Electronic Commerce, Consumer Search and Retailing Cost Reduction

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Abstract: This paper explains in a unified way four things. First, how e-commerce can generate different, empirically documented, price equilibria, where physical shops either compete with virtual shops for consumers with Internet access, or sell only to consumers with no Internet access. Second, how these price equilibria might involve price dispersion on-line. Third, why prices may be higher on-line. Fourth, why established firms can, but need not, be more reluctant than newly created firm to adopt e-commerce. For this purpose we develop a model where e-commerce: reduces consumers' search costs, involves trade-offs for consumers, and reduces retailing costs.

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JEL Classification: *D43, D83, L13, L81, M31, O31, O33*

1 Introduction

The Internet allowed the creation of a new retailing technology: ***electronic commerce*** (e-commerce)[3]. E-commerce sales are still relatively low, for every $1 spent on-line, $37 are spent off-line (*Times*, December 27, 1999), but some on-line firms are growing at 5% a week (*The Economist*, April 10, 1999). Articles as diverse as books, cars, computers, groceries, financial products, and clothes are sold on-line.

E-commerce has similarities with catalogue retailing. Without a physical shop, it offers products, that cannot be physically inspected, or immediately delivered, and are paid for usually with credit card. But, e-commerce also has unique attributes, since the Internet allows to cheaply store, search, and disseminate information; is available anywhere, anytime, for anyone who can accede to it; allows interactivity; provides perceptual experiences superior to those of a catalogue, but inferior to those of physical inspection; and serves as a transactions and physical distribution medium for information goods[4]. Due to this last aspect, conceivably, it will be in markets for information goods that e-commerce will have a bigger impact, as the recent evolution of markets for stocks, mortgages, or life insurance (Brown & Goolsbee (2000)) suggests.

This paper explains in a unified way four things. First, how e-commerce can generate different, empirically documented price equilibria, where physical shops either compete with virtual shops for consumers with Internet access, or sell only to consumers with no Internet access. Second, how these equilibria might involve price dispersion on-line. Third, why prices may be higher on-line. And fourth, why established firms can, but need not, be more reluctant than newly created firm to adopt e-commerce. For this purpose we develop a static, homogeneous product, partial equilibrium search model, with three important aspects: e-commerce reduces consumers' search costs, involves trade-offs for consumers, and reduces retailing costs.

E-commerce reduces consumers' search costs, because on the Web consumers can visit at a low cost virtual shops and learn prices[5], or can use ***shopbots***, software agents that automatically search for price information[6]. E-commerce involves trade-offs for consumers, because buying from a virtual shop does not require a shopping trip,

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[3] Transacting products based on the processing and transmission of digitalised data over the network of computer networks that use the transmission control protocol/Internet protocol, TCP/IP.

[4] Goods that can be digitized, i.e., expressed as zeros and ones.

[5] *Yahoo Internet Life*, August 19 1999, reports that it took 32 minutes to find a hotel in New York using "the old way", while only 6 minutes using "the net way".

[6] E.g., ClickTheButton, DealPilot , www.previewtravel.com for airfares, and www.microsurf.com for mortgages.

but requires waiting for delivery. E-commerce reduces retailing costs, compared to physical shops, because virtual shops allow savings on ***property costs,*** i.e., leases and acquisition of shop and warehouse space, on ***labor costs***, i.e., personnel to attend shops, and on ***inventory costs***, i.e., inventories for showcasing or immediate delivery[7].

In our model, firms decide whether to open virtual shops and set prices, and consumers search for prices. There are two consumer types: new consumers have Internet access, old consumers do not, or do not consider using the Internet an option. New consumers canvass prices through the Web, and then decide if they buy from a virtual or a physical shop. There are two firms: the old firm has a physical shop, the new firm does not. Virtual shops have lower marginal production costs than physical shops.

Since search and waiting for delivery are costly, new consumers accept prices above the minimum charged in the market. This gives firms market power.

The virtual shops' pricing behavior is simple. Virtual shops have the lowest cost and charge the lowest price. Thus, they are not constrained by consumer search, and charge their monopoly price.

The physical shop's pricing behavior depends of whether the old firm has a virtual shop, and on whether the new firm is in the market. Because new consumers have access to lower cost shops, and if waiting for delivery is not too costly, they only accept buying from a physical shop for a lower price than old consumers. When only the new firm opens a virtual shop, if the physical shop charges a lower price acceptable to both consumer types, it earns a lower per consumer profit, if it charges a higher price acceptable only to old consumers, it earns a higher per consumer profit. Thus, the physical shop trades-off ***volume of sales*** and ***per consumer profit***; sometimes it chooses to sell to all consumers, and sometimes only to old consumers. When both firms open virtual shops, the old firm faces an additional effect, besides the volume of sales and per consumer profit effects. If its physical shop charges a lower price acceptable to both consumer types, half of the new consumers it sells to would otherwise buy from the old firm's virtual shop, where per consumer profit is higher. This causes the old firm to have its physical shop charge a lower price to attract new consumers, only if the virtual shops' cost reduction is small; otherwise it prefers to sell to

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[7] On the Web, a banking transaction costs $.1, compared with $.27 at an ATM or $.52 over the phone, and processing an airline ticket costs $1, compared with $8 through a travel agent (*The Economist*, June 26, 1999). USA retailers with no physical presence in a state do not collect local sales taxes, 6%.

new consumers only from its virtual shop. We give empirical evidence of these price equilibria, and argue that they are different from others in search theory, where firms face consumers with different reservation prices.

If the new and old firms' virtual shops have different costs, there will be price dispersion on-line

Since information goods are more convenient to buy on-line, physical shops must charge lower prices than virtual shops to be able to sell them to new consumers.

The firms' incentives to open virtual shops depend on the virtual shops' cost reduction, and the new consumers' reservation price. If cost reduction is small, the new firm has more incentives to open a virtual shop; if cost reduction is large, and the new consumers' reservation price is high, this is no longer true. In fact, the old firm can choose to open a virtual shop when the new firm does not.

The model has two novel features. First, it captures some of the consumers' and firms' trade-offs regarding e-commerce. Second, the production and the search cost distributions are endogenous.

Section 2 presents the basic model, where reservation prices are exogenous, and section 3 characterizes its equilibria. Section 4 discusses the firms' incentives to open virtual shops. Section 5 presents the basic model with the new and old firm operating the new technology at different costs. Section 6 presents the model with endogenous reservation prices. Section 7 discusses price equilibria for information goods. Section 8 argues the model explains some retailing industry facts. Section 9 discusses related literature. Proofs are in the Appendix.

2 The Basic Model

In this section we formalize the firms' opening of a virtual shop and pricing decisions, given consumers' reservation prices, as a 2 stage game. Later we will insert this *Basic* model in a larger game that includes a third stage, where reservation prices are determined.

(a) The Setting

Consider a retail market for a homogeneous search good that opens for 1 period.

There are 2 alternative *retailing technologies*[8]: a *New*, virtual shop based technology, and an *Old*, physical shop based technology. A *Virtual Shop* has a Web site, where consumers can observe prices and buy, and its logistics is based on the Web. A *Physical Shop* has a physical location, where consumers can observe prices and buy, and its logistics is based on the physical world. A physical shop may have a Web site, but only to post prices[9]. A firm is *Old* if it has a physical shop, opened before the game, and *New*, if it does not.

The game has 2 stages. In stage 1 firms choose whether to open virtual shops. In stage 2 firms choose prices. Then consumers buy, delivery takes place, agents receive their payoffs, and the market closes.

Subscript j refers to firms and we index a new and an old firm by: n, o. Subscripts t refers to shops and we index a new firm's virtual shop, an old firm's virtual shop, and a physical shop by: vn, vo, p.

