Real and Virtual Competition

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Abstract

Although the Internet reduces market frictions by making it easier for consumers to obtain information about prices and product offerings, goods sold by electronic firms are not perfect substitutes for otherwise identical goods sold by conventional stores. Online purchases, due to non-zero shipping time, are associated with waiting costs, and they do not allow consumers to inspect the product prior to purchase. Visiting a conventional store, on the other hand, involves positive travelling costs. A model extending the circular city paradigm with two types of firms, conventional and electronic, is studied. Under the benchmark setting with only conventional firms in the market, each consumer visits the nearest store and purchases the product there. When electronic firms enter the market, an intriguing type of market segmentation may arise. First, each consumer travels to the nearest conventional store to "try on" the product. Second, conventional retailers increase their prices and sell the good only to consumers who discover that they have high valuations; consumers with low valuations return "home" and order the good online. In spite of the increased competition from Internet retailers, welfare decreases.

1 Introduction

Most economic analyses of the Internet have focused on its role as an information retrieval system that reduces consumer costs of obtaining information about prices and product offerings. Bakos' (1997) seminal article on electronic marketplaces, for instance, shows that reducing search costs improves market efficiency as a result of the increased competition among electronic retailers.[1]

Although the Internet reduces market frictions by making it easier for consumers to compare prices and product availability, goods sold over the Internet are clearly not perfect substitutes for otherwise identical goods sold by brick-and-mortar retailers. Hence, the focus of this paper is on the characteristics of goods that are associated with their modes of marketing and distribution. First, due to non-zero shipping time, there are waiting costs associated with online purchases. When these costs are substantial, electronic retailers "lose points" to conventional stores, where the buyer immediately has access to the product.

Second, goods purchased online cannot be inspected beforehand. This becomes a problem when there is uncertainty about how well the product "fits", which can only be resolved by physical inspection. *Searchable sensory attributes*, defined by Deregatu, Rangaswamy, and Wu (2000) as "attributes that can be directly determined through our senses, particularly, touch, smell, or sound, before we purchase a product", are important to many products. In the context of apparel, the fit of the garment and the texture of the material can be evaluated accurately before purchase only in a conventional store. One would need to visit a furniture store to learn if the Tempur-Pedic sleep system (pressure-relieving Swedish mattress) matches his/her individual needs. As another example, consider the purchase of the ThinkPad convertible tablet, a notebook that provides flexibility to take handwritten notes directly on the screen with a special digitizer pen. Consumers can best evaluate the tablet by trying it out in a retail store that sells electronic products. For some consumers, the digitizer pen will "feel right", for others – not quite.

With few exceptions (e.g., Brown and Goolsbee 2002, Sengupta and Wiggins 2006) the economics literature on Internet price competition takes prices charged by conventional retailers as given. This paper highlights the equilibrium interaction between electronic firms and their offline counterparts. How do consumers make their purchasing decisions: Do they buy a good from an ordinary "brick-and-mortar" firm or order the product online? What is the impact of the Internet on prices charged by ordinary firms? How is economic welfare affected by the Internet?

To address these questions, a model extending the circular-city paradigm introduced by Salop (1979) with two types of firms, ordinary stores and electronic retailers, is studied. The firms sell physically identical products and possess constant marginal cost technology; the fixed cost of entry is positive for brick-and-mortar stores and zero for electronic retailers.

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[1]Empirical works by Clay, Krishnan, and Wolff (2001) on books and by Brynjolfsson and Smith (2000) on books and CDs suggest that prices online are lower than offline, but online price dispersion is quite high.

Consumers want to buy one unit of the product. A consumer can only learn his valuation for the good prior to purchase by travelling to a brick-and-mortar firm and physically inspecting the product. Consumers cannot return poorly fitting products to electronic retailers, at least not at reasonable cost. Also, it is assumed that each consumer has access to the Internet and can visit an electronic firm without incurring any travelling costs, although there are waiting costs associated with ordering the product online. The waiting costs take the form of a discount factor and are, therefore, proportional to a consumer's valuation.

Standard Bertrand-style arguments establish that the Internet segment of the market is competitive; at least two electronic firms set the price equal to marginal cost. In a symmetric Nash equilibrium, conventional stores are located equidistantly around the circle and charge the same price, and the equilibrium number of conventional stores is determined from the zero-profit condition.

Two settings are investigated: the benchmark, in which only brick-and-mortar firms operate, and the Internet setting, in which both types of firms, conventional and electronic, exist in the market. With certain parameter restrictions in place, under the benchmark each consumer visits the nearest brick-and-mortar firm and purchases the product there. When electronic firms enter the market, an intriguing type of market segmentation arises. Each consumer travels to the nearest conventional store to "try on" the product. Brick-and-mortar retailers actually raise their prices and sell the good only to consumers who discover that they have high valuations. Consumers with low valuations return "home" and order the good online. The equilibrium number of brick-and-mortar firms is either the same or higher compared to the benchmark.

The result that brick-and-mortar firms raise prices when electronic firms enter the market contrasts with the common view that increased competition leads to lower prices.[2] This result can be explained by the effect electronic firms have on the elasticity of demand faced by conventional retailers. Because the demand becomes less elastic, brick-and-mortar firms raise their prices in equilibrium. Moreover, economic welfare goes down when electronic firms enter the market, because consumers with low valuations incur positive waiting costs when ordering the good online. Increase in the number of brick-and-mortar firms is yet another source of welfare decline.

In the first extension, the Internet setting with offline consumers, it is assumed that a proportion of consumers do not purchase online, either because they need the product right away or they simply avoid using the Internet for privacy reasons. In the second extension, the Internet setting with patient consumers, it is assumed that a proportion of consumers plan their purchases in advance, so waiting for the good to be delivered is costless to them. Various welfare effects are investigated.

This paper combines two streams of literature. The first one is marketing literature linked to consumer behavior in an online environment. Alba et al. (1997), Danaher, Wilson, and

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[2]For other theoretical examples in which increased competition among sellers leads to higher equilibrium prices, see Satterthwaite (1979) and Rosenthal (1980).

Davis (2003), Degeratu, Rangaswamy, and Wu (2000), Peterson, Balasubramanian, and Bronnenberg (1997), and Ratchford, Talukdar, and Lee (2001) have conducted empirical research exploring the differences between online and offline purchase experiences, assessing the impact of prices, brand names, and product attributes on consumer choices.[3] These studies suggest that Internet-related marketing is well suited for functional products for which online stores can give detailed attribute information. Brand names become more important when the product category contains sensory attributes that can only be evaluated through physical inspection.

The second stream is economic literature that examines the effect of the Internet on firms' product market behavior. Brown and Goolsbee (2002) use micro data on individual insurance policies to analyze the impact of the Internet comparison shopping sites on offline prices. The authors show that the introduction of the insurance-oriented web sites is initially associated with high price dispersion. As the use of these sites becomes more widespread, prices and dispersion fall. Sengupta and Wiggins (2006) provide empirical evidence on how the Internet sales affect prices paid for airline tickets. The results indicate that an increase in Internet purchases decreases online prices and, to the greater extent, offline prices. Scot Morton, Zettelmeyer, and Silva-Risso (2001) investigate the effect of Internet referral services on pricing behavior of car dealerships. They find that consumers who arrive to a dealership via the Internet pay less than traditional consumers.

