“Bricks & Clicks”: The Impact of Product Returns on the Strategies of Multi-Channel Retailers

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Abstract

The Internet has increased the flexibility of retailers allowing them to operate an online arm in addition to their physical stores. The online channel offers potential benefits in selling to customer segments that value the convenience of online shopping, but it also raises new challenges. These include the higher likelihood of costly product returns when customers’ ability to ‘touch and feel’ products is important in determining fit. We study competing retailers that can operate dual channels (“Bricks & Clicks”) and examine how pricing strategies and physical store assistance levels change as a result of the additional Internet outlet. A central result we obtain is that when differentiation among competing retailers is not too high, having an online channel can actually increase investment in store assistance levels (e.g., greater shelf display, more qualified sales staff, floor samples) and decrease profits. Consequently, when the decision to open an Internet channel is endogenized, there can exist an asymmetric equilibrium where only one retailer elects to operate an online arm but earns lower profits than its Bricks-Only rival. We also characterize equilibria where firms open an online channel, even though consumers only use it for research and learning purposes but buy in stores. A number of extensions are discussed, including retail settings where firms carry multiple product categories, shipping and handling costs, and the role of store assistance in impacting consumer perceived benefits.

(*Channels of Distribution, Retailing, Internet Marketing, Product Returns, Reverse Logistics, Competition*)

1 Introduction

As consumer access to the Internet continues to grow, and with U.S. online sales in 2008 reaching \$227 billion (Grau 2009), it is becoming increasingly apparent to retailers that they cannot ignore the possibility of selling products online.[1] While the stock market crash of 2000 wiped out many pure-play Internet retailers that were unable to generate sufficient traffic to their sites, most established retailers with strong traditional bricks and mortar presence have since ventured into the online world. These retailers can showcase their products online and leverage the familiarity with their brand to appeal to customers who value the convenience of online shopping.

The advantages offered by the online outlet do not come free, however. The problem, well known to direct marketers, is the hidden costs associated with product returns. The problem is particularly acute in categories where consumers need to "touch and feel" the product in order to determine how well it fits their tastes and needs. For example, it is very difficult for a consumer seeking a new sofa to ascertain how comfortable a particular model is without actually sitting on it. It is further difficult to judge the aesthetic appeal of the sofa's design, texture and color without physically seeing it as opposed to merely viewing a digital image on a computer screen. The same is true for fashion apparel, jewelry, sporting goods, artwork, etc. In such categories, many relevant attributes for consumer decision-making are "non-digital" and difficult to communicate electronically. By contrast, retailers do have control over the relevance of the shopping environment in stores. By placing samples of more models on the floor, or making sure that a full assortment of products is properly shelved and displayed, the merchant is more likely to ensure that the customer finds the right product. Hiring highly qualified salespeople or training existing ones to assist customers as they inspect and try out products, further decrease the likelihood of a mismatch. Thus, while the ability to reduce the chances of product returns online are quite limited for products with non-digital attributes, the retailer has this ability in its physical store through investment in appropriate sales assistance activities.

When product returns do occur, handling the returned merchandise can impose substantial costs on retailers. Beyond the need to collect the unwanted product from the customer, the retailer needs to either refurbish and restock the product if it can be resold, sell the product to a third party for a salvage value, or, in extreme cases, dispose of the product altogether. It

[1]It is estimated that close to 70% of the U.S. adult population (ages 14 and above) have Internet access, and approximately 90% of those with access have regular broadband connection (either at home or at work; Grau 2009 and CEA 2007). About two thirds of U.S. Internet users are estimated to have bought something online in 2008. We note that the online sales figure for 2008 includes leisure and unmanaged business travel sales; if one excludes these items then online sales reached \$132.3 billion in 2008.

is estimated, for example, that selling to a third party liquidator only recoups 10-20% of the returned product's original value (Stock et al. 2006). The substantial transaction and operational challenges of handling product returns, which are becoming particularly acute with the advent of the Internet, have resulted in the birth of a new industry dedicated to these reverse logistics activities. The recent rise and success of companies like Newgistics and The Retail Equation, which specialize in merchandise returns management, attests to this trend. As a percent of sales, the figures are staggering. Recent data shows that while overall customer returns are estimated at about 8.7% of retail sales, they are significantly higher for catalog and e-commerce retailers, ranging from 18-35% depending on the category.[2] In all, it is estimated that managing product returns costs U.S. companies well over $200 billion annually (Grimaldi 2008).

But the supply-side cost of returns is only one aspect of the problem. Returning mismatched merchandise can be costly for consumers as well. First, there is the opportunity cost of time associated with the return process (going back to the store or mailing an item back). Second, there is the disutility associated with not having a matching product for the duration of time from the initial purchase till the return. Third, not all return policies are lenient. In some cases a restocking fee is imposed on the consumer typically ranging from 10-25% of the purchase price, waiting periods are sometimes required before issuing cash refunds and, increasingly, retailers only offer exchanges or store credit (Spencer 2002). The higher probability of returning an item purchased on the web makes these costs all the more pronounced for the online channel. A consumer survey by JupiterResearch found that 45% of respondents with online access preferred to shop in physical stores because otherwise they "couldn't touch, feel, or see the product" (Evans 2009), and a recent Forrester survey found that 51% of online shoppers agreed or strongly agreed that returning products is a hassle that comes with online shopping.[3] Not surprisingly then, as a percent of overall sales in each category, products for which consumers require more physical inspection to determine fit are sold less online (typically only 5-10% of overall category sales) than products whose attributes/specs can easily be communicated digitally (typically 45-50% of overall category sales).[4] In sum, although the online channel may allow targeting customers that value the ability to economize on shopping trip expenses, the fact that higher returns often accompany online purchases has implications for buying behavior and, consequently, retailer

[2]Source: Gentry (1999), Loss Prevention Research Council (LPRC 2008), and Grimaldi (2008).

[3]The Forrester report (Mulpuru 2008) notes that: "most consumers still prefer stores...by shopping in stores, consumers can touch and feel items [and] avoid issues surrounding returns." Notably, 56% of consumers surveyed in 2008 by PriceGrabber.com considered "lack of touch and feel" as a primary concern with online shopping.

[4]For example, according to Forrester Research, the percent of category sales that take place online is as high as 45% for computer hardware/software; 24% for books, music/video; 18% for consumer electronics; but only 11% for jewelry; 10% for apparel and footwear; 9% for home furnishings; and 9% for cosmetics/fragrances.

actions.

Opening an online shopping channel, the “Click” arm, may prompt competing retailers to re-evaluate several of their key strategic practices. First, retailers may seek to adjust their pricing given that a certain portion of consumers will find it beneficial to buy online. But beyond adjusting prices, the new channel may cause retailers to re-think *how* they sell on the two channels. In particular, if some sales shift to the online outlet and less shoppers frequent stores, one might expect retailers to adjust downward in-store assistance levels. Taking this a step further, retailers need to determine whether it is in their best interest to operate an online channel to begin with. From a managerial standpoint, setting marketing mix variables when operating these multiple channels is seen as one of the most pressing challenges facing retailers today (Nunes and Cespedes 2003).

Our goal in this paper is to explore how adopting the “Bricks & Clicks”, multi-channel format affects the strategic behavior and profits of competing retailers, in categories where the physical inspection of products reduces the chances of returns. We specifically ask the following questions:

- How does the introduction of an online channel affect the level of in-store shopping assistance that retailers provide? Are there conditions under which retailers offer more store assistance even though a portion of consumers shops online?
- How does operating multiple channels affect pricing strategy? Are prices set to increase or decrease as a result of operating an online channel in addition to physical stores?
- Should we always expect profits to be higher in the Bricks & Clicks case given the added flexibility in channel format?
- Given the choice, would a retailer always want to open an online arm? Is it possible in equilibrium for one retailer to elect to operate only a physical store (“Bricks-Only”) while its rival operates both channels (“Bricks & Clicks”)?

To address these questions, we construct a model with firms that can operate dual channels. Consumers have the option to purchase products in stores, where they are able to physically inspect products, or to purchase online without such benefit. Firms set prices and can reduce the offline product return probability by investing in costly store assistance (SA). Consumers are heterogenous along two dimensions: (i) their preferences for the products offered by each retailer and (ii) their cost of making a shopping trip to the physical store. Our analysis proceeds in three phases. As a benchmark, we begin by analyzing the case of a monopolist retailer and compare its strategy and profits under the Bricks-Only and Bricks & Clicks channel formats.

We then introduce competition and compare firms' equilibrium strategies under the different channel structures. Subsequently, we endogenize the decision to open an online arm and analyze the conditions for both symmetric and asymmetric equilibria to emerge, including the possibility that none of the firms chooses to open an online outlet.

