Red Queen Pricing Effects in E-Retail Markets

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Abstract

A standard "solution" offered to the deleterious effects of all-out price competition is for firms to engage in differentiation strategies. This solution, however, depends critically on the inability of rivals to imitate a successful differentiation strategy. With imitation, we show how "Red Queen" pricing effects can arise: All firms have an incentive to vertically differentiate and increase markups, yet imitation by rivals drives prices down toward pre-differentiation levels. Thus, the price premia arising from differentiation strategies in e-retailing critically depend on the number of other firms that imitate the strategies. Based on data from Shopper.com, we find that an online firm that unilaterally differentiates itself from its rivals by participating in CNet's Certified Merchant program enjoys a 5 to 17 percent price premium. However, when other firms also follow this strategy, the price premium vanishes.

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"Now HERE you see, it takes all the running YOU can do, to keep in the same place. If you want to get somewhere, you must run at least twice as fast as that." —The Red Queen speaking to Alice in *Through the Looking Glass,* Lewis Carroll.

1 Introduction

Ellison and Ellison (2001) suggest that competition at price comparison sites and the resulting commoditization of the products being offered by E-retailers will likely give rise to prices being driven to marginal cost. Faced with such a stark competitive environment, the standard prescription of business strategy guides, such as *Information Rules* by Shapiro and Varian (1998), is for E-retailers to look for opportunities to differentiate themselves from their rivals as much as possible and thereby avoid the commoditization of these markets and the resultant "Bertrand Trap." While this is sound advice, can differentiation, by itself, enable firms to avoid the commoditization of these markets? Harder still, even if a firm is successful, can it avoid imitation by other firms?

In answering these questions, it is important to note that the intermediary operating the price comparison site also has an incentive to facilitate differentiation. After all, if prices are driven to marginal cost, there is little incentive for consumers to use the site to search out the lowest price and hence, the value of the site is diminished with the commoditization of e-retail markets (see Baye and Morgan, 2001 and Baye, Morgan, and Scholten, 2003). One way intermediaries on the Internet strive to facilitate differentiation among E-retailers is by creating mechanisms whereby firms can

advertise their service levels. The primary focus of this paper is to study how differentiation through a particular intermediary sponsored mechanism, the CNet Certified Merchant Program, affected retail prices listed on the Internet price comparison site, Shopper.com, and how imitation affects the premium firms might otherwise charge through such differentiation strategies.

We show that firms' incentives to vertically differentiate create what we refer to as "Red Queen" pricing effects in E-retail markets: *In many online environments, it takes all the vertical differentiation an E-retailer can do just to keep prices in the same place.* That is, each firm has a sharp incentive to provide a higher level of service than rivals and charge the associated price premium, but, when rivals imitate, the resulting competition pushes prices back down to pre-differentiation levels. Analogous situations have been documented by van Valen (1973) in the context of evolutionary biology. For example, evolutionary selection favors trees that grow taller to enjoy more sunlight, but ultimately results in a forest with taller trees – all of which enjoy the same amount of sunlight. Thus, each tree has an incentive to "vertically differentiate" (i.e., grow taller), yet with imitation, no tree gains any advantage over its rivals.

In the next section, we identify a class of vertical differentiation games that exhibit Red Queen pricing effects. Roughly, our Proposition 1 shows that these effects arise in E-retail environments where *relative* service plays an important role in consumer choice. In this case, an E-retailer might attempt to increase its relative service quality through its efforts to build a reputation, by streamlining the ordering and

shipping process, by providing additional customer service in the form of extensions of manufacturer warranties or generous return policies, and so on. The incentive to do so is clear: A firm unilaterally establishing such a position obtains a competitive advantage over its rivals—especially in fairly commoditized markets such as those on Shopper.com. However, other firms have similar incentives: When it is feasible for other firms to imitate and increase their own service qualities, it is optimal to do so. Of course, the situation where many firms provide similar service levels—that is, when multiple firms are CNet certified—leads to prices that are no higher than those prevailing in the absence of certification (although overall sales may be higher due to heightened consumer confidence in making online purchases). In short, the price competition among firms offering similar levels of service drives prices down toward initial levels, and the prediction is that no premium is associated with becoming CNet certified.

To examine the role of vertical differentiation and imitation on pricing – and in particular to test whether there is any evidence of Red Queen pricing effects in E-retail markets – we collected monthly data on a fixed set of 36 consumer electronics products sold at the price comparison site, Shopper.com, over the eighteen month period from 5 November 1999 through 5 May 2001. Since the pool of products in our sample differ in terms of both the nature and stage of their product life cycles, we obtain price variation that permits us to disentangle the impact of various strategies and market fundamentals on the pricing decisions of firms in online markets. Product

and firm turnover give rise to an unbalanced panel of data consisting of 9,435 daily price observations. A wide variety of product types are tracked, including add-on hardware components, personal digital assistants, and software.

How valuable is this differentiation? In markets where many firms are CNet certified, we find no difference in the prices charged by certified merchants. The competition among firms with service qualities that are perceived to be equal tends to once again commoditize the market and eliminates the ability of firms to use that mechanism to gain a competitive advantage. On the other hand, when a firm is one of only a few firms that are certified merchants, the situation is dramatically different. A seller who is the only CNet certified merchant for a particular product typically is able to charge 5 percent higher prices than its rivals. When a CNet certified merchant competes against one or more other CNet certified merchants, the premium essentially vanishes. Thus, we find empirical evidence that this particular differentiation mechanism essentially induces Red Queen pricing effects.

