. The game structure is as follows.

**Stage 0:** Nature chooses firm types. Firms observe Nature’s choice while consumers do not.

**Stage 1:** Firms choose strategies \( p_i \) for \( i = 1, 2 \).

**Stage 2:** Given the firms’ strategy profile, consumers revise beliefs and make purchase decisions.

In a separating equilibrium, firms’ strategies must be that both high quality and low quality firms are better-off playing their respective strategies than mimicking the other type’s strategy. Consumer beliefs are such that equilibrium strategies reveal the underlying states.

Fluet and Garella (2002) identify different types of separating equilibria depending on different regions of parameter values \( c \) and \( \delta \). There are two possibilities. First, when the sum of unit cost and quality differentials are sufficiently large \((c + \delta > 3/2)\), the full information equilibrium prices are sufficient for separation. Second, when \( c > 1 - \delta \) and \( \delta > 1/2 \), there exists separating equilibrium in which the high quality firm sets a

\(^{14}\)The assumption \( \delta \leq 1 \) is simply made for convenience. The condition \( c < 2\delta \) ensures that the high quality firm has a positive market share in equilibrium.
price that is greater than unity. Under the second situation, it can be shown that the high quality and low quality firm’s prices are both greater than their prices under full information. The following proposition will be used as a basis of our later empirical analysis.

**Proposition 3.1.** *In a separating equilibrium under incomplete information, both high and low quality firms will price at least as high as their respective price levels under complete information.*

**Proof.** It suffices to show that both types of firms price higher than their respective price levels under the second possibility. If the high quality firm sticks to the equilibrium strategy, its profits are \((p - c)\max\{1 - p/2\delta, 0\}\). We assume that \(p < 2\delta\) so the high quality firm will not be priced out of the market. The high quality firm’s profits are maximized at \(p = \delta + c/2\), which is greater than \(p^*_H\) since \(c < 2\delta\). The low quality firm will price at half the price of the high quality firm, which is also greater than \(p^*_L\). □

Later in our analysis, we compare those Cnet product-dates in which there exists at least one “identified low quality firm” with Nextag product-dates in which at least one firm is labelled as selling refurbished or open box products. Our regression results show that the price level for the former is higher than the latter, which is consistent with separating equilibria in which firms who sell new products use price to signal their quality.

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\(^{15}\)See proof of proposition 3.1.
3.3.2 Empirical Findings

Our approach is as follows. Using data on Nextag as a reference, we identify some “low quality firms” on CNET whom we suspect are selling refurbished or open box products but are not labelled as such. We then examine whether price is used as a quality signalling device based on Fluet and Garella (2002) model.

We first summarize some variables as follows.

- **Cnet**: This is a dummy variable that indicates whether a price observation comes from Cnet or Nextag. It is equal to one if a price observation comes from Cnet and zero if the observation comes from Nextag. The coefficient of this variable tells us whether the overall price level on Cnet is higher or lower than that on Nextag.

- **Refurbished**: This is a dummy variable that indicates whether a price observation is labelled as coming from a refurbished product. Since each price observation is associated with a firm listing it, this variable can be viewed as an indicator of whether a firm is labelled as selling refurbished products. We expect the coefficient of this variable to be negative since refurbished products are usually sold at lower prices than brand new products.

- **Open box**: This dummy variable indicates whether a price observation is labelled as coming from an open box product. Similar to the variable “Refurbished,” this variable indicates whether a firm is labelled as selling open box products. The coefficient of this variable is also expected to be negative.

- **New_reop**: This is also a dummy variable. Let the variable New_reop to be equal to one if an observation is NOT labelled as refurbished or open box while in the
same product-date, on the same site, there exists at least one other observation that is labelled as refurbished or open box. A coefficient of “New_reop” which is significantly different from zero would indicate that firms who sell “new” products (or more precisely, firms NOT labelled as selling refurbished or open box products) price differently with the existence of some other firm labelled as selling refurbished or open box products in the same product-date versus without.

The following control variables are used throughout our regressions.

*Banner*. This is a dummy variable which indicates whether a firm displays its logo on the search result list of a price comparison site. Since displaying its logo on a price comparison site is costly, a firm may need to charge higher prices in order to cover its costs. Baye and Morgan (2004) provide a model in which a firm can engage in “branding” activities, such as spending money and get its logo displayed on the search result list of a price comparison site, in order to create “loyals,” i.e., consumers loyal to a particular brand. They predict that higher branding activity leads to higher expected transaction prices for all consumers. Thus, the coefficient of the variable “Banner” is expected to be positive.

*Number of firms*. This refers to the number of firms listing prices in each product-date for both Cnet and Nextag. The number of firms are divided into different categories starting from 1 firm, 2 firms, 3 firms, ..., up to more than 12 firms.

*Popularity ranking*. We control for possible effects coming from popularity ranking. Firms’ popularity rankings are divided into different categories starting from rank 0 to 10, rank 10 to 20, up to rank 40 to 50.
Product dummies and Week dummies. These two dummies are used to control for product and week specific effects.

Product × Week dummies. As a product is newly introduced into the market, relatively more firms advertise it than when it has been in the market for some time. We create dummy variables interacting each of the 15 products and 17 weeks to control for possible “product life cycle” effects.

Identify Low Quality Firms on Cnet.
In our data set, no firms on Cnet are labelled as selling refurbished or open box products, but some firms on Nextag are clearly labelled as such. We use observations on Nextag as a reference and examine if firms labelled as selling refurbished or open box products on Nextag also advertise on Cnet in the same product-date. By doing so, we are able to identify firms on Cnet who conceal the fact that they sell refurbished or open box products. We then examine if price is used as a quality signalling device on those Cnet product-dates with at least one firm identified as selling refurbished or open box products.

We examine 150 such price pairs from the matched data set. They constitute about 40% of observations labelled as coming from refurbished or open box products.\textsuperscript{16} Table 5 summarizes the results. From Table 5, we see that for those 150 firms on Nextag labelled as selling refurbished or open box products, 93\% of them (139 firms) list the same prices as they do on Nextag if they also advertise on Cnet in the same product-date. We suspect that these 139 firms (or maybe all those 150 firms) not labelled as selling refurbished or open box products on Cnet are actually selling refurbished or open box products but are not labelled as such.

\textsuperscript{16}150/(278+99) \times 100\% = 39.78\%. See Table 2 for the number of refurbished and open box products.
Adjust Quality Related Variables and Test for Signalling.

From a consumer’s perspective, the information on a price comparison site is more complete if a firm who sells refurbished or open box product reveal this information than if it does not. Thus, our observations from Table 5 lead to the following question. For those firms who sell new products (products of high quality) on Cnet, would they price differently if in the same product-date some firms are actually selling refurbished or open box products (products of low quality) but are not labelled as such? More specifically, in product-dates in which some firms conceal the fact that they sell products of low quality, would firms who sell products of high quality use price as to signal their quality?

To answer this question, we make two adjustments for previously defined dummy variables. First, we adjust the definition of “refurbished or open box” observations by defining a new dummy variable that assigns a value of one both to firms on Nextag originally labelled as selling refurbished or open box products and to firms on Cnet that we suspect sell refurbished or open box products. Then, we adjust the definition of “New_reop” (firms who sell new products while in the same product-date at least one other firm is labelled as selling refurbished or open box products) based on the newly defined dummy variable. These two adjustments take into account the possibility that some firms on Cnet actually sell refurbished or open box products. Finally, we define another dummy variable (which will be called “Cnet product-date with identified low quality firms” later) that assigns a value of one to product-dates on Cnet with at least one firm identified as selling refurbished or open box products. This dummy variable will allow us to compare the price level of Cnet product-dates with identified low quality firms versus Nextag product-dates with firms labelled as selling refurbished or open box products.
The above mentioned three new variables are called “Adjusted refurbished or open box observations”, “Adjusted New_reop”, and “Cnet product-date with identified low quality firms” respectively and are defined as follows.

*Adjusted refurbished or open box observations.* This is a dummy variable. For each product-date, we assign a value of one to this dummy variable for two types of firms — firms on Nextag originally labelled as selling refurbished or open box products, and firms on CNET who also list prices on Nextag in the same product-date and are labelled as selling refurbished or open box products. The coefficient of this variable would more correctly reflect the price differences between refurbished or open box products versus brand new products. It is expected to be negative.

*Adjusted New_reop.* Again, this is a dummy variable. For each observation in each site-product-date, we assign a value of one to this dummy variable if the variable “Adjusted refurbished or open box observations” is equal to zero while in the same site-product-date, there exists at least one other observation with “Adjusted refurbished or open box observations” to be equal to one. Thus, the definition of this variable is similar to that of “New_reop” defined previously. However, the current variable is defined based on “Adjusted refurbished or open box observations” while variable “New_reop” is defined based on refurbished or open box observations before the adjustment. The coefficient of this variable would allow us to study if firms who sell “new” products (or more precisely, firms not selling refurbished or open box products after we make the adjustment) price differently with the existence of some other firm selling refurbished or open box products in the same site-product-date versus without.
“Cnet product-date with identified low quality firms.” We define this dummy variable as follows. The variable “Cnet product-date with identified low quality firms” is equal to one for Cnet product-dates in which there exists at least one firm which is identified as selling refurbished or open box products.

Using those previously defined variables, we run the following regression to study if price is used as a signalling device.

\[
\ln(\text{rebate adjusted price}) = \beta_0 + \beta_1 \cdot \text{Cnet} \\
+ \beta_2 \cdot \text{Adjusted refurbished or open box observations} \\
+ \beta_3 \cdot \text{Adjusted New_reop} \\
+ \beta_4 \cdot \text{Cnet product-date with identified low quality firms} \\
+ \text{other variables} 
\] (3.1)

Subscripts representing site, product, and date for each variable are suppressed in equation (3.1) for convenience.

From a consumer’s perspective, the information is more complete if a firm who sells refurbished or open box products clearly labels its product characteristics as such than if it conceals the fact on a price comparison site. Therefore, the environment a consumer faces on those “Cnet product-dates with identified low quality firms” is closer to an environment with incomplete information than those Nextag product-dates in which firms who sell refurbished or open box products clearly label their products as such.

According to Fluet and Garella (2002) model, in a separating equilibrium under incomplete information, both the high and low quality firms’ prices are higher than or equal to those under full information. Therefore, if the coefficient of “Cnet product-date with identified low quality firms” is significantly positive, this would provide evidence
that firms on Cnet who sell new products in a product-date in which at least one other firm sell refurbished or open box products use prices to signal their quality. Notice we make the implicit assumption that firms who sell new products on Cnet realize the potential presence of firms who sell refurbished or open box products but with no such labels. Our above argument is summarized as follows.