We show that for a monopolist, as one might expect, operating an online channel is always beneficial: the monopolist can offer less store assistance, raise prices and earn greater profits (and this is true regardless of whether the market is fully covered). However, in the duopoly context we find that firms can actually be worse off when they operate the additional online channel, and this occurs when competition between them is intense (i.e., the degree of retailer differentiation in the eyes of customers is low). The intuition being that when only operating an offline channel each firm realizes that an increase in the store assistance level triggers an aggressive pricing response by its rival (because all customers must visit stores and are affected by the change in store assistance; to defend its turf the rival will lower prices dramatically). This puts pressure on Bricks-Only firms to choose a lower store assistance level when the competitive intensity is high as compared to Bricks & Clicks firms. Thus, in the latter case firms choose a greater store assistance level even though less customers are shopping in stores. Yet because store assistance is costly and not all customers are benefiting from it, firms in the Bricks & Clicks case earn lower profits.

These consequences of operating an online arm for competing retailers can result in an asymmetric equilibrium in the choice of channel format in which the Bricks-Only firm is better off than the Bricks & Clicks firm. Specifically, when the decision to open an online arm is endogenous and the fixed costs of operating the additional channel are in a mid range, only one firm will choose the Bricks & Clicks format. However, if differentiation between the retailers is relatively low, the Bricks & Clicks firm is limited in its ability to capitalize on serving Internet customers and earns lower profits than its single-channel rival.

Collectively, our results suggest that opening an additional channel– namely the Internet outlet– can have important strategic implications for how retailers set marketing mix variables. Moreover, we show that one of the key aspects of the online channel– the inability to physically inspect products to reduce the likelihood of a return– can affect retailer decisions in the store, reduce overall profitability, and thus impact the decision to open the online arm.

The rest of the paper is organized as follows. The next section summarizes the relevant literature. This is followed by a description of the basic model setup and its analysis in Section 3. We first consider the benchmark monopoly case and then examine a duopoly setting. We compare in each case retailers' strategies and profits under the Bricks-Only and Bricks & Clicks channel formats. After establishing the underlying intuitions for how the online channel impacts firm behavior, in Section 4 we endogenize the decision to open an online arm. In Section 5 we discuss the model structure and describe additional analyses conducted to relax the key assumptions. Concluding remarks are given in Section 6. All proofs and technical details appear in the Appendix.

2 Related Literature

Our work is primarily related to two streams of research. The first examines the implications of the Internet for consumer and retailer behavior and the second studies various aspects associated with customer product returns. We discuss each of these streams in turn.

Early work on the Internet as a channel of distribution was mostly concerned with pure-play e-tailers (e.g., Bakos 1997) and competition between Bricks-Only retailers and a direct retailer (Balasubramanian 1998). Subsequent papers began studying the implications of operating dual channels. In Lal and Sarvary (1999), the introduction of an online channel is shown to affect consumers' search behavior and, under certain conditions, to result in higher equilibrium prices. Their model assumes that each consumer is exogenously familiar with the product fit of only one of the retailers and that firms are not able to control the ease/difficulty of consumer search. Zettelmeyer (2000) examines situations where competing retailers can provide information to consumers both online and offline to help them determine their utility for the products offered. Providing information is costless online, but there is a cost offline. Having dual channels is shown to increase the amount of information provided online, but only if a limited fraction of consumers have access to the Net. Our work differs from the above papers in that we focus on the implications of a product mismatch from the consumers' and firms' perspective. We further assume that all consumers have access to the Internet and that, given the nature of products under consideration, the uncertainty associated with determining fit can only be effectively reduced in physical stores. We examine the actions firms can take to manage product returns through investment in store assistance and pricing.[5] As indicated, our analysis is most pertinent for categories where the primary way to determine product fit is by physical inspection (and at the store the retailer can provide effective ways to do so). We, of course, acknowledge that for some categories retailers can provide product diagnostics for consumers online, for example when customer reviews are highly relevant (Chevalier and Mayzlin 2006) or when decision making is

[5]We note that our analysis centers on how the additional 'Clicks' arm affects the behavior of competing retailers. As such, we do not analyze situations where the central issue is whether a separate manufacturer will bypass its retailers and sell directly to consumers (see Chiang et al. 2003) or how an independent infomediary impacts competition in the value chain (see, Chen et al. 2002). Biyalogorsky and Naik (2003) present an empirical methodology to measure how online activities may affect offline sales.

based predominantly on attributes that can be communicated digitally (as with laptops that can be compared on consumer review sites). To understand the implications for our model, we solved an extension where retailers can also invest in online sales assistance (see discussion in Section 5 and formal details in the Technical Appendix).

The second related stream of research examines product returns strategies, but only in a single channel context. Davis et al. (1995) examine a retailer's incentives to offer a money back guarantee for mismatched products. They show that as long as the retailer's salvage value from returned merchandise is high enough, it is profitable to offer money back guarantees. Hess, Chu and Gerstner (1996) find that a retailer can use a non-refundable charge to limit opportunistic returns by customers who purchase the product to derive value for a limited period and then return it for a refund. More recently, Shulman et al. (2009) studied optimal returns policies by considering a retailer's incentives to charge consumers a higher restocking fee and to provide full information about products. They show that providing full information may hurt retailer profits because consumer uncertainty allows charging a higher price. Moorthy and Srinivasan (1995) examine the role of money back guarantees in a competitive context as a signal of product quality. They show that the high quality seller charges a higher price and offers a money back guarantee. In our model, such signalling issues do not arise. Although this literature provides valuable insights into our understanding of returns policies, it does not address the challenges faced by operating multiple channels. In particular, it ignores the trade-off between selling at a high price to capitalize on customer segments that value the convenience of online shopping and mitigating the returns problem through costly investment in store assistance. As we will show, the interplay between product return rates and operating dual channels has an impact on competing retailer strategies both in the physical stores as well as on the Internet.[6]

In sum, the central contribution of our work is in marrying the above two streams of literature by studying the implications of consumer product returns in a multi-channel context—a problem many retailers face today. We incorporate key characteristics of buyer behavior in deciding through which channel to shop and ask how the Internet, as a second viable channel, might impact strategic retailer behavior. Furthermore, we are unaware of prior work that has endogenized the decision by two Bricks and Mortar retailers to open an online arm.

[6]Padmanabhan and Png (1997) have looked at the issue of manufacturers allowing retailers to return unused quantities. They show that when demand is uncertain, such returns policies cause retailers to over-stock and this can reduce manufacturer profits. By contrast, we focus on consumer returns to retailers, examine the impact of consumer uncertainty regarding fit, and ask how the channel through which consumers buy matters for retailer strategy. The manufacturer-retailer setting has also been examined in terms of service provision to consumers. Iyer (1998) studies manufacturer contracts aimed at inducing competing retailers to differentiate: one retailer offers a low price and low service level while the rival offers a high price and high service level. Our paper focuses on the retailer-consumer setting and models the impact of greater service on reducing product returns.

3 The Basic Model

3.1 Setup

3.1.1 Retailers

Consider a market with two retailers, each offering a horizontally differentiated product. The product each retailer carries comes in a number of sizes, designs or models such that consumers have to determine which variant fits their needs or tastes best. Vertical quality is assumed to be identical for the products. When a consumer buys a product without physically inspecting it, there is a likelihood that it will be returned because of a mismatch.[7] The baseline (ex-ante) probability of a product mismatch is assumed to be equal for the two retailers. When a product is returned, the retailer has to incur a cost that includes any processing expenses, refurbishing/reconditioning expenses, or loss when the returned merchandise is sold for a salvage value in a secondary market. Consumers cannot physically inspect products prior to purchase on the Internet, but they can do so in stores. Furthermore, in their stores retailers can invest in conditions and factors that reduce the likelihood of a product mismatch and hence a return. As discussed in the Introduction, this might include having greater store capacity to properly showcase the full set of models and sizes of the product, the hiring of more knowledgeable salespeople at higher salaries, expending on customer service training programs, the installation of special equipment (such as sound rooms) to enhance the trial experience, and the foregoing of sample products placed "on the showroom floor". The greater the level of store assistance (SA) the retailer provides, the lower the likelihood that a product purchased at the store will be returned compared to when it is purchased online.

The timing of the game in the basic model is as follows. Retailers first decide on SA levels and then choose prices. Decisions in each stage are simultaneous. We assume that prices are the same on the Internet and in the store for each retailer. This is realistic if retailers worry about reputation backlash or customer dissatisfaction when consumers discover markedly different pricing schemes. This assumption is consistent with industry practice: nearly 80% of retailers have similar pricing across channels (NRF 2006) and surveys of prominent retail executives reveal that "same prices across all channels" is the foremost expectation that consumers have from multi-channel retailers (JupiterResearch 2007a).[8] In a separate Technical Appendix we

[7]Product returns can also be the result of defects, malfunction, or poor quality. This issue is separate from that of a mismatch due to fit, and its possible implications for our model are discussed in Section 5.