Our study contributes to a growing literature that generally finds that vertical differentiation *does not* permit firms to charge substantial price premia. For instance, Baylis and Perloff (2002) find no evidence that firms offering "superior service" charge price premiums for two brands of digital cameras and flatbed scanners sold at CNet.com. More generally, Pan, Ratchford and Shankar (2003) find that third party certification of service quality has no impact on E-retail prices. While Smith and Brynjolfsson (2001) and Clay et al. (2002) offer some evidence that Ama-

zon and other heavily branded book retailers charge price premiums of about $1.72 over generic sellers, the latter authors hint that even these small premiums may be "temporary."[1] Likewise, there is little evidence that more reputable sellers in online auctions sell products at higher prices than their less reputable rivals.[2] Our model of Red Queen pricing effects offers a theoretical rationale for these empirical findings. Further, consistent with the view expressed in Clay, et al., Red Queen pricing effects predict that vertical differentiation can (and does) lead to transitory price premia in these markets, but these premia vanish with imitation by other firms. Indeed, this is the main finding to come out of our data.

One should *not* view our results as evidence that differentiation is *never* a sustainable strategy. It is well documented in the economics and marketing literatures that horizontal and vertical differentiation can – in the presence of sufficiently costly imitation—lead to a sustainable competitive advantage.[3] The point is that when imitation is not very costly and when relative service quality is important—as is the

[1]The authors note on page 366: "The premium that Amazon was able to command relative to Barnesandnoble.com and Borders.com suggests that it had succeeded in (at least temporarily) differentiating its product."

[2]See Resnick and Zeckhauser (2002), Livingston (2003), and Bolton, Katok and Ockenfels (2003) for a discussion of the related auction literature, and for insights into the utility of user feedback ratings in auction markets on the Internet as well as in laboratory settings.

[3]For instance, Sarvary (1999) shows how firms can use online markets to leverage brand loyalty and enjoy higher profits. Lynch and Ariely (2000) and Clemons, Hann, and Hitt (2002) suggest that horizontal differentiation can be used as a tool to mitigate the price competition inherent in online markets ranging from wine to air travel.

case in the E-retail environments in our study and the studies described above—Red Queen pricing effects result.

The remainder of the paper proceeds as follows: Section 2 formally defines Red Queen pricing effects, establishes theoretical conditions under which they arise, and shows that they are particularly likely to arise in E-retail settings such as Shopper.com where firms make binary decisions to gain CNet certification or not. Section 3 describes our data and the institutional setting at Shopper.com, while Section 4 presents econometric results and tests for the presence of Red Queen pricing effects. Finally, Section 5 concludes.

2 Theory

This section formally defines what we call "Red Queen pricing effects," and identifies conditions under which these effects arise in E-retail environments. We also provide a numerical example that illustrates our results and highlights testable implications for pricing patterns observed at Shopper.com.

Consider an online market where n firms compete for consumers. While there are many dimensions in which these firms might attempt to differentiate themselves from rivals, suppose that, in the relevant planning horizon, the only endogenous dimension in which firms can differentiate is through service levels. Thus, while firms might sell products that consumers view as either differentiated or homogeneous, firms can attempt to influence consumer purchase decisions by enhancing the level of service

(denoted s_i) offered to consumers. Higher levels of service (such as more timely shipping or liberal return policies) are associated with higher values of s_i, while the minimum service level required to operate in the market is $s^0 > 0$.

Thus, a strategy for firm i consists of a price $p_i \in \Re_+$ and a service level $s_i \geq s^0$. Let p_{-i} and s_{-i} denote the vectors of pricing and service levels selected by firms other than i, and let firm i's profits be denoted $\pi_i(p_i, p_{-i}, s_i, s_{-i})$. We assume the profit functions are "well behaved" (that is, satisfy the usual continuity/concavity assumptions required for the existence of an interior Nash equilibrium), and that price and service are strategic complements ($\partial^2 \pi_i / \partial p_i \partial s_i > 0$).

In the sequel, we consider two environments. In the first, the service levels of all firms are set exogenously at the minimum level, s^0, and firms simply compete in price. Let p^0 denote a price charged by each firm in a symmetric Nash equilibrium in this environment. In the second, service levels are determined endogenously, and firms simultaneously compete in price and service. Let (p^*, s^*) denote the price and service level chosen by each firm in a symmetric Nash equilibrium in this environment.

With this notation, we are in a position to formally define Red Queen pricing effects.

Definition 1 *A market satisfying the following two conditions is said to exhibit* Red Queen pricing effects*:*

(i) Suppose all firms other than i adopt price and service levels (p^0, s^0)*. Then firm i can gain by unilaterally raising its price to* $p_i > p^0$ *and its service level to* $s_i > s^0$*.*

(ii) Suppose all firms optimally adjust prices and service levels to symmetric Nash equilibrium levels, (p^*, s^*)*. Then* $p^* = p^0$ *and* $s^* > s^0$*.*

Part (i) of the definition says that when rivals offer low service levels and price optimally, an innovating firm can gain by raising its service level and capture the resulting value created by charging a premium price. Part (ii) says that the strategic response of other firms leads to rational imitation. In equilibrium, all firms raise their service levels, but no firm can capture the resulting value created by charging a premium price. Our main proposition establishes sufficient conditions for Red Queen pricing effects to arise in online markets.