A significantly positive coefficient for “Cnet product-date with identified low quality firms” would be consistent with the hypothesis that high quality firms in Cnet product-dates with at least one identified low quality firm use price to signal their quality.

Our regression results are summarized in Table 7. From Table 7, we see that the coefficients on variables “Cnet,” “Adjusted refurbished or open box observations,” “Adjusted New_reop,” “Cnet product-date with identified low quality firms,” and “Banner” are all significant in both specification 1 and 2. Both specifications control for number of firms, popularity ranking, product and week specific effects. Specification 1 does not control for product life cycle effect while specification 2 does.

The coefficients on “Adjusted refurbished or open box observations” in specifications 1 and 2 are both negatively significant as expected, suggesting that firms who sell refurbished or open box products price lower (25.8% under specification 2) than firms who sell “new” products (or more precisely, firms not labelled or identified as selling refurbished or open box products after the adjustment). The coefficient on “Banner” is positively significant, which is consistent with Baye and Morgan (2004).

The coefficients of “Adjusted New_reop” in specifications 1 and 2 are both negative and significant. The implication is as follows. Consider pricing strategies of firms not
labelled nor identified as selling refurbished or open box products in two scenarios. In
the first scenario, at least one other firm is labelled or identified as selling refurbished or
open box products in the same site-product-date, while in the second scenario no firm
is labelled nor identified as selling refurbished or open box products in the same site-
product-date. The coefficients of “Adjusted New_reop” imply that firms not labelled nor
identified as selling refurbished or open box products price lower (3.67% in specification
2) in the first scenario than in the second scenario.

The coefficients of “Adjusted New_reop” in specifications 1 and 2 seem to suggest
that the existence of refurbished or open box products create some substitution to the
“new products,” and hence firms who sell new products have to lower their listed prices
than they otherwise would had there not been refurbished or open box products in the
same site-product-date. However, an alternative possibility is that firms not labelled nor
identified as selling refurbished or open box products may with a higher probability be
selling refurbished or open box products in the first scenario than in the second scenario,
and hence we observe a negative coefficient for “Adjusted New_reop.”

Now we look at the coefficient for “Cnet product-dates with identified low quality
firms.” This coefficient can be interpreted as the difference between two sets of price
differences. The first set of price difference is the difference in price levels between two
types of Cnet product-dates — Cnet product-dates with identified low quality firms
and Cnet product-dates without identified low quality firms. The second set of price
difference is the difference in price levels between two types of Nextag product-dates —
Nextag product-dates with at least one firm labelled as selling products of low quality,
i.e., refurbished or open box products, and Nextag product-dates with no firm labelled
as selling products of low quality. More precisely, the price level for Cnet product-dates
with identified low quality firms is about 26.82% lower than that without identified low quality firms while the price level for Nextag product-dates with at least one firm labelled as selling products of low quality is about 29.48% lower than that with no firm labelled as selling products of low quality.\textsuperscript{17}

Thus, the price difference between Cnet product-dates with identified low quality firms and without identified low quality firms is smaller than the price difference between Nextag product-dates with at least one firm labelled as selling products of low quality and with no firm labelled as selling products of low quality. The significantly positive coefficient of “Cnet product-date with identified low quality firms” is consistent with the predictions of Fluet and Garella (2002) model and provides evidence for price being used as a quality signaling device in Cnet product-dates in which some firms conceal the fact that they sell products of low quality.

Our regression results for equation (3.1) is based on the assumption that firms on Cnet identified as selling refurbished or open box products share the same coefficient ($\beta_4$) with firms on Cnet who sell “new” products while in the same product-date at least one other firm is identified as selling refurbished or open box products. We relax this assumption by allowing these two types of firms on Cnet to have different coefficients.

\textsuperscript{17}From specification 2, we compute the numbers $\hat{\beta}_2 + \hat{\beta}_3 + \hat{\beta}_4 = -0.2682$ and $\hat{\beta}_2 + \hat{\beta}_3 = -0.2948$ respectively.
The regression model now becomes

\[
\ln(\text{rebate adjusted price}) = \beta_0 + \beta_1 \cdot \text{Cnet} \\
+ \beta_2 \cdot \text{Adjusted refurbished or open box observations} \\
+ \beta_3 \cdot \text{Adjusted New_reop} \\
+ \beta_{41} \cdot \text{Cnet} \times \text{Adjusted refurbished or open box observations} \\
+ \beta_{42} \cdot \text{Cnet} \times \text{Adjusted New_reop} \\
+ \text{other variables.} \tag{3.2}
\]

The regressions results for equation (3.2) are summarized in Table 8. Similar to the specifications in Table 7, both the two specifications in Table 8 control for effects coming from display of banner, number of firms, popularity ranking, product and week specific effects. Specification 2 controls for product life cycle effects while specification 1 does not. Coefficients for variables “Adjusted refurbished or open box observations,” “Adjusted New_reop,” and “banner” are of expected sign and significant. The interpretations of these variables are the same as those in Table 7 and are omitted here.

Now we look at the coefficients for the two interactive variables. The interactive variable “Cnet \times \text{Adjusted refurbished or open box observations}” can be interpreted as the difference between two sets of price differences. The first set of price difference is the difference in price levels between identified low quality firms on Cnet and firms on Cnet who sell “new” products and in the same product-date no firm is identified as selling refurbished or open box products, i.e., “Cnet regular firms.” The second set of price difference is the difference in price levels between firms on Nextag labelled as selling refurbished or open box products and firms on Nextag who sell “new” products and in the same product-date no other firm is labelled as selling refurbished or open box products.
products, i.e., “Nextag regular firms.”

More precisely, identified low quality firms on Cnet price about 19.13% ($\hat{\beta}_2 + \hat{\beta}_{41}$ in equation (3.2)) lower than “Cnet regular firms,” while firms on Nextag labelled as selling refurbished or open box products price about 26.98% ($\hat{\beta}_2$) lower than “Nextag regular firms.” Thus, the significantly positive coefficient $\hat{\beta}_{41}$ implies that the price difference between Cnet identified low quality firms and “Cnet regular firms” is smaller than that between Nextag low quality firms and “Nextag regular firms.”

The coefficient for another interactive variable “Cnet×Adjusted New_reop” can be interpreted similarly. Specifically, the price level for firms on Cnet who sell “new” products while in the same product-date some other firm is identified as selling products of low quality is about 1.15% ($\hat{\beta}_3 + \hat{\beta}_{12}$) lower than “Cnet regular firms.” On the other hand, the price level for firms on Nextag who sell “new” products while in the same product-date some other firm is labelled as selling products of low quality is about 3.63% ($\hat{\beta}_3$) lower than “Nextag regular firms.” Again, the first set of price difference is smaller than the second of price difference. Thus, the significantly positive coefficient for “Cnet×Adjusted New_reop” is consistent with Fluet and Garella (2002) predictions.

We also run the same sets of regressions as in Table 7 and 8 based on the matched data set. The regression results are similar to those in Table 7 and 8 as shown in Table 10 and 11. Again, the significantly positive coefficients for “Cnet product-dates with identified low quality firms” as in Table 10, and for “Cnet×Adjusted refurbished or open box observations” and “Cnet×Adjusted New_reop” as in Table 11 are all consistent with Fluet and Garella (2002) predictions.


3.3.3 Robustness of Separating Equilibrium

To test the robustness of separating equilibrium, we run another three sets of regressions based on the collapsed Cnet data set. The results are shown in Table 12. We regress log maximum price for each Cnet product-date on the proportion of observations identified as coming from refurbished or open box products for each Cnet product-date and other variables. Our intuition is as follows. In a separating equilibrium, after controlling for the number of firms, the equilibrium price levels for both high and low quality firms do not depend on the distribution of firm types while in a pooling equilibrium, the equilibrium price level does depend on it. In particular, the maximum price level should decrease as the proportion of low quality firms increases, if firms play the pooling equilibrium. Therefore, a zero or positive coefficient on proportion of refurbished or open box products would tend to support a separating equilibrium. On the other hand, a negative coefficient would tend to support a pooling equilibrium.

Two new variables in the regressions are summarized as follows.

*Proportion of identified refurbished or open box observations.* This is the proportion of observations identified as coming from refurbished or open box products for each Cnet product-date.

*Proportion of banner.* For each Cnet product-date, this is the proportion of firms who display store logos on the Cnet search result list.

Specification 1 of Table 12 shows that as the proportion of Cnet identified refurbished or open box observations increases by 1%, the maximum price level in each Cnet product-date decreases by about 0.45%. However, this specification does not take into account effects coming from Cnet product-dates with firms identified as selling refurbished or open box products.
open box products. If we look at only Cnet product-dates with identified low quality firms, the regression results are in favor of separating equilibrium. Specification 2 shows that conditional on variable “Cnet product-date with identified low quality firms” being one, as the proportion of Cnet identified refurbished or open box observations increases by 1%, the maximum price level in each Cnet product-date increases by 0.03%. The effect is even larger (0.57% and significant) after we control for product life cycle effects. Thus, the regression results of specifications 2 and 3 are consistent with our regressions results in Tables 7 and 8 (as well as Tables 10 and 11) and provide some support for a separating equilibrium.

3.3.4 Identification Issue

Although we do not observe all firms who carry refurbished or open box products (products of low quality) from the search result lists of Cnet and Nextag, we are able to identify some “low quality firms” using information on Nextag as a reference. In doing this exercise, however, we implicitly assume that consumers do not make such inferences, and firms do not believe that consumers make such inferences.

An identification problem would arise if this assumption does not hold. If each consumer visits both sites and uses product qualities on one site to draw inferences about product qualities on the other site, firms who sell products of high quality would not have to use price to signal their quality. This is true even if a price comparison site does not require firms to reveal their product quality. Under this circumstance, the higher price level we observe for “Cnet product-dates with identified low quality firms” would stem from factors other than price as a signalling device.

However, for the above argument to hold, consumers must perform very complex
comparisons every time they shop. Note that consumers cannot make the same kind of inferences with just one visit to both sites for one good. Unless a consumer has a good perspective on how often this happens or actually go to a firm’s site in question to check, any inferences she can make are at best imperfect. Thus, our argument that since consumers are not sure about product qualities, firms who sell products of different qualities sort out themselves for the consumers would be plausible as long as not all consumers have complete knowledge about firms’ product qualities when they consult price comparison sites.

### 3.4 Other Issues

#### 3.4.1 Cnet Price Level Persistently Higher/Lower than Nextag?

With multiple price comparison sites on the internet, one may wonder if the overall (or average) price level on one site is persistently higher or lower than on the other. On the one hand, it does not seem to be plausible for firms on one site to charge persistently higher prices than on the other site because if consumers can learn from shopping experiences, then the site persistently offering higher prices will be driven out of business. This is particularly true in an environment in which consumers can get access to a list of prices on a particular product with just a few mouse clicks. On the other hand, however, if we view consumers who visit different price comparison sites as coming from different groups of people, then it may be reasonable to observe differences in price levels across sites.