[8]Liu, Gupta and Zhang (2006) provide strong support for why the assumption of price consistency across channels is reasonable (pg. 1800). They analyze the case of an incumbent bricks and mortar retailer debating whether to open an online arm. They show that when prices are required to be consistent, refraining from

discuss this assumption further and examine the case in which retailers can charge separate prices across channels.

3.1.2 Consumers

Consumers have unit demand for the product and are heterogeneous along two dimensions. First, with respect to their preferences for the two retailers we assume that consumers are uniformly distributed along a segment of unit length connecting the retailers. The closer a consumer is located to a given retailer the greater the utility s/he derives from that retailer's offering (and the lower the utility derived from the rival's offering). Since this is a measure of preference for the retailer's brand (or unique styles), it is irrespective of whether the product is purchased in a store or on the Internet.[9] In the duopoly context, for competition to have relevance we assume that consumers' reservation price for the product is such that the market is covered (in the monopolistic setting we also address the case of partial market coverage).[10]

Consumers are also heterogeneous with respect to their cost of shopping in stores. We assume a simple two-segment market structure: for a proportion of consumers the shopping trip cost is low, and for simplicity normalized to zero, while the remaining consumers incur a high shopping trip cost. These costs reflect the need to travel to the store, spend time locating desired items, stand in line to pay, etc. The cost of shopping online is zero for both consumer types, and all consumers have Internet access.

Consumers realize that purchasing a product entails the risk of a mismatch, and that the likelihood of this occurring is smaller if they buy in the store and benefit from the retailer's SA efforts. In the event of a product mismatch, consumers incur costs associated with returning merchandise. We assume that consumers return the product only once. After any such actual usage and return instance, they can reliably figure out which product variant fits them.[11] We assume that consumers do not intend to exit the market at this point and they not ask for a refund. This formulation is also equivalent to assuming that retailers only allow exchanges or provide credit for additional purchase when merchandise is returned.

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opening such an arm can deter pure e-tailer entry. Our model allows both retailers to operate dual channels (see also Section 4) and we examine the role of returns and store assistance in addition to price.

[9]For example, a consumer might prefer products offered by the Gap over those offered by Abercombie and Fitch. The importance of retailer brand on the Internet as a driver of consumer purchase has been demonstrated empirically (for example, Brynjolfsson and Smith 2000; and Smith and Brynjolfsson 2001).

[10]If the market is not covered in the equilibrium solution of the two firm setting, then each firm effectively acts like a monopolist that does not cover the market.

[11]It is enough to assume that after each purchase and "at home" mismatch trial the likelihood of another mismatch decreases. In this interpretation, r and c (defined shortly after Table 1) are associated with the expected cumulative and discounted cost of all future returns till a match is secured.

3.1.3 Notation and Formal Description of Consumer Utility and Retailer Profits

We use the following notation to capture the model setup as described above

Table 1: Notation Used in the Basic Model Setup

	Notation:
Variable:	
Index to denote each retailer	$i = 1, 2$
Index to denote retail channel	N =Internet, S =store
Likelihood of a product match (return) without physical inspection	λ, $(1-\lambda)$
Retailer cost of handling a returned product	g
Store Assistance (SA) level chosen by retailer i	λ_{S_i} $(0 \leq \lambda_{S_i} \leq 1)$
Cost of providing SA level λ_{S_i}	$\frac{1}{2}h(\lambda_{S_i})^2$
Price chosen by retailer i	p_i
Consumer reservation price	v
Consumer preference distance or disutility from each retailer	x and $(1-x)$;
	$x \sim U[0, 1]$
Degree of product differentiation between retailers	t
Proportion of consumers with low shopping trip costs	μ $(0 < \mu < 1)$
Shopping trip cost; Low or High	$k_j = k_L$ or k_H
Consumer cost of returning a mismatched product	m

It will prove useful to define two additional quantities related to product returns. Let $r \equiv (1-\lambda)g$ be the baseline (or 'no physical inspection') expected cost of handling a return for the retailer and $c \equiv (1-\lambda)m$ be the baseline expected return cost for the consumer. Note that the probability that a product purchased in the store is returned is $(1-\lambda_{S_i})(1-\lambda)$; hence for any $\lambda_{S_i} > 0$ the returns probability is smaller in physical stores.

Using the notation in Table 1, we can formalize the consumer's utility from purchasing in each channel and from each retailer. When purchasing at the physical store of retailer $i \in (1, 2)$ a consumer located at x with shopping trip cost k_j gets expected utility of

$$U_{S_1}(x, k_j) = v - p_1 - tx - (1-\lambda_{S_1})c - k_j, \quad U_{S_2}(x, k_j) = v - p_2 - t(1-x) - (1-\lambda_{S_2})c - k_j. \tag{1}$$

Note that, consistent with our assumptions on consumer behavior, after the product is returned all uncertainty concerning product fit is resolved for the customer who then gets the right version of the product from the firm. Hence, once a consumer buys a product they will always enjoy utility from it ($v - p_1 - tx$ or $v - p_2 - t(1-x)$); but may have to incur a return cost in case of an initial mismatch (which happens with probability $(1 - \lambda_{S_i})$).

When the consumer buys on the Internet, the expected utility from either retailer is

$$U_{N_1}(x, k_j) = v - p_1 - tx - c, \quad U_{N_2}(x, k_j) = v - p_2 - t(1-x) - c. \tag{2}$$

By comparing the expected utility of the different options, each consumer decides from which retailer and through which channel to purchase. Clearly, low shopping-trip cost consumers (k_L types) always visit stores, as it is costless for them to do so and it reduces the likelihood of returns. High shopping-trip cost consumers (k_H types), however, may prefer to buy on the Internet, even if it means higher chances of returns because of their even greater shopping trip costs to visit stores. Consumers' purchase decisions generate demand for each retailer per-channel, D_{S_i} and D_{N_i}. Denote the vector of prices and SA levels $\overrightarrow{p} = (p_1, p_2)$ and $\overrightarrow{\lambda} = (\lambda_{S_1}, \lambda_{S_2})$, respectively. Total expected profits for retailer i are then given by

$$\pi_i = (p_i - (1 - \lambda_{S_i})r) D_{S_i}(\vec{p}, \vec{\lambda}) + (p_i - r) D_{N_i}(\vec{p}, \vec{\lambda}) - 1/2h(\lambda_{S_i})^2. \tag{3}$$

We assume that retailers are risk neutral and maximize expected profits and that the SA cost factor, h, is large enough to ensure an interior solution for λ_{S_i} (see (A13) in the Appendix). For the Internet to be relevant as a selling channel, we further assume that k_H is large enough ($k_H > \max\{c, \frac{c+r}{2}\}$) so that the high-shopping trip cost consumers prefer to purchase online. In Section 4.1, we relax this assumption in the context of firms' incentives to endogenously set up an online arm and let customers with high-shopping trip costs purchase in stores. Please note that in Section 5 we discuss a number of key model assumptions and explain how we have examined relaxing many of them (with extra analysis presented in a separate Technical Appendix).

3.2 Benchmark: Monopoly Case

We start by examining the case of a monopolist retailer that owns both products and operates all channels. To allow us to closely relate the monopoly results and intuitions to those in the duopoly setting, where competition for consumers is relevant only when the market is fully covered, we first present the case of a single firm that serves the entire market. We then show that the monopoly results are robust to letting the market be partially covered.[12]

The monopolist selects its SA level and price to maximize total profits. When operating a Bricks-Only (BO) format, the optimal levels of these decision variables and profits are given in

[12]Full market coverage in the monopoly case requires that v be high enough; see the Appendix for details. In the Technical Appendix, we provide the corresponding analysis when neither of the market segments is fully covered, and also show robustness of the results when the monopolist owns only one product.

the second column of Table 2. When operating both a traditional bricks outlet and an online clicks outlet, i.e., Bricks & Clicks (B&C), the optimal levels are given in the third column of Table 2.

Table 2: Monopoly Solution

	Bricks-Only:	**Bricks & Clicks:**
Variable:		
SA level	$\hat{\lambda}_{BO_M} = \frac{r+c}{h}$	$\hat{\lambda}_{BC_M} = \frac{\mu r}{h}$
Price	$\hat{p}_{BO_M} = v - k_H - (1 - \lambda_{BO_M})c - t/2$	$\hat{p}_{BC_M} = v - c - t/2$
Profits	$\hat{\pi}_{BO_M} = v - k_H - c - t/2 - r + \frac{(c+r)^2}{2h}$	$\hat{\pi}_{BC_M} = v - c - t/2 - r + \frac{\mu^2 r^2}{2h}$

Comparing the solutions under the two retail formats leads to the following proposition.