Theoretical work that is somewhat similar to the model presented here is by Lal and Sarvary (1999). The authors distinguish between two types of product attributes, digital and nondigital. Whereas digital attributes can easily be conveyed via the Internet, nondigital attributes can only be judged in person at a retail store. The authors assume two firms that produce nondigital products and distribute them through their own stores and the Internet. Each consumer chooses between two products, but is familiar with only one of them. In the case of destination shopping, the introduction of the Internet increases the effective cost of search from "the cost of visiting more than one store" to "the cost of undertaking the entire shopping trip". As a result, consumers may not search, but instead order the familiar product product online. The authors show that under some parameter conditions the increased consumer loyalty induces firms to raise their prices.

Dinlersoz and Pereira (2007) present another theoretical study that focuses on differences in consumer preferences for traditional and electronic markets. The authors consider a retail market that is initially served by a single firm. A new firm, which has no physical presence, competes with the existing firm to open an online store. Each consumer derives utility of 1 from the product purchased in the physical store of the existing firm, $1-\nu$ from the product ordered online. Parameter ν is negative when online transactions are associated with convenient search

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[3]In their seminal article on interactive home shopping, Alba et al. (1997) examine consumers' incentives to adopt the new distribution channel. Interactive home shopping "enables consumers to access merchandise unavailable in their local markets, gather vertical information about merchandise at a low cost, efficiently screen the offerings of a broad cross-section of suppliers". The trade-offs are that department stores "afford buyers the opportunity to touch and feel merchandise" and "allow immediate delivery".

and savings in travelling costs (books and CDs). For other products, such as clothing items and furniture, delayed consumption and the inability to inspect the product physically decrease utility (i.e., ν is positive). Which firm is likely to be the leader in adoption of e-commerce technology – the existing firm or the new firm? The answer depends on consumer loyalty, differences in the firms' technologies and consumer preferences.

In the next section, the formal model is presented. The benchmark is analyzed in Section 3. In Section 4, the Internet setting is studied, and the effect of electronic firms on offline prices and economic welfare is investigated. Two extensions are explored in Section 5, concluding remarks appear in Section 6. All proofs appear in the Appendix.

2   The Model

In this section, the technology, the preferences of the agents, and the equilibrium concept are presented.

Two types of firms operate in the market: ordinary brick-and-mortar firms (b-firms), and electronic retailers (e-firms) that sell via the Internet. The two types produce the same physical good using different technologies. Electronic firms possess constant marginal cost technology,

$$C_e(q) = cq.$$

Brick-and-mortar firms possess constant marginal and fixed cost technology,

$$C_b(q) = \begin{cases} \phi + cq, & \text{if } q > 0 \\ 0, & \text{if } q = 0. \end{cases}$$

Fixed cost ϕ mainly refers to the building costs incurred if a b-firm enters the market.

Consumers with total mass L are distributed uniformly on a circle with a perimeter normalized to 1. Each consumer wants to buy one unit of the product. Consumer i derives utility of v_i if he buys the good from a b-firm and δv_i if he purchases from an e-firm, where $\delta \in (0, 1)$ is the discount factor. That is, the consumer incurs waiting costs of $(1 - \delta)v_i$ if he purchases the good online.[4] Consumer i's valuation v_i is random and can take one of two values: it is high, v_H, with probability λ, and low, v_L, with probability $1 - \lambda$. Consumer i does not know his valuation at the outset. He can, however, learn v_i prior to purchase by travelling to one of the brick-and-mortar firms located around the circle, which entails transportation cost t per unit of length.

Each consumer has an Internet connection and can visit an electronic firm without incurring any additional costs. For simplicity, it is assumed that the cost to a consumer of returning a poorly fitting product to an e-firm for a refund is prohibitive. Hence, visiting a brick-and-mortar firm involves positive travelling costs but allows consumers to inspect the product prior to purchase. Ordering the good from an electronic firm entails no travelling costs, but incurs

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[4]Even though shipping time may involve only a few days, δ may be significantly less than one if by waiting the consumer will miss an important opportunity to use the good.

positive waiting costs and does not allow consumers to resolve uncertainty before buying the product.

Electronic retailers are perfectly competitive. Standard Bertrand-style arguments establish that in equilibrium at least two e-firms set their prices equal to marginal cost. Brick-and-mortar firms compete with each other, taking into account that consumers can always order the product on the Internet. The equilibrium concept employed is a symmetric Nash equilibrium, in which b-firms are located equidistantly around the circle and charge the same price. Under the free entry assumption, the equilibrium number of b-firms in the market is determined from the zero-profit condition.

3 Benchmark: No Internet

In this section, the setting in which only brick-and-mortar firms operate in the market is analyzed.

Suppose consumer i visited a b-firm and learned his valuation v_i. The consumer purchases the good if the price charged by the firm, p_b, does not exceed v_i. Thus, his expected payoff of visiting the firm is given by

$$\lambda \max\{v_H - p_b, 0\} + (1 - \lambda) \max\{v_L - p_b, 0\} - tx_i,$$

where tx_i is consumer i's travelling costs.

How many b-firms will be in the market in equilibrium? Which price will they charge? Recall that in Salop's circular city model three equilibrium configurations are possible. In the *monopoly* equilibrium, which occurs for non-generic parameter values, the markets of any two neighboring firms do not overlap and each firm acts as a local monopolist. The markets just touch in the *kinked* equilibrium; they fully overlap at the *competitive* one.

Here consumer valuations are drawn from a binomial distribution, which complicates the analysis significantly. In particular, the competitive equilibrium configuration splits into three based on whether the equilibrium price is below, equal, or above v_L (Proposition 1). The same applies to the monopoly and kinked equilibria. Hence, there are nine possible equilibrium configurations. The conditions under which each of them occurs become much more complex, because the number of possible cases and deviations increases.

To simplify the analysis, the following will be assumed throughout the remainder of this section:

$$v_H > c + \frac{3}{2\lambda}\sqrt{\frac{t\phi}{L}}. \tag{A1}$$

This condition guarantees that there will be enough firms operating in the market that even the consumer located right in the middle between two neighboring firms (having to travel the farthest) receives strictly positive expected payoff. That is, the markets of any two neighboring firms fully overlap.[5]

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[5]Refer to Appendix B for the equilibrium analysis when (A1) does not hold.

It is notationally convenient to define the following constants – thresholds for parameter v_L:

$$\underline{v}_L \equiv c + \frac{1 - \sqrt{1 - \lambda}}{\lambda} \sqrt{\frac{t\phi}{L}},$$

$$\overline{v}_L \equiv c + \sqrt{\frac{t\phi}{L}}.$$

Observe that $c < \underline{v}_L < \overline{v}_L$ for any $\lambda \in (0, 1)$, and $\overline{v}_L < v_H$ by (A1).

Proposition 1 (Competitive Equilibrium Configurations under the Benchmark)**.**

(i) *If $v_L \in [0, \underline{v}_L)$, then the equilibrium price and number of b-firms are given by*

$$\begin{cases} p_b^* = c + \frac{1}{\lambda} \sqrt{\frac{t\phi}{L}}, \\ n_b^* = \sqrt{\frac{tL}{\phi}}. \end{cases}$$

Each consumer visits the closest b-firm and learns his valuation; only consumers with high valuations purchase the good.

