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Why Competition from a Multi-Channel E-Tailer Does Not Always Benefit Consumers

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ABSTRACT

Empirical studies have delivered mixed conclusions on whether the widely acclaimed assertions of lower electronic retail (e-tail) prices are true, and to what extent these prices impact conventional retail prices, profits and consumer welfare. For goods that require little in-person pre- or post-sales support such as CDs, DVDs, and books, we extend Balasubramanian's (1998) e-tailer-in-the-center of a circular spatial market model to examine the impact of a multi-channel e-tailer presence on retailers' decisions to relocate, on retail prices and profits, and on consumer welfare. We demonstrate several counter-intuitive results. For example, when the disutility of buying online and shipping costs are relatively low, retailers are better off by not relocating in response to an e-tailer's entry into the retail channel. In addition, such an entry – a multi-channel strategy – may lead to increased retail prices, and increased profits across the industry. Finally, consumers can be better off with less channel competition. The underlying message is that inferences regarding prices, profits, and consumer welfare critically depends on specifications of the good, of disutility and shipping costs versus transportation costs (or more generally, positioning), and of competition.

Keywords: Channels, E-Commerce, Pricing.

INTRODUCTION & BACKGROUND

Since the commercialization of the Internet, e-commerce has captured the attention of researchers and businesses alike. Business to consumer e-tailing promised competitively determined, convergent prices that could improve profits and consumer welfare. However, the impact of on-line prices on retail prices, profits and consumer welfare is not clear, in part because competition now includes e-tailing as part of multi-channel retailing strategies. In this research we ask whether such a multi-channel strategy helps to heighten or suppress the expected impact of e-commerce on retail prices, profit, and welfare.

Research has shown that prices are influenced by those in nearby markets (Asplund & Sandlin, 1999). Moreover, even online, or e-tail, sales are affected by the proximity of retailers (Forman, Ghose, and Goldfarb, 2009). Intuitively, e-tail prices should exert downward pressure on retail prices, as they in turn converge (Goolsbee, 2001). Indeed, many well-known studies hail the Internet as a catalyst for reduced prices. For example, Brynjolfsson and Smith (2000) showed that e-tail prices for books were 9% – 16% lower than retail prices, and lower e-tail prices have also been found for cars (Scott-Morton, Zettelmeyer, and Silva-Russo, 2001) and CDs (Lee, Lee, Chang and Lee, 2003). E-tail prices for personal computers (Goolsbee, 2001) and books (Chevalier & Goolsbee, 2003) were found to be sensitive to offline prices, showing that retailers and e-tailers compete directly. Tang and Xing (2001) found that price dispersion was lower among e-tailers compared to multi-channel retailers for DVDs. Moreover, Xing, Yang and Tang (2006) found multi-channel retailers charge higher prices for DVDs than e-tailers. Similar conclusions are echoed in other empirical studies (e.g., Brown & Goolsbee, 2002; Venkatesan, Metha, and Bapna, 2006).

However, many studies show that e-tail prices are not always lower than retail prices and do not necessarily converge. Clay, Krishnan, Wolff and Fernandez (2002) found similar average prices for books online as at retailers, with substantial dispersion online. Clemons, Hahn and Hitt (2002) found that airline ticket prices vary by as much as 18% online, Baylis and Perloff (2002) found price dispersion in cameras and scanners online, as did Baye, Margan and Scholten (2004) for a range of consumer products. Research on software and personal digital appliances concluded that firms can avoid price competition by selling a wider variety

of products (Bailey, Faraj, and Yuliang 2007). Ancarani and Shankar (2004) showed that for a variety of products, inclusion of shipping costs resulted in multi-channel retailers having the highest prices, followed by e-tailers and retailers. Finally, some research shows instances where e-tail prices are higher than retail prices (Ancarani, 2002; Le Blanc & Folkman Curasi, 2002; Schmitz & Latzer, 2002). A good review can be found in Xing, Ratchford and Shankar (2004).

Our Focus

We consider a market for goods that require little in-person pre- or post-sales support, so that proximity to a retailer is relatively unimportant for e-tail sales. Examples include CDs, DVDs, and books. Our model begins with a baseline market configuration of two retailers and an e-tailer as in Balasubramanian's (1998) model. From this baseline we address competition in the e-tail channel, and after an e-tailer enters the retail channel. The results of this latter analysis depend on whether retailers relocate. If they do not relocate – it is too costly or it is not profitable to do so – then there are three equilibrium cases. We solve for equilibrium retail and e-tail prices, retailers' and e-tailer's profits, and total costs to consumers - our measure of consumer welfare - for each market configuration.

The critical determinant of prices, profits and consumer welfare in each market configuration is the ratio of the e-tail transaction costs relative to the unit transportation cost, a measure we call the “e-tail cost ratio.” E-tail transaction costs capture the disutility of purchasing online – including limitations in fully assessing the product before purchase - as well as shipping and handling costs. The alternative to purchasing through the e-tail channel is physically traveling to the retailer at a unit transportation cost times the distance traveled. Thus, the nature of the good is manifest in the e-tail cost ratio: a low e-tail cost ratio is indicative of more homogeneous goods (books, CDs, etc.), as opposed to goods whose quality may be more difficult to assess (e.g., prepackaged Omaha steaks).

Our main findings are deduced from a comparison of the results obtained from the different market configurations and can be summarized as follows: first, if retail relocation is costly and the e-tail cost ratio is low, then retailers should not relocate in response to an e-tailer

entering the retail channel. A low e-tail cost ratio means that the e-tail channel is the main competition faced by each retail outlet, and relocation does not mitigate that threat. Second, there are several conditions under which an e-tailer in the retail channel increases retail prices. Intuitively, retail prices should fall with additional retail locations, but this expected outcome is confounded with the e-tailer's multi-channel price-setting strategy. Third, and related to the retail price results, industry profits can increase as a result of an e-tailer's entry into the retail channel. Finally, we find conditions under which consumers are better off with less competition in retail locations.

Although our model is based in part on the physical location of retailers and is restricted to goods that require little pre- and post-sales service, the application of our model, and the implications of the results, is broader. Rather than physical location, location could be considered as combinations of customer service features or other dimensions over which consumers have heterogeneous preferences. With this interpretation retail location and relocation are choices of positioning, and our results continue to apply within this context.

We proceed by first outlining the structure of our model and solve for prices, profits and consumer costs in each of the various market configurations detailed above. Then we present our main results in a series of theorems. We finish with conclusions summarizing the results.

THE MODEL

Our model setting is a circular spatial market of the type analyzed by Salop (1979) with a continuum of consumers, $x \in [0, 1]$ spread uniformly around a unit circumference. Each consumer is in the market for one unit of the good, consumption of which yields utility $U \in \mathcal{R}^+$, that we assume is large enough so that demand is inelastic and retailers compete for their business. All transportation occurs along the circle and is subject to a unit cost $t \in \mathcal{R}^+$. All customers have access to information regarding prices. The consumers' objective is to maximize their utility, which, with inelastic demand, is equivalent to minimizing the sum of the transportation cost incurred, tx , plus the price paid for the good, p_r .