Proposition 1 *The monopolist will always offer a lower level of store assistance, charge a higher price, and make higher profits if it operates an online channel in addition to a physical store.*

Thus, when a monopolist retailer operates an online selling channel in addition to a physical store (B&C) it will unequivocally decrease the amount of store assistance that it offers. The intuition is straightforward and can be gleaned from the first order conditions for the SA level in the BO and B&C cases given in (4) and (5), respectively. After rearranging terms we get

$$\text{Bricks-Only:} \quad c + r = \lambda h. \tag{4}$$

$$\text{Bricks \& Clicks:} \quad \underbrace{\mu r}_{\text{Marginal Benefit}} = \underbrace{\lambda h}_{\text{Marginal Cost}}. \tag{5}$$

To further elaborate, we note that a marginal increase in the SA level results in a lower likelihood of a return taking place in the store. For a monopolist in the BO setting, the marginal benefit of doing so is two-fold. First, there is a lower likelihood of having to incur the retailer cost of handling the return ($= r$). Second, there is a lower likelihood of each consumer incurring the cost of a return ($= c$) and, given that the monopolist faces no competition, it can extract this extra consumer surplus by increasing price. Hence, as is evident from (4), the marginal benefit of increasing the SA level in the BO case is proportional to $(c + r)$. By contrast, in the B&C case, a marginal increase in the SA level only reduces the likelihood of a return for customers who patron the physical stores (i.e., a fraction μ of customers). The monopolist achieves a marginal benefit of incurring less returns costs from serving these customers ($=\mu r$). However, even though store customers enjoy a reduction in the returns likelihood when $\hat{\lambda}_{BC_M}$ marginally increases, the monopolist does not charge extra for this consumer gain because products are optimally priced higher anyway to extract the full surplus from online customers (see Table 2). As a result, the marginal benefit from increasing the SA level is smaller in the B&C case relative to the BO case. Notwithstanding, the marginal cost incurred to increase the SA level is the same in both cases ($=\lambda h$). As such, given the lower marginal benefit but equal marginal cost, the monopolist's optimal solution entails a lower SA level in the B&C case.

Regarding prices, in the BO case the monopolist lowers prices by k_H to attract high shopping trip cost customers to the stores (see Table 2); this is avoided with the online channel where these customers do not incur this cost when shopping on the web (basically, the monopolist in the B&C case can price to extract the shopping trip cost savings of online customers). Consequently, prices are higher in the B&C case.

Finally, Proposition 1 indicates that when the market is fully covered the monopolist is *always* better off profit-wise with an online channel. This result is not surprising, and is consistent with prior research (Fructher and Tapiero, 2005). Essentially, when the monopolist has an online arm, it can extract more surplus from high shopping trip cost consumers allowing it to set a lower SA level for its offline customers. In the Appendix, we formally derive this result even for the general case when the market is not fully covered.

3.3 Duopoly

We now turn to studying the case of competing retailers, where each firm owns one of the products and non-cooperatively sets an SA level and then price. We solve for symmetric pure-strategy sub-game perfect equilibria in both the Bricks-Only (BO) and Bricks & Clicks (B&C) settings. The equilibrium solutions, which are unique, are given in Table 3.

Table 3: Duopoly Solution

	Bricks-Only:	**Bricks & Clicks:**
Variable:		
SA level	$\hat{\lambda}_{BO} = \frac{c+r}{3h}$	$\hat{\lambda}_{BC} = \frac{2\mu t(c+r)}{6ht-3rc\mu(1-\mu)}$
Price	$\hat{p}_{BO} = t + r(1-\hat{\lambda}_{BO})$	$\hat{p}_{BC} = t + r(1-\mu\hat{\lambda}_{BC})$
Profits	$\hat{\pi}_{BO} = \frac{1}{2}(t - h\hat{\lambda}_{BO}^2)$	$\hat{\pi}_{BC} = \frac{1}{2}(t - h\hat{\lambda}_{BC}^2)$

Comparing the equilibrium solutions under the two retail formats leads to the following proposition.

Proposition 2 *Comparing the Bricks-Only and Bricks & Clicks equilibria, we have:* $\hat{p}_{BC} > \hat{p}_{BO}$*, whereas* $\hat{\lambda}_{BC} > \hat{\lambda}_{BO}$ *and* $\hat{\pi}_{BC} < \hat{\pi}_{BO}$ *if and only if* $t < \bar{t}$*, where* $\bar{t} = \frac{\mu c r}{2h}$*.*

Proposition 2 reveals that, *in contrast to the monopoly case*, when the products are sold competitively we get the intriguing result that SA levels can actually be higher and profits lower in the Bricks & Clicks multi-channel format relative to the Bricks-Only case. Thus, even though fewer customers shop in stores while a proportion of customers purchase online, the retailers find themselves offering higher levels of store assistance and earning lower profits. And this occurs when the products are relatively undifferentiated, i.e., competition between retailers is intense.

The intuition for this result is that when a firm unilaterally considers increasing its SA level there are two forces at play. The first is the positive effect of lowering the returns likelihood and thus incurring less expected costs— as in the case of a monopolist, this favors a higher SA level in the BO case as it applies to all consumer purchases. However, the rival has an incentive to respond to this move in the next stage by lowering its price in order to avoid losing customers (who want to benefit from the increased SA level and may defect). Because prices are strategic complements ($\frac{\partial^2 \pi_i}{\partial p_i p_j} > 0$),[13] this results in a second effect whereby both firms aggressively cut prices in the ensuing subgame. Said differently, downstream price competition limits a firm's ability to fully extract the surplus generated for customers when it offers a greater SA level. As the change in SA level affects all customers in the BO case but only a fraction of customers in the B&C case, the desire to react by dropping prices is much more pronounced in the former case— and this dampens the incentive to select a high SA level in the BO case relative to the B&C case. If the competitive intensity is high enough (i.e., t is small), the strategic pricing effect dominates the direct benefit of lowering the returns probability and we get that B&C firms choose a higher SA level than BO firms in equilibrium.

To formalize these ideas, following Tirole (1988), we write the total differential of a marginal increase in the SA level by firm i in the BO and B&C cases, respectively:

$$\frac{d\pi_{BO_i}}{d\lambda_{BO_i}} = \frac{\partial \pi_{BO_i}}{\partial \lambda_{BO_i}} + \frac{\partial \pi_{BO_i}}{\partial p_{BO_j}} \frac{\partial \hat{p}_{BO_j}}{\partial \lambda_{BO_i}}, \tag{6}$$

$$\frac{d\pi_{BC_i}}{d\lambda_{BC_i}} = \underbrace{\frac{\partial \pi_{BC_i}}{\partial \lambda_{BC_i}}}_{\text{Direct Effect}} + \underbrace{\frac{\partial \pi_{BC_i}}{\partial p_{BC_j}} \frac{\partial \hat{p}_{BC_j}}{\partial \lambda_{BC_i}}}_{\text{Strategic Effect}}. \tag{7}$$

The first term on the right-hand side of each expression is the direct effect of increasing the SA level and, as we show in the Appendix, we have $\frac{\partial \pi_{BO_i}}{\partial \lambda_{BO_i}} > \frac{\partial \pi_{BC_i}}{\partial \lambda_{BC_i}} > 0$, i.e., a firm benefits more from a marginal increase in the SA level in the BO case (and, similar to the monopoly setting, this is in proportion to μ). The second term, which was absent for the monopolist, is the negative strategic pricing effect and we have $\left| \frac{\partial \pi_{BO_i}}{\partial p_{BO_j}} \frac{\partial \hat{p}_{BO_j}}{\partial \lambda_{BO_i}} \right| > \left| \frac{\partial \pi_{BC_i}}{\partial p_{BC_j}} \frac{\partial \hat{p}_{BC_j}}{\partial \lambda_{BC_i}} \right|$, i.e., firms will

[13]See Bulow et. al (1985) for details of the strategic complements definition.

Figure 1: Why SA Levels Can be Higher in the Bricks & Clicks Retail Format

react more aggressively in prices in the BO case. If $t < \bar{t}$, competitive intensity is acute and the strategic effect dominates— resulting in a greater overall incentive to increase SA levels in the B&C case. But because the greater SA level is costly, this leads to reduced profits. In effect then, more intense price competition acts as a way for firms in the BO case to limit investment in SA. We illustrate the intuition for this finding in Figure 1.

The comparative statics of the equilibrium solutions given in Table 3 with respect to the model parameters yield a number of findings that we wish to highlight. As might be expected, the solutions in the BO case do not depend on what fraction of consumers have low shopping trip costs (μ)— as all customers shop in stores anyway. However, in the B&C case there is an interesting non-monotonic relationship given in the following Corollary, which also helps understand the cutoff value $\bar{t}$ in Proposition 2.

Corollary 1 *In the Bricks & Clicks equilibrium, if* $t < \frac{cr}{2h}$ *there exists a* $\underline{\mu}$ *such that as the proportion of consumers with a low shopping trip cost increases:* $\hat{\lambda}_{BC}$ *will increase in the range* $\mu \in (0, \underline{\mu}]$ *and decrease in the range* $\mu \in (\underline{\mu}, 1)$.