We first take a look at the average price level for Cnet and Nextag respectively. Figure
1 plots average price levels for both sites using the matched data set. Each product is weighted equally. However, both curves representing the average price levels have some big jumps, most of which result from the fact that the average price measures are not computed entirely over the same set of products over the 4-months period. From Figure 1, we see that the average price level for Cnet is mostly higher than that for Nextag.

In an environment in which firms on a price comparison site are allowed to carry refurbished or open box products, differences in price levels across sites may be due to differences in proportions of firms who carry these “low quality products.” Thus, our question can be stated as follows. Is the price level on Cnet persistently higher or lower than that on Nextag after we control for factors that might affect differences in price levels across the two sites? Our regression results from Tables 7 and 8 (as well as 10 and 11) indicate that after taking into account the possibility that some firms carry refurbished or open box products, and controlling for branding, number of firms, product and weekly fixed effects, and product life cycle effects, the price level on Cnet is about 5.5% higher than those on Nextag.

We also report the analysis using variables before we identify firms who sell refurbished or open box products on Cnet. The regression results are summarized in Table 6 (using the whole data set) and Table 9 (using the matched data set) and are briefly described as follows.

Specification 1 of Table 6 (and Table 9) does not take into account the effect of refurbished or open box products, while the rest of the specifications do. All of the four specifications control for popularity ranking, product and week specific effects. Specification 4 controls for product life cycle effects in addition to product and week specific effects. From Table 6 (and Table 9), we see that variables “Cnet”, “Refurbished”, “Open
"box", "New_reop", and "Banner" are significant throughout all of the four specifications.

Coefficients of “Refurbished” and “Open box” in specifications 2 to 4 are all negative and significant as expected. Thus, firms who sell refurbished or open box products price lower than firms who sell “new products” (or more precisely, products not labelled as refurbished or open box). More specifically, firms labelled as selling refurbished products price about 15% to 17% lower than firms not labelled as selling refurbished products, and firms labelled as selling open box products price about 47% to 49% lower than firms not labelled as selling open box products. Also, the absolute values of coefficients for “Open box” are larger than those for “Refurbished”, suggesting that products are sold at lower prices if they are labelled as open box than if they are labelled as refurbished. The interpretation for variables “New_reop,” “Banner,” as well as other control variables are similar to their counterparts in Table 7 and 8 as discussed previously.

Thus, specifications 1 to 4 in Tables 6 and 9 suggest that after taking into account the effects of refurbished and open box products, and controlling for branding, number of firms, product and weekly fixed effects, product life cycle effects, the price level on Cnet is about 5.46% (Specification 4) higher than that on Nextag.

Our regression results (both before and after identifying Cnet low quality firms) suggest that after taking into account those factors that might affect the difference in price levels across sites, there are still about 5% of price difference that is not explained. Several factors that may lead to this difference are summarized as follows.\[^{18}\]

First, other than those firms on Cnet identified as or those firms on Nextag labelled as selling refurbished or open box products, there may exist other firms on Cnet or Nextag who sell products of low quality but are not identified. These non-identified low

\[^{18}\text{However, without further information on the data set, we are not able to address the influences of these factors by statistical analysis.}\]
quality firms are treated as firms who sell new products in our regressions.\textsuperscript{19} Second, the overall price level on one site would be different than on the other if price is used more as a signalling device on one site than on the other. While our regression results (Tables 7, 8, 10, and 11) provide evidence of price as a signalling device for Cnet product-dates with identified low quality firms, our results give no predictions for other product-dates on both sites. Third, differences in fee structures set by price comparison sites may also lead to differences in price levels across sites.

3.4.2 Do Firms List the Same Price if They Advertise on Both Sites?

Here, we summarize the number and proportion of firms who advertise on both Cnet and Nextag for each of our 20 products. We also examine if firms advertise the same price on Cnet and Nextag if they advertise on both sites.

Table 3 gives summary statistics on the average number of firms on each site, on both sites, as well as the average proportion of firms who advertise on both sites. The first two columns give the average number of firms on Cnet and Nextag respectively for each of the twenty products. The third column gives the average number of firms listing prices on both sites, while the last two columns give the average proportion of firms who advertise on both sites. On Cnet, the average proportion of firms who list prices on both sites ranges from 47.43\% to 64.56\% while on Nextag, the average proportion ranges from 41.35\% up to 80.41\%.

\textsuperscript{19}Without other information to cross reference firms on Nextag, we are not able to identify possible low quality firms on Nextag other than those already labelled as such. Moreover, we would not be able to identify a firm who sells refurbished or open box products but is neither labelled as such on Cnet nor Nextag.
To see if firms charge different prices when they list prices on both Cnet and Nextag, we pick those firms who advertise on both sites in the same product date from the matched data set. This results in a total of 26608 price pairs. As we see from Table 4, 89.21% of the price pairs have price difference of zero, while 9.04% of the observations have price difference to be within $200 dollars.\textsuperscript{20}

Since the proportion of firms who list different prices on Cnet and Nextag may be exaggerated by the existence of refurbished and open box products, as well as products with rebate offers. We do the same analysis on a smaller data set by excluding those price-pair observations with refurbished, open box, or rebate labels. The results are similar to the previous one. Most of the firms (90.87%) who advertise on both sites list the same price on Cnet and Nextag, while the rest list different prices on the two sites. There are 8.6% of the price-pair observations that have price difference to be within $200 dollars. Compared with the analysis with refurbished, open box, rebate labelled observations included, the price difference distribution has become much narrower.

\section*{3.5 Conclusions}

We collect a four-month data set from two leading price comparison sites — Cnet.shopper.com and Nextag.com. On Cnet, none of the firms are labelled as selling refurbished or open box products, while on Nextag some firms are labelled as such. We study pricing behaviors of firms on the two sites. Specifically, using data on Nextag as a reference, we are able to identify some “low quality firms” on Cnet. We examine pricing behavior of firms on Cnet product-dates with identified low quality firms and find evidence of price

\textsuperscript{20}Price differences here refer to rebate adjusted price differences.
as a signalling device.

Our data set also allow us to address other issues. Specifically, we examine the price levels across Cnet and Nextag. We find that, after taking into account factors that may affect differences in price levels across sites, the price level on Cnet is about 5.4% to 5.5% higher than that on Nextag. We also examine if firms list the same price when they advertise on both sites. We find that after adjusting for rebate prices, less than 10 percent of the firms that advertise on both sites in the same product-date charge different prices.

While we empirically examine whether price is used to signal product qualities, there may be other firm attributes that is subject to signalling. For example, a firm may use price to signal its quality of services or its variety of customization options. Thus, the contribution of our paper can be viewed as empirically identifying at least one type of signalling. Also, while our research provides evidence of price signalling for Cnet product-dates with “identified low quality firms,” we give no predictions about other product-dates across sites. A possible future research would be to find out whether Cnet has a more (or less) transparent information environment than Nextag, and to address the question of differences in degree of signalling across sites.
Appendix A

Proofs of the First Essay
Part A

Proof. (of Lemma 1.1, part (b), Page 6) Consider a consumer who subscribes to both sites. If she sees her local firm’s price on either site $A$, site $B$, or both sites, she simply purchases at the lowest price available on the site(s). However, if she does not see her local firm’s price on either of the two sites, she must decide whether to visit her local firm at cost $\varepsilon$. The subscriber chooses to visit her local firm only if the expected surplus gain from such a visit is at least as large as $\varepsilon$. Let $G$ be the price distribution function when a firm does not advertise, and $p_{AB}^{\min}$ be the lowest price available on both sites. Then we can state this condition as

$$\int_{p_{AB}^{\min}}^{p_{AB}^{\max}} [S(p) - S(p_{AB}^{\min})]dG(p) - \varepsilon \geq 0 \quad (A.1)$$

If a consumer does visit her local firm some of the time, her behavior must be characterized by a threshold level $p_{AB}^*$ such that

$$\int_{c}^{p_{AB}^*} [S(p) - S(p_{AB}^*)]dG(p) - \varepsilon \geq 0 \quad (A.2)$$

Thus, a subscriber will visit her local firm only if the lowest price available on the site(s) exceeds $p_{AB}^*$. But knowing this, the local firm will never charge a price that is lower than $p_{AB}^*$ when it does not advertise. Thus,

$$\int_{c}^{p_{AB}^*} [S(p) - S(p_{AB}^{\max})]dG(p) = 0 \quad (A.3)$$

This contradicts equation (A.2). □

Part B

(Page 8) The following shows more formally why it is not possible to have each firm advertising (on one site) with probability one given positive advertising fees set by both
sites. We divide our discussion into the following two subcases according to two possible ranges of advertising fees.

**CASE 1:** Consider $\phi_A > \phi_B > 0$ or $\phi_B > \phi_A > 0$. In this instance, every firm will advertise on the site with a lower advertising fee if they advertise at all. Then every firm advertising (on one site) with probability one cannot be an equilibrium because given that each consumer subscribes to both sites, firms will undercut each other’s advertised prices. Bertrand competition occurs and profits (gross of advertising fees) will be driven down to zero. Since advertising fees are both positive, any firm $i$ ($i = 1, 2, .., n$) would have an incentive to deviate to not advertising because if it advertises it earns negative net profits while if it does not, its profits are at least zero.

**CASE 2:** Consider $\phi_A = \phi_B > 0$. The argument is the same as in Case 1 if firms all play pure strategies. However, it is possible that firms play mixed strategies, i.e., firms all mix between advertising on one site and the other. Since a firm gets the same benefits by advertising on one site or the other, $\phi_A$ must equal $\phi_B$ if a firm plays a mixed strategy.

Without loss of generality, suppose each firm $i$ ($i = 1, 2, .., n$) mixes between advertising according to an atomless price distribution $F_A$ on site $A$ and advertising according to another atomless price distribution $F_B$ on site $B$.\(^1\) Denote the upper-bound of $F_A$ as $\bar{p}$ and the upper-bound of $F_B$ as $\bar{q}$. We first show that $F_A$ and $F_B$ have the same upper-bounds.