Retailers operate brick-and-mortar outlets selling identical products with marginal cost

normalized to zero. Each retailer is aware of the other’s offering price, and face a fixed entry cost $f \in \mathcal{R}^+$. To make our analysis more tractable, we assume that $4 \leq t/f < 9$ which in the basic Salop model results in an equilibrium with two retailers (Tirole, 1988) when necessary. We index these conventional retailers by $r \in \{A, B\}$. In this circular setting, each retailer gains by locating as far as possible from competitors (De Frutos, Hamoudi, and Jarque, 1999), hence our location of the two retailers at opposite sides of the circle (Figure 1). In a stylized model of this type the precise measurement of t/f is not obvious because of the way the parameters are scaled – the issue is that the relationship between transportation costs and entry costs determines the number of retailers in Salop’s model. The qualitative characteristics of our results extend to a Salop model that begins with different numbers of retailers.

Our starting point is Balasubramanian’s (1998) model where we assume the market is in equilibrium with two retailers and sunk entry costs, and an e-tailer that competes with each retailer. We then model the following sequence of actions: (i) retailers decide whether to enter the e-tail channel, (ii) the e-tailer decides whether to enter the retail channel, and (iii) retailers decide whether to relocate in response to e-tailer entry into the retail channel.

Our Starting Point: Balasubramanian’s 1998 Model

Balasubramanian’s model setup is Salop’s model in equilibrium, in which each retailer has a fixed position at equal distance from each other on the circumference and an e-tailer is sited at the virtual center with equal access to the entire market. The e-tailer offers the identical good to consumers at an effective price of $p_e + \mu$, where the e-tail price is p_e and $\mu \in \mathcal{R}^+$ is the e-tail transaction cost that does not vary with distance. It includes shipping and handling costs and could also capture a disutility cost of purchasing electronically. The location of a consumer that is indifferent between purchasing from the e-tailer or a retailer is determined by the indifference equation $p_e + \mu = p_r + tx$, giving the indifferent consumer’s distance away from a retailer as $x = [p_e - p_r + \mu]/t$. Consumers closer to a given retailer than x purchase from that retailer, while those further away purchase from the e-tailer. Figure 1 shows the two-retailer Balasubramanian model.

The e-tailer's and retailers' market shares are respectively $m_e = 1 - 4x$ and $m_r = 2x$. Each retailer's profit maximization problem is

$$\max_{p_r} \pi_r = \max_{p_r} \left\{ p_r \left[2 \frac{p_e - p_r + \mu}{t} \right] \right\}, \quad (1)$$

and the e-tailer's profit maximization problem is

$$\max_{p_e} \pi_e = \max_{p_e} \left\{ p_e \left[1 - 4 \frac{p_e - p_r + \mu}{t} \right] \right\}$$

assuming no e-tail entry costs. The resulting e-tail and retail Nash equilibrium prices are

$$p_e^b = t/6 - \mu/3 \quad \text{and} \quad p_r^b = t/12 + \mu/3, \quad (2)$$

where we use the superscript b to indicate Balasubramanian's model. Defining the e-tail cost ratio as μ/t , the e-tail price is positive only if

$$\mu/t < 1/2,$$

and we restrict our attention to this case for the remainder of the analysis. At the prices in Equation (2) the indifferent consumer is located at $x = 1/12 + \mu/3t$. Each retailer's market share is $m_r = 1/6 + 2\mu/3t$ and the e-tailer's market share is $m_e = 2/3 - 4\mu/3t$. Profits are

$$\pi_r^b = [t + 4\mu]^2/72t \quad \text{and} \quad \pi_e^b = [t - 2\mu]^2/9t. \quad (3)$$

The total cost to consumers is made up of profits plus the costs of transportation and disutility. Leaving the algebra for Appendix A this total cost is

$$\omega^b = \frac{11t^2 + 40\mu t - 16\mu^2}{72t}. \quad (4)$$

The retail price is higher than the e-tail price when $\mu/t > 1/8$. For the e-tailer, prices are decreasing in μ , while for the retailer prices are increasing in μ . When $\mu = 0$, the e-tailer's market share is $2/3$, leaving $1/3$ of the market to be shared between the two retailers. Both the e-tailer's, and the retailers' prices are increasing in t , since increasing transportation costs implies increased differentiation in the market, which makes consumer response less elastic. Facing e-tail competition, the retailer's price is always lower than otherwise, and thus all consumers are better off with competition from an e-tailer.

Retailers Decide Whether To Go E-Tail

One response retailers may choose when faced with competition from an e-tailer is to enter the e-tail channel. Without differentiation, outcome of competition in the e-tail channel is a unique equilibrium in which each charge marginal cost through the e-tail channel, which, with marginal costs normalized to zero, yields $p_e^c = 0$, where the superscript c indicates e-tail competition. Consequently there are zero e-tail profits. This is the classic Bertrand Paradox whereby, with undifferentiated competition, prices fall to marginal cost.

Marginal cost e-tail prices as a result of either or both retailers entering the e-tail channel diminishes retail profits in all of our subsequent market configurations. Because all retail prices are affected by price competition from the e-tail channel, firms are better off avoiding direct competition (Judd, 1985; Bahn & Fischer, 2003). Consequently, any market configuration that follows from a retailer entering the e-tail channel cannot be reached in equilibrium.

The E-Tailer Decides Whether To Go Retail

An additional strategy for the e-tailer is to enter the retail channel. An example of this is in the personal computer industry where both Apple and Gateway expanded into the retail channel around 1997 (Prince, 2007). Since then Dell and others have expanded into existing retail stores like Best Buy. The outcome of the e-tailer's retail presence depends in part on whether the retailers can relocate. Our analysis proceeds by considering the subsequent outcomes depending on whether retailers can relocate. We solve for and compare prices, profits and welfare resulting from each possible market configuration given our model's constraints.

Retailers relocate

When retailers can relocate, the analysis proceeds in two stages: first, retailers decide where to relocate, and then the e-tailer, the e-tailer's retail outlet, and retailers compete in prices. We examine these in reverse order. The price competition in the latter stage also arises if

there were initially three retailers, and one was first to enter the e-tail channel.

Stage 2: Retail relocation

The critical issue in examining what occurs when retailers relocate is whether they compete (i) with each other, (ii) with the e-tailer's retail outlet, or (iii) with the e-tailer. The following lemma shows that if the e-tail channel has positive market share, then the retailers and the e-tailer's retail outlet all compete with the e-tail channel. Proofs are available in Appendix A.

Lemma 1: Retail relocation is such that either (a) both retailers and the e-tailer's retail outlet compete with the e-tail channel, or (b) the e-tail channel has no market share, and the e-tailer's retail outlet and retailers compete.

Taking the e-tail cost ratio, μ/t , to be small enough so that the e-tail channel has positive market share, the consequence of Lemma 1 is that relocation serves to distance the retailers from the e-tailer's retail outlet and from each other so that they all compete with the e-tail channel. Indeed, there is no unique optimal relocation point for retailers - avoiding direct competition with other retail outlets is the crucial element of their relocation strategy. With two retailers in the model set-up, using results from Balasubramanian (1998), as μ/t becomes large such that $\mu/t \rightarrow 1/2$ the e-tail price becomes zero, and consequently any fixed cost of entry is too large for the e-tailer's retail outlet to be launched profitably.