Corollary 1 reveals that equilibrium SA levels will follow an inverse-U pattern as more shoppers are of the low-shopping trip cost type. The intuition is as follows. When $\mu = 0$ there is obviously no point in offering store assistance as all consumers shop online. Initially as μ increases, having more consumers that shop in stores drives retailers to offer greater SA levels to

Figure 2: SA Levels as a Function of Proportion of Consumers with Low Shopping Trip Costs

reduce these consumers' chance of product returns. Consistent with the findings in Proposition 2, if the degree of retailer differentiation is low enough, at some point the SA level $\hat{\lambda}_{BC}$ will exceed $\hat{\lambda}_{BO}$. However, when μ increases further and the vast majority of consumers shop in stores, the negative effect of greater SA on profits prompts retailers to revert back to the SA level they would set when there was only a Bricks outlet (note from Table 3 that $\hat{\lambda}_{BC} \underset{\mu\to 1}{\to} \hat{\lambda}_{BO}$).

Figure 2 depicts the equilibrium SA levels as a function of the proportion of consumers that shop in stores (μ). The left pane is for the case of low retailer differentiation and the right pane is for the case of high differentiation. It is clear that the SA level in the Bricks-Only equilibrium ($\hat{\lambda}_{BO}$) is constant (as it does not depend on μ). In the Bricks & Clicks case, on the other hand, the SA level ($\hat{\lambda}_{BC}$) will initially increase in μ and, if the competitive intensity is high (t small), we obtain a region where the SA level is greater than in the Bricks-Only case.

Another interesting comparative static, pertaining to both the BO and B&C solutions, is that as the cost of providing SA increases (h goes up) profitability goes up. Hence, and somewhat counterintuitively, firms benefit from higher costs. The intuition is that as the cost of providing SA increases, firms are prompted to reduce their SA levels in equilibrium. Given that firms were over-supplying SA due to competition (SA levels are strategic complements), reducing the SA level results in greater profits. In this respect, the SA cost factor (h) produces a kind of Bertrand super-trap (Cabral and Villas-Boas 2005): holding prices and SA levels constant each firm is better off when h decreases, but taking into account the strategic impact each firm is worse off when h decreases.[14] A summary of all the comparative statics of the duopoly equilibria

[14] Said differently, given the strategic interaction, the firms actually benefit from greater SA costs because this results in their decreasing equilibrium SA levels and increasing prices, which yields greater profits. We thank an

is provided in the Technical Appendix, along with a brief discussion of intuitions.

4 Endogenizing the Online Presence Decision

Several retailers today operate an online channel in addition to their traditional stores. In the previous section we showed that, contrary to the popular belief, operating the additional online arm can drive down retailer profits in a competitive context (Proposition 2). From a normative perspective then, it is not clear whether it is in a firm's best strategic interest to operate the online selling channel. More specifically, when firms can make a long-term decision on whether to open an Internet selling channel, it is conceivable that if one firm decides to do so then the other firm is better off staying offline. To shed light on this issue, in this section we endogenize the decision to open an online arm. First, we generalize the game presented in Section 3 to include a stage in which firms decide whether to incur a costly investment to open an online arm. Then, we extend the endogenous retail format decision to the case where consumers can benefit from the online channel by learning information relevant for their shopping expedition, even though they end up purchasing in stores.

We introduce a first stage to the game in which firms simultaneously decide if they want to operate an Internet selling channel. There is a fixed cost of $F_N \geq 0$ that a firm opening an online arm has to incur. This cost reflects such issues as investment in IT infrastructure necessary to manage online operations, employing skilled personnel (both technical and customer-service related), and logistics outlays to support the additional channel. The rest of the game is set up as before: in the second stage firms make SA decisions, and finally they price their products.

To solve the game, we need to determine the equilibria of three subgames: both firms decide to open online stores, neither of them decides to do so, or only one of them does. We have already covered the first two cases in the previous section and determined the values of $\hat{\pi}_{BC}$ and $\hat{\pi}_{BO}$. Performing similar calculations, we can determine firms' profits in the subgame of the asymmetric case. Let us assume, without loss of generality, that firm 1 decides to open an online arm but firm 2 does not, denoted as (BC, BO). The subgame profits firms earn are:

$$\hat{\pi}^2_{BC,BO} = \frac{\left(9ht - \mu(r+c)^2\right)\left(3ht(2+\mu) - \mu(c+r)(2c+(3\mu-1)r)\right)^2}{18\mu h\left(9ht - 2\mu(r+c)^2\right)^2}, \qquad \hat{\pi}^1_{BC,BO} = \tag{8}$$

$$\hat{\pi}^2_{BC,BO} + (1-\mu)\frac{36h^2t^2 - \mu(27\mu r^2 + 44rc + 13r^2 + 4c^2)ht + 2\mu^2 r(c+r)^2(2c + r(3\mu-1))}{6\mu h\left(9ht - 2\mu(r+c)^2\right)}.$$

The equilibria of the game in the decision to open the online arm depend on the profits that can be achieved in the third stage and on the value of F_N. Four types of equilibria are

anonymous reviewer for pointing this out to us.

possible: two symmetric ones– in which both firms open online arms (BC,BC) or neither does so (BO,BO), and two asymmetric ones– in which firms' roles are reversed– (BO,BC) and (BC,BO). The conditions for each of these equilibria are given below.

Proposition 3 *There exist* $\underline{F}(c, r, h, t, \mu)$ *and* $\overline{F}(c, r, h, t, \mu)$ ($\underline{F} \leq \overline{F}$) *such that*

(a) (BO,BO) *is the unique equilibrium if and only if* $\overline{F} < F_N$*.*

(b) (BC,BO) *and* (BO,BC) *are the only equilibria possible when* $\underline{F} \leq F_N \leq \overline{F}$*.*

(c) (BC,BC) *is the unique equilibrium if and only if* $F_N < \underline{F}$*.*

It is intuitive that when the fixed cost of opening an online store is very high, neither firm will choose to sell online and only the (BO, BO) equilibrium is sustainable. At the other extreme, if the cost is very low, both firms will open an online arm and (BC, BC) is the only sustainable equilibrium.[15] In the middle region of fixed costs, the more interesting asymmetric equilibrium can emerge: one firm opens an online arm and the other does not. Moreover, as the next corollary shows, the firm opening the online arm may earn *lower* product market profits than the Bricks-Only firm.

Corollary 2 *There exists a* $\tilde{t} > 0$ *such that if* $t < \tilde{t}$ *then:* $\hat{\pi}^2_{BC,BO} > \hat{\pi}^1_{BC,BO}$.

Thus, an asymmetric equilibrium can emerge in which the multi-channel firm is worse off than its single-channel, Bricks-Only rival. The intuition follows from our previous findings whereby the profitability of operating the additional online arm, relative to only operating an offline channel, depends on how intense price competition is, which, in turn, depends on the degree of differentiation t. When firms aggressively compete in prices in the last stage (i.e., t is small), the B&C firm is induced to select a relatively high SA level, which dampens its profits. Although it makes sense for one firm to open the online arm (i.e., higher overall profits than only having an offline store and playing out the BO,BO equilibrium), the single-channel rival benefits even more and does not want to deviate. Of course, if t is large enough, then the B&C firm makes greater profits than its rival because it is able to capitalize on serving online customers by charging a much higher price and offering a low SA level.

[15] Note that $\underline{F}$ can be negative, that is, the (BC, BC) equilibrium is not always the outcome for low (non-negative) fixed costs. As we show in the proof of the Proposition, however, there is a range of parameter values for which $\underline{F}$ >0. We thank the AE for asking us to clarify this point.

4.1 Learning Online, Shopping Offline

We have seen that the decision to open an online arm is non-trivial since profits may be negatively affected. However, we have not considered the possibility that consumers may benefit from retailers' web presence even though they make their final purchase in physical stores. Specifically, it is plausible that customers with high shopping trip costs ultimately decide to shop offline, to benefit from SA in stores, but that the costs they incur are lower if they gather some preliminary information online. For example, they may be able to check in advance which retail location has the product in stock, where to find the product in the store, get product details that can be communicated accurately digitally (where manufactured, materials used, quantifiable attributes, etc.). Although the information does not help in determining fit, it can still be of use in making the trip to the store more efficient (spend less time at the store, avoid having to check multiple locations, etc.). Mounting evidence suggests that a large number of consumers indeed gather information online but make their final purchase offline (Verhoef et al 2007). One of the primary reasons consumers cite for such behavior is that ultimately they prefer to "touch and feel" products prior to purchase; and also explicitly voice concern over returns if they don't make the trip to the store. Moreover, a recent Forrester study (Grau 2009) finds that sales in bricks and mortar stores by consumers who first researched online are more than three times higher than online sales— with many executives well aware that the online channel they set up is primarily serving customers who end up buying in stores.