Proposition 1 *Suppose* (p^*, s^*) *is a Nash equilibrium in which, for all* i*,* $\pi_i(p_i, p_{-i}, s_i, s_{-i}) = \phi(p_i, p_{-i}, s_i, s_{-i}) + h(p_{-i}, s_i, s_{-i})$*;* ϕ *is homogeneous of degree zero in* (s_i, s_{-i}) *and strictly increasing in* s_i*; and* $\partial h(p_{-i}, s^0, s_{-i})/\partial s_i = 0$*. Then the market exhibits Red Queen pricing effects.*

Proof. First, notice that, given p_{-i}, and s_{-i}, firm i's optimal price and service level solve the first-order conditions:

$$\begin{aligned} \frac{\partial \pi_i}{\partial p_i} &= \frac{\partial \phi(p_i, p_{-i}, s_i, s_{-i})}{\partial p_i} = 0 \\ \frac{\partial \pi_i}{\partial s_i} &= \frac{\partial \phi(p_i, p_{-i}, s_i, s_{-i})}{\partial s_i} + \frac{\partial h(p_{-i}, s_i, s_{-i})}{\partial s_i} = 0. \end{aligned}$$

To show that part (i) of Definition 1 holds, fix $s_i = s^0$ for all i and suppose firms only set prices. When rival firms all price at p^0, then $p_i = p^0$ solves

$$\frac{\partial \phi\left(p^0, p^0_{-i}, s^0, s^0_{-i}\right)}{\partial p_i} = 0,$$

since p^0 is a symmetric equilibrium of the game where service levels are exogenously fixed at s^0. Notice that if firm i increased its quality level then it would wish to raise its price, since

$$\frac{\partial p_i}{\partial s_i} = \frac{\frac{\partial^2 \phi\left(p^0, p^0_{-i}, s^0, s^0_{-i}\right)}{\partial p_i \partial s_i}}{-\frac{\partial^2 \phi\left(p^0, p^0_{-i}, s^0, s^0_{-i}\right)}{\partial p_i^2}} > 0,$$

where the inequality follows from strict concavity and the fact that p_i and s_i are strategic complements.

Further, such a firm would wish to raise its service level. To see this, notice that

$$\begin{aligned} & \frac{\partial \phi\left(p^0, p^0_{-i}, s^0, s^0_{-i}\right)}{\partial s_i} + \frac{\partial h\left(p^0_{-i}, s^0, s^0_{-i}\right)}{\partial s_i} \\ = & \frac{\partial \phi\left(p^0, p^0_{-i}, s^0, s^0_{-i}\right)}{\partial s_i} \\ > & 0 \end{aligned}$$

where the equality follows from the fact that $\partial h\left(p^0_{-i}, s^0, s^0_{-i}\right)/\partial s_i = 0$ and the inequality follows from the fact that ϕ is strictly increasing in s_i.

To show that part (ii) of Definition 1 holds, notice that, since the profit functions are symmetric, there exists a symmetric equilibrium where all firms choose identical pure strategies, (p^*, s^*). Further, there exists a $\lambda > 0$ such that $s^* = \lambda s^0$.

Since (p^*, s^*) is part of a symmetric equilibrium, it follows that $p_i = p^*$ solves

$$\frac{\partial \phi\left(p^*, p^*_{-i}, s^*, s^*_{-i}\right)}{\partial p_i} = 0.$$

Since ϕ is homogeneous of degree zero in s, it also follows that

$$\begin{aligned} \frac{\partial \phi\left(p^*, p^*_{-i}, s^*, s^*_{-i}\right)}{\partial p_i} &= \frac{\partial \phi\left(p^*, p^*_{-i}, \lambda s^0, \lambda s^0_{-i}\right)}{\partial p_i} \\ &= \frac{\partial \phi\left(p^*, p^*_{-i}, s^0, s^0_{-i}\right)}{\partial p_i}. \end{aligned}$$

Therefore, if p^0 is an equilibrium price when all firms have service level s^0, it is also an equilibrium price charged by all firms in a symmetric Nash equilibrium where service levels are endogenously determined. This completes the proof. ■

To illustrate the role that relative service levels play in generating Red Queen pricing effects, consider the following extreme case where higher service levels merely shift market share from one firm to another. Specifically, consider a duopoly market where firms compete in a standard differentiated products Bertrand setting. Suppose the market demand for firm i is given by

$$D_i = K - p_i + \delta p_j,$$

where $K = L + \frac{s_i}{s_i+s_j} M$ and $\delta \in (0,1)$. Firms have constant marginal cost, $c < L$, of selling the good, and the cost of providing service level s_i is quadratic: $\tau \left(s_i - s^0\right)^2$, where $\tau > 0$. Thus, firm i's profits are given by

$$\pi_i = (p_i - c)\left(L + \frac{s_i}{s_i + s_j} M - p_i + \delta p_j\right) - \tau \left(s_i - s^0\right)^2. \tag{1}$$

Notice that we may rewrite this profit function in the form:

$$\pi_i \left(p_i, p_j, s_i, s_j\right) = \phi \left(p_i, p_j, s_i, s_j\right) + h\left(s_i\right),$$

where $\phi = (p_i - c)\left(L + \frac{s_i}{s_i+s_j} M - p_i + \delta p_j\right)$ and $h = -\tau \left(s_i - s^0\right)^2$. This profit function satisfies the conditions in Proposition 1; therefore, one may conclude that the market will exhibit Red Queen pricing effects. In this simple example, only relative service levels impact a firm's demand and this leads to a "prisoner's dilemma" situation for each firm. That is, each firm has an incentive to boost service in an attempt

to gain market share, but the other firm does likewise, and, consequently, prices are driven down to the same level as when both firms offered only minimal service levels.

It is important to stress that, while the above example illustrates the polar case where service levels only have the effect of stealing market share from rivals, Proposition 1 shows that Red Queen pricing effects also arise in more general settings where service levels do have demand-enhancing effects. All that is required is that there be additive separability between market-share effects (denoted by the ϕ term in Proposition 1) and other effects, including demand-enhancing effects (which are contained in the h term in Proposition 1).

With an eye toward the analysis of the data in the sequel, it is also useful to note that Red Queen pricing effects identified here can also arise when the set of feasible service levels is discrete. To see this, suppose the payoffs are as in equation (1), but suppose firms' service level decisions are binary, i.e. $s_i \in \{s^0, s^1\}$, where $s^1 > s^0$. This setting approximates the institutional environment we examine in the next section; s^1 is the level of service required for a merchant at Shopper.com to obtain CNet certification, while s^0 is the minimal service level required to list prices at Shopper.com.