(b) Consumers

There is a unit measure continuum of risk neutral consumers of 2 types. *New* consumers, a proportion $1 \in (0,1]$, have Internet access; *Old* consumers do not. At price p a consumer demands $D(p)$, where $D(.)$ is a differentiable, decreasing, bounded function, with a bounded inverse.

Consumers ignore the prices of individual shops, and can only learn them by visiting the shops. Old consumers visit the physical shop's physical location, and if offered a price no higher than r, where $D(r) \equiv 0$, buy and receive the product. When there are no virtual shops, new consumers behave similarly. Otherwise, new consumers canvass prices through the Web[10]. They have the list of Web sites, obtained, e.g., from a search engine, but do not know to which type of shop the directions correspond. At the end of section 6 we explain the role of the assumptions that consumers do not know beforehand to which type of shops the Web sites correspond, that the physical shop has a Web site, and that when there are virtual shops, new consumers must canvass prices through the Web. We assume that:

(H.1) Each new consumers picks randomly which Web site to visit, from the set he has not sampled yet.

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[8] Technologies that make products available for use or consumption. This concept is related to that of a *distribution channel* (see Kotler (1994)).

[9] Bailey (1998) and Brynjolfsson & Smith (1999) found that, e.g., Cody's and Powell's Books, posted prices on the Web, but only sold at their physical locations.

[10] In 2000, about half of the US car buyers will use the Internet. Most of them not to buy, but to obtain information to bargain lower prices out of local dealers (*The Economist*, February 14, 1998).

The new consumers' reservation price for a type t shop is r_t. When new consumers visit a new (old) firm's virtual shop, if offered a price no higher than r_{vn} (r_{vo}), they buy, and wait for delivery; when they visit a physical shop's Web site, if offered a price no higher than r_p, they go to the shop's physical location, buy, and receive the product; otherwise they reject the offer and search again[11]. Visiting a Web site or a physical shop's physical location, and waiting for delivery of the product bought from a virtual shop, involve costs which we will ignore until section 6.

(c) Firms

There are 2 risk neutral firms: a new and an old firm. If the new firm decides not to open a virtual shop, it exits the game (with a *0* payoff). Opening a virtual shop involves a set-up cost, $K \in (0, +\infty)$. The probability with which firm j opens a virtual shop is a_j; let $a = (a_n, a_o)$. At the end of stage 1 a is observed by all players. If at least 1 virtual shop opens, the physical shop creates its own Web site, where it posts its price.

Marginal production costs are constant for both shop types. The marginal cost of shop t is c_t. A virtual shop has a lower marginal cost than a physical shop. Let $c_p \in (0, r)$ and $c_{vn} = c_{vo} = c_v = c_p - D_c$, where c_p is the common production cost, and $D_c \in (0, c_p]$ is the **production cost reduction** induced by the new technology. All players know c_p and c_v.

The old firm can charge different prices at its 2 shops[12]. Shop t's price and per consumer profit are p_t and $p(p_t; c_t) := (p_t - c_t)D(p_t)$. Let $\hat{p}_t := argmax_p \, p(p; c_t)$. Assume that $p(.)$ is strictly quasi-concave in p, and that even for the maximum cost reduction the physical shop can charge $\hat{p}_v$ without losses, i.e., $c_p < \hat{p}_v$ for $D_c = c_p$. Shop t's expected consumer share and expected profit are: $f_t(p_t)$ and $P(p_t; c_t) := p(p_t; c_t) f_t(p_t)$. The new and old firm's net expected profits are: $V^n := [P(p_{vn}; c_v) - K] a_n$ and $V^o := P(p_p; c_p) + [P(p_{vo}; c_v) - K] a_o$.

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[11] As an alternative to sequential search new consumers could use shopbots, which in our context could be thought of as using a **newspaper search technology** (Braverman (1980), Salop & Stiglitz (1977), Wilde & Schwartz (1979)), i.e., perfect information at a fixed cost. This, however, contrasts, with the reality of e-commerce (Brynjolfsson & Smith (1999)). Shopbots are useful to limit the set of shops under consideration, but it is unclear that consumers will buy through them. Aspects like the return policy or post sale services, can only be learned at the firms' sites. In addition, some vendors block shopbots from searching their sites.
[12] Barnesandnoble.com charges different prices than Barnes and Noble's physical shops.

A firm's stage 1 **strategy**, is a rule that for every firm type, says with which probability a firm should open a virtual shop. A firm's stage 2 **strategy**, is a rule that for each history and shop type, says which price a shop should charge. A firm's **payoff** is expected profit, net of the investment expenditure.

(d) Equilibrium

A subgame perfect Nash **Equilibrium** is: an opening and a pricing rule, for each shop and firm type, $\left\{\left(a_j^*, p_t^*\right) j = n, o; \ t = vn, vo, p\right\}$, such that:

(E.1) Given any r_t and a, firms choose p_t^* to solve problems: $max_{p_{vn}} V^n$ and $max_{\{p_{vo}, p_p\}} V^o$;

(E.2) Given any r_t, and p_t^*, firms choose a_j^* to solve problem: $max_{a_j} V^j$.

3 Equilibrium of the Basic Model

In this section we construct the basic model's equilibrium by working backwards. First, given reservation prices and the profile of opening of virtual shops decisions, we derive the firms' equilibrium prices. Virtual shops charge their monopoly price. The physical shop charges sometimes the new consumers' reservation price, sometimes its monopoly price. Second, given reservation prices and equilibrium prices, we derive the firms' equilibrium opening of virtual shop's rule. Either firm sometimes opens a virtual shop, sometimes does not. There are 6 types of equilibria, depending on whether firms choose to open a virtual shop, and whether the physical shop sells to all or only to old consumers.

3.1 Stage 2: The Price Game

In this sub-section we characterize equilibrium prices.

The number of shops that charge a price acceptable to new consumers, i.e., $p_t \leq r_t$, $t = vn, vo, p$, is a. If virtual shop t charges a price higher than r_t, it makes no sales; if it charges a price no higher than r_t, given **(H.1)** and that there is a continuum of new consumers, its expected consumer share is l/a. Thus, for $0 < a$:

$$\phi_t(p; \rho_t) = \begin{cases} 0 & \Leftarrow \rho_t < p \\ \lambda/\alpha & \Leftarrow p \leq \rho_t \end{cases} \quad t = vn, vo$$

(we omit a and l in f_t).

If the physical shop charges a price higher than r, it makes no sales; if it charges a price higher than r_p, but no higher than r, it sells to old consumers, $1 - l$; if it charges a price no higher than the r_p, its expected consumer share is $l / a + 1 - l$. Thus, for $0 < a$:

$$\phi_p(p; \rho_p) = \begin{cases} 0 & \Leftarrow r \\ 1 - \lambda & \Leftarrow \rho_p < p \le r \\ \lambda/\alpha + 1 - \lambda & \Leftarrow p \le \rho_p \end{cases}$$

(we omit a, l and r in f_p).

We assume that $r_p < \widehat{p}_p$, which rules out the uninteresting cases, where although virtual shops exist, the physical shop is able to sell to new consumers at $\widehat{p}_p$, its monopoly price. We assume also that r_t is strictly higher than the lowest of the prices consumers can find if they search:

(H.2) $\min \left\{ p_{t'} \right\} \le \rho_t$ $\qquad$ $t' \ne t$

This assumption rules out equilibria which are not subgame perfect in the larger model if search and waiting for delivery are costly. It follows that costly search and impatience give firms market power[13], since they lead new consumers to accept prices above the minimum charged in the market. By **(H.2)**, $0 < a$.

When neither firm opens a virtual shop, $a = (0, 0)$, the industry is a monopoly. The number of shops that charge a price acceptable to new consumers when firms play (a_n, a_o) in stage 1 is $a^{a_n a_o}$; $a^{00} = 1$.