(ii) *If $v_L \in [\underline{v}_L, \overline{v}_L]$, then the equilibrium price and number of b-firms are given by*

$$\begin{cases} p_b^* = v_L, \\ n_b^* = \frac{L}{\phi}(v_L - c). \end{cases}$$

Each consumer visits the closest b-firm and purchases the good.

(iii) *If $v_L \in (\overline{v}_L, v_H]$, then the equilibrium price and number of b-firms are given by*

$$\begin{cases} p_b^* = c + \sqrt{\frac{t\phi}{L}}, \\ n_b^* = \sqrt{\frac{tL}{\phi}}. \end{cases}$$

Each consumer visits the closest b-firm and purchases the good.

First, consider low values of v_L. The equilibrium price is such that only consumers with high valuations buy the product. Indeed,

$$v_L < \underline{v}_L < c + \frac{1}{\lambda} \sqrt{\frac{t\phi}{L}}$$

and

$$c + \frac{1}{\lambda} \sqrt{\frac{t\phi}{L}} < v_H$$

by (A1). It is interesting to compare configuration (i) with Salop's competitive equilibrium, where

$$\begin{cases} \overline{p} = c + \sqrt{\frac{t\phi}{L}}, \\ \overline{n} = \sqrt{\frac{tL}{\phi}}. \end{cases}$$

It follows that the number of firms is the same, but the price margin is higher by factor $1/\lambda$ – the inverse of the probability a consumer purchases the product.

If $v_L \in [\underline{v}_L, \overline{v}_L]$, the demand discontinuity results in firms setting their prices equal to v_L and selling the product to all consumers.

If the lowest realization of consumer valuation is high, equilibrium price is below v_L,

$$c + \sqrt{\frac{t\phi}{L}} = \overline{v}_L < v_L.$$

Note that configuration (iii) coincides with Salop's competitive equilibrium.

4 The Internet

In this section, the setting in which both types of firms, brick-and-mortar stores and electronic retailers, operate in the market is considered. For ease of exposition, this setting is called the *Internet setting*.

First, suppose consumer i orders the good from an online retailer. Because electronic firms are perfectly competitive and set their prices equal to marginal cost, his expected payoff is simply

$$\delta(\lambda v_H + (1 - \lambda)v_L) - c.$$

Second, suppose consumer i visited a b-firm and learned his valuation v_i. At this point, the consumer has three options: buy the good at the store, return home and purchase from an online retailer, or not buy the good. Thus, his expected payoff of visiting the b-firm is given by

$$\lambda \max\{v_H - p_b, \delta v_H - c, 0\} + (1 - \lambda) \max\{v_L - p_b, \delta v_L - c, 0\} - tx_i.$$

How does the introduction of the Internet affect brick-and-mortar firms? Who will purchase from b-firms, who – from electronic retailers? The answers to these questions depend on the parameters of the model. If δ is low, say less than c/v_H, then consumers will never order the product online. In this case, the equilibrium price and number of b-firms will remain unchanged.

Consider the other extreme. If δ is close to 1, then there will be no b-firms operating in the market. Indeed, a b-firm would have to set its price below $c + (1 - \delta)v_H$ to make positive sales, failing to cover the entry fee. Consumers will order the product online if

$$\delta(\lambda v_H + (1 - \lambda)v_L) - c > 0.$$

Otherwise, they will not buy the product at all. (A consumer wish he could learn his valuation at a b-firm and then, if he likes the product, order it online, but there are no b-firms in the market!)

Proposition 2 shows that if δ is not too high and not too low, the following type of market segmentation might arise in equilibrium. Each consumer visits a b-firm and learns his valuation;

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consumers with low valuations return home and purchase the good online, whereas consumers with high valuations buy the product from b-firms.

It is notationally convenient to define the following constants – the upper and lower bounds for parameter δ:

$$\underline{\delta} \equiv \frac{c}{c + \frac{1-\sqrt{1-\lambda}}{\lambda}\sqrt{\frac{t\phi}{L}}},$$

$$\overline{\delta} \equiv \frac{v_H - \frac{3}{2\lambda}\sqrt{\frac{t\phi}{L}}}{v_H}.$$

Observe that $\underline{\delta} < \overline{\delta}$ requires

$$v_H > \frac{3}{2(1 - \sqrt{1-\lambda})}c + \frac{3}{2\lambda}\sqrt{\frac{t\phi}{L}}, \qquad (A2)$$

which is stronger than (A1). This inequality will be assumed to hold throughout the remainder of the paper. Also, let

$$\tilde{v}_L \equiv \frac{1 - \sqrt{1-\lambda}}{(1-\delta)\lambda}\sqrt{\frac{t\phi}{L}}.$$

Proposition 2 (Market Segmentation under the Internet Setting). *If $\delta \in (\underline{\delta}, \overline{\delta})$ and $v_L \in (c/\delta, \tilde{v}_L)$, then the equilibrium price and number of b-firms are given by*

$$\begin{cases} p_b^{**} = c + \frac{1}{\lambda}\sqrt{\frac{t\phi}{L}}, \\ n_b^{**} = \sqrt{\frac{tL}{\phi}}. \end{cases}$$

Each consumer visits the closest b-firm and learns his valuation; consumers with high valuations purchase the good from b-firms, whereas consumers with low valuations return home and order the product online.

It is easy to verify that (A2) together with the conditions of Proposition 2 imply $\delta v_L > c$ and

$$(1-\delta)v_L < p_b^{**} - c = \frac{1}{\lambda}\sqrt{\frac{t\phi}{L}} < (1-\delta)v_H.$$

Hence, consumers with low valuations order the product online. Consumers with high valuations prefer to pay higher price to have immediate access to the product.

The next proposition follows directly from propositions 1 and 2. It shows that, in certain cases, welfare actually falls when electronic firms enter the market!

Proposition 3 (Welfare). *Let $\delta \in (\underline{\delta}, \overline{\delta})$ and $v_L \in (c/\delta, \tilde{v}_L)$. The following welfare comparison holds between the benchmark and the Internet setting.*

(i) *Consider $v_L \in (c/\delta, \underline{v}_L)$. In this case only consumers with high valuations purchase the product under the benchmark. When e-firms enter the market, the equilibrium price and number of b-firms remain unchanged, consumers with low valuations order the product online. Welfare goes up.*

(ii) *Consider $v_L \in [\underline{v}_L, \tilde{v}_L)$. In this case all consumers purchase the product under the benchmark. When e-firms enter the market, the equilibrium price goes up, consumers with low valuations switch to electronic retailers. The number of b-firms either remains unchanged or increases. Welfare goes down.*

First, note that (A2) and $\delta \in (\underline{\delta}, \overline{\delta})$ imply $c/\delta < \underline{v}_L < \min\{\tilde{v}_L, \overline{v}_L\}$. Thresholds $\overline{v}_L$ and $\tilde{v}_L$, however, cannot be ranked.

