

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

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Abstract

We study 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. We find that (1) using the indicator whether a product is refurbished or open box or not as a proxy for quality, we 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 refurbished and open box products, number of firms, popularity ranking, product and week specific effects, and product life cycle effects; (3) after adjusting for rebate prices, less than 10 percent of the firms that advertise on both sites charge different prices.

Keywords: Price Comparison Sites; Signaling

JEL classification: D4; D8; L13; M3

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I. 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](http://A2Zcomputers.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.¹ While some firms on a price comparison site clearly label themselves as selling refurbished or open box products, there are times when consumers need to click through a firm’s website in order to find out the true quality of its product.

¹While 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.

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 signaling 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 signaling 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.² Our regression results indicate that the pricing behaviors of firms on those Cnet product-dates are consistent with the predictions of Fluet

²Each 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.

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.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 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)

³Both 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.

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.

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

⁴See also Bagwell (1992), Hertzendorf (1993), and Overgaard (1993) for quality signalling in the monopoly case.

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.

Our paper is organized as follows. Section II describes the similarities and differences of price comparison sites Cnet and Nextag and summarizes the data set used in our research. Section III 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 IV discuss two issues. First, we 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 V

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.

concludes. Tables and graphs are collected at the end of this paper.

II. 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 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.⁷ Moreover, they are charged depending on the number of qualified consumer

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.

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

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.⁸ 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.

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

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.

“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

⁹Some 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.

¹⁰For 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.

¹¹We 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.

¹²For 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.

III. Price As a Signalling Device?

A. 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 δ , 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, 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

¹³Fluet 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) .

$d_H(p_H, p_L) = \min\{1 - (p_H - p_L)/\delta, 1\}$ 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 δ . 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 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.¹⁵ The following proposition will be used as a basis of our later empirical analysis.

¹⁴The 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.

¹⁵See proof of proposition 1.

Proposition 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^* . \square

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.

B. *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.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.

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

¹⁶ $150/(278 + 99) \times 100\% = 39.78\%$. See Table 2 for the number of refurbished and open box products.

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 ob-

ervation 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.

$$\begin{aligned}
 \ln(\text{rebate adjusted price}) &= \beta_0 + \beta_1 \cdot \text{Cnet} \\
 &+ \beta_2 \cdot \text{Adjusted refurbished or open box observations} \\
 &+ \beta_3 \cdot \text{Adjusted New_reop} \\
 &+ \beta_4 \cdot \text{Cnet product-date with identified low quality firms} \\
 &+ \text{other variables} \tag{1}
 \end{aligned}$$

Subscripts representing site, product, and date for each variable are suppressed in equation (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.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 (1) is based on the assumption that firms on Cnet identified as selling refurbished or open box products share the same coefficient (β_4) with firms on Cnet who sell “new” products while in the same

¹⁷From 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.

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. The regression model now becomes

$$\begin{aligned}
 \ln(\text{rebate adjusted price}) = & \beta_0 + \beta_1 \cdot \text{Cnet} \\
 & + \beta_2 \cdot \text{Adjusted refurbished or open box observations} \\
 & + \beta_3 \cdot \text{Adjusted New_reop} \\
 & + \beta_{41} \cdot \text{Cnet} \times \text{Adjusted refurbished or open box observations} \\
 & + \beta_{42} \cdot \text{Cnet} \times \text{Adjusted New_reop} \\
 & + \text{other variables.}
 \end{aligned} \tag{2}$$

The regressions results for equation (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×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, 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 (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% ($\hat{\beta}_3 + \hat{\beta}_{42}$) 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.

C. *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. 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.

D. *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.

IV. Other Issues

A. *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 counter parts 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 quality firms are treated as firms who sell new products in our regressions.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

¹⁸However, without further information on the data set, we are not able to address the influences of these factors by statistical analysis.

¹⁹Without 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.

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.

B. *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%.

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.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

²⁰Price differences here refer to rebate adjusted price differences.

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.

V. 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 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.

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