Next we examine the case where only the new firm opens a virtual shop, and hence the industry's supply side consists of the physical shop, and the new firm's virtual shop. The value of r_p for which the old firm is indifferent between charging $p_p = r_p$, and charging $p_p = \widehat{p}_p$, given $a = (1, 0)$ and $p_{vn} \le r_{vn}$, is p_o^s, i.e. $p(p_o^s(1); c_p)[l/2 + 1 - l] \equiv p(\widehat{p}_p; c_p)(1 - l)$. We assume that when the old firm is indifferent between selling to both consumers types and selling only to old consumers, it chooses the latter.

Proposition 1: If $a = (1, 0)$, then: **(i)** $p_{vn}^* = \widehat{p}_v$; **(ii)**

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[13] The ability to raise price above marginal cost.

$$p_p^* = \begin{cases} \rho_p & \Leftarrow \ p_o^s(\lambda) < \rho_p \\ \widehat{p}_p & \Leftarrow \ \rho_p \leq p_o^s(\lambda) \end{cases}$$

where $p_o^s(.)$ is decreasing, and $p_o^s(1) = c_p$.　　　　　　　　　　　　　　　　§

Since the new firm's virtual shop charges the lowest price in the market, and given (**H.2**), it is never constrained by consumer search and always charges $\widehat{p}_v$. The physical shop also benefits from the market power generated by costly search, and from being the only shop old consumers can buy from, by charging a higher price than the new firm's virtual shop. However, it is constrained by consumer search, if it is beneficial to sell to both consumer types[14].. Let $\widehat{l}(r_p) := (p_o^s)^{-1}(r_p)$. If r_p is high, i.e., $p_o^s(1) < r_p$, or alternatively, if l is large, i.e., $\widehat{l}(r_p) < 1$ (figure 1), the old firm wants to sell to both consumers types, so reduces its price below $\widehat{p}_p$ and charges r_p. If r_p is low, i.e., $r_p < p_o^s(1)$, or alternatively, if l is small, i.e., $l < \widehat{l}(r_p)$, the old firm wants to sell only to old consumers and charges $\widehat{p}_p$.[15] The higher is l, the more willing is the physical shop to lower its price to sell to new consumers. From **Proposition 1**:

$$\alpha^{10} = \begin{cases} 2 & \Leftarrow \ p_o^s(\lambda) < \rho_p \\ 1 & \Leftarrow \ \rho_p \leq p_o^s(\lambda) \end{cases}$$

When the old firm does not open a virtual shop and charges r_p instead of $\widehat{p}_p$, it sells to $l/2$ new consumers, earning an additional $p(r_p; c_p)(l/2)$, the ***Volume of Sales*** effect, but loses $-[p(\widehat{p}_p; c_p) - p(r_p; c_p)]$ per old consumer, and a total of $-[p(\widehat{p}_p; c_p) - p(r_p; c_p)](1-l)$, the ***per Consumer Profit*** effect. Thus, the physical shop trades-off volume of sales and per consumer profit[16].

When the physical shop charges r_p new consumers search only once[17]; otherwise new consumers may search twice, until they find the virtual shop.

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[14] And the threat of a second search by new consumers is credible, i.e., $r_p < \widehat{p}_p$.

[15] When $r_p < p_p^*$ the physical shop could shut its Web site.

[16] The physical shop could price discriminate between new and old consumers, by, e.g., offering coupons at its Web site. It might, however, be reluctant to do so, because when informed about them, old consumers could perceive these price differences as unfair. See Sinha (2000) for a discussion of this issue.

[17] The option to search serves only as a credible, out of equilibrium threat, constraining the old firm's price decisions.

When only the new firm opens a virtual shop, depending on $(r_p, 1)$, there can be 2 types of price equilibria. In both the virtual shop charges $\hat{p}_v$. The physical shop, at a ***Competing*** equilibrium charges r_p, and at a ***Segmentation*** equilibrium charges $\hat{p}_p$.

[Insert figure 1 here]

Next we examine the case where both firms open virtual shops, and hence the industry's supply side consists of a physical shop and 2 virtual shops. The level of r_p for which the old firm is indifferent between its physical shop selling to both consumer types and selling only to old consumers, given $a = (1, 1)$ and $p_t \leq r_t$, $t = vn, vo$, is p_m^s, i.e., $p(\hat{p}_v; c_v)(1/3) + p(p_m^s(1, D_c); c_p)[1/3 + 1 - 1] \equiv p(\hat{p}_v; c_v)(1/2) + p(\hat{p}_p; c_p)(1 - 1)$. We assume that when the old firm is indifferent between its physical shop charging $p_p = r_p$, and charging $p_p = \hat{p}_p$, it chooses the latter; and that for $D_c = c_p$, $2 < p(\hat{p}_v; c_v)/p(\hat{p}_p; c_p)$, which can be interpreted as the ***Large Cost Reduction Opportunities*** case. The value of D_c for which $p(\hat{p}_v; c_v)/p(\hat{p}_p; c_p) \equiv 2$, is D_c^c.[18]

Proposition 2: If $a = (1, 1)$, then: **(i)** $p_{vn}^* = p_{vo}^* = \hat{p}_v$; **(ii)**

$$p_p^* = \begin{cases} \hat{p}_p & \text{for } \Delta_c \in \left[\Delta_c^c, c\right] \\ \begin{cases} \rho_p & \Leftarrow p_m^s(\lambda, \Delta_c) < \rho_p \\ \hat{p}_p & \Leftarrow \rho_p \leq p_m^s(\lambda, \Delta_c) \end{cases} & \text{for } \Delta_c \in \left(0, \Delta_c^c\right) \end{cases}$$

where $p_m^s(\cdot)$ is decreasing in 1, increasing in D_c, $p_o^s(1) \leq p_m^s(1, D_c)$, and $p_m^s(1, D_c) < \hat{p}_p$.   §

Note that $p_{vn}^* = p_{vo}^* = \hat{p}_v$ is an expression of Diamond's (1971) paradox[19]. From **Proposition 2**:

$$\alpha^{11} = \begin{cases} 2 & \text{for } \Delta_c \in \left[\Delta_c^c, c\right] \\ \begin{cases} 3 & \Leftarrow p_m^s(\lambda, \Delta_c) < \rho_p \\ 2 & \Leftarrow \rho_p \leq p_m^s(\lambda, \Delta_c) \end{cases} & \text{for } \Delta_c \in \left(0, \Delta_c^c\right) \end{cases}$$

When the old firm opens a virtual shop, it faces another ***per Consumer Profit*** effect, now with respect to new consumers, besides the ***Volume of Sales*** effect, $p(r_p; c_p)(1/6)$, and the previous ***per Consumer Profit*** effect

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[18] Price $\hat{p}_v$ depends on c_v, and thus on D_c. If $2 < p(\hat{p}_v; c_v)/p(\hat{p}_p; c_p)$, $D_c^c \leq c_p$, whereas if $p(\hat{p}_v; c_v)/p(\hat{p}_p; c_p) \leq 2$, $D_c^c = c_p$.

[19] Low cost shops charge their monopoly price, regardless of how low the search cost is, and how many shops there are. See Davis & Holt (1996) for experimental evidence.

with respect to old consumers, $-\left[p(\hat{p}_p;c_p)-p(r_p;c_p)\right](1-1)$. If its physical shop charges r_p instead of $\hat{p}_p$, half of the new consumers it sells to, $1/6$, would otherwise buy from its own virtual shop, causing a loss of $-\left[p(\hat{p}_v;c_v)-p(r_p;c_p)\right](1/6)$. This additional effect causes the old firm to only want to reduce its physical shop's price below $\hat{p}_p$ to attract new consumers, if cost reduction is small, i.e., $D_c \leq D_c^c$. Otherwise, the old firm prefers to sell to new consumers only from its virtual shop. And when the old firm's physical shop does reduce its price to attract new consumers, it does so for higher reservation price values than when it does not open a virtual shop, $p_o^s \leq p_m^s$ (figure 1). Even when all consumers have Internet access, $1 = 1$, if cost reduction is small, and $p_m^s < r_p$, the old firm still sells from the physical shop, $p_m^s(1,D_c) < \hat{p}_p$, since this allows it to have a new consumer share of $2l/3$ instead of $1/2$.