Let W^* and W^{**} denote welfare under the benchmark and the Internet setting, respectively. Consider $v_L \in (c/\delta, \underline{v}_L)$. Because consumers with low valuations purchase the product online under the Internet setting, welfare goes up by

$$W^{**} - W^* = L(1 - \lambda)(\delta v_L - c) > 0.$$

Next, consider $v_L \in [\underline{v}_L, \min\{\tilde{v}_L, \overline{v}_L\})$. Under the benchmark, brick-and-mortar firms set their prices equal to v_L and sell the good to all consumers. When e-firms enter the market, b-firms would have to lower their prices to $c + (1 - \delta)v_L$ to keep consumers (with low valuations, in particular) from switching. Instead, b-firms increase their prices. Under the Internet setting, consumers with high valuations still purchase the good from b-firms, whereas consumers with low valuations switch to electronic retailers. The equilibrium number of b-firms increases. The change in welfare equals

$$W^{**} - W^* = -L(1 - \lambda)(1 - \delta)v_L - \left[\frac{tL}{4n_b^{**}} + \phi n_b^{**} - \frac{tL}{4n_b^*} - \phi n_b^* \right] < 0.$$

The first term is the waiting costs incurred by consumers with low valuations. Another source of welfare decline is increase in excessive entry, the characteristic of Salop's model. Algebraically, the term in brackets is the change in the travelling (consumers travel $(4n)^{-1}$ on average) and entry costs. It is positive because $n_b^{**} > n_b^*$, and n_b^*, in turn, exceeds the socially optimal number of firms

$$n^{so} = \frac{1}{2}\sqrt{\frac{tL}{\phi}}.$$

If $\overline{v}_L < \tilde{v}_L$, consider $v_L \in [\overline{v}_L, \tilde{v}_L)$. Under the benchmark, brick-and-mortar firms set their prices below v_L. When e-firms enter the market, b-firms increase their price margins by factor $1/\lambda$ and sell the product only to consumers with high valuations. Because the number of b-firms remains the same, the change in welfare equals

$$W^{**} - W^* = -L(1 - \lambda)(1 - \delta)v_L < 0.$$

5   Extensions

In this section two extensions are considered. In the first extension, the assumption that all consumers have access to the Internet is relaxed. In the second extension, it is assumed that a fraction of consumers find it much less costly to wait for a delivery than the others.

5.1 Offline Consumers

Assume that a proportion ϵ of consumers do not consider purchasing online as an option, for various reasons. Some consumers might need the product right away (imagine a person who procrastinated on the purchase of a birthday present for his/her spouse until the day before), others avoid using the Internet for privacy reasons, or they simply do not have access to the Internet.

Thus, there are ϵ offline consumers and $1 - \epsilon$ original ones. The analysis of the model becomes much more complicated. However, as long as ϵ is sufficiently small, the new equilibrium price and number of b-firms will differ only marginally from p_b^{**} and n_b^{**} obtained under the Internet setting, and the purchasing behavior of original consumers remains the same.

Proposition 4 (Equilibrium with Offline Consumers)**.** *Let $\delta \in (\underline{\delta}, \overline{\delta})$, $v_L \in (c/\delta, \tilde{v}_L)$ and ϵ is sufficiently small, then either*

(i) *All consumers visit b-firms. Original consumers with high valuations purchase the good from b-firms, those with low valuations return home and order the product online. Only offline consumers with high valuations purchase the good from b-firms.*

$$\begin{cases} p_b^{**}(\epsilon) = c + \frac{1}{\lambda}\sqrt{\frac{t\phi}{L}}, \\ n_b^{**}(\epsilon) = \sqrt{\frac{tL}{\phi}}. \end{cases}$$

or

(ii) *All consumers visit b-firms. Original consumers with high valuations purchase the good from b-firms, those with low valuations return home and order the product online. Offline consumers purchase the good from b-firms irrespective of their valuations.*

$$\begin{cases} p_b^{**}(\epsilon) = c + \frac{1}{\sqrt{\lambda^2(1-\epsilon)+\epsilon}}\sqrt{\frac{t\phi}{L}}, \\ n_b^{**}(\epsilon) = \frac{\lambda(1-\epsilon)+\epsilon}{\sqrt{\lambda^2(1-\epsilon)+\epsilon}}\sqrt{\frac{tL}{\phi}}. \end{cases}$$

The conditions under which each of the above equilibrium configurations obtains are outlined in the Appendix.

Let $W^{**}(\epsilon)$ denote welfare under the current extension. Is it higher or lower compared with the Internet setting? Consider case (i). The introduction of offline consumers does not affect brick-and-mortar firms when $v_L < p_b^{**}$ and ϵ is sufficiently small (so that the deviation to v_L is unprofitable). Hence, $p_b^{**}(\epsilon) = p_b^{**}$ and $n_b^{**}(\epsilon) = n_b^{**}$. Welfare goes down, because offline consumers with low valuations do not purchase the product,

$$W^{**}(\epsilon) - W^{**} = -L(1-\lambda)\epsilon(\delta v_L - c) < 0.$$

Consider case (ii). Offline consumers do affect brick-and-mortar firms when $v_L > p_b^{**}$. Straightforward algebra reveals $p_b^{**}(\epsilon) < p_b^{**}$ and $n_b^{**}(\epsilon) < n_b^{**}$. The change in welfare equals

$$W^{**}(\epsilon) - W^{**} = L(1-\lambda)\epsilon(1-\delta)v_L - \left[\frac{tL}{4n_b^{**}(\epsilon)} + \phi n_b^{**}(\epsilon) - \frac{tL}{4n_b^{**}} - \phi n_b^{**} \right] > 0.$$

The first term is the waiting costs saved by offline consumers with low valuations. Another source of welfare increase is reduction of excessive entry. (The term in brackets is negative because $n_b^{**} > n_b^{**}(\epsilon)$, and $n_b^{**}(\epsilon)$, in turn, exceeds the socially optimal number of firms.)

As to original consumers, they pay a lower price at b-firms, but travel more. It is shown in the Appendix that

$$\lambda(p_b^{**} - p_b^{**}(\epsilon)) > \frac{t}{4n_b^{**}(\epsilon)} - \frac{t}{4n_b^{**}}.$$

Therefore, original consumers fare better in the presence of offline consumers.

The main message of the the previous section is that when $v_L \in [\underline{v}_L, \tilde{v}_L)$, welfare goes down with the introduction of the Internet. This result is reinforced in the current extension for $v_L \in [\underline{v}_L, \min\{p_b^{**}, \tilde{v}_L\})$.[6]

5.2 Patient Consumers

Now assume that a small proportion ξ of consumers possess discount factor of 1. (These consumers plan their purchases well in advance, so waiting for the good to be delivered is costless for them.) Thus, there are ξ patient consumers and $1 - \xi$ original ones.

Proposition 5 (Equilibrium with Patient Consumers)**.** *Let $\delta \in (\underline{\delta}, \overline{\delta})$, $v_L \in (c/\delta, \tilde{v}_L)$ and ξ is sufficiently small, then*

$$\begin{cases} p_b^{**}(\xi) = c + \frac{1}{\lambda\sqrt{1-\xi}}\sqrt{\frac{t\phi}{L}}, \\ n_b^{**}(\xi) = \sqrt{1-\xi}\sqrt{\frac{tL}{\phi}}. \end{cases}$$

Patient consumers order the product online from the outset. Each original consumer visits the closest b-firm and purchases the product there if his valuation is high, otherwise he returns home and orders the good online.