If neither firm is CNet certified (i.e., $s_1 = s_2 = s^0$), then optimal pricing by each firm is

$$p^0 = \frac{L + c}{2 - \delta} + \frac{M}{2 - \delta}\frac{1}{2}.$$

When both firms are CNet certified (i.e., $s_1 = s_2 = s^1$), then optimal pricing by each

firm is

$$p^* = \frac{L+c}{2-\delta} + \frac{M}{2-\delta}\frac{1}{2}.$$

Since $p^0 = p^*$, condition (ii) for Red Queen pricing effects is satisfied, and there is no price premium charged when both firms are CNet certified.

When firm j is not certified ($s_j = s^0$), it is optimal for firm i to become certified – provided τ is sufficiently small; hence $s_i = s^1 > s^0$. In this case, optimal pricing by each firm is:

$$\begin{aligned} p_i\left(s_i = s^1, s_j = s^0\right) &= \frac{L+c}{2-\delta} + \frac{M\left(\delta s^0 + 2s^1\right)}{\left(s^0+s^1\right)\left(4-\delta^2\right)} \\ p_j\left(s_i = s^1, s_j = s^0\right) &= \frac{L+c}{2-\delta} + \frac{M\left(\delta s^1 + 2s^0\right)}{\left(s^0+s^1\right)\left(4-\delta^2\right)} \end{aligned}$$

Notice that a firm that unilaterally obtains certification status can profitably raise its price to:

$$\begin{aligned} p_i\left(s_i = s^1, s_j = s^0\right) &= \frac{L+c}{2-\delta} + \frac{M\left(\delta s^0 + 2s^1\right)}{\left(s^0+s^1\right)\left(4-\delta^2\right)} \\ &= \frac{L+c}{2-\delta} + \frac{M}{2-\delta}\left(\frac{s^0}{\left(s^0+s^1\right)}\frac{\delta}{2+\delta} + \frac{s^1}{\left(s^0+s^1\right)}\frac{2}{2+\delta}\right) \\ &> \frac{L+c}{2-\delta} + \frac{M}{2-\delta}\left(\frac{1}{2}\right) \\ &= p^0. \end{aligned}$$

Thus, condition (i) for Red Queen pricing effects is also satisfied, and the single certified firm enjoys a higher markup.

In short, this example suggests that market environments such as those at Shopper.com are likely to exhibit Red Queen pricing effects. Controlling for other factors,

a firm that unilaterally chooses to become CNet certified can charge a price premium of

$$\begin{aligned}\Delta &= \frac{M}{2-\delta}\left(\frac{\frac{s^0}{(s^0+s^1)}\delta+\frac{s^1}{(s^0+s^1)}2}{2+\delta}-\frac{1}{2}\right)\\ &> 0.\end{aligned}$$

However, this premium vanishes if both firms opt to become CNet certified.

3 Data Description

Our analysis is based on monthly data on 36 of the best-selling consumer electronics products sold at Shopper.com between 5 November 1999 and 5 May 2001. Shopper.com is a price comparison site that provides consumers with a list of sellers (and their prices) for fairly expensive consumer electronics products. For instance, consider a consumer who wanted to purchase a Palm V personal digital assistant on 5 November 1999. A visit to Shopper.com and a simple mouse click returned a list of 48 different firms that sell this product, for prices ranging from a low of $278.89 and a high of $415.00. The resulting list also provides a variety of information about seller characteristics, such as shipping costs, product availability, and whether the vendor is "CNet certified." Shopper.com is a high-traffic site with an active user base that translates into many leads for its seller network.[4]

We selected the top 36 products, based on CNet's rankings on 5 November 1999,

[4]According to Nielsen NetRatings on January 2002, Shopper.com's U.S. user base accesses 4 million page views daily. These page views generated 85,000 daily leads, where a lead is defined as

and then downloaded the relevant information on the 5th of each month thereafter through 5 May 2001. Thus, in contrast to more recent data analyzed by Baye, Morgan, and Scholten (2003), in this study we track a *fixed* set of products. Over the entire period, 190 different firms sold one or more of these 36 products at some point during the period. The prices and number of sellers for each product obviously varied over the period. Thus, these data capture products at various stages of their life cycles.

Table 1 provides a summary of the products covered, and some summary statistics. As indicated, the sample includes (at the time) popular software titles, PDAs, digital cameras, and other computer hardware components and peripherals. These products range in price from a daily average of $18.55 to over $700. Thus, a wide array of products is sampled that likely appeal to a large number of consumers with diverse demographic backgrounds. Notice that the number of sellers and the number of dates in which the products were sold varies across product markets. On the low end of the spectrum, the market for an upgrade version of Windows 98 is very thin: There is a single merchant in each of three months that this software was listed. In contrast, the market for a Nikon Coolpix 950 camera is thick. On average, there are about 50 merchants listing prices for this camera, and this product was listed on all 19 months in our sample. More generally, the average product in our sample sold for about $200,

when a user clicks-through to a merchant's site from a Cnet site. Moreover, according to internal company research, Cnet's audience is six times more likely than the average Web user to purchase hardware items online.

was sold by about 16 firms, and was available on 15 of the 19 months we sampled. Of the 36 products tracked, over two-thirds were sold by at least 10 merchants. We note that product life-cycle effects led to some products not being listed toward the end of our study. While all 36 of the products shown in Table 1 were available on 5 November 1999, by the end of our study only 10 of these products were listed for sale at Shopper.com.