Stage 1: Prices

Assume for the moment that the e-tail channel retains a positive market share after e-tailer entry into the retail channel and the retailers' relocation. Figure 2 depicts when the two retailers and the e-tailer's retail outlet locate equidistantly from each other. The consumer indifferent between purchasing from a retailer or through the e-tail channel is defined by $p_r + tx = p_e + \mu$, giving $x = [p_e - p_r + \mu]/t$. Because the e-tailer's retail outlet is also competing against its e-tail channel, the consumer that is indifferent between purchasing from the e-tailer's retail outlet and the e-tail channel is determined by $p_{er} + ty = p_e + \mu$, where $y = [p_e - p_{er} + \mu]/t$ represents the distance away from the e-tailer's retail outlet.

Each retailer's market share is $m_r = 2x$, the e-tailer's retail market share is $m_{er} = 2y$,

and the e-tail portion of the market is defined as unity, less the sum of the two retailer's shares and the e-tailer's retail share: $m_e = 1 - 2m_r - m_{er} = 1 - 4x - 2y$. The e-tailer's profit maximization problem is now

$$\max_{p_e, p_{er}} \pi_e = \max_{p_e, p_{er}} \left\{ p_e \left[1 - 4 \frac{p_e - p_r + \mu}{t} - 2 \frac{p_e - p_{er} + \mu}{t} \right] + p_{er} \left[2 \frac{p_e - p_{er} + \mu}{t} \right] \right\}. \quad (5)$$

The two first-order conditions are

$$\frac{\partial \pi_e}{\partial p_e} = t - 12p_e + 4p_r + 4p_{er} - 6\mu = 0 \quad \text{and} \quad \frac{\partial \pi_e}{\partial p_{er}} = 4p_e - 4p_{er} + 2\mu = 0, \quad (6)$$

where the latter equation can be more usefully written as $p_{er} = p_e + \mu/2$. Because each retailer's market share is determined by the same indifference equation as in Balasubramanian's model, each retailer's profit maximization problem is the same as Equation (1), and the first-order condition yields

$$p_r = [p_e + \mu]/2. \quad (7)$$

Substituting these two prices into Equation (6) we can solve for p_e , and then for the remaining prices. Using superscript r to indicate the case when the retailers relocate, this yields

$$p_e^r = t/6 - \mu/3, \quad p_{er}^r = t/6 + \mu/6 \quad \text{and} \quad p_r^r = t/12 + \mu/3. \quad (8)$$

The e-tail and retail prices are the same as in Balasubramanian's model. Consequently, each retailer's market share and profit remains as before (see Equation (3)).

Prices from Equation (8) give $x = 1/12 + \mu/3t$ (same as Balasubramanian's model) and $y = \mu/2t$. For there to be positive e-tail market share requires $m_{er} + 2m_r = 2y + 4x < 1$. Using Equation (8) to find the values for x and y implies that

$$\mu/t < 2/7 = .2857. \quad (9)$$

Thus, Equation (9) defines the range of the e-tail cost ratio where there is a positive e-tail market share.

For the e-tailer, profits are

$$\pi_e^r = p_e^r m_e + p_{er}^r m_{er} = \frac{17\mu^2 - 8\mu t + 2t^2}{18t} = \frac{14\mu^2 - 11\mu t + 2t^2}{18t} + \frac{\mu}{6} \left[\frac{\mu}{t} + 1 \right], \quad (10)$$

where the terms on the right hand side of the last equality are from the e-tailer's e-tail and retail channels respectively. Comparing Equation (10) to the e-tailer's profit in Equation (3), the net gain in profit from the e-tailer's decision to go retail is $\mu^2/2t > 0$, meaning that it is individually rational for the e-tailer to enter the retail channel.

Leaving the algebra for Appendix A, the total cost to consumers is the sum of retail and e-tail profits, the e-tail transaction cost and transportation costs:

$$\omega^r = \frac{11t^2 + 40\mu t - 34\mu^2}{72t}. \quad (11)$$

Retailers do not relocate

Consider now when high relocation costs fix the retailers' locations. If the e-tailer enters the retail channel, then it must be sited in one of the two e-tail wedges (see Figure 3) in order to locate as far as possible from other retailers. There are three cases: Case 1, all retail outlets (including the e-tailer's) compete with the e-tail channel, Case 2, the e-tailer's retail outlet competes only with the retailers, or Case 3, the e-tailer's e-tail channel affects prices without directly competing with its retail outlet.

Case 1: All retailers compete with the e-tail channel

This first case is shown in Figure 3 - assuming that the e-tailer established its retail outlet in the lower portion. In this case all retailers, including the e-tailer's retail outlet, compete with the e-tail channel.

The consumer indifferent between purchasing from the e-tail channel or a retailer is defined by $p_r + tx = p_e + \mu$, or $x = [p_e - p_r + \mu]/t$. Similar to when retailers relocate, let y represent the customer that is indifferent between purchasing from the e-tail channel or the e-tailer's retail outlet, such that $p_{er} + ty = p_e + \mu$, giving $y = [p_e - p_{er} + \mu]/t$.

We assume for the moment that $x + y \leq 1/4$, that is, the e-tailer has a (weakly) positive e-tail market share in the lower half of Figure 3. The total e-tail market share is represented by the wedge on the upper half of Figure 3 and the two smaller segments between x and y on the lower portion, $m_e = 2[1/4 - x] + 2[1/4 - x - y] = 1 - 4x - 2y$. The e-tailer's retail

market share is $m_{er} = 2y$ thereby giving the e-tailer a total market share of $1 - 4x$. The e-tailer's profit maximization problem is

$$\max_{p_e, p_{er}} \pi_e = \max_{p_e, p_{er}} \left\{ p_e \left[1 - 4 \frac{p_e - p_r + \mu}{t} - 2 \frac{p_e - p_{er} + \mu}{t} \right] + p_{er} \left[2 \frac{p_e - p_{er} + \mu}{t} \right] \right\}, \quad (12)$$

which is identical to Equation (5). In addition, the retailers' profit maximization is the same as Equation (1), and the first order condition yields Equation (7). The same factors determine market share for the retailers and the e-tailer in this case as when the retailers can relocate; consequently, prices are as in Equation (8), retailer profits are the same as in Equation (3), and e-tailer profits are as in Equation (10). As before, the net gain to the e-tailer entering the retail channel is positive, so it is individually rational for the e-tailer to do so. Moreover, because the same proportions of consumers are covered by the two retailers, the e-tailer's retail outlet, and the e-tail channel, the total e-tail transaction cost and transportation costs are given by Equation (27) in Appendix A, and the total cost to consumers is given by Equation (11).

Consider the constraint $x + y \leq 1/4$. At the equilibrium prices in this case given by Equation (8) and Equation (10), this constraint is satisfied if

$$\mu/t \leq 1/5. \quad (13)$$

Thus, Equation (13) defines Case 1, and when this constraint is satisfied prices and profits are the same regardless of whether retailers can relocate.

Case 2: E-tailer's retail outlet competes directly with retailers

This case is depicted in Figure 4. There is no e-tail share in the lower half, and the e-tailer's retail outlet competes directly with the retailers, while the e-tail channel competes with the retailers in the upper portion of Figure 4.