**Claim 1.** $F_A$ and $F_B$ have the same upper bounds. That is, $\bar{p} = \bar{q}$.

\(^1\)The situation when firms all mix between advertising according to a price distribution on one site and advertising a pure price on the other site, or the situation when firms all mix between advertising a pure price on one site and the other could be thought of as special cases of the more general case considered here.
Proof. This can be shown by contradiction. Assume \( p > q \), then if firm \( i \) \((i = 1, 2, \ldots, n)\) charges \( \bar{p} \), its expected profits would be zero since none of the other \( n - 1 \) firms will ever charge a price that is higher than \( \bar{p} \). However, if firm \( i \) charges \( \bar{q} \), its expected profits would be greater than zero because it earns positive profits in the event the rest \( n - 1 \) firms’ advertised prices are all higher than firm \( i \)’s. This contradicts our assumption that firm \( i \) plays a mixed strategy since its expected profits are not the same under each pure strategy in the support. By symmetry, it is not possible to have \( \bar{p} < \bar{q} \). Hence, in equilibrium, \( \bar{p} = \bar{q} \).

Next, we have the following claim:

**Claim 2.** \( F_A \) and \( F_B \) both degenerate in equilibrium.

**Proof.** This is shown by contradiction. Suppose \( F_A \) (or \( F_B \)) is non-degenerate. Then firm \( i \)’s expected profits would be zero if it charges the upper-bound price, while its expected profits would be greater than zero if it charges a price that is lower than the upper-bound. Hence firm \( i \) will not mix between any price in the support of \( F_A \) (or \( F_B \)) and the upper-bound price. This implies that \( F_A \) (or \( F_B \)) degenerates.

However, since \( F_A \) and \( F_B \) have the same upper-bounds, the degenerated prices have to be the same. Hence, any firm’s advertised prices on both sites are the same. That is, firm \( i \) mixes between advertising a pure price on one site and advertising the same pure price on the other site. This leads to Bertrand competition among firms and the advertised prices will be driven down to the marginal cost \( c \). In the end, each firm mixes between advertising a price of \( c \) on site \( A \) and a price of \( c \) on site \( B \). Thus, each firm earns zero profits (gross of advertising fees) for sure. Since \( \phi_A = \phi_B > 0 \), each firm has
an incentive to deviate to not advertising because by advertising, a firm earns negative net profits while if it does not advertise, its profits are at least zero.

**Part C**

In Proposition 2.1 (Page 24), different types of Nash equilibria are identified for different values of advertising fees set by sites A and B. The third type of equilibrium exists when the advertising fees are both too high. The fourth type of equilibrium exists when at least one of the two advertising fees is zero.

Now we look at the first and the second types of equilibrium. The second type of equilibrium differs from the first type in that the advertising fees are not equal. Since every consumer subscribes to both sites, no matter what other firms do, a firm gets the same expected profits (gross of advertising fees) whether it advertises on A or on B. Thus, if $\phi_A \neq \phi_B$, advertising on the site with a lower advertising fee dominates advertising on the site with a higher advertising fee.

This can be seen by looking at the following two equations. Let $S_{-i}$ be the strategy space for all firms excepting firm $i$. Let $p_{-i}$ be the lowest price advertised by these $n-1$ firms. Then firm $i$’s expected profits if it advertises a price $p$ on site A given the rest of the firms’ strategies are

$$E\pi_i(p, A, s_{-i}) = \Pr(p \leq p_{-i})\pi(p) - \phi_A \quad (A.4)$$

That is, firm $i$ gets the entire market and earns profits of $\pi(p)$ if its advertised price is lower than the lowest price advertised by the rest of the $n-1$ firms. Firm $i$ pays advertising fee $\phi_A$ when advertising on site A. Similarly, if firm $i$ advertises a price $p$ on site B given the rest of the $n-1$ firms’ strategies, its expected profits are

$$E\pi_i(p, B, s_{-i}) = \Pr(p \leq p_{-i})\pi(p) - \phi_B \quad (A.5)$$
From (A.4) and (A.5) we see that advertising on the site with a lower advertising fee dominates advertising on the site with a higher advertising fee.

Next we characterize firms’ advertising strategies as specified in the first type of equilibrium. When firm $i$ advertises a price $p$ on site $A$, its expected profits are:

$$E\pi_i(p, A) = \sum_{j=0}^{n-1} \binom{n-1}{j} \alpha^j (1 - \alpha)^{n-1-j} (1 - F(p))^j \pi(p) - \phi_A.$$  \hspace{1cm} (A.6)

Using the Binomial Theorem, we can rewrite equation (A.6) as follows.

$$E\pi_i(p, A) = \pi(p)[1 - \alpha F(p)]^{n-1} - \phi_A.$$  \hspace{1cm} (A.7)

Equation (A.6) states that the expected profits of firm $i$ if it advertises price $p$ on site $A$ depend upon the number of other firms who also advertise. When $j$ firms advertise, and their advertised prices are all higher than firm $i$’s advertised price, firm $i$ gets the entire market and earns $\pi(p)$.

Equation (A.7) also has an intuitive interpretation. Consider any firm other than firm $i$. For this firm to beat firm $i$’s price, it must advertise. Furthermore, its advertised price has to be lower than firm $i$’s advertised price. Thus, $\alpha F(p)$ is the probability that this firm beats firm $i$’s advertised price and $1 - \alpha F(p)$ is the probability that firm $i$ beats this firm’s advertised price. In order to win the whole market, firm $i$ has to beat the rest of the $n - 1$ firms, which occurs with probability $(1 - \alpha F(p))^{n-1}$. Similarly, firm $i$’s expected profits if it advertises a price $p$ on site $B$ are

$$E\pi_i(p, B) = \pi(p)[1 - \alpha F(p)]^{n-1} - \phi_B.$$  \hspace{1cm} (A.8)

When firm $i$ does not advertise, it gets profits only when none of the other $n - 1$ firms advertise. In this instance, it gets $\frac{\pi(r)}{n}$ from its local consumers. Thus, when firm
i does not advertise and charges the monopoly price $r$, its expected profits are:

$$E\pi_i(r, N) = (1 - \alpha)^{n-1}\pi\left(\frac{r}{n}\right). \quad (A.9)$$

Denote $\phi \equiv \phi_A = \phi_B$. We first set $E\pi_i(p, A) = E\pi_i(r, N)$ at $p = r$ and get the probability of advertising:

$$\alpha = 1 - \left[\frac{n\phi}{(n-1)\pi(r)}\right]^{\frac{1}{n-1}}.$$

Notice that $\alpha \in (0,1)$ whenever $\phi \in (0, \frac{n-1}{n} \pi(r))$. The distribution function $F$ can be solved by setting (A.7) equal to (A.9), which gives

$$F(p) = \frac{1}{\alpha}[1 - \left(\frac{(1 - \alpha)^{n-1}\pi(r) + n\phi}{n\pi(p)}\right)^{\frac{1}{n-1}}].$$

The function $F$ must satisfy certain properties in order to be a distribution function. First, $F$ is an atomless distribution with support $[p, r]$. The lower support of $F$, $p$, can be obtained by setting $F(p) = 0$ and solving to get

$$p = \pi^{-1}(\frac{n\phi}{n - 1}).$$

We know $c < p < r$ since $\frac{n\phi}{n - 1} > 0$ and $\pi(p)$ is strictly increasing up to $r$. Next, $F$ is increasing. This is because $\pi(p)$ is continuous and increasing up to $r$. Third, no firm can gain by pricing outside the support of $F$. It can be shown that if firm $i$ is to deviate to price outside the support of $F$ given the rest of the firms’ strategies, its expected profits would be strictly lower than that if it prices according to $F$.\footnote{Suppose firm $i$ advertises a price $p' < p$. Then its expected profits would be less than if it advertised the price $p$. This is because $E\pi_i(p', A) = \pi(p')(1 - \alpha F(p'))^{n-1} - \phi = \pi(p') - \phi < E\pi_i(p, A) = \pi(p)(1 - \alpha F(p))^{n-1} - \phi = \pi(p) - \phi$. On the other hand, suppose firm $i$ advertises a price $p'' > r$. Then its expected profits would be $E\pi_i(p'', A) = \pi(p'')(1 - \alpha)^{n-1} - \phi$, which is less than $E\pi_i(r, A) = \pi(r)(1 - \alpha)^{n-1} - \phi$ since $\pi(p)$ is maximized at $r$.}

Substituting $\alpha = 1 - \left[\frac{n\phi}{(n-1)\pi(r)}\right]^{\frac{1}{n-1}}$ into (A.9), we get equilibrium profits for each firm of $\phi^{\frac{1}{n-1}}$. Thus, when $0 < \phi < \frac{n-1}{n} \pi(r)$, $E\pi_i(p, A) = E\pi_i(r, N) = \frac{\phi}{n-1}$, i.e., a firm gets the same expected profits whether it advertises or does not advertise.
Appendix B

Proofs of the Second Essay
(Proof of Lemma 2.2, page 26.) Lemma 2.2 could be proved by using the following table.

Table 1: Consumers’ Expected Surpluses for Local Firm’s Various Strategies

<table>
<thead>
<tr>
<th>Local on</th>
<th>$U_A$</th>
<th>$U_B$</th>
<th>$U_{AB}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$S(p_A^{\text{min}})$</td>
<td>(1)$S(p_B^{\text{min}})$</td>
<td>$S(\min{p_A^{\text{min}}, p_B^{\text{min}}}) - \varepsilon$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2)$S(\min{p_A^{\text{min}}, p_\text{local}})$</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>(1)$S(p_A^{\text{min}})$</td>
<td>$S(p_B^{\text{min}})$</td>
<td>$S(\min{p_A^{\text{min}}, p_B^{\text{min}}})$</td>
</tr>
<tr>
<td></td>
<td>(2)$S(\min{p_A^{\text{min}}, p_\text{local}}) - \varepsilon$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>$S(p_A^{\text{min}})$</td>
<td>$S(p_B^{\text{min}})$</td>
<td>$S(\min{p_A^{\text{min}}, p_B^{\text{min}}})$</td>
</tr>
<tr>
<td>N</td>
<td>(1)$S(p_A^{\text{min}})$</td>
<td>(1)$S(p_B^{\text{min}})$</td>
<td>(1)$S(\min{p_A^{\text{min}}, p_B^{\text{min}}})$</td>
</tr>
<tr>
<td></td>
<td>(2)$S(\min{p_A^{\text{min}}, p_\text{local}}) - \varepsilon$</td>
<td>(2)$S(\min{p_B^{\text{min}}, p_\text{local}}) - \varepsilon$</td>
<td>(2)$S(\min{p_A^{\text{min}}, p_B^{\text{min}}, p_\text{local}}) - \varepsilon$</td>
</tr>
</tbody>
</table>

This table gives different surpluses to a consumer for different combinations of her subscription decisions and her local firm’s advertising decisions. For example, consider a consumer who subscribes to site B only and her local firm advertises on site A only. (See the first cell in the second column.) There are two possibilities. First, the consumer buys at the lowest price on site B ($p_B^{\text{min}}$) if she does not visit her local firm. Second, if she visits her local firm, she buys at the lowest price among those charged by firms advertising on site B and her local firm ($\min\{p_B^{\text{min}}, p_\text{local}\}$), but in this instance she has to pay $\varepsilon$. She chooses the higher of the two. The other cells in this table are interpreted similarly.