Compared with the Internet setting, the equilibrium price is higher and the number of b-firms is lower, $p_b^{**}(\xi) < p_b^{**}$ and $n_b^{**}(\xi) < n_b^{**}$. Let $W^{**}(\xi)$ denote welfare under the current extension. Is it higher or lower than W^{**}?

$$W^{**}(\xi) - W^{**} = L\lambda\xi(1-\delta)v_H - \left[(1-\xi)\frac{tL}{4n_b^{**}(\xi)} + \phi n_b^{**}(\xi) - \frac{tL}{4n_b^{**}} - \phi n_b^{**}\right] > 0.$$

Welfare goes up due to reduction of excessive entry and the travelling costs saved by patient consumers (the term in brackets), even if one ignores the fact that patient consumers incur zero waiting costs (the first term).

Despite the increase in welfare, original consumers lose from the existence of patient consumers, because they pay higher price at b-firms and, on average, travel more.

Finally, it follows from $W^{**}(\xi) - W^{**} > 0$ that the existence of offline consumers weakens the most interesting result of Proposition 3 that the introduction of the Internet might lead to lower welfare.

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[6]Although $\underline{v}_L$ is, obviously, below p_b^{**}, p_b^{**} and $\tilde{v}_L$ cannot be ranked based on (A2) and $\delta \in (\underline{\delta}, \overline{\delta})$.

6   Conclusion

This paper examines the impact of the Internet on prices charged by conventional retailers and economic welfare. Two settings were investigated in the context of a circular city model, the benchmark with brick-and-mortar stores, and the Internet setting with two types of firms, conventional and electronic.

Under the benchmark, when the individual expected demand is inelastic, brick-and-mortar firms charge the price accepted by consumers who discover they have high valuations. When individual expected demand is elastic, the firms charge the price accepted by all consumers.

Under the Internet setting, parameter restrictions were derived that give rise to the following type of market segmentation. Each consumer visits a conventional store and inspects the product; consumers with high valuations buy the good there, whereas consumers with low valuations return home and order the product online.

With these parameter restrictions in place, the impact of the Internet on economic welfare was explored. In the case of inelastic demand, welfare rises when electronic firms enter the market, because consumers with low valuations order the good on the Internet. In the case of elastic demand, welfare falls. One source of welfare decline is that consumers with low valuations switch their purchases from conventional retailers to Internet firms and, therefore, experience waiting costs. The other source is increase in excessive entry.

The main message of this paper is that goods that are physically identical may often, nevertheless, be differentiated by the modes through which they are marketed and sold. Electronic retailing, although it reduces consumer search and travelling costs, is not frictionless. Consumers do not always know what they are getting when they purchase a product online and they often must experience significant delays between the time they order a good and the time they receive it. Moreover, when these frictions interact with the market imperfections coming in conventional retailing, the resulting increase in competition need not lead to a superior social outcome.

Appendix

Proof of Proposition 1

Each part is proven in turn.

(i) Suppose $v_L \in [0, \underline{v}_L)$. Consider a firm that charges price p_b, which is accepted by consumers with high valuations. Its rivals located at distance $1/n_b^*$ charge price p_b^*, which is also accepted only by consumers with high valuations. The firm captures consumers living within distance x defined by

$$\lambda(v_H - p_b) - tx = \lambda(v_H - p_b^*) - t\left(\frac{1}{n_b^*} - x\right),$$

or

$$x(p_b, p_b^*) = \frac{1}{2t}\left(\frac{t}{n_b^*} + \lambda p_b^* - \lambda p_b\right).$$

The firm's profit function equals

$$\Pi(p_b, p_b^*) = 2\lambda L x(p_b, p_b^*)(p_b - c) - \phi = \frac{\lambda L}{t}\left(\frac{t}{n_b^*} + \lambda p_b^* - \lambda p_b\right)(p_b - c) - \phi.$$

Substituting $p_b = p_b^*$ into the first-order conditions yields

$$\frac{t}{n_b^*} - \lambda(p_b^* - c) = 0,$$

or

$$p_b^* = c + \frac{t}{\lambda n_b^*}.$$

The equilibrium number of firms can be found from the zero-profit condition

$$\frac{\lambda L}{n_b^*}\frac{t}{\lambda n_b^*} = \phi,$$

where the first term on the right is the number of consumers who purchase from each b-firm in equilibrium, and the second term is the price margin. Hence,

$$n_b^* = \sqrt{\frac{tL}{\phi}}.$$

Substituting n_b^* back into the equilibrium price yields

$$p_b^* = c + \frac{1}{\lambda}\sqrt{\frac{t\phi}{L}}.$$

Next, suppose the firm deviates from p_b^* and sets its price to v_L in order to sell the good to all consumers. In this case the firm captures consumers living within distance $\hat{x}$ defined by

$$\lambda v_H + (1 - \lambda)v_L - v_L - t\hat{x} = \lambda(v_H - p_b^*) - t\left(\frac{1}{n_b^*} - \hat{x}\right),$$

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or

$$\hat{x} = \frac{1}{2t}\left(\frac{t}{n_b^*} + \lambda p_b^* - \lambda v_L\right).$$

The firm's profit from this deviation is

$$\hat{\Pi} = 2L\hat{x}(v_L - c) - \phi = \frac{L}{t}\left(\frac{t}{n_b^*} + \lambda p_b^* - \lambda v_L\right)(v_L - c) - \phi$$

$$= \frac{L}{t}\left(2\sqrt{\frac{t\phi}{L}} - \lambda(v_L - c)\right)(v_L - c) - \phi.$$

Straightforward, but tedious algebra shows that $\hat{\Pi} < 0$ if and only if $v_L < \underline{v}_L$.

Finally, consider the consumer located right in the middle between two neighboring firms. His payoff is positive by (A1),

$$\lambda(v_H - p_b^*) - \frac{t}{2n_b^*} = \lambda\left(v_H - c - \frac{1}{\lambda}\sqrt{\frac{t\phi}{L}}\right) - \frac{1}{2}\sqrt{\frac{t\phi}{L}} = \lambda\left(v_H - c - \frac{3}{2\lambda}\sqrt{\frac{t\phi}{L}}\right) > 0.$$

(ii) Suppose $v_L \in [\underline{v}_L, \overline{v}_L]$. Consider a firm that charges price p_b, which is accepted by all consumers. Its rivals located at distance $1/n_b^*$ charge price p_b^*, which is also accepted by all consumers. The firm captures consumers living within distance x defined by

$$\lambda v_H + (1 - \lambda)v_L - p_b - tx = \lambda v_H + (1 - \lambda)v_L - p_b^* - t\left(\frac{1}{n_b^*} - x\right),$$

or

$$x(p_b, p_b^*) = \frac{1}{2t}\left(\frac{t}{n_b^*} + p_b^* - p_b\right).$$

The firm maximizes

$$\Pi(p_b, p_b^*) = 2Lx(p_b, p_b^*)(p_b - c) - \phi = \frac{L}{t}\left(\frac{t}{n_b^*} + p_b^* - p_b\right)(p_b - c) - \phi$$

subject to

$$p_b \le v_L.$$

The solution is

$$\hat{p}_b = \min\left\{v_L, \frac{1}{2}\left(\frac{t}{n_b^*} + p_b^* + c\right)\right\}.$$

Substituting $p_b^* = v_L$ and $n_b^* = L(v_L - c)/\phi$ yields

$$\hat{p}_b = \min\left\{v_L, \frac{1}{2}\left(\frac{t\phi}{L(v_L - c)} + v_L + c\right)\right\}$$

$$= \min\left\{v_L, v_L + \frac{1}{2(v_L - c)}\left[\frac{t\phi}{L} - (v_L - c)^2\right]\right\}.$$

The term in brackets is non-negative because $v_L \le \overline{v}_L$. Hence, $\hat{p}_b = v_L$.