To account for this behavior, we assume that by browsing the online arm a high shopping trip cost consumer can reduce her cost of visiting the store by k_W ($0 \leq k_W < k_H$). We note that if k_W is small, such that high shopping trip consumers still prefer to purchase online, the model is essentially the same as the B&C scenario analyzed up to now. Therefore, we concentrate here on the case where k_W is high enough— such that the effective shopping trip cost of high types after browsing online, $k_H - k_W$, will induce them to visit offline stores.[16] From a strategic standpoint then, the question arises as to whether the firms will want to open an online arm given these implications on consumer behavior and, if so, what profits should they expect in equilibrium.

Starting the analysis from the second stage subgame, if both firms set up online arms (we call this case Bricks & Learning Clicks: BLC,BLC), the results are the same as in the Bricks-Only case. This is intuitive: all customers shop in stores and the competition between the two retailers makes it impossible for them to leverage the extra value they offer to consumers (i.e.,

[16] Formally, we require $k_H - k_W < \frac{c(c+r)}{3h}$. The case where k_H is itself very small, such that high shopping trip cost customers buy offline in equilibrium even in the B&C case, is analyzed in the Technical Appendix.

the benefit of k_W cancels out for the marginal consumer due to competition) and both firms' profits are equal to $\hat{\pi}_{BO}$ (SA levels and prices are as in the BO,BO case; see Table 3). However, if only firm 1 operates an online arm then simple calculations yield that its profits are

$$\hat{\pi}^1_{BLC,BO} = \hat{\pi}_{BO} \left(1 + \frac{(1-\mu)k_W}{9ht - 2(c+r)^2}\right)^2, \tag{9}$$

whereas firm 2's profits are

$$\hat{\pi}^2_{BLC,BO} = \hat{\pi}_{BO} \left(1 - \frac{(1-\mu)k_W}{9ht - 2(c+r)^2}\right)^2. \tag{10}$$

Clearly, $\hat{\pi}^2_{BLC,BO} < \hat{\pi}_{BO} < \hat{\pi}^1_{BLC,BO}$. Thus, the firm offering online research benefits reaps the rewards of doing so because it can now extract extra surplus from high shopping trip consumers and, conversely, the firm not offering website browsing is at a disadvantage.

Turning now to the equilibrium of the entire game, the findings are similar to those in Proposition 3, except that the asymmetric cases do not arise. If F_N is low then both firms open online stores (BLC,BLC) where consumers learn online but shop offline, whereas if F_N is high then neither firm establishes an online presence.

Proposition 4 *There exists an $\tilde{F}(c, r, h, t, \mu)$ such that if $k_H - k_W < \frac{c(c+r)}{3h}$ then*

(a) (BLC,BLC) *is the unique equilibrium if and only if $F_N < \tilde{F}$.*

(c) (BO,BO) *is the unique equilibrium if and only if $\tilde{F} < F_N$.*

Thus, as in Proposition 3, when firms find it prohibitively costly to maintain the Internet channel then neither firm will open it. However, when the cost is low enough, both firms will open online arms. Although no consumer purchases online, high shopping trip cost customers benefit from learning online when shopping offline. What makes this result noteworthy is that firms do not make higher product market profits when operating the online channel, indeed they make exactly the same profits as without them, but they also have to incur the investment costs (F_N). Hence, firms are overall worse off than when they can both commit to not opening the online channel. The reason for this outcome is akin to a prisoner's dilemma type situation. If only one firm opens an online arm, it puts its rival at a huge disadvantage due to the learning benefits the online arm offers customers with high shopping trip costs (per (10)). Thus, the rival's best response is to open an online arm as well.

Although the equilibrium outcome is Pareto-worse for firms, the big winners are high shopping trip consumers who enjoy greater surplus: competition keeps prices down, while the online arm offers informational value. The result is consistent with the emergence of a phenomenon that industry analysts call "cross-channel shopping", whereby consumers learn online yet shop offline; the size of this group is far greater than that of consumers who buy online (Grau 2009). It is further consistent with the way many managers now view the role of their online arm— as a marketing element that complements the physical store rather than cannibalizing it, and one that they cannot afford to ignore given competition (Mulpuru and Holt 2009).

5 Discussion of Model Assumptions and Extra Analysis

Our stylized model has several features that merit discussion. These include assumptions on the actions of firms and on consumer behavior, which were made to best reflect reality while at the same time keep the model as simple as possible and the analysis tractable. The structure we employed was intended to allow focusing on the primary research questions of interest. In this section, we discuss the key model assumptions and describe extra analysis we conducted to relax several of them (formal details are available in a separate Technical Appendix).

5.1 Supply-side Assumptions

Offering Multiple Product Categories– In our analysis each retailer carried one type of product. However, in reality, many retailers offer multiple product categories. For example, Best Buy carries a number of different consumer electronic goods ranging from digital devices (cameras, computers, etc.) to home appliances (refrigerators, laundry machines, etc.), and The Gap offers various apparel categories (jeans, activewear, swimwear, etc.) as well as a number of accessory categories (bags, shoes, belts, etc.). One may wonder how carrying multiple product categories, each associated with a different base probability of return, impacts retailer strategy and profits. To address this question, we analyzed a model where each firm carries two product categories. Our main finding is that if there is a substantial difference in the likelihood of return between the categories, then retailers may only offer the "safer" product (with a lower base returns probability) online and restrict selling the "riskier" product to the traditional store. Our findings here are consistent with the data of Verhoef et al. (2007), who report that consumers in a multi-channel setting find substantially less assortment online than offline. The practices of several retailers also seem to support our findings. For example, national furniture retailer La-Z-Boy opened an online channel in mid 2008, but only offers a limited assortment of styles for sale online (and those mainly include its classic items; Trop, 2008).[17] Midwest-based retailer

[17]On its website, La-Z-Boy explicitly states in its "Frequently Asked Questions" section that "a *limited* assortment of products is available online" (emphasis added).

Meijer sells various product categories online, but clothing is only offered in its physical stores (see Figure 3). Lastly, it is interesting to note that a number of fashion retailers are shifting from a strategy of offering a full range of products online to being more selective and offering only a limited assortment on their websites (JupiterResearch 2007b).

Price Differences Across Outlets– Our model assumes that each retailer sets a single price, i.e., consumers were charged the same price in both channels. This is consistent with the practice in most multi-channel settings (as pointed out at the end of Section 3.1.1), and with recent surveys of retail executives revealing that "same prices across all channels" is the foremost expectation that consumers have from multi-channel retailers (JupiterResearch 2007a). It is instructive, however, to examine what happens when retailers are able to charge a different price in each channel. In the Technical Appendix, we examine two settings. In the first, we find that if prices online are not bound in any way by prices offline, then B&C firms will always set a lower SA level and earn higher profits relative to the BO case. In other words, completely separate pricing reinstates the monopolist result whereby firms are better off with the addition of the online channel. But if the discrepancy in prices has a limit, the main findings obtained in the equal pricing case of Section 3.3 qualitatively hold.

Shipping Costs and Variable Costs– All non-digital products bought online have to be processed and shipped to the customer's designated location. The related costs can either be borne by the retailer or passed (at least in part) onto the customer at the seller's discretion. We analyzed a variant of our model that includes shipping and handling costs for online purchases. We find that the existence of these costs does not affect our results presented in Section 3.3: the shipping costs are simply added to the online prices, which is common in practice. Thus, the finding that SA levels can be higher and profits lower in the B&C competitive setting still hold even when shipping and handling costs are introduced.

We also examined the effects of different variable costs of serving consumers online and offline. If the variables costs are the same on the Internet and in physical stores then our results remain unchanged, except that prices will include the variable cost component. However, if variable costs are lower online, then the retailers will be biased towards serving online customers and offer lower store assistance offline. (Conversely, if variable costs are lower in physical stores then retailers will naturally offer more store assistance).

Shopping Assistance Online – Our paper has focused on products for which physical inspection is the primary way for consumers to increase the chances of finding a match. This meant that sales assistance was primarily relevant in stores.[18] However, for some product categories, such as books and music, offering digital samples online or access to consumer reviews can make the online channel more conducive to deciding which products to buy than visiting stores. Other examples include certain electronics products where the ability to receive accurate specs and expert explanations online reduce the chances of a mismatch. Not surprisingly, these latter product categories are sold extensively online, and retailers may have an incentive to invest in the online environment to facilitate consumers' experience when shopping for them. In the Technical Appendix, we examined the implications of allowing retailers to invest in SA online. We find that if it is effective and cheaper to provide SA online, then firms will offer SA only on the Internet and sell everything online. If, however, it is sufficiently cheaper to offer SA in stores, then we get the same results as in the basic model (Section 3).