We discuss each row respectively. In each row we compare the expected surplus from subscribing to both sites ($U_{AB}$) to that from subscribing to one site ($U_A$ or $U_B$).

**First Row:** Consider the first row in which the local firm advertises on site A only. Compare $U_{AB}$ with $U_B$, i.e., the utility from subscribing to both sites with that
from subscribing to site $B$ only. Given that the local firm advertises on site $A$ only, we observe that if $p_{A}^{\text{min}} \geq p_{B}^{\text{min}}$, $U_{AB} \geq U_{B}$; but if $p_{A}^{\text{min}} < p_{B}^{\text{min}}$, $U_{AB} > U_{B}$. This is because $S(p_{B}^{\text{min}}) < S(\min\{p_{A}^{\text{min}}, p_{B}^{\text{min}}\})$ and $S(\min\{p_{B}^{\text{min}}, p_{\text{local}}\}) - \varepsilon \leq S(\min\{p_{B}^{\text{min}}, p_{A}^{\text{min}}\}) - \varepsilon < S(\min\{p_{A}^{\text{min}}, p_{B}^{\text{min}}\})$. Notice that the expected surplus of a consumer who subscribes to both sites conditional on the event that the local firm advertises on site $A$ only could be written as follows:

$$E(U_{AB}|\text{local on } A) = E(U_{AB}|p_{A}^{\text{min}} \geq p_{B}^{\text{min}}, \text{local on } A)Pr(p_{A}^{\text{min}} \geq p_{B}^{\text{min}}|\text{local on } A)$$

$$+ E(U_{AB}|p_{A}^{\text{min}} < p_{B}^{\text{min}}, \text{local on } A)Pr(p_{A}^{\text{min}} < p_{B}^{\text{min}}|\text{local on } A).$$ (B.1)

Similarly, the expected surplus of a consumer who subscribes to site $B$ only conditional on the event that the local firm advertises on site $A$ only could be written as follows:

$$E(U_{B}|\text{local on } A) = E(U_{B}|p_{A}^{\text{min}} \geq p_{B}^{\text{min}}, \text{local on } A)Pr(p_{A}^{\text{min}} \geq p_{B}^{\text{min}}|\text{local on } A)$$

$$+ E(U_{B}|p_{A}^{\text{min}} < p_{B}^{\text{min}}, \text{local on } A)Pr(p_{A}^{\text{min}} < p_{B}^{\text{min}}|\text{local on } A).$$ (B.2)

Looking at (B.1)-(B.2), we see that, if $Pr(p_{A}^{\text{min}} < p_{B}^{\text{min}}|\text{local on } A) > 0$, then $E(U_{AB}|\text{local on } A) > E(U_{B}|\text{local on } A)$. Similarly, by comparing $U_{AB}$ with $U_{A}$, we see that, if $Pr(p_{B}^{\text{min}} < p_{A}^{\text{min}}|\text{local on } A) > 0$, then $E(U_{AB}|\text{local on } A)$ is greater than $E(U_{A}|\text{local on } A)$.

**Second Row:** The discussion on comparing $U_{AB}$ with $U_{A}$ (or $U_{B}$) conditional on the event that the local firm advertises on site $B$ only is the same as the discussion above and is omitted.

**Third Row:** The local firm advertises on both sites. We first compare $U_{AB}$ with $U_{B}$ and observe that: when $p_{A}^{\text{min}} \geq p_{B}^{\text{min}}$, $U_{AB} = U_{B}$; but when $p_{A}^{\text{min}} < p_{B}^{\text{min}}$, $U_{AB} > U_{B}$. Thus, if $Pr(p_{A}^{\text{min}} < p_{B}^{\text{min}}|\text{local on } AB) > 0$, then $E(U_{AB}|\text{local on } AB) > E(U_{B}|\text{local on } AB)$. Similarly, we compare $U_{AB}$ with $U_{A}$ and conclude that, if $Pr(p_{A}^{\text{min}} > p_{B}^{\text{min}}|\text{local on } AB) > 0$, then $E(U_{AB}|\text{local on } AB) > E(U_{A}|\text{local on } AB)$.
**Fourth Row:** The local firm does not advertise. Consider a consumer who subscribes to site $B$ only. Such a consumer will visit the site she subscribes to, i.e., site $B$, first. Since her local firm’s price does not appear on the site, she must decide whether to spend $\varepsilon$ to visit her local firm. Suppose she knows for sure that her local firm does not advertise, then the consumer’s maximization problem is described as follows:

$$
\max_{p_B} \mathbb{E}_{p_B^{\min}} \left\{ 1(p_B^{\min} \leq p_B) S(p_B^{\min}) + 1(p_B^{\min} > p_B) \left[ \int_{c}^{p_B^{\min}} S(p) dG(p) \right.ight.
\left.\left. + (1 - G(p_B^{\min})) S(p_B^{\min}) - \varepsilon \right] \right\}.
$$

Equation (B.3) defines the threshold level $p_B^{**}$. That is, for a consumer who subscribes to site $B$ only, $p_B^{**}$ is the threshold level if she knows that her local firm does not advertise. Her decision rule is as follows. She visits her local firm if and only if the lowest price observed on site $B$, i.e., $p_B^{\min}$, is greater than $p_B^{**}$. Notice that we can rewrite the terms in the curly braces of (B.3) as:

$$
S(p_B^{\min}) + 1(p_B^{\min} > p_B) \left[ \int_{c}^{p_B^{\min}} S(p) dG(p) - G(p_B^{\min}) S(p_B^{\min}) - \varepsilon \right],
$$

which could further be written as follows:

$$
S(p_B^{\min}) + 1(p_B^{\min} > p_B) \left[ \int_{c}^{p_B^{\min}} [S(p) - S(p_B^{\min})] dG(p) - \varepsilon \right] .
$$

Define $\Delta \equiv \int_{c}^{p_B^{\min}} [S(p) - S(p_B^{\min})] dG(p) - \varepsilon$, we see that, to maximize (B.3), $1(p_B^{\min} > p_B)$ must equal one for any $p_B^{\min}$ such that $\Delta$ is positive, but equal zero for any $p_B^{\min}$ such that $\Delta$ is negative. Thus, the consumer visits her local firm if and only if the expected surplus gain from such a visit is greater than the cost $\varepsilon$, i.e., $\Delta > 0$. This is consistent with the optimal decision rule described previously.

However, notice that since the consumer subscribes to site $B$ only, when she does not observe her local firm’s price on site $B$, she is not sure whether her local firm advertises
on the other site, site $A$, or does not advertise at all. The consumer’s maximization problem is described as follows:

$$\max_{p_B} E_{p_B^{\text{min}}} \{1(p_B^{\text{min}} \leq p_B)S(p_B^{\text{min}})$$

$$+ 1(p_B^{\text{min}} > p_B)\left\{ \frac{\alpha_A}{1 - \alpha_B} \left[ \int_{p_b^{\text{min}}}^{p_B^{\text{min}}} S(p)dF_A(p) + (1 - F_A(p_B^{\text{min}}))S(p_B^{\text{min}}) \right] \right.$$ 

$$+ \frac{\alpha_N}{1 - \alpha_B} \left[ \int_{p_b^{\text{min}}}^{p_B^{\text{min}}} S(p)dG(p) + (1 - G(p_B^{\text{min}}))S(p_B^{\text{min}}) \right] \} - \varepsilon \} \}.$$

Equation (B.4) defines the threshold level $p_B^*$. That is, for a consumer who subscribes to site $B$ only, $p_B^*$ is the threshold level if she does not know whether her local firm does not advertise or advertises on the other site, site $A$. For such a consumer, her decision rule is as follows: she visits her local firm if the lowest price observed on site $B$, i.e., $p_B^{\text{min}}$, is greater than $p_B^*$. On the other hand, she will not visit her local firm if $p_B^{\text{min}} < p_B^*$. For a consumer who subscribes to site $B$ only, when her local firm does not advertise, if she uses $p_B^{**}$ as the threshold, her expected surplus is at least as large as that if she uses $p_B^*$ as the threshold. That is

$$E_{p_B^{\text{min}}} \max \{S(p_B^{\text{min}}), E_G S[\min\{p_B^{\text{min}}, p_{\text{local}}\}] - \varepsilon \}$$

$$= E_{p_B^{\text{min}}} \{1(p_B^{\text{min}} < p_B^{**})S(p_B^{\text{min}}) + 1(p_B^{\text{min}} \geq p_B^{**})[E_G S[\min\{p_B^{\text{min}}, p_{\text{local}}\}] - \varepsilon] \}$$

$$\geq E_{p_B^{\text{min}}} \{1(p_B^{\text{min}} < p_B^*)S(p_B^{\text{min}}) + 1(p_B^{\text{min}} \geq p_B^*)[E_G S[\min\{p_B^{\text{min}}, p_{\text{local}}\}] - \varepsilon] \}.$$ 

Now we would like to show that given that the local firm does not advertise, the expected surplus from subscribing to both sites is at least as large as that from subscribing to site $B$ only, using $p_B^{**}$ as the threshold. Then we may use the above inequality to conclude that the expected surplus from subscribing to both sites is at least as large as that from subscribing to site $B$ only, using $p_B^*$ as the threshold.
The expected surplus to a consumer who subscribes to both sites conditional on the fact that her local firm does not advertise is as follows:

\[ E_{p_{A}^{\text{min}}, p_{B}^{\text{min}}} \max\{S(\min\{p_{A}^{\text{min}}, p_{B}^{\text{min}}\}), E_{G}[\min\{p_{A}^{\text{min}}, p_{B}^{\text{min}}, p_{\text{local}}\}] - \varepsilon\}. \quad (B.5) \]

Compare (B.5) with the expected surplus from subscribing to site B only, using \( p_{B}^{*} \) as the threshold, i.e., \( E_{p_{B}^{\text{min}}} \max\{S(p_{B}^{\text{min}}), E_{G}[\min\{p_{B}^{\text{min}}, p_{\text{local}}\}] - \varepsilon\} \). Both terms in (B.5) are higher than their counterparts in this expression. We see that, conditional on the fact that the local firm does not advertise, the expected surplus from subscribing to both sites is at least as large as that from subscribing to site B only. Thus, we know that conditional on the fact that the local firm does not advertise, the expected surplus from subscribing to both sites is at least as large as that from subscribing to site B only, using \( p_{B}^{*} \) as the threshold.