During the period studied, consumers could access all of the information provided by Shopper.com at no charge. However, merchants had to pay to become a member of the Shopper.com merchant network. This entailed a one-time setup fee of $1,000, plus a monthly fee of $100 and sliding scale of click-through fees on the order of $.40 per click. In addition, we note that merchants input their own prices each day, and must also input detailed product information for each product, such as the product manufacturer name and exact SKU. This guarantees that products listed on a single page are physically identical. Merchants must also provide a URL link to the product page so that users can easily click through to the merchant's site and obtain further product information. While merchants are not required to disclose shipping cost and product availability data, merchants can optionally display this information. Finally, at the time of our study, Shopper.com required that the price input by firms represent the actual price charged on a credit-card purchase for a new product (not used or reconditioned), and these prices must be exclusive of any rebates.

During the period we study, the primary way merchants in the Shopper.com

network could differentiate themselves was by participating in the "CNet Certified Merchant" program. To be designated as a CNet Certified Merchant, a firm subjects itself to audits to guarantee that it provides accurate inventory and shipping cost information; provides CNet with a customer service policy and posts this information at its website; honors displayed prices; uses an encryption technology that securely processes online transactions; provides order confirmation within one business day; provides professional packaging; and responds to any consumer correspondence within two business days.

Table 2 provides summary statistics for certified merchants and non-certified merchants for each of the products in our sample. Columns 2 and 4 of Table 2 reveal that the majority of firms selling each product are, in fact, CNet certified merchants. Notice that, for 23 of 35 products, the average list price charged by certified merchants is greater than the average list price charged by non-certified merchants. These simple averages might lead one to conclude that certified merchants are able to charge a premium price relative to non-certified merchants. An unmatched two-sample t-test of mean list prices, however, reveals that the average list price of certified merchants is statistically greater, at the 5 percent level, for only 8 of the 36 products. Thus, despite merchants' best efforts to distinguish themselves by attaining certified merchants status, competition appears to commoditize the markets for many of the products in this sample. Certified merchants are able to charge premia on less than one-fourth of the products in this sample of popular products, and the average difference (aggregated

across all products and dates) is less than 2 percent. Comparisons of mean prices – controlling for shipping costs, inventory, numbers of sellers, and Gomez reviews – lead to qualitatively similar results. In short, without controls for Red Queen effects, there is little evidence for any systematic differences in prices charged by certified and non-certified merchants.

4 Econometric Analysis and Results

The results presented in Table 2, which suggest that CNet certified firms are unable to charge price premia, fail to account for Red Queen pricing effects. As discussed above, a firm that vertically differentiates in CNet certification space is predicted to be able to charge a price premium when other firms are not similarly differentiated but this premium should evaporate when rival firms imitate.

To examine these predictions, we ran a series of OLS regressions. In all cases, the dependent variable is the natural logarithm of the price charged by firm i for product k at date t. In each case, we included a binary dummy variable for each product to control for unobservable product characteristics, and a binary dummy variable for each date to control for unobservable changes over the 19 month period in such variables as the number of consumers visiting the Shopper.com site. The results from these regressions are presented in Tables 3 and 4.

In Table 3, specification 1 includes three additional dummy variables. "Logo" indicates whether the firm's name is presented in the form of a logo. Since large

firms are more likely to use logos than small firms, this dummy variable provides a crude proxy for the impact of firm size on costs and, thus, prices. As would be expected, the estimated coefficient is negative and statistically significant at the 1 percent level. The estimated value of -.05 means that a firm displaying a logo, on average, charges prices that are 5 percent lower than firms than do not display a logo. This is consistent with logos being used by larger firms, which may enjoy lower costs. The variable "Certified Merchant" is a dummy variable which takes on a value of 1 if the firm is CNet certified and 0 otherwise. Notice that the estimate of -.001 is not statistically significant. Thus, similar to the results summarized in Table 2, CNet certification by itself does not appear to permit a firm to charge a price premium.

The final variable included in Specification 1, which is the heart of Red Queen pricing effects, is a dummy variable "One of 1 CNet Certified Merchants" which takes on a value of 1 if firm i is the *only* CNet certified merchant in the market and a value of zero otherwise. Notice this coefficient is positive and statistically significant at the 1 percent level. The estimated value of .124 means that a firm that is the only certified merchant selling the product charges a price premium of 12.4 percent, compared to when the firm is certified and there are other certified firms in the market. Thus, the first specification indicates that if a firm unilaterally differentiates itself by becoming CNet certified, it can charge a substantial price premium – but if other firms do likewise, it cannot. This supports the hypothesis that the CNet certification environment at Shopper.com leads to Red Queen pricing effects.

Specification 2 generalizes specification 1 to include k dummy variables ($k = 1, 2, ..., 9$) that take on a value of 1 if firm i is "One of k Certified Merchants" selling the product, and zero otherwise. Again, Logo is negative and significant, while the pure effect of being a certified merchant does not have a statistically significant impact on price. Notice that this specification leads to qualitatively similar results, in that the premium enjoyed by a certified merchant ranges from 15.1 percent to 7.9 percent, depending on whether the firm is the only certified merchant or one of 4 certified merchants.

Specification 3 generalizes specification 2 by including firm-specific effects to control for heterogeneities across firms (such as reputational differences not captured in CNet certification as well as differences in costs). Not surprisingly, with these more general controls, Logo is no longer statistically significant, suggesting that it is a poor proxy for firm differences. The general pattern of the other coefficients is similar to the previous specifications; differentiation through certification leads to relatively large premia when only a few firms are certified, but virtually no price premium when multiple firms are certified.

Specification 4 generalizes specification 3 to include controls for market structure by incorporating dummy variables that control for different numbers of sellers regardless of certification status (up to a total of 9 firms). This more general specification suggests that differentiation through CNet certification leads to a price premium only when one or two firms use the strategy. In particular, when a firm is the only certi-

fied merchant, it can charge a premium of 17.2 percent. This premium drops to 9.3 percent when two firms are certified, and is not statistically different from zero when three firms use the strategy.