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(iii) Suppose $v_L \in (\overline{v}_L, v_H]$. Consider a firm that charges price p_b, which is accepted by all consumers. Its rivals located at distance $1/n_b^*$ charge price p_b^*, which is also accepted by all consumers. The firm captures consumers living within distance x defined by

$$\lambda v_H + (1 - \lambda)v_L - p_b - tx = \lambda v_H + (1 - \lambda)v_L - p_b^* - t\left(\frac{1}{n_b^*} - x\right),$$

or

$$x(p_b, p_b^*) = \frac{1}{2t}\left(\frac{t}{n_b^*} + p_b^* - p_b\right).$$

The firm's profit function equals

$$\Pi(p_b, p_b^*) = 2Lx(p_b, p_b^*)(p_b - c) - \phi = \frac{L}{t}\left(\frac{t}{n_b^*} + p_b^* - p_b\right)(p_b - c) - \phi.$$

Substituting $p_b = p_b^*$ into the first-order conditions yields

$$\frac{t}{n_b^*} - (p_b^* - c) = 0,$$

or

$$p_b^* = c + \frac{t}{n_b^*}.$$

The equilibrium number of firms can be found from the zero-profit condition

$$\frac{L}{n_b^*}\frac{t}{n_b^*} = \phi,$$

hence,

$$n_b^* = \sqrt{\frac{tL}{\phi}}.$$

Substituting n_b^* back into the equilibrium price yields

$$p_b^* = c + \sqrt{\frac{t\phi}{L}}.$$

Proof of Proposition 2

First, observe that $c/\delta < \tilde{v}_L$ for $\delta > \underline{\delta}$. Facing price p_b^{**} charged by b-firms, consumers with low valuations order the good online if

$$\delta v_L - c > \max\{0, v_L - p_b^{**}\} = \max\left\{0, v_L - c - \frac{1}{\lambda}\sqrt{\frac{t\phi}{L}}\right\},$$

or

$$\frac{c}{\delta} < v_L < \frac{1}{(1-\delta)\lambda}\sqrt{\frac{t\phi}{L}},$$

which clearly holds for $v_L \in (c/\delta, \tilde{v}_L)$. Consumers with high valuations buy the good from b-firms if

$$v_H - p_b^{**} > \delta v_H - c,$$

or

$$\delta < \frac{v_H - \frac{1}{\lambda}\sqrt{\frac{t\phi}{L}}}{v_H},$$

which holds for $\delta < \overline{\delta}$.

Next, suppose a b-firm deviates from p_b^{**} and sets its price to $c + (1-\delta)v_L$ in order to sell the good to all consumers. In this case the firm captures consumers living within distance $\hat{x}$ defined by

$$\lambda v_H + (1-\lambda)v_L - (c + (1-\delta)v_L) - t\hat{x} = \lambda(v_H - p_b^{**}) + (1-\lambda)(\delta v_L - c) - t\left(\frac{1}{n_b^{**}} - \hat{x}\right),$$

or

$$\hat{x} = \frac{1}{2t}\left(\frac{t}{n_b^{**}} + \lambda p_b^{**} - \lambda(c + (1-\delta)v_L)\right).$$

The firm's profit from this deviation is

$$\hat{\Pi} = 2L\hat{x}(1-\delta)v_L - \phi = \frac{L}{t}\left(\frac{t}{n_b^{**}} + \lambda p_b^{**} - \lambda(c + (1-\delta)v_L)\right)(1-\delta)v_L - \phi$$

$$= \frac{L}{t}\left(2\sqrt{\frac{t\phi}{L}} - \lambda(1-\delta)v_L\right) - \phi.$$

Straightforward, but tedious algebra shows that $\hat{\Pi} < 0$ if and only if $v_L < \tilde{v}_L$.

Finally, consider the consumer located right in the middle between two neighboring b-firms. His expected payoff from visiting a b-firm is higher than ordering the good online in the first place if

$$\lambda(v_H - p_b^{**}) + (1-\lambda)(\delta v_L - c) - \frac{t}{2n_b^{**}} > \lambda(\delta v_H - c) + (1-\lambda)(\delta v_L - c),$$

or

$$\delta < \frac{v_H - \frac{3}{2\lambda}\sqrt{\frac{t\phi}{L}}}{v_H} = \overline{\delta}.$$

Proof of Proposition 3

First, consider the Internet setting. By Proposition 2, consumers with high valuations purchase the product from b-firms, whereas consumers with low valuations order online. The surplus generated by producing and distributing the good equals

$$S^{**} = L(\lambda v_H + (1-\lambda)\delta v_L - c).$$

Summing up the entry and travelling costs (consumers travel $1/(4n_b^{**})$ on average) yields

$$C^{**} = \frac{tL}{4n_b^{**}} + \phi n_b^{**} = \frac{tL}{4}\left(\sqrt{\frac{tL}{\phi}}\right)^{-1} + \phi\sqrt{\frac{tL}{\phi}} = \frac{5L}{4}\sqrt{\frac{t\phi}{L}}.$$

Hence, welfare under the Internet setting is given by

$$W^{**} = S^{**} - C^{**} = L(\lambda v_H + (1-\lambda)\delta v_L - c) - \frac{5L}{4}\sqrt{\frac{t\phi}{L}}.$$

Next, consider the benchmark.

(i) When $v_L \in [c/\delta, \underline{v}_L)$, only consumers with high valuations purchase the product in equilibrium. The surplus generated by producing and distributing the good equals

$$S^* = L\lambda(v_H - c).$$

Summing up entry and travelling costs yields

$$C^* = \frac{tL}{4n_b^*} + \phi n_b^* = \frac{tL}{4}\left(\sqrt{\frac{tL}{\phi}}\right)^{-1} + \phi\sqrt{\frac{tL}{\phi}} = \frac{5L}{4}\sqrt{\frac{t\phi}{L}}.$$

Hence, welfare under the benchmark is given by

$$W^* = L\lambda(v_H - c) - \frac{5L}{4}\sqrt{\frac{t\phi}{L}}.$$

The change in welfare is positive:

$$W^{**} - W^* = L(1-\lambda)(\delta v_L - c) > 0.$$

(iia) Consider $v_L \in [\underline{v}_L, \min\{\tilde{v}_L, \overline{v}_L\})$. In this case,

$$S^* = L(\lambda v_H + (1-\lambda)v_L - c),$$

$$C^* = \frac{tL}{4n_b^*} + \phi n_b^* = \frac{tL}{4}\left(\frac{L}{\phi}(v_L - c)\right)^{-1} + \phi\frac{L}{\phi}(v_L - c) = \frac{t\phi}{4(v_L - c)} + L(v_L - c).$$

Welfare equals

$$W^* = L(\lambda v_H + (1-\lambda)v_L - c)) - \left(\frac{t\phi}{4(v_L - c)} + L(v_L - c)\right),$$

hence,

$$W^{**} - W^* = -L(1-\lambda)(1-\delta)v_L - \left[\frac{t\phi}{4(v_L - c)} + L(v_L - c) - \frac{5L}{4}\sqrt{\frac{t\phi}{L}}\right].$$

Straightforward, but tedious algebra shows that the term in brackets is positive. Hence, $W^{**} - W^* < 0$.