When both firms open virtual shops, depending on $(r_p, 1, D_c)$, there is a *Competing* and a *Segmentation* equilibrium.

The price equilibria of case $a = (1,1)$ are different from other search theory equilibria where firms must choose whether to sell only to high reservation price consumers, or to sell also to low reservation price consumers (e.g., Braverman (1980), Burdett & Judd (1983), Rob (1985), Salop & Stiglitz (1977), Varian (89), Wilde & Schwartz (1979)), because the old firm's problem is not just whether to sell to low reservation price consumers, but also how to sell to them, since it can do so either through its virtual or its physical shop.

Next we examine the case where only the old firm opens a virtual shop, and hence the industry's supply side consists of the old firm's physical and virtual shops.

Proposition 3: If $a = (0, 1)$, then: **(i)** $p_{vo}^* = \hat{p}_v$; **(ii)** $p_p^* = \hat{p}_p$. §

Now since the old firm is alone in the industry, it has no incentive to reduce its physical shop's price below $\hat{p}_p$. Any new consumer its physical shop might attract is stolen from its virtual shop, where per consumer profit is no smaller. And, if all consumers have Internet access, $1 = 1$, since $r_p < \hat{p}_p$, the physical shop has zero sales, which could be interpreted as shutting down. From **Proposition 3**: $a^{01} = 1$.

When only the old firm opens a virtual shop there is a *Segmentation* equilibrium.

Table 1 summarizes the price equilibria's main features.

[Insert table 1 here]

Next we order the equilibrium price distributions for the various stage 1 decision profiles. The market equilibrium price distribution when in stage 1 firms play (a_n, a_o) is $F^{a_n a_o}(.)$; $F'(.) \prec F(.)$ means "distribution $F(.)$ dominates distribution $F'(.)$ in the first-order stochastic sense".[20]

Proposition 4: (i) $F^{10} \prec F^{01} \prec F^{00}$; (ii) $F^{11} \prec F^{01}$ §

Since F^{00} dominates all other distributions, if at least 1 virtual shop opens prices fall through 2 effects. The ***Cost Reduction*** effect is the fall on prices caused by the production cost reduction induced by e-commerce. The ***Price Competition*** effect is the fall on prices induced by the physical shop lowering its price to compete for new consumers with the new firm's virtual shop. If the new firm opens a virtual shop prices fall, since $F^{10} \prec F^{00}$ and $F^{11} \prec F^{01}$. If the old firm opens a virtual shop, prices only fall for sure if it is the only virtual shop $F^{01} \prec F^{00}$. When the new firm opens a virtual shop, the old firm opening a virtual shop puts more weight on the left tail of the price distribution. But, since $p_o^s \leq p_m^s$, the physical shop charges a no lower price than when it has no virtual shop. Thus, F^{11} and F^{10} are not comparable in the first-order stochastic sense.

3.2 Stage 1: The Opening of Virtual Shops Game

In this sub-section we characterize the equilibrium opening rule and establish existence of equilibrium.

Firm j's net profit when in stage 1 firms play (a_n, a_o), and after both firms and play optimally is $V_{a_n a_o}^j$. The difference between firm j's net profits when it opens a virtual shop, and when it does not, given that firm j plays $d = 0, 1$ in stage 1 is $D_{1|d}^j$, e.g., $D_{1|1}^o = V_{11}^o - V_{10}^o$ and $D_{1|1}^n = V_{11}^n - V_{01}^n = V_{11}^n$. Firm j's ***Expected Incremental Profit*** of opening a virtual shop is $S_j := a_{j'} D_{1|1}^j + (1 - a_{j'}) D_{1|0}^j$, $j' \neq j$.

Firm j's optimal stage 1 decision is to open a virtual shop if its expected incremental profit is positive.

Proposition 5: Equilibrium exists. §

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[20] Distribution $F(.)$ ***Dominates*** distribution $F'(.)$ in the ***First-Order Stochastic*** sense if $F(.) \leq F'(.)$, for all p.

Given the range of values the S_j's can take, virtually any profile of decisions to open a virtual shop can be an equilibrium. In section 4 we describe equilibrium profiles for particular cases.

4 Incentives to Open Virtual Shops

In this section we discuss the firms' incentives to open virtual shops. We show that if cost reduction is small, the new firm opens a virtual shop when the old firm does, and also when the old firm does not; otherwise the old firm may open a virtual shop when the new firm does not.

We start by discussing how opening a virtual shop impacts the new and old firms' profits. Since the new firm has no physical shop, opening a virtual shop enables it to sell to new consumers. The **Business Creating** effect is the increase in the new firm's profit from opening a virtual shop, $p(\widehat{p}_v; c_v)(1/a)$. The impact of opening a virtual shop on the old firm's profit can be decomposed in 3 potential effects. The old firm can sell to new consumers through its physical shop. But, if it opens a virtual shop it can sell to them at a lower cost. The **Cost Reduction** effect is the increase in the old firm's profit from selling to new consumers through its virtual shop instead of its physical shop, $\left[p(\widehat{p}_v; c_v) - p(p_p^*; c_p)\right](1/m_c)$, where $1/m_c$ is the proportion of new consumers that buy from the old firm's virtual shop, but that would buy from the physical shop if the old firm did not open a virtual shop. By opening a virtual shop when the new firm also does, the old firm improves its ability to sell to new consumers. The **Market Penetration** effect is the increase in the old firm's profit, due to the rise in its new consumers' share, from opening a virtual shop when the new firm also does, $p(\widehat{p}_v; c_v)(1/m_p)$, where $1/m_p$ is the proportion of new consumers that buy from the old firm's virtual shop, but that would buy from the new firm's virtual shop if the old firm did not open a virtual shop. By opening a virtual shop when the new firm also does, the old firm can sell to new consumers through its virtual shop, and have its physical shop sell only to old consumers. The **Price Discrimination** effect is the increase in the old firm's profit from switching from a **Competing** to a **Segmentation** equilibrium, $\left[p(\widehat{p}_p; c_p) - p(r_p; c_p)\right](1-1)$.[21]

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[21] The **Cost Reduction** effect is present in D_{I0}^o, and in D_{I1}^o if $p_o^s \leq r_p$; the **Market Penetration** effect is present in D_{I1}^o if $r_p < p_o^s$ for $D_c^c < D_c$, and if $r_p \in \left[p_o^s, p_m^s\right)$ for $D_c \leq D_c^c$; the **Price Discrimination** effect is present in D_{I1}^o if $p_o^s \leq r_p$ for $D_c^c < D_c$, and if $r_p \in \left[p_o^s, p_m^s\right)$ for $D_c \leq D_c^c$.

The next lemma orders the firms incremental payoffs. The value of D_c for which $p(\hat{p}_v; c_v)/p(\hat{p}_p; c_p) \equiv 3/2$,

is $\breve{D}_c(3/2)$.

Lemma 1: (i) If $D_c \, \hat{I} \, \left(0, \breve{D}_c(3/2)\right)$, then $D_{1|0}^o < V_{11}^n$, and thus $\max\left\{D_{1|0}^o, D_{1|1}^o\right\} < V_{11}^n \leq V_{10}^n$. **(ii)** If $p_o^s(1) < r_p$ and

$D_c \, \hat{I} \, \left(D_c^c, c\right]$, then $V_{11}^n = V_{10}^n < D_{1|0}^o$, and thus $D_{1|1}^o < V_{10}^n < D_{1|0}^o$. **(iii)** $\breve{D}_c(3/2) < D_c^c$. §

Since the new firm's consumer share is no bigger when the old firm opens a virtual shop than when it does

not: $V_{11}^n \leq V_{10}^n$. When both firms open a virtual shop, the **Business Creating** effect dominates the **Market**

Penetration, **Cost Reduction** and **Price Discrimination** effects: $D_{1|1}^o \leq V_{11}^n$, and thus $D_{1|1}^o \leq V_{11}^n \leq V_{10}^n$.