On balance, the results in Table 3 suggest that a firm that unilaterally attempts to differentiate itself by becoming CNet certified can charge a substantial price premium. In contrast, when several other firms imitate the strategy, each firm's ability to charge a premium is greatly diminished. One deficiency in these findings, however, is that the econometric results reported in Table 3 do not control for product-specific life-cycle and product-specific market-structure effects. As discussed earlier, product prices tend to fall during their life cycles, and not all products mature at the same rate. To the extent that products sold by non-certified merchants decline more rapidly than products sold by certified merchants, the previous results will tend to overstate the value of differentiation through CNet certification.

To mitigate these potential biases, we also controlled for product-specific life cycle and product-specific market structure effects by also running specifications that include interaction terms for product and date dummy variables. Effectively, this controls for product-specific life-cycle and product-specific market-structure effects by accounting for unobservable differences over time and across products in the level of competition, desirability of the product to consumers, and so on. These results are summarized in Table 4.

Notice that in all of the specifications reported in Table 4, the extra controls

dramatically reduce the estimated price premium enjoyed by a firm that unilaterally adopts the CNet differentiation strategy. For example, in specification 1 we see that after controlling for product-specific life cycle and product-specific market structure effects, the estimated price premium enjoyed by a firm that unilaterally adopts a CNet certification strategy is .054. Thus, instead of the 12.4 percent premium reported in Table 3, the premium drops to 5.4 percent. Notice that the "One of 1 Certified Merchant" estimates in Table 4 are much less sensitive to the inclusion of controls for different numbers of certified merchants (specification 2) or controls for firm-specific effects (specification 3) than those reported in Table 3. In all cases in Table 4, a firm that unilaterally adopts a CNet certification strategy charges a premium of about 5 percent, and this premium statistically vanishes when additional firms adopt the strategy.

Finally, we note that all of the specifications summarized in Tables 3 and 4 explain over 98 percent of the variation in individual firm prices. While dummies to account for unobservable firm heterogeneity and product life-cycle effects together explain less than 1 percent of the variation in prices, the inclusion of the latter reduce the estimated premium enjoyed by a firm that unilaterally differentiates itself from 15 percent to about 5 percent.

5 Conclusion

Our major findings are two-fold. First, regardless of the specification, differentiation in CNet certification space is significantly more valuable when a single firm does so than when multiple firms use the strategy; there appear to be "Red Queen" pricing effects in these data. Second, while our findings are qualitatively the same with and without controls for product-specific life-cycle and product-specific market-structure effects, the estimates from the two approaches are quantitatively different. Controlling for these effects reduces estimates of the price premium stemming from the unilateral use of online differentiation strategies from 15 percent to about 5 percent.

Expressed differently, our results indicate that firms competing in highly competitive online markets can mitigate the deleterious effects of price competition by engaging in vertical differentiation strategies, but the ultimate value of such strategies crucially depends on the number of rival firms that ultimately employ similar strategies. Controlling for product-specific life-cycle and product-specific market-structure effects, our data suggests that a firm that unilaterally differentiates itself from its rivals by participating in CNet's Certified Merchants program can charge a 5 percent price premium. However, when other firms imitate this strategy, the price premium vanishes. More generally, our results indicate that in examining the efficacy of differentiation and reputation-enhancing strategies in online markets, it is important to control not only for the number of firms using similar strategies but also for product life cycle and market structure effects.

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Table 1: Summary Statistics

Product	Total Number of Prices Listed	Number of Months Listed	Average Number of Sellers	Average Price
3Com Homeconnect	488	19	25.68 (6.99)	$ 128.36 (5.99)
ADOBE ACROBAT V4.0	478	19	25.16 (7.16)	218.29 (6.60)
ADOBE PHOTOSHOP V5.0.2	28	12	2.33 (1.15)	620.61 (13.07)
ATX MBD	278	17	16.35 (9.08)	134.01 (3.89)
CASSIOPEIA E-105	125	10	12.50 (11.03)	580.90 (16.78)
Creative Labs 3D Blaster RIVA TNT2 Ultra	176	10	17.60 (17.99)	172.78 (5.82)
Creative Labs Blaster CDRW 4224	21	8	2.63 (2.62)	153.28 (4.43)
Creative Labs CDRW 6424	45	10	4.50 (7.68)	202.20 (11.87)
Creative Labs PC-DVD Encore 6X	203	15	13.53 (15.21)	198.84 (29.91)
Creative Labs PC-DVD RAM 5.2GB	236	16	14.75 (12.98)	343.31 (91.54)
Creative Labs Sound Blaster Live Value	150	18	8.33 (2.81)	54.55 (8.59)
Creative Labs Video Blaster WebCam 3	445	19	23.42 (11.96)	54.86 (9.29)
Diamond Viper V770 Ultra	163	11	14.82 (18.22)	149.30 (26.60)
EpsonStylus Color 740	527	17	31.00 (17.54)	146.22 (29.82)
FRONTPAGE 2000	595	19	31.32 (7.82)	131.05 (2.41)
HALF LIFE	80	15	5.33 (6.53)	27.73 (10.92)
HP CD-Writer Plus 8200i	140	13	10.77 (13.13)	209.63 (7.41)
INTELLIMOUSE EXPLORER	541	19	28.47 (7.02)	60.00 (2.23)
Intel Create & Share Camera Pack USB	5	4	1.25 (0.50)	145.35 (44.81)
MONEY DELUXE 2000	388	15	25.87 (12.04)	56.76 (1.85)
Matrox Millennium G400 MAX	112	15	7.47 (5.64)	214.23 (8.15)
Nikon Coolpix 950	940	19	49.47 (12.32)	752.17 (53.79)
OFFICIAL RED HAT LINUX V6.0	76	17	4.47 (3.20)	70.66 (4.64)
Olympus C-2000Z	231	19	12.16 (9.51)	661.23 (97.00)
Olympus D-340R	238	17	14.00 (12.69)	268.96 (18.71)
PAINT SHOP PRO V5.0	61	15	4.07 (3.90)	68.64 (2.17)
PENTIUM III 450	138	14	9.86 (10.47)	218.84 (20.53)
PENTIUM III 500	249	16	15.56 (13.11)	215.82 (50.97)
Palm III	90	10	9.00 (9.45)	207.34 (33.17)
Palm IIIx	273	18	15.17 (18.66)	232.39 (22.24)
Palm V	525	19	27.63 (17.12)	322.35 (19.33)
QUICKEN DELUXE 2000	408	17	24.00 (14.80)	53.34 (2.11)
STAR WARS EPISODE I: RACER	463	19	24.37 (11.11)	24.10 (7.43)
STAR WARS X-WING ALLIANCE	343	19	18.05 (7.46)	21.10 (4.38)
UPGRADE WINDOWS 98	3	3	1.00 -	76.69 (16.78)
VIRUSSCAN CLASSIC V4.0	173	16	10.81 (10.62)	18.55 (1.40)
Overall Average		14.97	15.63	$ 200.40