In the upper portion of Figure 4, as before, the consumer that is indifferent between purchasing from the e-tail channel or from a retailer is defined by $p_r + tx = p_e + \mu$, giving $x = [p_e - p_r + \mu]/t$. In the lower portion of Figure 4 the consumer that is indifferent between purchasing from the e-tailer's retail outlet or a retailer is represented by z and is defined by $p_{er} + t[1/4 - z] = p_r + tz$, giving $z = [p_{er} - p_r]/2t + 1/8$. For the e-tail channel to have no

market share in the lower portion of Figure 4, the cost at z of purchasing from the e-tail channel must be (weakly) greater than the cost of purchasing from either retailer, or the e-tailer's retail outlet:

$$p_{er} + t[1/4 - z] = p_r + tz \leq p_e + \mu. \quad (14)$$

With these definitions we can write the three market shares as $m_r = x + z$, $m_e = 1/2 - 2x$, and $m_{er} = 1/2 - 2z$. For retailers the profit maximization problem is

$$\max_{p_r} \pi_r = \max_{p_r} \{p_r[x + z]\} = \max_{p_r} \left\{ p_r \left[\frac{p_e - p_r + \mu}{t} + \frac{p_{er} - p_r}{2t} + \frac{1}{8} \right] \right\},$$

and their first-order condition is

$$\frac{\partial \pi_r}{\partial p_r} = \frac{p_e - 3p_r + \mu}{t} + \frac{p_{er}}{2t} + \frac{1}{8} = 0. \quad (15)$$

For the e-tailer the profit maximization problem is

$$\begin{aligned} \max_{p_e, p_{er}} \pi_e &= \max_{p_e, p_{er}} \{p_e M_e + p_{er} M_{er}\} = \max_{p_e, p_{er}} \left\{ p_e \left[\frac{1}{2} - 2x \right] + p_{er} \left[\frac{1}{2} - 2z \right] \right\} \\ &= \max_{p_e, p_{er}} \left\{ p_e \left[\frac{1}{2} - 2 \frac{p_e - p_r + \mu}{t} \right] + p_{er} \left[\frac{1}{2} - 2 \frac{p_{er} - p_r}{2t} - \frac{2}{8} \right] \right\}. \end{aligned}$$

The two first-order conditions are

$$\frac{\partial \pi_e}{\partial p_e} = \frac{1}{2} - \frac{4p_e - 2p_r + 2\mu}{t} = 0 \quad \text{and} \quad \frac{\partial \pi_e}{\partial p_{er}} = \frac{1}{4} - \frac{2p_{er} - p_r}{t} = 0. \quad (16)$$

Using the superscript $n2$ to denote this second case when retailers cannot relocate, solutions to the three first-order conditions in Equation (15) and Equation (16) give the following prices

$$p_e^{n2} = 7t/36 - 7\mu/18, \quad p_{er}^{n2} = 7t/36 + \mu/9 \quad \text{and} \quad p_r^{n2} = 5t/36 + 2\mu/9. \quad (17)$$

Prices from Equation (17) give $x = 1/18 + 7\mu/18t$ and $z = 11/72 - \mu/18t$.

The profits for the retailers and for the e-tailer are, respectively

$$\pi_r^{n2} = \frac{25t^2 + 80\mu t + 64\mu^2}{864t} \quad \text{and} \quad \pi_e^{n2} = p_e^{n2} m_e + p_{er}^{n2} m_{er} = \frac{49t^2 - 112\mu t + 136\mu^2}{432t} \quad (18)$$

Checking our constraint Equation (14) we have

$$\frac{7t}{24} + \frac{\mu}{6} \leq \frac{7t}{36} + \frac{11\mu}{18},$$

which simplifies to

$$7/32 \leq \mu/t. \quad (19)$$

The inequality in Equation (19) represents the upper limit of the e-tail cost ratio such that the e-tailer's retail outlet and e-tail channel do not directly compete, and defines the range over which Case 2 applies. With Equation (19), the net gain for the e-tailer from entering the retail channel is positive and it is rational for the e-tailer to enter.

Again leaving the algebra for Appendix A, the total cost to consumers is the sum of retail and e-tail profits, and the e-tail transaction cost and transportation costs:

$$\omega^{n2} = \frac{179t^2 + 304\mu t - 136\mu^2}{864t}. \quad (20)$$

Case 3: E-tail channel affects prices without gaining a share in lower portion of the market

Consider the constraints from Cases 1 and 2, that is Equation (13) and Equation (19). Combining those constraints leaves

$$1/5 \leq \mu/t \leq 7/32. \quad (21)$$

In this case - Case 3, the e-tail channel does not share in the lower portion of the market (Figure 3), although its e-tail prices can impact retail prices by providing consumers an alternative channel and price. This is analogous to the kinked equilibrium in the Salop (1979) model. To determine prices and profits based on μ/t in this interval, we reformulate the e-tailer's profits in Case 1 as a constrained optimization using a Lagrangian, where the market shares are as in Case 1, that is, $m_e = 1 - 4x - 2y$ and $m_{er} = 2y$:

$$\begin{aligned} \max_{p_e, p_{er}} L_e = & \max_{p_e, p_{er}} \left\{ p_e \left[1 - 4 \frac{p_e - p_r + \mu}{t} - 2 \frac{p_e - p_{er} + \mu}{t} \right] + p_{er} \left[2 \frac{p_e - p_{er} + \mu}{t} \right] \right. \\ & \left. + \lambda \left[\frac{1}{4} - \frac{p_e - p_r + \mu}{t} - \frac{p_e - p_{er} + \mu}{t} \right] \right\}, \end{aligned}$$

where the last term embeds the constraint $x + y \leq 1/4$. When the constraint is not binding we have the same problem as Equation (12). When the constraint is binding the first two necessary conditions are similar to Equation (6) but with an additional term from the constraint,

$$\frac{\partial L_e}{\partial p_e} = t - 12p_e + 4p_r + 4p_{er} - 6\mu - \frac{2\lambda}{t} = 0, \quad \frac{\partial L_e}{\partial p_{er}} = 4p_e + 2\mu - 4p_{er} + \frac{\lambda}{t} = 0,$$

and the third condition is $\partial L_e / \partial \lambda = 0$ which results in the constraint satisfied with equality. When this constraint is binding the relevant competing price for retailers is p_{er} , so we can use the retailers' first-order condition from Case 2, Equation (15), as the necessary condition for retailers to maximize profits. Using the superscript $n3$ to denote the case when the constraint $x + y \leq 1/4$ binds, the prices that result from these four equations are

$$p_e^{n3} = 7t/26 - 19\mu/26, \quad p_{er}^{n3} = 7t/52 + 5\mu/13 \quad \text{and} \quad p_r^{n3} = 2t/13 + 2\mu/13, \quad (22)$$

and the shadow price of the constraint is $\lambda = 32\mu t/13 - 7t^2/13$. The e-tail price, p_e^{n3} , is positive if $\mu/t < 7/19$, which is satisfied by the combined constraint Equation (21).

We can solve for market share and profits of the retailers and the e-tailer. As in Case 2, in the upper portion consumers are indifferent between a retailer and the e-tail channel at x , and in the lower portion between a retailer and the e-tailer's retail channel at z . The market share for the e-tail channel is $m_e = 1/2 - 2x$ and for the e-tailer's retail outlet it is $m_{er} = 1/2 - 2z$. Each retailer's market share is $m_r = x + z$. By substituting the results obtained in Equation (22), which are different from the prices that resulted in Case 2, we find $x = 11/26 - 41\mu/26t$ and $z = 3/26 + 3\mu/26t$.