We are now in a position to show Lemma 2.2. Suppose \( \alpha_{A} > 0 \). Then the probability that all firms advertise on site A, conditional on the fact that the local firm advertises on site A, will be greater than zero. That is, \( Pr(\text{all firms advertise on } A| \text{ local on } A) = \alpha_{A}^{n-1} > 0 \). Thus, the probability that no firms advertise on site B, conditional on the fact that the local firm advertises on site A, is greater than zero, i.e., \( Pr(\text{no firms advertise on } B| \text{ local on } A) > 0 \). This further implies that \( Pr(p_{A}^{\text{min}} < p_{B}^{\text{min}}| \text{ local on } A) > 0 \). That is, the probability that the lowest price observed on site A is lower than the lowest price observed on site B, conditional on the fact that the local firm advertises on site A, is greater than zero. From the previous discussion, we know this implies that conditional on the fact that the local firm advertises on site A, the expected surplus from subscribing to both sites is strictly greater than the expected surplus from subscribing to site B only, i.e., \( E(U_{AB}| \text{ local on } A) > E(U_{B}| \text{ local on } A) \). Thus, the (unconditional) expected surplus from subscribing
to both sites is greater than the (unconditional) expected surplus from subscribing to site B only, i.e., \( E(U_{AB}) > E(U_B) \).\(^1\) We conclude that, as long as \( \alpha > 0 \), a consumer will be strictly better off subscribing to both sites than subscribing to site B only. We thus established Lemma 2.2.

**Part B**

(Proof of Proposition 2.6, page 29.) If a firm advertises price \( p \) on both sites, its expected profits will be

\[
E\pi_i(p, AB) = \sum_{j=0}^{n-1} \binom{n-1}{j} \beta^j (1 - \beta)^{n-1-j} (1 - H(p)) j \pi(p) - \phi_A - \phi_B. \tag{B.6}
\]

That is, firm \( i \)'s expected profits if it advertises a price \( p \) on both sites is a weighted average of its profits when \( j \) other firms also advertise on both sites. In the event exactly \( j \) out of the remaining \( n-1 \) firms advertise, firm \( i \) gets positive sales and earns profits if and only if their advertised prices are all higher than firm \( i \)'s advertised price, \( p \). Firm \( i \) pays advertising fees \( \phi_A + \phi_B \) by advertising on both sites. Using the Binomial Theorem, the above expression could be written as

\[
E\pi_i(p, AB) = \pi(p)(1 - \beta H(p))^{n-1} - \phi_A - \phi_B. \tag{B.7}
\]

If firm \( i \) does not advertise, it charges the monopoly price \( r \) and it sells to its local consumers only when none of the remaining \( n-1 \) firms advertise. Hence, firm \( i \)'s expected profits if it does not advertise are

\[
E\pi_i(r, N) = (1 - \beta)^{n-1} \frac{\pi(r)}{n}. \tag{B.8}
\]

\(^1\) \( E(U_{AB}) = E(U_{AB} \mid \text{local on } A) Pr(\text{local on } A) + E(U_{AB} \mid \text{local on } B) Pr(\text{local on } B) + E(U_{AB} \mid \text{local not advertise}) Pr(\text{local not advertise}) + E(U_{AB} \mid \text{local on } AB) Pr(\text{local on } AB) \).
Setting (B.7) to be equal to (B.8) at \( p = r \) and imposing the condition that \( H(r) = 1 \), we get a firm’s probability of advertising:

\[
\beta = 1 - \left[ \frac{n(\phi_A + \phi_B)}{(n-1)\pi(r)} \right]^{\frac{1}{n-1}}. \tag{B.9}
\]

Notice that \( \beta \in (0, 1) \) whenever \( \phi_A + \phi_B \in (0, \frac{n-1}{n}\pi(r)) \).

Equating (B.7) and (B.8) and solving for \( H \) gives

\[
H(p) = \frac{1}{\beta} \left\{ 1 - \left[ \frac{(1-\beta)^{n-1}\pi(r) + n(\phi_A + \phi_B)}{n\pi(p)} \right]^{\frac{1}{n-1}} \right\}. \tag{B.10}
\]

To show that \( H \) is part of an equilibrium, we need to show the following. First, \( H \) is an atomless distribution with support \([p_2, r]\). The lower support of \( H, p_2 \), could be obtained by setting \( H(p_2) = 0 \) and solving to get

\[
p_2 = \pi^{-1} \left[ \frac{n}{n-1}(\phi_A + \phi_B) \right].
\]

Since \( \frac{n}{n-1}(\phi_A + \phi_B) > 0 \), \( \pi(p_2) = \frac{n}{n-1}(\phi_A + \phi_B) > 0 \) and hence \( p_2 > c \). Also, since \( \phi_A + \phi_B < \frac{n-1}{n}\pi(r) \), \( \frac{n}{n-1}(\phi_A + \phi_B) < \pi(r) \), and hence \( p_2 = \pi^{-1} \left[ \frac{n}{n-1}(\phi_A + \phi_B) \right] < r \).

Second, \( H \) is increasing. This is because \( \pi(p) \) is continuous and increasing up to \( r \).

Finally, it can be shown that a firm earns strictly lower expected profits if it deviates to advertising a price outside the support of \( H \) when the rest \( n-1 \) firms all advertise according to \( H \).

**Part C**

(Proof of Lemma 2.5, page 29.) Lemma 2.5 ensures that in equilibrium, a firm who advertises on both sites would not deviate to advertising on only one site. Given the remaining \( n-1 \) firms all mix between not advertising and advertising on both sites, if
firm $i$ deviates to advertising a price $p$ on site $A$ only, its expected profits will be

$$E\pi_i(p, A) = \sum_{j=1}^{n-1} \binom{n-1}{j} \beta^j (1 - \beta)^{n-1-j} (1 - H(p))^j \mu_A \pi(p)$$

$$+ (1 - \beta)^{n-1} [\mu_A \pi(p) + \frac{\mu_B}{n} \pi(p)] - \phi_A.$$  \hfill (B.11)

The first term of (B.11) is the expected profits for firm $i$ when its advertised price is lower than those advertised by all of those $j$ firms ($j \geq 1$) who advertise. The second term is the expected profits for firm $i$ when none of the remaining $n - 1$ firms advertises. Firm $i$ pays advertising fee $\phi_A$ by advertising on site $A$ only. Using the Binomial Theorem, we can rewrite the previous equation as

$$E\pi_i(p, A) = \mu_A \pi(p)(1 - \beta H(p))^{n-1} + (1 - \beta)^{n-1} \frac{\mu_B}{n} \pi(p) - \phi_A.$$  \hfill (B.12)

In order for a firm not to deviate and advertise on one site only, the payoff for the firm from advertising on both sites has to be at least as much as that from advertising on only one site. Hence, we need $E\pi_i(p, AB) \geq E\pi_i(p, A)$. Using (B.9) and (B.10), this condition reduces to

$$\phi_B \leq (\phi_A + \phi_B) [(1 - \mu_A) \frac{n}{n-1} - \frac{\mu_B}{n-1} \frac{\pi(p)}{\pi(r)}] \text{ for all } p \in [p_2, r].$$  \hfill (B.13)

However, notice that if firm $i$ is to deviate to advertising on one site only, it will advertise the monopoly price $r$. The reason is as follows. If firm $i$ deviates to advertise on site $A$ only, its problem is to maximize (B.12), i.e., the deviation profits. Equation (B.12) could be written as

$$E\pi_i(p, A) = \mu_A [E\pi_i(p, AB) + \phi_A + \phi_B] + (1 - \beta)^{n-1} \frac{\mu_B}{n} \pi(p) - \phi_A.$$  

Since $E\pi_i(p, AB)$ is simply the equilibrium profits and $\pi(p)$ is maximized at $r$, $E\pi_i(p, A)$ is maximized at $r$. The intuition is as follows. Compared with advertising on both sites,
the main benefit to firm $i$ from advertising on one site is that when none of the remaining $n-1$ firms advertises, firm $i$ can get profits from its local consumers who subscribe to the other site even though it does not advertise on the other site. This benefit increases with the price level. Hence, if firm $i$ deviates to advertising on only one site, it will advertise the monopoly price $r$.

Setting $p = r$, equation (B.13) reduces to $\frac{\mu_B}{\mu_A} \geq \frac{\phi_B}{\phi_A}$. Similarly, for firm $i$ not to deviate to advertise on site $B$ only, we need $\frac{\mu_B}{\mu_A} \leq \frac{\phi_B}{\phi_A}$. Hence, in equilibrium,

$$\frac{\mu_B}{\mu_A} = \frac{\phi_B}{\phi_A}.$$  

Notice that since $p_2 = \pi^{-1}[n^{-1}(\phi_A + \phi_B)] < r$, $\phi_A + \phi_B < \frac{n-1}{n} \pi(r)$. 

Appendix C

Tables and Figures of Chapter 3
<table>
<thead>
<tr>
<th>Product Number</th>
<th>Product Name</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apple 15-inch PowerBook G4</td>
<td>M8981LL/A</td>
</tr>
<tr>
<td>2</td>
<td>Apple 17-inch PowerBook G4</td>
<td>M9110LL/A</td>
</tr>
<tr>
<td>3</td>
<td>Canon CanoScan 5000F</td>
<td>7879A002</td>
</tr>
<tr>
<td>4</td>
<td>Canon EOS 10D</td>
<td>8363A013</td>
</tr>
<tr>
<td>5</td>
<td>Canon Elura 50</td>
<td>8713A001</td>
</tr>
<tr>
<td>6</td>
<td>Canon GL2</td>
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</tr>
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<td>7</td>
<td>Canon MultiPass MP730</td>
<td>8297A002</td>
</tr>
<tr>
<td>8</td>
<td>Canon Optura 20</td>
<td>8528A001</td>
</tr>
<tr>
<td>9</td>
<td>Canon PowerShot S400 Digital Elph</td>
<td>8392A001</td>
</tr>
<tr>
<td>10</td>
<td>Canon PowerShot S50</td>
<td>8445A001</td>
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<td>Canon XL1S Professional Mini DV Camcorder</td>
<td>7046A001AA</td>
</tr>
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<td>Creative Nomad MuVo NX (128 MB)</td>
<td>73PD037000000</td>
</tr>
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<td>Creative Nomad MuVo NX (256 MB)</td>
<td>73PD00000016</td>
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<td>B11B162101</td>
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<td>15</td>
<td>Fujifilm FinePix S5000</td>
<td>43860875</td>
</tr>
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<td>16</td>
<td>HP Scanjet 3970</td>
<td>Q3191A#A2L</td>
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<td>17</td>
<td>Roxio Easy CD &amp; DVD Creator 6</td>
<td>207000</td>
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<td>18</td>
<td>Samsung Yepp YP-55 (256MB)</td>
<td>YP-55V</td>
</tr>
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<td>19</td>
<td>Sony Cyber Shot DSC F717</td>
<td>DSC-F717</td>
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<tr>
<td>20</td>
<td>Sony Cyber Shot DSC-F828</td>
<td>DSC-F828</td>
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Table 2. Summary Statistics