* Standard errors in parentheses.

Table 2: Summary Statistics for Cnet Certified and Non-certified Merchants

Product	Average Number of Sellers		Average Price		Unmatched Two-Sample *t*-Test for Difference in Mean Prices (p-values) ***
	Cnet Certified Merchants	Non-Certified Merchants	Cnet Certified Merchants	Non-certified Merchants	
3Com Homeconnect	19.63	6.05	$ 128.16	$ 128.10	0.4895
	(6.41)	(2.84)	(5.89)	(7.47)	
ADOBE ACROBAT V4.0	21.32	4.06	216.41	227.51	0.9989
	(6.44)	(2.01)	(6.58)	(12.92)	
ADOBE PHOTOSHOP V5.0.2	2.25	1.00	620.50	635.00	--
	(1.22)	--	(12.96)	--	
ATX MBD	13.82	2.69	135.78	130.97	0.0137 **
	(8.23)	(2.24)	(5.80)	(6.14)	
CASSIOPEIA E-105	10.60	3.80	581.98	564.23	0.0264 **
	(9.72)	(1.92)	(16.59)	(11.53)	
Creative Labs 3D Blaster RIVA TNT2 Ultra	14.10	5.00	175.15	166.77	0.0405 **
	(15.85)	(3.37)	(8.92)	(9.32)	
Creative Labs Blaster CDRW 4224	3.00	1.00	154.13	151.95	0.2796
	(2.76)	-	(5.94)	-	
Creative Labs CDRW 6424	4.10	1.33	203.30	191.35	0.0802 *
	(7.46)	(0.58)	(12.19)	(11.40)	
Creative Labs PC-DVD Encore 6X	12.00	3.18	203.54	197.80	0.2871
	(13.90)	(2.44)	(12.45)	(35.18)	
Creative Labs PC-DVD RAM 5.2GB	11.31	4.23	327.81	395.76	0.9443
	(10.48)	(4.23)	(85.54)	(135.55)	
Creative Labs Sound Blaster Live Value	6.94	2.29	54.05	58.55	0.8618
	(2.36)	(0.99)	(9.90)	(12.70)	
Creative Labs Video Blaster WebCam 3	19.94	5.58	55.40	54.86	0.4351
	(8.12)	(3.34)	(9.61)	(9.78)	
Diamond Viper V770 Ultra	13.70	4.33	147.10	155.90	0.7712
	(17.44)	(3.01)	(27.09)	(8.63)	
EpsonStylus Color 740	23.76	7.24	140.58	157.59	0.9190
	(13.74)	(5.55)	(35.01)	(34.28)	
FRONTPAGE 2000	25.53	5.79	130.50	133.23	0.9960
	(6.71)	(3.22)	(2.52)	(3.41)	
HALF LIFE	7.25	1.47	36.59	27.41	0.0138 **
	(7.46)	(0.74)	(3.32)	(10.59)	
HP CD-Writer Plus 8200i	9.33	3.11	211.61	198.69	0.0090 **
	(12.36)	(3.26)	(8.29)	(14.49)	
INTELLIMOUSE EXPLORER	22.84	5.63	60.20	58.78	0.1234
	(6.40)	(2.50)	(2.08)	(4.85)	
Intel Create & Share Camera Pack USB	1.33	1.00	157.26	109.63	--
	(0.58)	--	(46.49)	--	
MONEY DELUXE 2000	20.80	5.43	56.83	55.98	0.1881
	(9.65)	(3.52)	(2.18)	(2.84)	
Matrox Millennium G400 MAX	6.14	2.17	214.24	214.22	0.4981
	(5.20)	(1.27)	(8.63)	(11.10)	
Nikon Coolpix 950	30.68	18.79	760.85	736.66	0.0740 *
	(10.25)	(7.08)	(49.51)	(51.29)	
OFFICIAL RED HAT LINUX V6.0	3.88	1.25	71.33	61.47	0.0092 **
	(3.06)	(0.46)	(4.71)	(14.80)	
Olympus C-2000Z	8.25	5.50	728.29	607.64	0.0003 **
	(9.39)	(3.38)	(69.08)	(107.07)	
Olympus D-340R	9.64	6.06	280.38	263.51	0.0077 **
	(11.57)	(4.25)	(18.15)	(18.18)	
PAINT SHOP PRO V5.0	3.53	1.33	68.49	70.96	0.9819
	(3.68)	(0.52)	(2.12)	(2.62)	
PENTIUM III 450	7.93	2.45	215.26	232.78	0.9014
	(10.05)	(1.92)	(19.96)	(44.12)	
PENTIUM III 500	13.67	3.14	219.79	215.76	0.4122
	(12.05)	(2.18)	(51.46)	(44.76)	
Palm III	8.00	3.00	215.14	198.35	0.1597
	(9.07)	(2.10)	(20.24)	(42.49)	
Palm IIIx	14.13	3.59	238.75	226.56	0.0820 *
	(16.29)	(4.65)	(19.15)	(27.75)	
Palm V	22.12	7.84	319.43	324.25	0.7752
	(12.82)	(5.59)	(19.38)	(18.41)	
QUICKEN DELUXE 2000	19.82	5.46	53.44	51.18	0.1619
	(11.98)	(3.45)	(1.62)	(9.11)	
STAR WARS EPISODE I: RACER	19.26	6.06	24.11	25.27	0.6737
	(8.42)	(3.43)	(7.59)	(7.53)	
STAR WARS X-WING ALLIANCE	14.53	4.19	20.40	24.51	0.9956
	(5.63)	(2.14)	(4.40)	(4.26)	
UPGRADE WINDOWS 98	1.00	-	76.69	--	--
	-	--	(16.78)	--	
VIRUSSCAN CLASSIC V4.0	7.88	3.92	18.64	17.74	0.0942 *
	(9.00)	(3.32)	(1.37)	(2.15)	