The profits from the e-tail channel and e-tailer's retail outlet respectively are $(49t^2 - 175\mu t + 114\mu^2)/676t$ and $(49t^2 + 98\mu t - 120\mu^2)/1352t$. Together this yields a total profit of

$$\pi_e^{n3} = 3 \frac{49t^2 - 84\mu t + 36\mu^2}{1352t}. \quad (23)$$

With Equation (21) the net gain from entering the retail channel is positive, and it is rational for the e-tailer to do so. Each retailer's profit is

$$\pi_r^{n3} = \frac{6t^2 + 12\mu t + 6\mu^2}{169t}. \quad (24)$$

In Case 3, leaving the tedious algebra for Appendix A, the total cost to consumers is the sum of retail and e-tail profits, the e-tail transaction cost and transportation costs:

$$\omega^{n3} = \frac{1055t^2 - 4676\mu t + 15732\mu^2}{2704t}. \quad (25)$$

MAIN RESULTS

Our main results concern retail relocation, retail prices, profits, and consumer welfare - and all make use of the e-tail cost ratio, μ/t .

Retail relocation

When retailers do not relocate in response to the e-tailer's retail outlet, our three separate cases can be identified using the e-tail cost ratio:

- Case 1: The e-tail cost ratio is low ($\mu/t \leq 1/5 = .2$).
- Case 2: The e-tail cost ratio is high ($\mu/t \geq 7/32 = .2188$).
- Case 3: The e-tail cost ratio is moderate ($1/5 = .2 < \mu/t < .2188 = 7/32$).

Our first theorem states when retailers should choose not to relocate in response to an e-tailer's entry into the retail channel. Table 1 summarizes the profits and total cost to consumers from our earlier analysis.

Insert Table 1 Here

Theorem 1: When an e-tailer enters the retail channel and relocation costs are positive, if the e-tail cost ratio is less than .2623, then retailers should not relocate.

When the e-tail cost ratio is low, the e-tail channel is competitive even for consumers that are between retailers located relatively close to each other. Therefore, a retailer's location relative to the location of other retailers does not affect their profits so that relocation at any cost is not profit-maximizing. Moreover, even when the e-tail cost ratio is moderate or in the lower segment of high (less than .2623), profits are higher for retailers if they do not relocate, because the e-tail channel is a stronger competitive force than the location of the e-tailer's retail outlet. As we saw in the previous section, when the e-tail cost ratio is above .2857, from Equation (9) where retailers can relocate, e-tailer entry into the retail channel is not profitable, further limiting the e-tail cost ratio range where retailers should relocate.

In practice, if the e-tail cost ratio is in the range defined in Theorem 1, then it favors the e-tail channel to the extent that all retail outlets effectively compete with the e-tail channel rather than with each other, and relocation is not a profitable response.

If the e-tail cost ratio is low, then retail relocation also has implications for social welfare. This is given in the following corollary.

Corollary 1: When an e-tailer enters the retail channel and relocation costs are positive, if the e-tail cost ratio is less than .2, then it is social welfare maximizing for retailers not to relocate.

In Case 1 neither individual retail or e-tail profits, nor consumer costs, are positively impacted by relocation; thus, the relocation costs are a net loss of social welfare.

Retail prices

It is straightforward that competition in the e-tail channel causes retail prices to fall relative to Balasubramanian's model. Additional retail competition, however, does not always decrease prices. Our second theorem shows that under certain circumstances additional retail competition from an e-tailer in the retail channel can increase retail prices. Table 2 summarizes prices from our analyses.

Insert Table 2 Here

Theorem 2: If retailers relocate, then an e-tailer's retail outlet weakly increases retail prices. Otherwise, if the e-tail cost ratio is less than .2 (Case 1) or if it is between .2188 and .25 (subset of Case 2), then an e-tailer's retail outlet increases retail prices.

When there are no relocation costs for retailers, their response to retail entry by the e-tailer is to relocate and maintain their prices as before to compete with the e-tail channel. The e-tailer, however, sets its retail outlet price to compete with its e-tail channel price (see the bottom of Figure 2) and in this way is a multi-channel monopolist. As a result, the e-tailer charges a higher price at its retail outlet than retailers so that it may gain greater profit from those consumers whose next best alternative is to purchase from the e-tail channel. Therefore, compared to an e-tailer solely in the e-tail channel, retail prices

faced by consumers are the same for those closer to the retailers and are higher for those closer to the e-tailer's retail outlet.

If relocation costs are positive such that retailers do not relocate, then there are different cases to consider. If the e-tail cost ratio is low (Case 1), then the results are the same as when the retailers relocate (described above) - retail prices are the same as, and the e-tailer's retail outlet prices are higher than retail prices in the Balasubramanian model.

If the e-tail cost ratio is high (Case 2), then retail prices are higher than retail prices in the Balasubramanian model because competition on one end of each retailer's market is with the e-tailer's retail outlet rather than with the e-tail channel. If the e-tail cost ratio is high - but not too high - then prices at the e-tailer's retail outlet are higher than retail prices in the Balasubramanian model for the same reason - the e-tailer's retail outlet competes with retailers. In spite of this, if the e-tail cost ratio is higher than .25, then competition from the e-tail channel is mitigated by a relatively high disutility and shipping costs, and retail prices in the Balasubramanian model are greater than those at the e-tailer's retail outlet. Interestingly, when the e-tail cost ratio is moderate the same situation arises whereby relative to retail prices in the Balasubramanian model, retail prices are higher but the e-tailer's retail outlet price is lower.

Profits

Table 1 shows retail profits and e-tail profits for each market configuration. The additional presence in the market of a multi-channel e-tailer can increase profits. The next theorem shows that an e-tailer in the retail channel increases industry profits.

Theorem 3: Industry profits are higher when the e-tailer sells through both the e-tail and retail channels than when the e-tailer sells only through the e-tail channel.

A multi-channel e-tailer yields higher profits for both retailers as well as for the e-tailer. Allowing the e-tail and retail channels to compete directly facilitates optimization by way of market forces, rather than artificially imposing an upper limit on the market share of any given channel (Figure 3). Even when the e-tail channel does not have market share in the lower portion of the market, this is mitigated by the positive externalities resulting from

the retailers' proximity (Stahl, 1982; Tirole, 1988), while the e-tailer exploits access to more distantly located segments of the market.

Consumer welfare

Our measure of consumer welfare is the total cost to consumers. This includes payments to retailers and e-tailers plus the transportation costs, aggregated over all consumers. Table 1 shows the total cost to consumers for each market configuration.

When the e-tailer enters the retail channel it adds another retail location from which consumers can purchase. We expect that an additional retail location increases retail competition, thereby decreasing retail prices, which in turn puts downward pressure on e-tail prices, making consumers better off. But, as our next theorem shows, when the e-tail cost ratio is moderate and relocation costs are such that retailers do not relocate, the e-tailer in the retail channel decreases consumer welfare.

Theorem 4: If the e-tail cost ratio is moderate, between .2 and .2947, and retailers do not relocate, then consumers are worse off when the e-tailer enters the retail channel.