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<tr>
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<th>Matched Dataset</th>
<th></th>
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<td></td>
<td>CNET</td>
<td>NEXTAG</td>
<td>CNET</td>
<td>NEXTAG</td>
</tr>
<tr>
<td>Total Number of Products</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Total Number of ‘Product-Dates’</td>
<td>1774</td>
<td>1898</td>
<td>1538</td>
<td>1538</td>
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<tr>
<td>Total Number of Price Listings</td>
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<td>59728</td>
<td>49184</td>
<td>48227</td>
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<tr>
<td>Number of Obs labeled as Refurbished</td>
<td>0</td>
<td>362</td>
<td>0</td>
<td>278</td>
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<tr>
<td>Number of Obs labeled as Open Box</td>
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<td>149</td>
<td>0</td>
<td>99</td>
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<td>$807.88</td>
<td>$827.82</td>
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<td>Average (Equal weight for each product)</td>
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<tr>
<td>Price</td>
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<td>Number of Firms on Both Sites</td>
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<td>17.13</td>
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<td></td>
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<td>Proportion of Firms on Both Sites</td>
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<td>58.56%</td>
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<td></td>
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<tr>
<td>Price Dispersion Measures</td>
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<td></td>
<td></td>
<td></td>
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<td>Average Percentage Gap</td>
<td>3.34%</td>
<td>5.88%</td>
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<tr>
<td>Average Percentage Range</td>
<td>54.30%</td>
<td>111.92%</td>
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<tr>
<td>Average Coefficient of Variation</td>
<td>10.70%</td>
<td>12.69%</td>
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### Table 3. Average Number of Firms on Each Site, on Both Sites, and Average Proportion of Firms on Both Sites

<table>
<thead>
<tr>
<th>product_name</th>
<th>Average number of firms</th>
<th>Average number of firms listing prices on both sites</th>
<th>Average proportion of firms on both</th>
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<tr>
<td></td>
<td>CNET</td>
<td>NEXTAG</td>
<td>CNET</td>
</tr>
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<td>Apple 15-inch PowerBook G4</td>
<td>15.63</td>
<td>14.65</td>
<td>9.95</td>
</tr>
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<td>Apple 17-inch PowerBook G4</td>
<td>18.45</td>
<td>15.99</td>
<td>10.64</td>
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<td>Canon CanoScan 5000F</td>
<td>26.58</td>
<td>19.86</td>
<td>16.12</td>
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<td>Canon EOS 10D</td>
<td>29.03</td>
<td>32.98</td>
<td>17.30</td>
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<td>Canon Elura 50</td>
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<td>Canon GL2</td>
<td>36.30</td>
<td>41.94</td>
<td>17.83</td>
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<td>Canon MultiPass MP730</td>
<td>28.04</td>
<td>22.04</td>
<td>14.55</td>
</tr>
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<td>Canon Optura 20</td>
<td>38.65</td>
<td>42.25</td>
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<td>57.12</td>
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<td>Canon PowerShot S50</td>
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<td>14.79</td>
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<td>22.27</td>
<td>19.16</td>
<td>11.55</td>
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<td>22.31</td>
<td>15.65</td>
<td>11.71</td>
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<td>Fujifilm FinePix S5000</td>
<td>46.90</td>
<td>46.60</td>
<td>24.93</td>
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<td>HP Scanjet 3970</td>
<td>22.05</td>
<td>16.22</td>
<td>12.96</td>
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<td>Roxio Easy CD &amp; DVD Creator 6</td>
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<td>23.17</td>
<td>12.26</td>
</tr>
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<td>7.74</td>
<td>8.93</td>
<td>4.56</td>
</tr>
<tr>
<td>Sony Cyber Shot DSC F717</td>
<td>55.90</td>
<td>60.74</td>
<td>31.13</td>
</tr>
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<td>Sony Cyber Shot DSC-F828</td>
<td>29.37</td>
<td>29.88</td>
<td>17.37</td>
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</table>
Table 4. Number of Rebate Adjusted Price Equivalence/Differences for Firms Who Advertise on Both Sites
Price Difference = Cnet Rebate Adjusted Price – Nextag Rebate Adjusted Price

<table>
<thead>
<tr>
<th>Price Difference Category</th>
<th>Matched Dataset</th>
<th>Dataset with rebate, refurbished, and openbox observations excluded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Price Pairs</td>
<td>%</td>
</tr>
<tr>
<td>-$1200 to -$1000</td>
<td>10</td>
<td>0.04%</td>
</tr>
<tr>
<td>-$1000 to -$800</td>
<td>143</td>
<td>0.54%</td>
</tr>
<tr>
<td>-$800 to -$600</td>
<td>17</td>
<td>0.06%</td>
</tr>
<tr>
<td>-$600 to -$400</td>
<td>44</td>
<td>0.17%</td>
</tr>
<tr>
<td>-$400 to -$200</td>
<td>102</td>
<td>0.38%</td>
</tr>
<tr>
<td>-$200 to $0</td>
<td>1523</td>
<td>5.72%</td>
</tr>
<tr>
<td>$0</td>
<td>23736</td>
<td>89.21%</td>
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<tr>
<td>$0 to $200</td>
<td>884</td>
<td>3.32%</td>
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<tr>
<td>$200 to $400</td>
<td>129</td>
<td>0.48%</td>
</tr>
<tr>
<td>$400 to $600</td>
<td>12</td>
<td>0.05%</td>
</tr>
<tr>
<td>$600 to $800</td>
<td>8</td>
<td>0.03%</td>
</tr>
<tr>
<td>Total Number of Price Pairs</td>
<td>26608</td>
<td>100%</td>
</tr>
<tr>
<td>Price Difference Category</td>
<td>Number of Price Pairs</td>
<td>Firms labeled as refurbished or openbox on Nextag who also advertise on Cnet</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>$105.27</td>
<td>1</td>
<td>0.67%</td>
</tr>
<tr>
<td>$50.99</td>
<td>1</td>
<td>0.67%</td>
</tr>
<tr>
<td>$2.25</td>
<td>1</td>
<td>0.67%</td>
</tr>
<tr>
<td>$2</td>
<td>1</td>
<td>0.67%</td>
</tr>
<tr>
<td>0</td>
<td>139</td>
<td>93%</td>
</tr>
<tr>
<td>$2.25</td>
<td>3</td>
<td>2%</td>
</tr>
<tr>
<td>$17.72</td>
<td>3</td>
<td>2%</td>
</tr>
<tr>
<td>$43</td>
<td>1</td>
<td>0.67%</td>
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<tr>
<td>Total Number of Price Pairs</td>
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</tr>
</tbody>
</table>
Table 6. Regression Results for the Whole Data Set.

Dependent Variable: ln(Rebate Adjusted Price)

<table>
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<tr>
<th>Specification</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNET</td>
<td>0.0668 (54.02)**</td>
<td>0.0641 (52.10)**</td>
<td>0.0595 (44.90)**</td>
<td>0.0547 (37.58)**</td>
</tr>
<tr>
<td>Refurbished</td>
<td>-0.1504 (-16.56)**</td>
<td>-0.1586 (-17.39)**</td>
<td>-0.1741 (-19.15)**</td>
<td>-0.1741 (-19.15)**</td>
</tr>
<tr>
<td>Open box</td>
<td>-0.4719 (-33.46)**</td>
<td>-0.4779 (-33.86)**</td>
<td>-0.4864 (-34.77)**</td>
<td>-0.4864 (-34.77)**</td>
</tr>
<tr>
<td>New_reop</td>
<td>-0.0175 (-9.59)**</td>
<td>-0.0324 (-14.62)**</td>
<td>-0.0324 (-14.62)**</td>
<td>-0.0324 (-14.62)**</td>
</tr>
<tr>
<td>Banner</td>
<td>0.0708 (62.62)**</td>
<td>0.0685 (60.83)**</td>
<td>0.0684 (60.77)**</td>
<td>0.0678 (60.96)**</td>
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Number of Firms

<table>
<thead>
<tr>
<th></th>
<th>1 firm</th>
<th>2 firms</th>
<th>3 firms</th>
<th>4 firms</th>
<th>5 firms</th>
<th>6 firms</th>
<th>7 firms</th>
<th>8 firms</th>
<th>9 firms</th>
<th>10 firms</th>
<th>11 firms</th>
<th>12 firms</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0.1335 (1.34)</td>
<td>--</td>
<td>0.0755 (1.51)</td>
<td>0.0479 (1.50)</td>
<td>0.0712 (2.55)*</td>
<td>0.0887 (6.50)**</td>
<td>0.1052 (4.84)**</td>
<td>0.0694 (5.60)**</td>
<td>0.0790 (5.29)**</td>
<td>0.0670 (6.29)**</td>
<td>0.0574 (5.11)**</td>
<td>0.0307 (3.14)**</td>
</tr>
<tr>
<td></td>
<td>0.1303 (1.32)</td>
<td>--</td>
<td>0.0726 (1.46)</td>
<td>0.0464 (1.46)</td>
<td>0.0697 (2.52)*</td>
<td>0.0856 (6.31)**</td>
<td>0.1019 (4.72)**</td>
<td>0.0673 (5.46)**</td>
<td>0.0783 (5.27)**</td>
<td>0.0707 (6.66)**</td>
<td>0.0585 (5.23)**</td>
<td>0.0308 (3.17)**</td>
</tr>
<tr>
<td></td>
<td>0.1275 (1.29)</td>
<td>--</td>
<td>0.0696 (1.40)</td>
<td>0.0428 (1.35)</td>
<td>0.0681 (2.46)*</td>
<td>0.0808 (5.95)**</td>
<td>0.0960 (4.45)**</td>
<td>0.0640 (5.19)**</td>
<td>0.0761 (5.13)**</td>
<td>0.0732 (6.90)**</td>
<td>0.0587 (5.26)**</td>
<td>0.0311 (3.20)**</td>
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</tr>
</tbody>
</table>

Number of Observations 116723 116723 116723 116723

Note: In the whole data set, there does not exist a site-product-date in which exactly two firms list prices. T-statistics are in the parentheses.