Expression $V_{1d}^n - D_{1|0}^o$, $d = 0, 1$, equals the difference between the **Business Creating** and the **Cost**

Reduction effects. If D_c is small, i.e., $D_c < \breve{D}_c(3/2)$, the **Business Creating** effect dominates the **Cost Reduction**

effect, $D_{1|0}^o < V_{11}^n$, and thus: $\max\left\{D_{1|0}^o, D_{1|1}^o\right\} < V_{11}^n \leq V_{10}^n$. If, however, D_c is large, i.e., $D_c^c < D_c$, and the physical shop

competes for new consumers, i.e., $p_o^s(1) < r_p$ or alternatively $\hat{I}(r_p) < 1$, the **Cost Reduction** effect dominates the

Business Creating effect, $V_{10}^n < D_{1|0}^o$. Furthermore, for $a = (1, 0)$ the model has a **Competing** equilibrium, and for

$a = (1, 1)$ a **Segmentation** equilibrium. Thus, $V_{11}^n = V_{10}^n$, and consequently: $D_{1|1}^o < V_{11}^n = V_{10}^n < D_{1|0}^o$.

Next we characterize the opening of virtual shops equilibrium profiles, for **Lemma 1**'s 2 cases. To focus on

pure strategy equilibria, we assume that when a firm is indifferent between opening and not opening a virtual shop it

chooses the former[22]. We assume also that $0 \leq \max\left\{D_{1|0}^o, V_{10}^n\right\}$, which rules out $a^* = (0, 0)$. Let $w = (1, c_p, D_c, \kappa, r_p)$

Proposition 6: (i) If $D_c \, \hat{I} \, \left(0, \breve{D}_c(3/2)\right)$, then:

$$a^* = \begin{cases} (1, 0) & \Leftarrow & \left\{w \mid \Delta_{1|1}^o < 0\right\} \\ (1, 1) & \Leftarrow & \left\{w \mid 0 \leq \Delta_{1|1}^o\right\} \end{cases}$$

(ii) If $p_o^s(1) < r_p$ and $D_c \, \hat{I} \, \left(D_c^c, c\right]$, then:

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[22] Although Proposition 6 is not exhaustive, an equilibrium in pure strategies does exist for all parameter values.

$$a^* = \begin{cases} (0,1) & \Leftarrow \left\{ w \mid V_{10}^n < 0 \leq \Delta_{1|0}^o \right\} \\ (1,0) & \Leftarrow \left\{ w \mid \Delta_{1|1}^o < 0 \leq V_{10}^n \right\} \\ (1,1) & \Leftarrow \left\{ w \mid 0 \leq \Delta_{1|1}^o \right\} \end{cases}$$

§

If D_c is small, the new firm opens a virtual shop when the old firm does, and also when the old firm does not: $D_{1|1}^o < 0$. We interpret this as the old firm having less incentive to open a virtual shop.

[Insert figure 2 here]

For $(1, D_c) \hat{I} \left(0, \hat{I}_c(r_p) \right) \times \left(0, \breve{D}_c(3/2) \right)$, $D_{1|1}^o$ and V_{10}^n are increasing in $(1, D_c)$, and decreasing in K (figure 2 (i)). If $(1, D_c)$ are small, $D_{1|1}^o < 0 \leq V_{10}^n$, and thus $a^* = (1,0)$; for larger values of $(1, D_c)$, $0 \leq D_{1|1}^o$, and thus $a^* = (1,1)$. And although the model is static, this could explain why typically new firms opened virtual shops before old firms. Initially $(1, D_c)$ were small because few consumers had Internet access, and firms did not fully understand the new technology. Overtime, more consumers gained access to the Internet, and firms learned how to use the new technology.

If, however, $(1, D_c)$ are large, the old firm may open a virtual shop when the new firm does not: $V_{10}^n < 0 \leq D_{1|0}^o$.

For $(1, D_c) \hat{I} \left(\hat{I}_c(r_p), 1 \right) \times \left(D_c^c, 1 \right]$, $D_{1|0}^o$, $D_{1|1}^o$ and V_{10}^n are increasing in $(1, D_c)$, and decreasing in K (figure 2: (ii)). If $(1, D_c)$ are larger than $\left(\hat{I}_c(r_p), D_c^c \right)$ but not by much, $V_{10}^n < 0 \leq D_{1|0}^o$, and thus $a^* = (0,1)$; for larger values of $(1, D_c)$, again $0 \leq D_{1|1}^o$, and thus $a^* = (1,1)$.

The model shows how the old firm might have less incentive to open a virtual shop if cost reduction is small. But, if cost reduction is large, the old firm need not have less incentive. In fact, it can choose to open a virtual shop when the new firm does not.

It has been claimed that an old firm may be reluctant to use e-commerce for fear of its virtual shop, with supposedly a lower per consumer profit, stealing business from its physical shop, i.e., **Cannibalization**[23]. Note first that cannibalization is part of the **Cost Reduction** effect. If a virtual shop has lower costs than a physical shop, and market power, this intra-firm transfer of new consumers is profitable[24]. Second, if an old firm opens a virtual shop it can increase its new consumers' share, **Market Penetration** effect, and price discriminate between new and old consumers, **Price Discrimination** effect, both of which are also profitable[25]. In the next section we add some comments on this issue.

5 Firm Asymmetry

In this section, we discuss how a possible asymmetry between the new and old firm with respect to the new technology, affects the firms' pricing behavior and incremental profits for the basic model.

We assumed that the new and old firm are equally capable of achieving the new technology's cost reduction. However, if virtual shops require new forms of organization that take advantage of the new technology's low cost of information processing and transmission, if integrating virtual and physical shop retailing is hard, and if old firms' employees resist the new technology because it devalues their skills, newly created firms might achieve larger retailing cost reductions than established firms. To model this asymmetry between new and old firms let $c_{vo} = c_p - (1 - e)D_c$, where $e \in [0, 1]$ indicates the **efficiency loss** of the old firm relative to the new firm.

The firms' pricing behavior remains unchanged, except for $a = (1, 1)$, where $p_{vo}^* = min\{r_{vo}, \widehat{p}_{vo}\}$, $\widehat{p}_{vo} \in [\widehat{p}_v, \widehat{p}_p)$. This implies that there may be price dispersion among virtual shops[26].

[Insert figure 3 here]

Now $D_{1|0}^o < V_{11}^n$, if D_c is small, or, if D_c is large but e is also large (figure 3). And $V_{10}^n < D_{1|0}^o$, if D_c is large and e is small. And for e large enough $D_{1|0}^o < V_{11}^n$ for all values of D_c.

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[23] Toys"R"Us invested $80 million to launch a virtual division, but Robert Mogg, the man in charge, resigned, claiming that the firm was afraid of competing with its own physical shops (*El País*, September 5, 1999). Alba et al. (1997): "E-commerce offers an advantage to retailers that have low penetration (…). On the other hand, companies with high penetration might experience significant cannibalization of its in-shop sales, making e-commerce less attractive".

[24] Baseball Express, claims that its Web site stole sales from its catalogue, but that selling on the Web is more profitable (*The New York Times*, September, 2, 1999).

[25] Ward & Morganosky (2000) and Ward (1999) also arrive to a negative conclusion on cannibalization, although for different reasons.

[26] See Baye & Morgan (2000) and Ayer & Pazgal (2000) for alternative ways of generating price dispersion on-line.