Intuitively, when the e-tail cost ratio is low (Case 1) consumers are affected more significantly by transportation costs, and each retailer, including the e-tailers' retail outlet, competes with the e-tail channel. As the e-tail cost ratio increases into the range covered by our Case 3, the e-tail channel has no share in the lower portion (of Figure 3), meaning all consumers in the lower portion purchase from retail locations and pay transportation costs. Because the e-tailer chooses its e-tail price to compete with retailers on the upper portion, and its retail price to compete with retailers on the lower portion, consumer costs are increased due to the additional transportation costs incurred in the lower portion. However, as the e-tail cost ratio increases, additional transportation costs paid by consumers in the lower portion is less significant, and the additional retail location increases consumer welfare.

CONCLUSIONS

Our research has yielded four main results. First, if the e-tail cost ratio is low, then retailers do not relocate when faced with retail channel entry from an e-tailer. When the e-tail cost ratio is even lower, then no relocation is social welfare maximizing. Second, when retailers can relocate, entry of an e-tailer into the retail channel increases retail prices. Third, industry profits increase with an e-tailer's entry into the retail channel. Finally, when the e-tail cost ratio is moderate, consumers are better off without e-tailer entry into the retail channel. We believe these results hold even when there is differentiated competition in the e-tail channel so long as the differentiation is independent of the location differentiation in the retail channel.

There are three key messages from these results. When the e-tail cost ratio is low - when the disutility of buying online and shipping costs are low - then retailers retain their original locations and do not relocate. This occurs because when the e-tail cost ratio is low, the e-tail channel always competes directly with each retail outlet - both retailers and the e-tailer's retail outlet. The implication for management is that under these conditions relocating is not an effective strategy for retailers to avoid direct e-tail competition. The next message for management is that an e-tailer's retail presence - a multi-channel strategy - is a way for the industry to increase retail prices and industry profits. Consequently, and perhaps surprisingly, consumers are not necessarily better off with an e-tailer in the retail channel.

Indeed, there is a moderate range of the e-tail cost ratio where consumer welfare is higher if the e-tailer does not enter the retail channel - that is, some consumers are better off having fewer retail locations to select from. This is because in this range of the e-tail cost ratio the retailers compete with the e-tail channel on one side, and the e-tailer's retail channel on the other side. In this situation the e-tailer's two channels do not compete so its pricing decisions are separate, removing the downward pressure on its two prices. This leads to our main message for researchers, which is that even in this simple model, prices, profits, and consumer welfare are determined by a variety of factors, and this may underlie the equivocal empirical results concerning the impact of online retail competition on these measures.

For the types of goods to which our model applies, location is best thought of as a physical

location. However, as we indicated in the introduction, the application of our model, and the implications of the results, is broader. Considering, for example, features of customer service such as service quality and customer relationship management, the distribution of consumers around the Salop model circle could be interpreted as a distribution of consumer preferences over combinations of customer service features. With this interpretation of location, all consumers view the e-tail channel the same way. For example, Amazon's customer service features may be equally valued by all consumers. In turn, different retailer locations may be viewed by consumers as alternative combinations of customer service features, and in this way consumers may differ in their preference for a given retailer. Thus, retail location and relocation can be interpreted as a choice of different combinations of customer service features – or more generally, positioning – and within that context our results continue to apply.

A direction for future research is to consider consumers that are heterogeneous in their e-tail transaction cost – either through a random distribution of high-low costs or based on the need for pre- and post-sales support.

REFERENCES

- Ancarani, F. (2002). Pricing and internet: frictionless commerce or pricer's paradise. *European Management Journal*, 20(6), 680-687.
- Ancarani, F., & Shankar, V. (2004). Price levels and price dispersion within and across multiple retailer types: further evidence and extension. *Journal of the Academy of Marketing Science*, 32(2), 176-187.
- Asplund, M., & Sandlin, J. (1999). Competition in interrelated markets: an empirical study. *International Journal of Industrial Organization*, 17(3), 353 - 369.
- Bahn, D., & Fischer, P. (2003). Click and mortar: balancing brick and mortar business strategy and operations with auxiliary electronic commerce. *Information Technology Management*, 4(2/3), 319-334.

- Bailey, J., Faraj, S., & Yuliang, Y. (2007). The road more travelled: web traffic and price competition in internet retailing. *Electronic Markets*, 17(1), 56-67.
- Balasubramanian, S. (1998). Mall vs. mail: a strategic analysis of competition between direct marketers and conventional retailers. *Marketing Science*, 17(3), 181 - 195.
- Baye, M.R., Morgan, J., & Scholten, P. (2004). Price dispersion in the small and the large: Evidence from an internet price comparison site. *Journal of Industrial Economics*, 52(4), 463-496.
- Baylis, K., & Perloff, J. M. (2002). Price dispersion on the internet: good firms and bad firms. *Review of Industrial Organization*, 21(3), 305-324.
- Brown, J. R., & Goolsbee, A. (2002). Does the internet make markets more competitive? Evidence from the life insurance industry. *Journal of Political Economy*, 110(3), 481-508.
- Brynjolfsson, E., & Smith, M. (2000). Frictionless commerce? A comparison of internet and conventional retailers. *Management Science*, 46(4), 563 - 585.
- Chevalier, J., & Goolsbee, A. (2003). Measuring prices and price competition online. *Quantitative Marketing and Economics*, 1(2), 203-222.
- Clay, K., Krishnan, R., Wolff, E., & Fernandes, D. (2002). Retail strategies on the web: price and non-price competition in the on-line book industry. *Journal of Industrial Economics*, 50(3), 351-367.
- Clemons, E., Hahn, I.H., & Hitt, L. (2002). Price dispersion and differentiation in online travel: an empirical investigation. *Management Science*, 48(4), 534-549.
- De Frutos, M.A., Hamoudi, H., & Jarque, X. (1999). Equilibrium existence in the circle model with linear quadratic transportation cost. *Regional Science and Urban Economics*, 29(5), 605 - 615.
- Forman, C., Ghose, A., & Goldfarb, A. (2009). Competition between local and electronic markets: how the benefit of buying online depends on where you live. *Management Science*, 55(1), 47-57.

- Goolsbee, A. (2001). Competition in the computer industry: online versus retail. *Journal of Industrial Economics*, 49(4), 487-490.
- Judd, K. (1985). Credible spatial preemption. *Rand Journal of Economics*, 16(1), 153-166.
- Le Blanc, L. A., & Folkman Curasi, C. (2002). Differential pricing for electronics on the internet and competing channels. *Quarterly Journal of Electronic Commerce*, 3(2), 97-110.
- Lee, H.G., Lee, S., Chang, K.H.Y., & Lee, R.H. (2003). Is the internet making retail transactions more efficient? Comparison of online and off-line CD retail markets. *Electronic Commerce Research and Applications*, 2(3), 266 -278.
- Prince, J.T. (2007). The beginnings of online/retail competition and its origins: an Application to personal computers. *International Journal of Industrial Organization*, 25(1), 139-156.
- Salop, S. (1979). Monopolistic competition with outside goods. *Bell Journal of Economics*, 10(1), 141-156.
- Scott Morton, F., Zettelmeyer, F., & Silva-Risso, J. (2001). Internet car retailing. *Journal of Industrial Economics*, 49(4), 501 - 519.
- Schmitz, S.W., & Latzer, M. (2002). Competition in B2C e-commerce: analysis issues and empirical evidence," *Electronic Markets*, 12(3), 163-175.
- Stahl, K. (1982). Consumer search and the spatial distribution of retailing. *Journal of Industrial Economics*, 31(1/2), 97 - 114.
- Tang, F., & Xing, X. (2001). Will the growth of multi-channel retailing diminish the pricing efficiency of the Web? *Journal of Retailing*, 77, 319-333
- Tirole, J. (1988) *The Theory of Industrial Organization*. Cambridge, MA: MIT Press.
- Venkatesan, R., Mehta, K., & Bapna, R. (2006). Understanding the consequences of retailer characteristics, market characteristics and online pricing strategies. *Decision Support Systems*, 42(3), 1759-1775.
- Xing, X., Ratchford, B.T., & Shankar, V. (2004). Price dispersion on the internet: a review

and directions for future research. *Journal of Interactive Marketing*, 18(4), 116-135.