* significant under 5% significance level; ** significant under 1% significance level

---

96
Table 7. Test for Signaling – Regression Results for the Whole Data Set.  
Dependent variable: ln(Rebate Adjusted Price)

<table>
<thead>
<tr>
<th>Specification</th>
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<th>2.</th>
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<tr>
<td>Cnet</td>
<td>0.0601 (44.80)**</td>
<td>0.0553 (37.66)**</td>
</tr>
<tr>
<td>Adjusted refurbished or open box observations</td>
<td>-0.2413 (-35.30)**</td>
<td>-0.2581 (-37.43)**</td>
</tr>
<tr>
<td>Adjusted New_reop</td>
<td>-0.0194 (-10.50)**</td>
<td>-0.0367 (-15.79)**</td>
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<tr>
<td>Cnet product-date with identified low quality firms</td>
<td>0.0161 (5.04)**</td>
<td>0.0265 (7.68)**</td>
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<tr>
<td>Banner</td>
<td>0.0686 (60.89)**</td>
<td>0.0680 (61.10)**</td>
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<td>0.0733 (5.39)**</td>
<td>-0.0091 (-0.38)</td>
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<td>7 firms</td>
<td>0.0905 (4.19)**</td>
<td>0.0209 (0.70)</td>
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<tr>
<td>8 firms</td>
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<td>9 firms</td>
<td>0.0826 (5.55)**</td>
<td>0.0137 (0.74)</td>
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<td>0.0733 (6.91)**</td>
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<td>12 firms</td>
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<td>Yes</td>
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<td>Week Dummies</td>
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<tr>
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Note: In the whole data set, there does not exist a site-product-date in which exactly two firms list prices.  
t-statistics are in the parentheses.  
* significant under 5% significance level; ** significant under 1% significance level
Table 8. Test for Signaling – Regression Results for the Whole Data Set.
Different Coefficients for Cnet adjusted refurbished or open box observations and Cnet adjusted New_reop.
Dependent variable: ln(Rebate Adjusted Price)

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<tr>
<th>Specification</th>
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<td>0.0601 (44.80)**</td>
<td>0.0553 (37.67)**</td>
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<td>Adjusted New_reop</td>
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<td>Cnet×Adjusted refurbished or open box observations</td>
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<td>Cnet×Adjusted New_reop</td>
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<td>0.0248 (7.11)**</td>
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<tr>
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<th>10 firms</th>
<th>11 firms</th>
<th>12 firms</th>
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<td>0.0680 (1.37)</td>
<td>--</td>
<td>0.0352 (1.11)</td>
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<td>0.0631 (2.28)*</td>
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<td>0.0738 (5.42)**</td>
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<td>0.0909 (4.21)**</td>
<td>0.0719 (5.81)**</td>
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<td>-0.0682 (-1.16)</td>
<td>--</td>
<td>-0.0942 (-2.22)*</td>
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<td>-0.0416 (-1.17)</td>
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<td>0.0206 (0.69)</td>
<td>-0.0091 (-0.56)</td>
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<td>0.0631 (2.28)*</td>
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<td>0.0738 (5.42)**</td>
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<td>0.0909 (4.21)**</td>
<td>0.0719 (5.81)**</td>
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<td>0.0206 (0.69)</td>
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<td>-0.0942 (-2.22)*</td>
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<td>0.0206 (0.69)</td>
<td>-0.0091 (-0.56)</td>
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<td>Week Dummies</td>
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Note: In the whole data set, there does not exist a site-product-date in which exactly two firms list prices. t-statistics are in the parentheses.
* significant under 5% significance level; ** significant under 1% significance level
Table 9. Regression Results for the Matched Data Set.  
Dependent variable: ln(Rebate Adjusted Price)

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<tr>
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<td>0.0343 (3.32)**</td>
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<td>Yes</td>
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<td>Product Dummies</td>
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<td>Yes</td>
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<td>Week Dummies</td>
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<td>Yes</td>
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<td>No</td>
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Note: In the matched dataset, there does not exist a site-product-date in which one or two firms list prices.  
t-statistics are in the parentheses.  
* significant under 5% significance level; ** significant under 1% significance level
<table>
<thead>
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<th>Specification</th>
<th>1.</th>
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<td>Cnet</td>
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<td>0.0544 (36.24)**</td>
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<td>0.0664 (54.15)**</td>
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<tr>
<td>3 firms</td>
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<tr>
<td>Product Dummies</td>
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<td>Week Dummies</td>
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<td>Product × Week Dummies</td>
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</table>

Note: In the matched dataset, there does not exist a site-product-date in which one or two firms list prices. t-statistics are in the parentheses. * significant under 5% significance level; ** significant under 1% significance level
**Table 11. Test for Signaling – Regression Results for the Matched Data Set.**

Different Coefficients for Cnet adjusted refurbished or open box observations and Cnet adjusted New_reop.

Dependent variable: ln(Rebate Adjusted Price)

<table>
<thead>
<tr>
<th>Specification</th>
<th>1.</th>
<th>2.</th>
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<td>0.0663 (54.12)**</td>
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**Number of Firms**

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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0628 (5.01)**</td>
<td>0.0247 (1.67)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0361 (3.49)**</td>
<td>0.0015 (0.12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Popularity Ranking**: Yes, Yes
**Product Dummies**: Yes, Yes
**Week Dummies**: Yes, Yes
**Product×Week Dummies**: No, Yes
**R-square**: 0.9749, 0.9754
**Number of Observations**: 97411, 97411

Note: In the matched dataset, there does not exist a site-product-date in which one or two firms list prices. t-statistics are in the parentheses.

* significant under 5% significance level; ** significant under 1% significance level
<table>
<thead>
<tr>
<th>Specification</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of identified refurbished or open box observations</td>
<td>-0.0045 (-2.92)**</td>
<td>0.0003 (0.13)</td>
<td>0.0057 (2.83)**</td>
</tr>
<tr>
<td>Cnet product-date with identified low quality firms</td>
<td>-0.0401 (-2.97)**</td>
<td>-0.0738 (-5.68)**</td>
<td>-0.0738 (-5.68)**</td>
</tr>
<tr>
<td>Proportion of banner</td>
<td>0.0019 (3.11)**</td>
<td>0.0018 (3.00)**</td>
<td>0.0005 (0.61)</td>
</tr>
<tr>
<td>Number of Firms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 firm</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2 firms</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>3 firms</td>
<td>0.0777 (0.94)</td>
<td>0.0806 (0.98)</td>
<td>-0.0301 (-0.38)</td>
</tr>
<tr>
<td>4 firms</td>
<td>0.0900 (2.48)*</td>
<td>0.0923 (2.55)*</td>
<td>-0.0273 (-0.44)</td>
</tr>
<tr>
<td>5 firms</td>
<td>0.1120 (3.29)**</td>
<td>0.1125 (3.31)**</td>
<td>-0.0237 (-0.49)</td>
</tr>
<tr>
<td>6 firms</td>
<td>0.0794 (2.88)**</td>
<td>0.0785 (2.86)**</td>
<td>-0.0258 (-0.55)</td>
</tr>
<tr>
<td>7 firms</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>8 firms</td>
<td>0.1125 (3.92)**</td>
<td>0.0970 (3.33)**</td>
<td>-0.0307 (-0.76)</td>
</tr>
<tr>
<td>9 firms</td>
<td>0.1198 (3.66)**</td>
<td>0.1086 (3.30)**</td>
<td>-0.0252 (-0.67)</td>
</tr>
<tr>
<td>10 firms</td>
<td>0.0776 (2.79)**</td>
<td>0.0751 (2.70)**</td>
<td>-0.0259 (-0.69)</td>
</tr>
<tr>
<td>11 firms</td>
<td>0.0565 (2.01)*</td>
<td>0.0550 (1.96)</td>
<td>-0.0239 (-0.73)</td>
</tr>
<tr>
<td>12 firms</td>
<td>0.0576 (2.62)**</td>
<td>0.0585 (2.67)**</td>
<td>-0.0168 (-0.76)</td>
</tr>
<tr>
<td>Popularity Ranking</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Week Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product × Week Dummies</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>R-square</td>
<td>0.9953</td>
<td>0.9953</td>
<td>0.9981</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>1774</td>
<td>1774</td>
<td>1774</td>
</tr>
</tbody>
</table>

Note: In the Collapsed Cnet data set, there does not exist a product-date in which one, two, or seven firms list prices. *t*-statistics are in the parentheses.

* significant under 5% significance level; ** significant under 1% significance level
### Table 13. Summary of Regression Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNET</td>
<td>A dummy variable with CNET = 1 and Nextag = 0.</td>
</tr>
<tr>
<td>Refurbished</td>
<td>A dummy variable which indicates whether an observation is labelled as coming from a refurbished product.</td>
</tr>
<tr>
<td>Open box</td>
<td>A dummy variable which indicates whether an observation is labelled as coming from an open box product.</td>
</tr>
<tr>
<td>New_reop</td>
<td>Dummy variable. New_reop = 1 if an observation is NOT labelled as refurbished or open box while in the same site-product-date, there exists at least one other observation labelled as refurbished or open box.</td>
</tr>
<tr>
<td>Adjusted refurbished or open box</td>
<td>Dummy variable. For each product-date, we assign a value of one to this dummy variable for two types of firms – firms on Nextag originally labelled as selling refurbished or open box products, and firms on CNET identified as selling refurbished or open box products.</td>
</tr>
<tr>
<td>Adjusted New_reop</td>
<td>Dummy variable. For each observation in each site-product-date, we assign a value of one to this variable if an observation is neither labelled nor identified as refurbished or open box while in the same site-product-date, there exists at least one other observation labeled or identified as refurbished or open box.</td>
</tr>
<tr>
<td>Proportion of identified refurbished or open box observations</td>
<td>This is the proportion of observations identified as coming from refurbished or open box products for each Cnet product-date.</td>
</tr>
<tr>
<td>Cnet product-date with identified low quality firms</td>
<td>A dummy variable. It is equal to one for Cnet product-dates in which there exists at least one firm identified as selling refurbished or open box products.</td>
</tr>
<tr>
<td>Banner</td>
<td>A dummy variable. Banner = 1 if a firm displays its logo on the search result list of a price comparison site.</td>
</tr>
<tr>
<td>Proportion of banner</td>
<td>For each product-date, this is the proportion of firms who display store logos on the search result list of a price comparison site.</td>
</tr>
<tr>
<td>Number of Firms</td>
<td>Number of firms listing prices in each product-date for both Cnet and Nextag. The number of firms are divided into different categories starting from 1 firm, 2 firms, 3 firms, ... up to more than 12 firms.</td>
</tr>
<tr>
<td>Popularity Ranking</td>
<td>Firms’ popularity rankings are divided into different categories starting from rank 0 to 10, rank 10 to 20, up to rank 40 to 50.</td>
</tr>
<tr>
<td>Product dummies</td>
<td>These are used to control for product specific effects.</td>
</tr>
<tr>
<td>Week dummies</td>
<td>These are used to control for week specific effects.</td>
</tr>
<tr>
<td>Product × Week dummies</td>
<td>A dummy variable which interacts each of the 15 products and 17 weeks.</td>
</tr>
</tbody>
</table>
Figure 1: Average Prices for Cnet and Nextag
Bibliography