Product Returns Due to Defects– Our focus in this paper has been on returns originating from lack of customer fit, in order to highlight this critical aspect of online vs. offline purchasing. In reality, product returns can also result from the good malfunctioning or being damaged. To examine the role of product defects in the context of our model, it is important to first specify how and when the players can identify defects. If, for example, consumers can only identify a faulty product after using it for a short period of time and not at the point of purchase, then it does not matter whether they buy online or offline. If, on the other hand, consumers can inspect the good at the point of purchase and tell whether it is defective, then buying in a physical store versus online makes a big difference. The second relevant issue to consider is the firm's ability to endogenously reduce the rate of defects. If firms cannot or do not want to invest in upfront quality control, but in-store sales assistance helps identify defective products, then the analysis is equivalent to our fit/mismatch approach and yields the same results. Perhaps a realistic set of assumptions is that the firm can undertake costly actions to reduce product defects (say through tighter quality control measures) and consumers can ascertain whether a product is defective in physical stores but cannot do so online. In this case, firms' investments to reduce the rate of defects only matter for online shoppers. This scenario is thus somewhat similar to the case we have just discussed regarding store assistance online, with the exception that the baseline returns probability (now a function of both the defects rate and mismatch likelihood) are lower offline, where consumers can identify defective products. For consumers,

[18] There is ample empirical evidence that for categories such as apparel and furniture consumers do consider the ability to touch and feel products in their decision of where to shop (Anderson et al. 2009). Indeed, while the average return rate in 2007 for apparel and shoes purchased in stores was about 6.65%, it was 30% online. (Sources: "2007 online retail sales hit $175 billion," *Internet Retailer Strategies for Multi-Channel Retailing*, January 28, 2008; LPRC, 2008; Martinez, 2008).

a lack of investment in lowering the defects rate would be equivalent to being charged a higher price online. Incorporating these ideas into a formal model would be rather complex (since there would be two upfront investments to characterize and the expressions for expected returns probability would become much more complicated), but we conjecture that the results for SA levels and prices would be similar in spirit to the case in which there is a limited price difference allowed across channels which we examine in the Technical Appendix. Whether new findings emerge with respect to firms' additional decision variable on quality control or the parameters related to defective returns are issues we leave for future research.

Returns Policy– Our model did not allow firms to determine the terms of the returns policy. For example, a retailer could impose a restocking fee on consumers when a product is returned, or set a limit on the time a product return will be accepted.[19] Restocking fees or time limits essentially impose an extra cost of returns on consumers and a decrease in cost on retailers—which would be reflected in the parameters c and r, respectively. The question arises as to how endogenizing the returns policy decision would affect our findings.[20] We solved an extension where each retailer has the option of imposing a restocking fee for returned products. We find that – similar to the analysis of charging extra for shipping costs – retailers impose a restocking fee up to the maximal allowable amount.

Operating a Catalog Channel– Besides the Internet, retailers can directly sell to consumers through catalogs. Several aspects of catalogs are similar to the Internet: there is no ability to physically inspect products, delivery is direct to the consumer's designated location, and there are shipping costs involved. Hence, to some extent, for the "touch and feel" type products considered here our findings could apply to multi-channel retailers operating a store and catalog channel. That said, there are a number of differences. First, a catalog has to be physically printed and mailed to the consumer. This results in added variable costs relative to the Internet and in the fact that only consumers receiving the catalog have access to it. Second, the consumer has to mail or call in the order, resulting in additional delays/effort. Third, the space in a catalog is often limited, hence our conclusions may be confounded with this constraint. Fourth, looking through the physical pages of the catalog produces a somewhat different shopping experience

[19]Restocking fees can range between 0-50% of the original price of the item. The duration of allowable returns can range from a few days to lifetime policies.

[20]Shulman et al. (2009), for example, examine a monopoly setting and identify conditions for the retailer to set a restocking fee that is lower (higher) than the actual cost of handling the return in order to encourage (discourage) uncertain consumers to make an initial purchase. This allows the retailer to optimally balance the creation of demand on the one hand and a reduction of returns volume on the other. In our case, the market is competitive and fully covered; hence the former incentive of creating demand is absent.

than the virtual environment online. Fifth, the Internet offers consumers greater flexibility in terms of when and where to shop, but requires internet connectivity. If these differences are substantial for specific categories, then our findings reported in the paper may need to be qualified when generalizing to catalogs. Studying the strategic use of the catalog channel in these cases may also require incorporating different variables. Our focus on the Internet channel is driven by the reality that catalog sales comprise only a fraction (less than 10%) of online sales.[21]

5.2 Demand-side Assumptions

Store Assistance Affecting Consumer Utility– In our model, we assume that the role of store assistance is to increase the likelihood of product fit for consumers visiting the store. However, SA can potentially have other positive effects on consumer decisions. Most importantly, the benefit a customer perceives s/he will gain from consuming the product may be affected by SA. We analyzed a variant of the basic model, where the consumer's expected valuation of the product is $v(1+\lambda_S)$ when purchasing offline— that is, SA increases the perceived consumer valuation of the product. It turns out that the increase in perceived valuation from store assistance has the same impact as a lowering of the returns costs incurred by the customer (c); hence the results are similar to those reported in the paper.

Heterogeneity in Consumer Characteristics/Tastes– Our model incorporated two forms of consumer heterogeneity— in horizontal preferences for the offerings of the two retailers and in shopping trip costs to visit stores. Several issues are worthwhile discussing in connection with our assumptions. First, although preferences for retailers were modeled as continuous, the shopping trip costs were dichotomous (a two-segment approach). Modifying the model to allow continuously distributed shopping trip costs substantially complicates the analysis and obfuscates comparisons across the different channel formats. That said, in the Technical Appendix we show that our main results hold even if we increase the number of segments beyond two (with each segment having different shopping trip costs).

Second, our model assumed a homogeneous probability of product match. In reality, of course, consumers may differ in terms of their ex-ante probability that a purchase will result

[21] Verhoef et al. (2007) provide a comparison of the various channels, including catalogs, along a number of factors relevant for consumer purchasing behavior. Interestingly, Pauwels and Neslin (2008) show that when an apparel retailer that sold only remotely (catalog and Internet) opened physical stores, then the latter cannibalized catalog but not Internet sales. This would suggest that, going forward, physical stores and the Internet are likely to be the predominant outlets for multi-channel retailers. Furthermore, analysts expect the CAGR of Internet sales to be roughly triple those of catalogs over the next five years (Brohan, 2008).

in a return. In the Technical Appendix we show that relaxing this aspect of our model does not qualitatively affect our findings. This is because as long as firms cannot identify consumers based on their likelihood of a return (and even if so cannot price discriminate) then firms would use an expected probability of return that directly maps into our model structure.

Third, in our model a segment of consumers purchased online to save their high shopping trip cost (i.e., avoid incurring a disutility). In reality, some consumers may derive positive utility from shopping online relative to shopping in physical stores. This might be the case for consumers who value the sense of control that comes with the online purchase experience or who appreciate the ability to search multiple sites. In an extension, we analyzed a model that includes a segment of consumers that derive extra utility from shopping online.

Consumer Dynamics– Our model does not explicitly incorporate consumer dynamics; as may be the case when a consumer's assessment of which product would best match his/her needs depends on past purchases in the category. This is consistent with our focus on categories where models, styles and versions change from purchase occasion to purchase occasion; thus inducing uncertainty in fit and a benefit from visiting stores each time. However, some sub-categories may exhibit consumer learning over time. For example, a pair of Levi's 505 jeans remains the same; hence a consumer in the market for the same jeans style for the second or third time will have a lower probability of return (though the individual's size may have changed or the specific shade/cut desired is different). In such instances, it is conceivable that a product that was considered "risky" when introduced, over time becomes "safe". Based on our analysis, this could result in a product only being carried in stores in the first period and carried both in stores and online in the second period. It would be interesting to understand what effect such inter-temporal dynamics have on retailers' behavior aimed at engendering familiarity in the first period in order to reap higher profits in the second period. We leave the examination of such dynamic issues for future research. It is worthwhile mentioning that this problem is related to the experience goods literature, which examines goods whose quality (fit) can only be judged via consumption (see the classic Nelson 1970, 1974 papers).

In our model, consumers choose the retailer and selling channel with the highest expected utility to them. Implicit in this formulation is that, in the event of a mismatch, having tried the product of one retailer reduces the chances of returns with that retailer for the remaining product variants. This differs from treatments in which consumers are assumed to "exit the market" after a single mismatch incident. We also do not allow consumers to shop around for a better match at both retail outlets. This is because the primary reason for mismatch in our model is related to an inability to completely resolve uncertainty, before actual usage, associated with all product variants (color, size, texture, etc.) offered by each retailer.[22]

Access to the Online Channel– Consumers in our model were assumed to all have Internet access. Increasingly, consumers do have Internet access and thus our model reflects the situation that will, most likely, eventually take shape. However, one might still wonder whether our findings hold if Internet penetration is much lower. For example, the UK is considered one of the most advanced e-commerce markets in Europe, yet only about 50% of the population have regular online access. Clearly, if all consumers can only purchase in stores, the model essentially reverts back to the Bricks-Only case. If there is a sub-set of consumers that cannot purchase online, this could have implications for multi-channel retailers but would not qualitatively affect our findings (see Technical Appendix). Consequently, we believe that even if we modeled the situation where consumer access to the online channel increased over time (and firms take that into consideration) this should not affect our findings.