Xing, X., Yang, Z., & Tang, F. (2006). A comparison of time-varying online price and price dispersion between multichannel and dotcom DVD retailers. *Journal of Interactive Marketing*, 20(2), 3-20.

APPENDIX

Balasubramanian's (1998) Model: Total Cost to Consumers

The total e-tail transaction cost to consumers is $\tau_e^b = \mu m_e = 2\mu/3 - 4\mu^2/3t$. The average distance for any consumer to a retailer is $x/2$. Because the market share of the two retailers is $2m_r$, the total transportation cost incurred is

$$\tau_r^b = t [x/2] 2m_r = 2 t x^2 = [4\mu + t]^2/72t. \quad (26)$$

Together, the total e-tail transaction cost and transportation costs are

$$\tau^b = \tau_e^b + \tau_r^b = \frac{t^2 + 56\mu t - 80\mu^2}{72t},$$

and the total cost to consumers is as in Equation (4):

$$\omega^b = 2\pi_r^b + \pi_e^b + \tau^b = \frac{11t^2 + 40\mu t - 16\mu^2}{72t}.$$

Proof of Lemma 1: By contradiction. Consider when the e-tail channel has a positive market share. First, suppose that at the optimal location and at equilibrium prices there is no e-tail share between retailers. This means retailers prefer to compete with each other than with the e-tail channel. For x half way between the two retailers, this means that $p_r + tx > p_e + \mu$ so at x they have less competition. But if this is true, then the consumer at x will purchase from e-tail. Next, suppose that at the optimal location and at equilibrium prices there is no e-tail share between the retailers and the e-tailer's retail outlet. This means retailers prefer to compete with the e-tailer's retail outlet. Then for consumer y that is indifferent between retail and the e-tailer's retail outlet this means $p_{er} + ty > p_e + \mu$. But if this is true, then consumer y will purchase from e-tail. Q.E.D.

The E-tailer Goes Retail and Retailers Relocate: Total Cost to Consumers

The total e-tail transaction cost to consumers is

$$\tau_e^r = \mu m_e = \mu[1 - 4x - 2y] = \mu[2/3 - 7\mu/3t] = 2\mu/3 - 7\mu^2/3t.$$

Thus, for $m_e > 0$ requires $\mu/t < 2/7$. As in Balasubramanian's (1998) model, the transportation cost incurred to the two retailers is $[4\mu + t]^2/72t$ from Equation (26). The average

distance is $y/2 = \mu/4t$. The transportation cost incurred to the e-tailer's retail outlet is then $t [\mu/4t] m_{er} = \mu^2/4t$, and the total transportation cost incurred is

$$\tau_r^r = \frac{[4\mu + t]^2}{72t} + \frac{\mu^2}{4t} = \frac{t^2 + 8\mu t + 34\mu^2}{72t}.$$

Together, the total e-tail transaction cost and transportation costs are

$$\tau^r = \tau_e^r + \tau_r^r = \frac{t^2 + 56\mu t - 134\mu^2}{72t}, \quad (27)$$

and the total cost to consumers is

$$\omega^r = 2\pi_r^r + \pi_e^r + \tau^r = \frac{11t^2 + 40\mu t - 34\mu^2}{72t}.$$

The E-tailer Goes Retail and Retailers do not Relocate: Total Cost to Consumers in Case 2

The average distance for any consumer in the upper portion to a retailer is $x/2$. The total e-tail transaction cost to consumers is

$$\tau_e^{n2} = \mu m_e = \mu[1/2 - 2x] = 7\mu/18 - 7\mu^2/9t.$$

The average distance for any consumer in the lower portion to a retailer is $z/2$. The market share for each retailer in the upper portion is x , and in the lower portion it is z . Thus, the transportation cost incurred to the two retailers' outlets is

$$2t [x^2/2 + z^2/2] = t[x^2 + z^2] = \frac{137t^2 + 136\mu t + 800\mu^2}{5184t}.$$

The average distance from a consumer purchasing from the e-tailer's retail outlet is $[1/4 - z]/2$. The transportation cost incurred to the e-tailer's retail outlet is

$$t m_{er}[1/4 - z]/2 = t [1/2 - 2z][1/4 - z]/2 = t/16 - tz/2 + tz^2 = \frac{49t^2 + 56\mu t + 16\mu^2}{5184t},$$

and the total transportation cost incurred is

$$\tau_r^{n2} = \frac{31t^2 + 32\mu t + 136\mu^2}{864t}.$$

Together, the total e-tail transaction cost and transportation costs are

$$\tau^{n2} = \tau_e^{n2} + \tau_r^{n2} = \frac{31t^2 + 368\mu t - 536\mu^2}{864t},$$

and the total cost to customers is

$$\omega^{n2} = 2\pi_r^{n2} + \pi_e^{n2} + \tau^{n2} = \frac{179t^2 + 304\mu t - 136\mu^2}{864t}.$$

The E-tailer Goes Retail and Retailers do not Relocate: Total Cost to Consumers in Case 3

The structure of total e-tail transaction costs and transportation costs is the same as in Case 2, but with prices from Equation (22). The average distance for any consumer in the upper portion to a retailer is $x/2$. The total e-tail transaction cost to consumers is

$$\tau_e^{n3} = \mu m_e = \mu[1/2 - 2x] = -9\mu/26 + 82\mu^2/26t.$$

The average distance for any consumer in the lower portion to a retailer is $z/2$. The transportation cost incurred to the two retailers' outlets is

$$2t[x^2/2 + z^2/2] = t[x^2 + z^2] = \frac{5t^2 - 34\mu t + 65\mu^2}{26t}.$$

The average distance for a consumer purchasing from the e-tailer's retail outlet is $[1/4 - z]/2$, so the transportation cost incurred to the e-tailer's retail outlet is

$$t m_{er} [1/4 - z]/2 = \frac{49t^2 - 84\mu t + 36\mu^2}{2704t},$$

and the total transportation cost incurred is

$$\tau_r^{n3} = \frac{569t^2 - 3620\mu t + 6796\mu^2}{2704t}.$$

Together the total e-tail transaction and transportation costs are

$$\tau^{n3} = \frac{569t^2 - 4556\mu t + 15324\mu^2}{2704t},$$

and the total cost to consumers is

$$\omega^{n3} = 2\pi_r^{n3} + \pi_e^{n3} + \tau^{n3} = \frac{1055t^2 - 4676\mu t + 15732\mu^2}{2704t}.$$

Proof of Theorem 1: When the e-tail cost ratio is low (Case 1), retail profits are the same whether or not retailers relocate (see Equation (3)). When the e-tail cost ratio is moderate (Case 3), retail profits if retailers do not relocate (see Equation (24)) are greater than the retail profits if they relocate (see Equation (3)). Finally, for $\mu/t < .2623$ (a subset of Case 2), retail profits if retailers do not relocate are given in Equation (18), and these retail profits are greater than the retail profits if they relocate (see Equation (3)). Q.E.D.