The *Cost Reduction* effect becomes $\left[p\left(min\left\{r_{vo}, \widehat{p}_{vo}\right\} c_{vo}\right) - p\left(p_p^*; c_p\right)\right]\left(1/m_c\right)$, which can be negative if r_{vo}

is small and c_{vo} large, giving some justification to the fear of *Cannibalization*. The *Market Penetration* effect

$p\left(min\left\{r_{vo}, \widehat{p}_{vo}\right\} c_{vo}\right)\left(1/m_p\right)$ also becomes smaller.

6 Endogenous Reservation Prices

In this section we add a third stage to the model where reservation prices are determined, given consumers' search and waiting costs. The game consists of 3 stages. The first 2 unfold as in the basic model. In stage 3 consumers make their search and purchase decisions; then delivery takes place, agents receive their payoffs, and the market closes.

To complete the model we introduce the following costs. Visiting the physical shop involves cost $s \in \left(0, +\infty\right)$, which includes the opportunity cost of the time spent, and associated expenses like driving. Visiting a Web site involves cost $s - D_s$, which includes the opportunity cost of the time spent, and associated expenses like phone calls and Internet fees, and where $D_s \in \left(0, s\right)$ is the *search cost reduction* induced by the new technology. Waiting for delivery of a product bought from a virtual shop involves cost d, that results from deferring consumption. Searching Web sites is instantaneous, a consumer may observe any number of prices, and may at any time accept any offer received to date. Let $S(p) := \int_p^\infty D(t)\,dt$. The surplus of a consumer that buys from a type t shop at price p_t is $S(p_t) - u_t$, where $u_t = s$ if $t = p$, and $u_t = d$ if $t = vn, vo$. Let $DS := S(\widehat{p}_v) - S(\widehat{p}_p)$.

Old consumers, and new consumers when $a = \left(0,0\right)$, visit the physical shop, and if offered a price $p \leq r$ buy and receive the product, getting a surplus of $S(p) - s$. When $a \neq \left(0,0\right)$, new consumers first visit a Web site chosen at random: **(H.1)**.[27] Then, they decide if they accept the best offer at hand and terminate search; or if they reject it, retaining the option to recall it later, and visit one of the other shop's Web sites. If new consumers have visited all shops, they accept the offer with the highest surplus.

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[27] This first step is usually absent in the search literature since it is assumed that consumers get their first price observation for free.

A consumer's ***information set*** just after his k-th search step consists of all previously observed prices. A consumer's stage 3 ***strategy***, s, is a stopping rule, that for any sequence of observations, says if search should stop or continue. A consumer's ***payoff*** is the expected consumer surplus, net of the search expenditure.

A subgame perfect Nash ***Equilibrium*** is: a stopping rule for new consumers, and an opening and a pricing rule, for each shop and firm type, $\left\{\left(a_j^*, p_t^*, s^*\right) j = n, o; t = vn, vo, p\right\}$, such that:

(E.0) Given any a and p_t, new consumers choose s^* to maximize net expected surplus;

(E.1) Given any a, and s^*, firms choose p_t^* to solve problems: $max_{p_{vn}} V^n$ and $max_{\{p_{vo}, p_p\}} V^o$;

(E.2) Given s^* and p_t^*, firms choose a_j^* to solve problem: $max_{a_j} V^j$.

Next we characterize the new consumers equilibrium search behavior for $a \neq (0,0)$.

When $a = (1,0)(0,1)$, new consumers' search may involve 3 steps. In step 3 consumers know both prices and the optimal strategy is to accept p_t if $S(p_t) - u_t \geq S(p_{t'}) - u_{t'}$. In step 2, a consumer who was offered p_t at the shop he choose to visit at random in step 1, gains $\left[S(p_{t'}) - u_{t'} - S(p_t) + u_t\right]$ by searching. Search is optimal if and only if $s - D_s < \left[S(p_{t'}) - u_{t'} - S(p_t) + u_t\right]$. Let $r_t^{a_n a_o}$ equate the marginal search cost, $s - D_s$, to the marginal benefit when firms play (a_n, a_o) in stages 1:

$$\left[S(p_{t'}) - u_{t'} - S(\rho_t^{a_n a_o}) + u_t\right] = \sigma - \Delta_\sigma \qquad t' \neq t \tag{1}$$

The new consumers' optimal search rule is to accept offer p_t and terminate search, if $p_t \leq r_t^{a_n a_o}$, and reject offer p_t and proceed to step 3, if $p_t > r_t^{a_n a_o}$.[28] Equation (1) defines implicitly reservation price function $r_t^{a_n a_o} = R_t^{a_n a_o}(.)$, which is increasing in $p_{t'}$. Also, $R_t^{a_n a_o}(p_p, s, D_s, d)$, $t = vn, vo$, are increasing in s, and decreasing in D_s and d, and $R_p^{a_n a_o}(p_t, D_s, d)$, $t = vn, vo$, is increasing in d, and decreasing in D_s. It is straightforward to show that the maximum price for which new consumers accept the physical shop's offer in step 3 is strictly smaller than r_p^{10}. Thus the

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[28] See Reinganum (1979) or Benabou (1993).

physical shop cannot charge a price higher than r_p^{10}, expecting that it will be rejected in step 2, but accepted in step 3.

If $p_{vn}^* = p_{vo}^*$, $r_{vn}^{10} = r_{vo}^{01}$.

The next lemma establishes the parameter restrictions required for $r_p^{a_n a_o} < \widehat{p}_p$ and **(H.2)**.

Lemma 2: (i) If $D_s < d$, then $p_t < r_p^{a_n a_o}$, $t = vn, vo$. **(ii)** If $d < 2s - D_s$, then $p_p < r_t^{a_n a_o}$, $t = vn, vo$. **(iii)** If

$d < DS + D_s$, then $r_p^{a_n a_o} < \widehat{p}_p$.   §

From **Lemma 2: (i)-(ii)**, **(H.2)** follows from search and waiting for delivery being costly. Since new consumers have access to lower cost shops, and from **Lemma 2: (iii)** if waiting for delivery is not too costly, new consumers only accept buying from the physical shop for a lower price than old consumers: $r_p < \widehat{p}_p < r$. From now on let $d \in \left(D_s, D_s + \min\{DS, 2(s - D_s)\}\right)$.

When $a = (1, 1)$, new consumers' search may consist of 4 steps. Steps 3 and 4 are similar to steps 2 and 3 of the previous 2 cases. In step 2, there are 2 Web sites to sample. Let $S(p_{t''}) - u_{t''} < S(p_{t'}) - u_{t'}$. If $S(p_t) - u_t < S(p_{t''}) - u_{t''}$, a new consumer who is offered p_t, gains $\left[S(p_{t'}) - u_{t'} - S(p_t) + u_t\right]$ by sampling shop t', and gains $\left[S(p_{t''}) - u_{t''} - S(p_t) + u_t\right]$ by sampling shop t''. If $S(p_{t''}) - u_{t''} \le S(p_t) - u_t < S(p_{t'}) - u_{t'}$, new consumers' expect to gain $\left[S(p_{t'}) - u_{t'} - S(p_t) + u_t\right]/2$ by searching, since they reject shop t'''s offer. The optimal search rule is to hold reservation price r_t^{11} which equates the marginal benefit to the marginal cost:

$$\begin{cases} \dfrac{1}{2}\left[S(p_{t'}) - u_{t'} - S(\rho_t^{11}) + u_t\right] + \dfrac{1}{2}\left[S(p_{t''}) - u_{t''} - S(\rho_t^{11}) + u_t\right] = \sigma - \Delta_\sigma & \Leftarrow \ S(r_t^{11}) - u_t < S(p_{t''}) - u_{t''} \\[2mm] \dfrac{1}{2}\left[S(p_{t'}) - u_{t'} - S(\rho_t^{11}) + u_t\right] = \sigma - \Delta_\sigma & \Leftarrow \ S(p_{t''}) - u_{t''} \le S(r_t^{11}) - u_t < S(p_{t'}) - u_{t'} \end{cases} \tag{2}$$

Equation (2) also defines implicitly reservation price function $R_t^{11}(.)$, which is non-decreasing in $p_{t'}$ and $p_{t''}$. As before, is straightforward to show that the maximum price for which new consumers accept the physical shop's offer, is smaller in step t than in step $t+1$, $t = 2, 3$. Lemma 2 holds, and if $s < \left(S(\widehat{p}_p) + D_s\right)/2$, in equilibrium consumers always have a strictly positive net surplus.