(iib) If $\overline{v}_L < \tilde{v}_L$, consider $v_L \in [\overline{v}_L, \tilde{v}_L)$. In this case,

$$S^* = L(\lambda v_H + (1-\lambda)v_L - c),$$

$$C^* = \frac{tL}{4n_b^*} + \phi n_b^* = \frac{tL}{4}\left(\sqrt{\frac{tL}{\phi}}\right)^{-1} + \phi\sqrt{\frac{tL}{\phi}} = \frac{5L}{4}\sqrt{\frac{t\phi}{L}}.$$

Welfare equals

$$W^* = L(\lambda v_H + (1-\lambda)v_L - c)) - \frac{5L}{4}\sqrt{\frac{t\phi}{L}},$$

hence,

$$W^{**} - W^* == -L(1-\lambda)(1-\delta)v_L < 0.$$

Proof of Proposition 4

Each part is proven in turn.

(i) Consider $v_L \in (c/\delta, \min\{\tilde{v}_L, p_b^{**}\})$. When there are n_b^{**} b-firms on the circle and they charge price p_b^{**}, each offline consumer visits the closest b-firm and purchases the product there if his valuation is high. Indeed,

$$\lambda(v_H - p_b^{**}) - \frac{t}{2n_b^{**}} > 0$$

holds because

$$\lambda(v_H - p_b^{**}) + (1-\lambda)(\delta v_L - c) - \frac{t}{2n_b^{**}} > \lambda(\delta v_H - c) + (1-\lambda)(\delta v_L - c)$$

holds for $\delta < \bar{\delta}$ (see proof of Proposition 2). Hence, $p_b^{**}(\epsilon) = p_b^{**}$ and $n_b^{**}(\epsilon) = n_b^{**}$ for small values of ϵ, such that the deviation to v_L is unprofitable.

(ii) If $p_b^{**} < \tilde{v}_L$, consider $v_L \in [p_b^{**}, \tilde{v}_L)$. Consider a b-firm that charges price p_b, which is accepted by all offline consumers and original consumers with high valuations. Its rivals located at distance $1/n_b^{**}(\epsilon)$ charge price $p_b^{**}(\epsilon)$, which is also accepted by all offline consumers and original consumers with high valuations. The firm captures original consumers within distance x defined by

$$\lambda(v_H - p_b) + (1-\lambda)(\delta v_L - c) - tx$$
$$= \lambda(v_H - p_b^{**}(\epsilon)) + (1-\lambda)(\delta v_L - c) - t\left(\frac{1}{n_b^{**}(\epsilon)} - x\right)$$

and offline consumers located within distance x' defined by

$$\lambda v_H + (1-\lambda)v_L - p_b - tx' = \lambda v_H + (1-\lambda)v_L - p_b^{**}(\epsilon) - t\left(\frac{1}{n_b^{**}(\epsilon)} - x'\right).$$

Hence,

$$x = \frac{1}{2t}\left(\frac{t}{n_b^{**}(\epsilon)} + \lambda p_b^{**}(\epsilon) - \lambda p_b\right)$$

and

$$x' = \frac{1}{2t}\left(\frac{t}{n_b^{**}(\epsilon)} + p_b^{**}(\epsilon) - p_b\right).$$

The firm's profit function equals

$$\Pi(p_b, p_b^{**}(\epsilon)) = 2L(\lambda(1-\epsilon)x + \epsilon x')(p_b - c) - \phi$$
$$= \frac{L}{t}\left(\left(\lambda(1-\epsilon) + \epsilon\right)\frac{t}{n_b^{**}(\epsilon)} + (\lambda^2(1-\epsilon) + \epsilon)(p_b^{**}(\epsilon) - p_b)\right)(p_b - c) - \phi.$$

Substituting $p_b = p_b^{**}(\epsilon)$ into the first-order conditions yields

$$(\lambda(1-\epsilon) + \epsilon)\frac{t}{n_b^{**}(\epsilon)} - (\lambda^2(1-\epsilon) + \epsilon)(p_b^{**}(\epsilon) - c) = 0,$$

or

$$p_b^{**}(\epsilon) = c + \frac{(\lambda(1-\epsilon) + \epsilon)t}{(\lambda^2(1-\epsilon) + \epsilon)n_b^{**}(\epsilon)}.$$

The equilibrium number of b-firms can be found from the zero-profit condition

$$\frac{(\lambda(1-\epsilon) + \epsilon)L}{n_b^{**}(\epsilon)} \frac{(\lambda(1-\epsilon) + \epsilon)t}{(\lambda^2(1-\epsilon) + \epsilon)n_b^{**}(\epsilon)} = \phi,$$

hence,

$$n_b^{**}(\epsilon) = \frac{\lambda(1-\epsilon) + \epsilon}{\sqrt{\lambda^2(1-\epsilon) + \epsilon}} \sqrt{\frac{tL}{\phi}}.$$

Substituting $n_b^{**}(\epsilon)$ back into the equilibrium price yields

$$p_b^{**}(\epsilon) = c + \frac{1}{\sqrt{\lambda^2(1-\epsilon) + \epsilon}} \sqrt{\frac{t\phi}{L}}.$$

Proof: Original consumers fare better in the presence of offline consumers

Straightforward, but tedious algebra that follows below reveals

$$\lambda(p_b^{**} - p_b^{**}(\epsilon)) > \frac{t}{4n_b^{**}(\epsilon)} - \frac{t}{4n_b^{**}}.$$

That is,

$$\lambda\left(\frac{1}{\lambda} - \frac{1}{\sqrt{\lambda^2(1-\epsilon) + \epsilon}}\right) > \frac{1}{4}\left(\frac{\sqrt{\lambda^2(1-\epsilon) + \epsilon}}{\lambda(1-\epsilon) + \epsilon} - 1\right).$$

Expanding $\sqrt{\lambda^2(1-\epsilon) + \epsilon}$ around $\epsilon = 0$ yields

$$\sqrt{\lambda^2(1-\epsilon) + \epsilon} \approx \lambda + \frac{1-\lambda^2}{2\lambda}\epsilon.$$

The inequality becomes

$$1 - \frac{\lambda}{\lambda + \frac{1-\lambda^2}{2\lambda}\epsilon} > \frac{1}{4}\left(\frac{\lambda + \frac{1-\lambda^2}{2\lambda}\epsilon}{\lambda(1-\epsilon) + \epsilon} - 1\right),$$

or

$$\frac{\epsilon(1-\lambda^2)}{2\lambda^2 + (1-\lambda^2)\epsilon} > \frac{\epsilon(1-\lambda)^2}{4\left(2\lambda^2 + 2\lambda(1-\lambda)\epsilon\right)}.$$

Dividing both sides by $\epsilon(1-\lambda)$ yields

$$\frac{1+\lambda}{2\lambda^2 + (1-\lambda^2)\epsilon} > \frac{1-\lambda}{4\left(2\lambda^2 + 2\lambda(1-\lambda)\epsilon\right)}.$$

Because the above inequality holds strictly when $\epsilon = 0$, it will also hold for sufficiently small values of ϵ.