Proof of Corollary to Theorem 1: If the e-tail cost ratio is low (Case 1), then retail profits, e-tail profits, and the total cost to consumers are given in Equations (3), (10) and (11) respectively - independent of whether retailers relocate. Q.E.D.

Proof of Theorem 2: If retail relocation is costless, then retailers relocate and the retailers prices are the same as in Balasubramanian's model. From Equation (8) (and Equation (2)) we find that $p_r^r(= p_r^b) < p_{er}^r$.

Otherwise, Case 1 applies for $\mu/t \leq .2$ and Case 2 for $.2188 \leq \mu/t < .25$. Comparing p_r^b from Equation (2) with retail prices in Cases 1 and 2 (p_r^r from Equation (8) as Case 1 retail prices are the same as when retailers can relocate; p_r^{n2} from Equation (17)) we find that $p_r^b = p_r^r < p_r^{n2}$. Thus, retail prices are equal or higher when the e-tailer has a retail outlet. For Case 1 from Equations (2) and (8) we have $p_r^b < p_{er}^r$. For Case 2 from Equations (2) and (17) we have $p_r^b < p_{er}^{n2}$ if $\mu/t < .25$. Q.E.D.

Proof of Theorem 3: First consider when retailers relocate. Retail profits are the same as when the e-tailer sells only through the e-tail channel. For the e-tailer, profits from Equation (10) are greater than those in Equation (3).

Now consider when retailers do not relocate. In Case 1 retail profits are the same as when the e-tailer only sells through the e-tail channel, and e-tailer profits from Equation (10) are greater than those in Equation (3) - both as above. In Case 3 retailer profits in Equation (24) are greater than those in Equation (3), and e-tailer profits in Equation (23) are greater than those in Equation (3). Finally, in Case 2 e-tailer profits are higher in Equation (18)

than those in Equation (3). However, retailer profits in Equation (18) are only greater than those in Equation (3) if the e-tail cost ratio is less than .3061, and the sum of e-tailer and retail profits (noting there are two retailers) in Equation (18) is greater than the sum of those in Equation (3). Q.E.D.

Proof of Theorem 4: If $.2 < \mu/t \leq .2188$, then from a comparison of Equation (25) and Equation (4) it is straightforward that $\omega^3 > \omega^b$. If $.2188 \leq \mu/t < .2947$, then from a comparison of Equation (20) and Equation (4) it is straightforward that $\omega^2 > \omega^b$. Q.E.D.

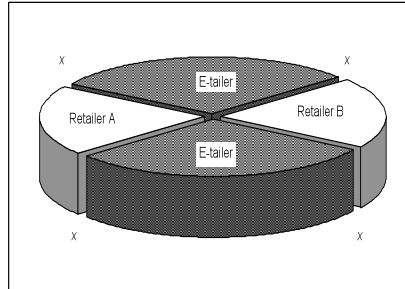


Figure 1: E-tail entry.

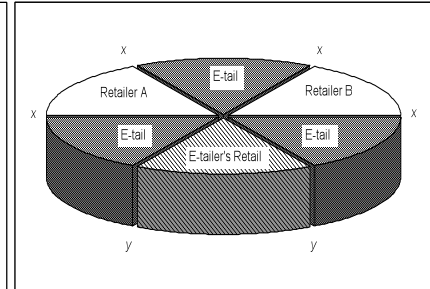


Figure 2: E-tailer goes retail, retailers relocate.

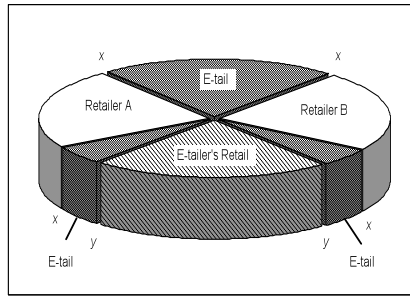


Figure 3: E-tailer goes retail; all retailers compete with e-tail channel.

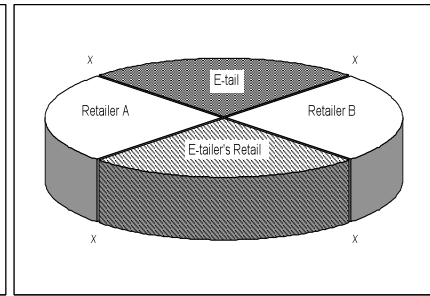


Figure 4: E-tailer has no presence in lower half.

Table 1: Profits and total cost to consumers (DNR: do not relocate).

Model	Retailer Profit	E-Tailer Profit	Cost to Consumers
Balasubramanian	$\pi_r^b = [t + 4\mu]^2/72t$	$\pi_e^b = [t - 2\mu]^2/9t$	$\omega^b = \frac{11t^2+40\mu t-16\mu^2}{72t}$
Retailers Relocate	$\pi_r^r = [t + 4\mu]^2/72t$	$\pi_e^r = \frac{17\mu^2-8\mu t+2t^2}{18t}$	$\omega^r = \frac{11t^2+40\mu t-34\mu^2}{72t}$
Retailers DNR Case 1	$\pi_r^{n1} = [t + 4\mu]^2/72t$	$\pi_e^{n1} = \frac{17\mu^2-8\mu t+2t^2}{18t}$	$\omega^{n1} = \frac{11t^2+40\mu t-34\mu^2}{72t}$
Retailers DNR Case 2	$\pi_r^{n2} = \frac{25t^2+80\mu t+64\mu^2}{864t}$	$\pi_e^{n2} = \frac{49t^2-112\mu t+136\mu^2}{432t}$	$\omega^{n2} = \frac{179t^2+304\mu t-136\mu^2}{864t}$
Retailers DNR Case 3	$\pi_r^{n3} = \frac{6t^2+12\mu t+6\mu^2}{169t}$	$\pi_e^{n3} = 3\frac{49t^2-84\mu t+36\mu^2}{1352t}$	$\omega^{n3} = \frac{1055t^2-4676\mu t+15732\mu^2}{2704t}$

Table 2: Prices.

Model	Conv. Retail	E-Tail	E-Tailer Retail
Balasubramanian	$p_r^b = \mu/3 + t/12$	$p_e^b = t/6 - \mu/3$	
Retailers Relocate	$p_r^r = t/12 + \mu/3$	$p_e^r = t/6 - \mu/3$	$p_{er}^r = t/6 + \mu/6$
Retailers DNR Case 1	$p_r^{n1} = t/12 + \mu/3$	$p_e^{n1} = t/6 - \mu/3$	$p_{er}^{n1} = t/6 + \mu/6$
Retailers DNR Case 2	$p_r^{n2} = 5t/36 + 2\mu/9$	$p_e^{n2} = 7t/36 - 7\mu/18$	$p_{er}^{n2} = 7t/36 + \mu/9$
Retailers DNR Case 3	$p_r^{n3} = 2t/13 + 2\mu/13$	$p_e^{n3} = 7t/26 - 19\mu/26$	$p_{er}^{n3} = 7t/52 + 5$