Equilibrium prices are as in section 3 and **Proposition 5** holds.

We conclude this section by explaining the role of the assumptions that consumers do not know beforehand to which type of shops the Web sites correspond, that the physical shops has a Web site, and that when there are virtual shops, new consumers must canvass prices through the Web. In Reinganum (1979) and Benabou (1993), firms have different costs, play pure strategies, and consumers do not know the firms' costs c. Thus, although consumers know the firms' equilibrium price rule $p^*(.)$, they do not know the firms' equilibrium prices $p^*(c)$, and have to search to learn them. In our model consumers know (c_p, c_v). Thus, the first 2 assumptions ensure that meaningful search occurs. Alternatively, consumers could not know (c_p, c_v). This would mean developing a more complicated incomplete information game. If when there are virtual shops, we allow new consumers to choose weather to canvass prices through the Web, the *Competing* Equilibrium becomes non-generic, unless we also make new consumers heterogeneous with respect to e.g., d, which has an expository cost. Finally, although these assumptions are intended to ensure meaningful search in a simple setting, they are not without justification, since as we argue in footnotes 9 and 10, some consumers in some markets behave similarly.

7 Information Goods

In this section we discuss the price equilibria for the case where $d = 0$ and reservation prices are endogenous. We argue that for this case virtual shops' prices may be higher than the physical shop's price.

Restriction $0 < D_s < d$, potentially rules out information goods, for which d is small, possibly zero. So assume $d = 0$. From (1), $R_p^{a_n a_o}(p_t, s, D_s, d) < p_t$, $t = vn, vo$. **Lemma 2: (ii)** and **(iii)** holds.

Equilibrium prices are as in section 3, with an important difference. When $a = (1,0)$ and $p_o^s < r_p$, or $a = (1,1)$ and $p_m^s < r_p$, if $0 < D_s < d$, $p_t^* = \hat{p}_v < r_p = p_p^*$, whereas if $d = 0$, $p_p^* = r_p < \hat{p}_v = p_t^*$, $t = vn, vo$. If buying from a virtual shop is more convenient than buying from a physical shop, the physical shop must charge a lower price than virtual shops to sell to new consumers.

Case $d = 0$ illustrates an intuitive point. Functionally identical goods sold through different retailing technologies, acquire different attributes. E-commerce reduces prices through the *Price Competition* and *Cost Reduction* effects. If in addition consumers value negatively e-commerce's attributes, relative to those of other

retailing technologies, consumers will only buy on-line if compensated by lower prices, which pushes prices further down. If, however, consumers value positively e-commerce's attributes, they will pay for the convenience of buying on-line, and the net effect can be such that prices are higher on-line than off-line.

8 The Model's Predictions and Observed Behavior

In this section we argue that the model explains observed behavior both across industries and countries.

The model explains the wider spread of e-commerce in the book and stockbroking retail industries, and allows a characterization of those sectors for the USA. For those industries the search cost reduction is large, since product information is easy to digitalize and communicate, and the production cost reduction is also large, since the delivery costs are low, and the savings on property, labor and inventory costs are big.

In the book retailing industry, new firms, like Amazon, adopted e-commerce before old firms, like Barnes & Noble and Borders. Brynjolfsson & Smith (1999) find that prices average 9-16% less on virtual shops than on physical shops that old firms' virtual shops charge 8.7% more than new firms' virtual shops, and that on-line the price range is 33% of the average price[29]. And recently, Barnes & Noble and Borders matched within hours an Amazon 50% discount on best sellers on their virtual, but not on their physical shops (*The New York Times*, May 18, 1999). This suggests that old firms compete with new firms for new consumers on their virtual shops, but not on their physical shops, i.e., that the industry is at a *Segmentation* equilibrium**.**

In the stockbroking retail industry, new firms, like Ameritrade and E*trade, also adopted e-commerce before old firms, like Charles Schwab. Off-line prices have been much higher that on-line prices, but are falling. Last year Charles Schwab lowered the off-line clients' charge from $65 to $30 to match the on-line fee (*New York Times*, August 16, 1999). This suggests a change from a *Segmentation* equilibrium, with old firms not competing for new consumers on their physical shops, to a *Competing* equilibrium, with old firms lowering their physical shop's prices to compete for new consumers. This change could explained by a raise in the proportion of new consumers (**Proposition 2: (ii))**.

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[29] Other empirical studies are: Brown & Goolsbee (2000), Clemons, Hann & Hitt (1999), Friberg, Ganslandt & Sandstrom (2000), and Morton, Zettekmeyer & Risso (2000).

The next two cases are further examples of physical shops lowering prices to compete for new consumers. In the USA, where in 1998, 30% of car purchase involved some use of the Internet (*The Economist*, May 22, 1999), according to Chrysler's ex-chairman, Bob Eaton, buyers use virtual dealers, like CarDirect.com, not only to buy cars but also to get information, that allows them "to bully better buys out of their local dealers" (*The Economist*, February 14, 1998). In Hong Kong, the launching of adM@art, a virtual grocery firm, "triggered a bruising supermarket price war" (*The Economist*, September 18, 1999).

Finally, the model explains the wider development of e-commerce in the USA than in Europe or Japan[30]. First, in the USA, the proportion of new consumers is larger, because the Internet is more widely spread[31], and there is a tradition of catalogue shopping. Second, the search and production cost reductions are larger in the USA, because, e.g., the telecommunications and postal distribution sectors are more competitive. Third, the setup cost of the new technology is lower in the USA because the number of firms selling e-commerce technology is larger, and because it is easier to access venture capital.

9 Related Literature

This section inserts the paper on the literature. Our paper relates to 3 literature branches. First, to the e-commerce marketing literature: Alba, Lynch, Weitz, Janiszewski, Lutz, Sawyer & Wood (1997), Bakos (1997), Lal & Sarvary (1998), Peterson, Balasubramanian, & Bronnenberg, (1997), Zettelmeyer (1997). Bakos (1997) presents a model of circular product differentiation, where consumers search for prices and product characteristics, i.e., locations. All consumers have Internet access. If search costs for price and product information are separated, and if e-commerce lowers the former, prices decrease; if it lowers the latter, prices can increase.

Second, our paper relates to the literature that analyzes competition between alternative retailing technologies: Balasubramanian (1998), Bouckaert (2000), Friberg, Ganslandt & Sandstrom (2000), Michael (1994). Balasubramanian (1998) and Bouckaert (2000) use a model of circular product differentiation to analyze competition between catalogue and physical shop retailing. Physical shops are located on the circumference, and catalogue firms

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[30]On 1998, Europeans spent $650 million on the Internet, and Japanese $500 million, while USA consumers spent $5 billion during the holiday season alone (*The New York Times*, April 26, 1999, and *The Economist*, August 7, 1999).

[31] In the US 26.30% of the population use the Internet, while only 6.90% of the population of OCDE's other countries does (*El Pais*, July 12, 1999, *Source*: UN).

at the center of the circle. The presence of a catalogue firm lowers prices, and the number of physical shops in the market.

Third, our paper relates to the advertising and markets for information literatures: Baye & Morgan (1998), Caillaud & Jullien (2000), Iyer & Pazgal (2000), Kephart & Greenwald (1999). Baye & Morgan (1998) examine the interaction between markets for information and the product market they serve. They show that the product market can exhibits price dispersion even if consumers are fully informed. Kephart & Greenwald (1999) investigate the impact of shopbots on markets. Shopbots allow users to choose the number of searches, and make search cost depend only weakly on the number of searches, i.e., nonlinear, leading to a more extensive search.