S.E. in parentheses.

* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** H_0: $\mu_{\text{certified merchant}} - \mu_{\text{non-certified merchant}} = 0$ vs. H_A:$\mu_{\text{certified merchant}} - \mu_{\text{non-certified merchant}} > 0$

Table 3: Determinants of Individual Firm Prices: Regressions without Controls for Product-Specific Life-Cycle/Market-Structure Effects

Dependent Variable: Natural Log of List Price

	Specification 1		Specification 2		Specification 3		Specification 4	
	Coefficient	***t*-Statistic**	**Coefficient**	***t*-Statistic**	**Coefficient**	***t*-Statistic**	**Coefficient**	***t*-Statistic**
Logo	-0.050	(9.45) ***	-0.050	(9.54) **	0.000	(0.02)	0.000	(0.05)
Certified Merchant	-0.001	(0.19)	-0.007	(1.66) *	0.003	(0.53)	0.006	(1.13)
One of 1 Certified Merchants	0.124	(6.74) ***	0.151	(7.95) ***	0.153	(8.66) ***	0.172	(3.56) ***
One of 2 Certified Merchants			0.144	(6.72) ***	0.157	(7.56) ***	0.093	(3.44) ***
One of 3 Certified Merchants			0.096	(4.52) ***	0.100	(4.92) ***	0.034	(1.34)
One of 4 Certified Merchants			0.079	(4.76) ***	0.088	(5.64) ***	0.040	(1.99) **
One of 5 Certified Merchants			0.003	(0.19)	0.008	(0.47)	-0.028	(1.47)
One of 6 Certified Merchants			0.001	(0.09)	0.006	(0.44)	-0.015	(0.99)
One of 7 Certified Merchants			0.036	(2.20) **	0.030	(1.97) **	0.020	(1.19)
One of 8 Certified Merchants			0.019	(1.11)	0.016	(1.10)	0.013	(0.84)
One of 9 Certified Merchants			0.029	(1.18)	0.027	(1.22)	0.029	(1.34)
Date Fixed Effects	Y		Y		Y		Y	
Product Fixed Effects	Y		Y		Y		Y	
Firm Fixed Effects	N		N		Y		Y	
Market Structure Effects	N		N		N		Y	
Number of Observations	9435		9435		9435		9435	
R^2	0.98		0.98		0.98		0.98	

Robust t-statistics in parentheses

* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 4: Determinants of Individual Firm Prices: Regressions with Controls for Product-Specific Life-Cycle and Product-Specific Market-Structure Effects

Dependent Variable: Natural Log of List Price

	Specification 1		**Specification 2**		**Specification 3**		**Specification 4**	
	Coefficient	***t*-Statistics**	**Coefficient**	***t*-Statistics**	**Coefficient**	***t*-Statistics**	**Coefficient**	***t*-Statistics**
Logo	-0.048	(12.77) ***	-0.048	(12.74) ***	0.000	(0.04)	0.000	(0.04)
Certified Merchant	-0.001	(0.25)	-0.002	(0.41)	0.006	(1.36)	0.006	(1.36)
One of 1 Certified Merchants	0.054	(1.77) *	0.055	(1.78) *	0.052	(1.94) **	0.052	(1.94) **
One of 2 Certified Merchants			0.028	(0.87)	0.002	(0.09)	0.002	(0.09)
One of 3 Certified Merchants			-0.030	(0.73)	-0.052	(1.53)	-0.052	(1.53)
One of 4 Certified Merchants			0.034	(0.84)	0.016	(0.48)	0.016	(0.48)
One of 5 Certified Merchants			0.009	(0.28)	-0.012	(0.48)	-0.012	(0.48)
One of 6 Certified Merchants			-0.018	(0.86)	-0.033	(1.8) *	-0.033	(1.8) *
One of 7 Certified Merchants			0.030	(0.99)	0.007	(0.27)	0.007	(0.27)
One of 8 Certified Merchants			0.001	(0.06)	-0.004	(0.22)	-0.004	(0.22)
One of 9 Certified Merchants			-0.014	(0.22)	-0.041	(0.87)	-0.041	(0.87)
Date Fixed Effects	Y		Y		Y		Y	
Product Fixed Effects	Y		Y		Y		Y	
Firm Fixed Effects	N		N		Y		Y	
Market Structure Effects	N		N		N		Y	
Product*Date Interactions	Y		Y		Y		Y	
Number of Observations	9435		9435		9435		9435	
R^2	0.98		0.98		0.99		0.99	

Robust t-statistics in parentheses
* significant at 10% level; ** significant at 5% level; *** significant at 1% level