Proof of Proposition 5

Because $v_L > c$, patient consumers order the product online from the outset. Consider a b-firm that charges price p_b, which is accepted by original consumers with high valuations. Its rivals located at distance $1/n_b^{**}(\xi)$ charge price $p_b^{**}(\xi)$, which is also accepted by original consumers with high valuations. The firm captures original consumers within distance x defined by

$$\lambda(v_H - p_b) + (1 - \lambda)(\delta v_L - c) - tx$$
$$= \lambda(v_H - p_b^{**}(\xi)) + (1 - \lambda)(\delta v_L - c) - t\left(\frac{1}{n_b^{**}(\xi)} - x\right),$$

or

$$x = \frac{1}{2t}\left(\frac{t}{n_b^{**}(\xi)} + \lambda p_b^{**}(\xi) - \lambda p_b\right).$$

The firm's profit function equals

$$\Pi(p_b, p_b^{**}(\xi)) = 2L\lambda(1 - \xi)x(p_b - c) - \phi = \frac{\lambda(1 - \xi)L}{t}\left(\frac{t}{n_b^{**}(\xi)} + \lambda p_b^{**}(\xi) - \lambda p_b\right)(p_b - c) - \phi.$$

Substituting $p_b = p_b^{**}(\xi)$ into the first-order conditions yields

$$\frac{t}{n_b^{**}(\xi)} - \lambda(p_b^{**}(\xi) - c) = 0,$$

or

$$p_b^{**}(\xi) = c + \frac{t}{\lambda n_b^{**}(\xi)}.$$

The equilibrium number of firms can be found from the zero-profit condition

$$\frac{\lambda(1 - \xi)L}{n_b^{**}(\xi)}\frac{t}{\lambda n_b^{**}(\xi)} = \phi,$$

hence,

$$n_b^{**}(\xi) = \sqrt{1 - \xi}\sqrt{\frac{tL}{\phi}}.$$

Substituting $n_b^{**}(\xi)$ back into the equilibrium price yields

$$p_b^{**}(\xi) = c + \frac{1}{\lambda\sqrt{1 - \xi}}\sqrt{\frac{t\phi}{L}}.$$

Appendix B

Proposition 6 specifies the parameter conditions under which each of three possible monopoly equilibrium configurations obtains. The proof is straightforward, but rather tedious, and will be provided upon request.

Proposition 6 (Monopoly Equilibrium Configurations under the Benchmark).
Assume $v_H > c$.

(i) *If*

$$\begin{cases} c < \lambda v_H, \\ 0 \le v_L < \frac{1}{2}\left(v_H + c - \sqrt{(v_H - c)^2 - (\lambda v_H - c)^2}\right), \end{cases}$$

and

$$\phi = \frac{\lambda L}{2t}(\lambda v_H - c)^2,$$

then each firm acts as a local monopolist and charges price

$$p_b^* = \frac{\lambda v_H + c}{2}$$

that attracts consumers located within distance $(\lambda v_H - c)/t$. Of all consumers who travel to a firm only those with high valuations purchase the product.

(ii) *If either*

$$\begin{cases} c < \lambda v_H, \\ \frac{1}{2}\left(v_H + c - \sqrt{(v_H - c)^2 - (\lambda v_H - c)^2}\right) \le v_L \le \frac{1}{1+\lambda}(\lambda v_H + c), \end{cases}$$

or

$$\begin{cases} \lambda v_H \le c, \\ c < v_L \le \frac{1}{1+\lambda}(\lambda v_H + c), \end{cases}$$

and

$$\phi = \frac{2L}{t}\lambda(v_H - v_L)(v_L - c),$$

then each firm acts as a local monopolist and charges price $p_b^* = v_L$ that attracts consumers located within distance $\lambda(v_H - v_L)/t$. All consumers who travel to a firm purchase the product.

(iii) *If*

$$\frac{1}{1+\lambda}(\lambda v_H + c) < v_L \le v_H$$

and

$$\phi = \frac{L}{2t}(\lambda v_H + (1 - \lambda v_L) - c)^2,$$

then each firm acts as a local monopolist and charges price

$$p_b^* = \frac{\lambda v_H + (1 - \lambda)v_L + c}{2}$$

that attracts consumers located within distance $(\lambda v_H + (1 - \lambda)v_L - c)/t$. All consumers who travel to a firm purchase the product.

It is straightforward to verify that $c < (\lambda v_H + c)/(1+\lambda)$. Also, the following comparison holds for $c < \lambda v_H$:

$$c < \frac{1}{2}\left(v_H + c - \sqrt{(v_H - c)^2 - (\lambda v_H - c)^2}\right) < \frac{1}{1+\lambda}(\lambda v_H + c).$$

Corollary 1. *There will be no firms operating in the market in either of the following five parameter regions:*

$$\begin{cases} c < \lambda v_H, \\ 0 \leq v_L < \frac{1}{2}\left(v_H + c - \sqrt{(v_H - c)^2 - (\lambda v_H - c)^2}\right), \\ \phi > \frac{\lambda L}{2t}(\lambda v_H - c)^2. \end{cases} \tag{1}$$

$$\begin{cases} c < \lambda v_H, \\ \frac{1}{2}\left(v_H + c - \sqrt{(v_H - c)^2 - (\lambda v_H - c)^2}\right) \leq v_L \leq \frac{1}{1+\lambda}(\lambda v_H + c), \\ \phi > \frac{2L}{t}\lambda(v_H - v_L)(v_L - c). \end{cases} \tag{2}$$

$$\begin{cases} \lambda v_H \leq c, \\ v_L \leq c. \end{cases} \tag{3}$$

$$\begin{cases} \lambda v_H \leq c, \\ c < v_L \leq \frac{1}{1+\lambda}(\lambda v_H + c), \\ \phi > \frac{2L}{t}\lambda(v_H - v_L)(v_L - c). \end{cases} \tag{4}$$

$$\begin{cases} \frac{1}{1+\lambda}(\lambda v_H + c) < v_L \leq v_H, \\ \phi > \frac{L}{2t}(\lambda v_H + (1 - \lambda v_L) - c)^2. \end{cases} \tag{5}$$

When entry cost ϕ is not as low as in (A1), and not as high as in Corollary 1, one of three possible *kinked* equilibrium configurations obtains (the equilibrium price might be below, equal, or above v_L). The markets of any two neighboring firms just touch (i.e., the consumer located in the middle receives zero payoff from visiting either of the two firms). This, however, does not mean that the firms act as local monopolists. The firms do compete with each other, but less vigorous than in Proposition 1. (In Proposition 1 the firms steal customers from each other, and the consumers in the middle receive strictly positive payoffs.)

Derivation of the exact conditions under which each of three kinked equilibrium configurations obtains is algebraically much more intense than the proofs of Proposition 1 and Proposition 6.

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