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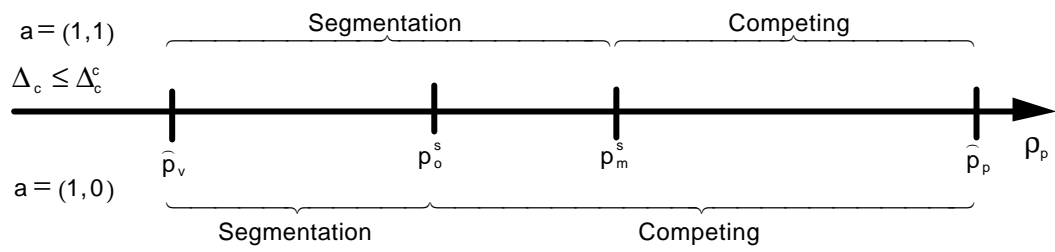
Figure 1: Price Equilibria

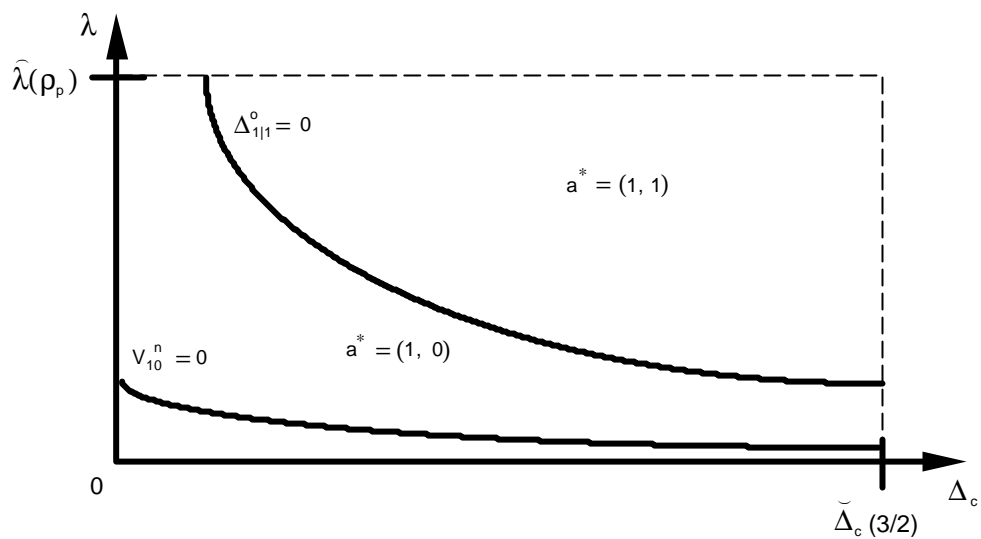**Figure 2 (i) : Opening of Virtual Shops Equilibrium Profiles**

λ

$\widehat{\lambda}(\rho_p)$

$\Delta^o_{1|1} = 0$

$a^* = (1, 1)$

$V^n_{10} = 0$

$a^* = (1, 0)$

0

Δ_c

$\breve{\Delta}_c \, (3/2)$

Figure 2 (ii) : Opening of Virtual   Shops Equilibrium   Profiles

λ

1

$V^n_{10} = 0$

$\Delta^o_{1|1} = 0$

$a^* = (1, 1)$

$a^* = (1, 0)$

$a^* = (0, 1)$

$\Delta^o_{1|0} = 0$

$\widehat{\lambda}(\rho_p)$

Δ^c_c

c

Δ_c
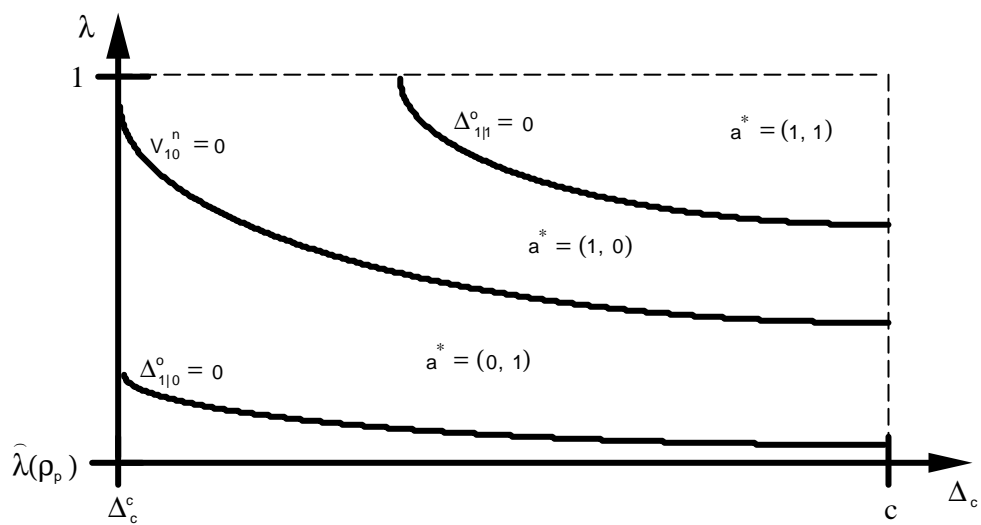
Figure 3: Cost Asymmetry
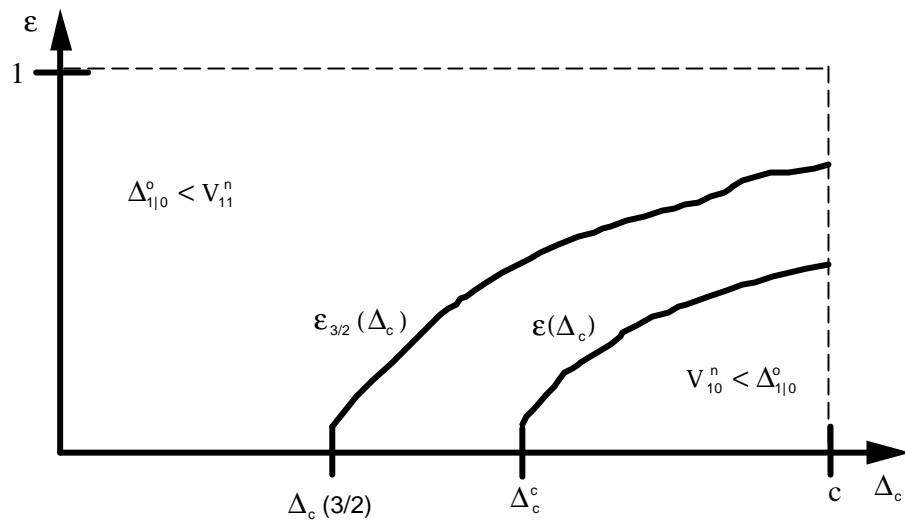
Table 1: Summary of Model's Price Equilibria

a			p_p^*	Share vn	Share vo	Share p	Equilibrium
$(1,0)$	$p_o^s < r_p$		r_p	*1/2*	–	*1/2 + 1 − 1*	*Competing*
	$r_p \le p_o^s$		$\widehat{p}_p$	*1*	–	*1 − 1*	*Segmentation*
$(0,1)$	–		$\widehat{p}_p$	–	*1/2*	*1 − 1*	*Segmentation*
$(1,1)$	$D_c \le D_c^c$	$p_m^s < r_p$	r_p	*1/3*	*1/3*	*1/3 + 1 − 1*	*Competing*
		$r_p \le p_m^s$	$\widehat{p}_p$	*1/2*	*1/2*	*1 − 1*	*Segmentation*
	$D_c^c < D_c$		$\widehat{p}_p$	*1/2*	*1/2*	*1 − 1*	*Segmentation*