We also note that the more room there is to increase Internet penetration, typically the higher the observed year on year growth rate in online sales. For example, online sales grew at a CAGR of more than 20% in the U.S. between 2001-2006, but as Internet access saturated the rate declined (only 13% in 2008 and expected to be about 10% in 2009-2012). In Europe, where average penetration is lower, the growth rate was still well over 20% in 2008. Consequently, in absolute dollar terms, most categories are experiencing healthy year on year sales increases online. But, importantly, as a percent of total retail spending, it is still the case that touch and feel categories are predominantly sold offline. For example, although 2007 online apparel sales are impressive, \$22.7 billion in the U.S. and £1.7 billion in the UK, these figures represent a relatively small percent of total apparel sales (10% and 4.5%, respectively). Our model would suggest that these sales come from consumers who experience a high cost of visiting the stores (and that have Internet access).

6 Conclusion

The advent of the Internet has created an additional way for traditional retailers to make products available to customers. With over three quarters of U.S. households expected to

[22]With respect to shopping trip costs, in real life the same consumer may have a different inclination to purchase through a given channel from occasion to occasion. For example, the consumer may be time/effort constrained in one period and therefore be part of the high shopping trip cost segment and in another period be much less constrained. But this would not reflect a trend that makes the consumer more or less likely to use a given channel over time. Our static model assumes that such random components “wash out” in the aggregate so that segment sizes are roughly stable over time, even though specific individuals may switch between them.

have Internet access by the end of 2009, consumers must consider not only which retailer to shop from but in many instances through which channel. Our research has looked at how operating an online selling channel, in conjunction with a physical store, will impact retailer strategies and profits. Our focus has been on categories where the ability to physically inspect products is important in determining fit and thus reducing the likelihood of returns. Such returns have both supply-side and demand-side implications. Beyond asking how the Internet channel is likely to affect pricing decisions, our analysis has also addressed the questions of how the store environment is likely to change as a result of the dual channel structure and under what conditions we should anticipate retailers to open an online arm. In an extension, we also addressed such questions as whether the range of categories sold in stores will be mirrored online.

Our results show that these elements of the marketing mix are closely inter-related and also depend on the degree of retailer differentiation. If such differentiation is high, retailers tend to exploit consumers' relatively strong brand preferences by charging high prices, while reducing in-store assistance levels relative to the Bricks-Only case. The opposite is true if differentiation is low. We obtained the intriguing result whereby the introduction of the online channel can prompt competing retailers to offer more in-store assistance in order to make the offline environment more conducive to finding a match– even though less consumers shop there. However, because offering greater store assistance is costly, the retailers earn lower profits than in the Bricks-Only case.

Our main findings suggest that in product categories where: a) consumers can benefit from store assistance to determine fit and reduce the likelihood of returns, and b) price competition between retailers is relatively intense— we may observe retailers increasing store assistance levels after opening an online arm. One category where we might expect this to occur is apparel. Indeed, several retailer moves in the past few years are consistent with our findings. Take J.C. Penney as an example.[23] This multi-billion dollar retailer operates an online arm (with online sales estimated at roughly 6.5% of total revenues in 2008). Despite the growing shift in sales to the online channel, J.C. Penney over the past two years has invested considerably in store assistance. In particular, the company invested millions of dollars in a new initiative it calls "CustomerFIRST", which entails a more intensive associate training program, detailed management tracking and feedback to associates and a revamped incentive scheme. The main goal of the program is to facilitate the consumer shopping experience in stores. In commenting on CustomerFIRST, executives at the company highlight the competitive environment as a primary factor for launching the program. Further note that the initiative comes even as comparable

[23]The information for this example was compiled from the following sources: *BussinessWire* (2009a,b); FDW (2009); *BussinessWire* (2008).

store sales across the industry (including at J.C. Penney) have declined over the last two years, which would be consistent with SA level increasing despite lower store patronage. Note also that it is still the case that most consumers are willing to travel to J.C. Penney stores to purchase apparel (per the conditions on μ in Corollary 1). J.C. Penney is not alone in this industry. For instance, J. Crew, which sells clothing items over the Internet in addition to physical stores, recently added a novel service to support customers in stores. Specifically, the company is gradually rolling out a "Just Ask" help desk where representatives act as "concierges" to assist customers on the floor. The new service requires investments in training, personnel and physical fixtures. Once again, the competitive climate has been explicitly cited by CEO Mickey Drexler as a factor leading to the new offering (Williamson 2008).

The above examples show how, in the course of following the trend of opening Internet outlets, firms can find themselves in tougher position. Interestingly, and following similar reasoning, when the decision to open the online arm is endogenized an asymmetric equilibrium can arise whereby only one firm operates an online channel yet makes lower profits than its single-channel, Bricks-Only rival. We also characterized an equilibrium where both firms open the online arm even though they make lower total profits and all consumers shop in stores. In this case the retailers' websites only serve as a learning tool for reducing consumers shopping trip costs. The retailers get caught up in a sort of 'prisoner's dilemma' situation: if one retailer opens the online channel, its rival is better off opening it as well, though this makes both retailers worse off than if they could commit to not having online presence.

Our results are robust to the incorporation of shipping and handling costs. In particular, we find that retailers will tend to pass these expenses onto online customers, yet may still increase store assistance levels and thus earn lower total profits. We also analyzed, in an extension, the case of multiple product categories. Here we found that retailers need to be mindful that some products are too "risky" to offer online because of the high chance of returns. This would help explain why we have recently witnessed several retailers, particularly in fashion related categories, become more selective and limit the sales of certain categories to physical stores. It would also suggest that, for some categories, retailers need to carefully plan the product quantities to stock in stores, given that all consumers will tend to shop there.

Appendix

Proof of Proposition 1: Here, we prove the case in which v is high enough so that both consumer segments are fully covered. First, we solve the Bricks-Only case. Since v is high enough, the monopolist will target all consumers to extract the most profit. Since $k_H > c$, the optimal price will be the lowest net utility of any k_H type consumer $p = v - k_H - (1-\lambda)c - t/2$. Then, differentiating the profit function with respect to λ and setting it to 0, we get $\hat{\lambda}_{BO_M} = \frac{r+c}{h}$. In the Bricks & Clicks case, the optimal price will be $v - c - t/2$. Differentiating the profit function with respect to λ and setting it to 0, we get $\hat{\lambda}_{BC_M} = \frac{\mu r}{h}$. It can easily be verified by plugging into the profit functions that under these prices and SA levels $\hat{\pi}_{BC_M} > \hat{\pi}_{BO_M}$. □

Monopolist profits in non-fully covered markets: When the market is not necessarily covered, comparing the Bricks-Only case with the Bricks & Clicks case, we observe that all consumers are weakly better off if there is an Internet store and prices and SA levels are fixed (at λ' and p'): for low shopping trip cost consumers there is no difference, whereas high shopping trip cost consumers have the choice of going to the online store if they are better off there. However, the firm has to incur higher return costs for each online customer (λr higher). Let us examine three cases separately. If none of the high shopping trip cost segment makes a purchase in the BO case then partial market coverage is not an issue, as monopoly profits must be weakly higher when adding an online arm. When both segments are fully covered, price changes do not necessarily affect demand as we have seen in the previous proof. Thus, we may assume that the high shopping trip cost segment is partially covered. Recall that λ' and p' denote the optimal Bricks-Only monopoly SA level and price. Let us examine the situation when, after opening an online store, the monopolist increases the price to $p = p' + \lambda' r$ and keeps the SA level at $\lambda = \lambda'$. The number of customers that the firm loses in the low shopping trip cost segment is at most $\mu\lambda r/t$, thus the profit loss is at most $p\mu\lambda r/t$ (it is actually smaller than this due to the increased price leading to higher margins). On the other hand, the number of new customers in the high shopping trip cost segment is at least $(1-\mu)(k_H - (1-\lambda)c - \lambda r)/t$. This is due to the increased surplus of customers who do not have to incur shopping trip costs anymore. Thus the profit increase is at least $p(1-\mu)(k_H - (1-\lambda)c - \lambda r)/t$. One can check that if $k_H > \tilde{k}(\mu, r, c) = \frac{r}{1-\mu} + c$ then $p(1-\mu)(k_H - (1-\lambda)c - \lambda r)/t \geq p\mu\lambda r/t$ for any $0 \leq \lambda \leq 1$. Therefore, applying a price increase the monopolist is capable of at least maintaining the BO profit level when opening an online selling channel. The optimal profits are likely to be even higher. □

Proof of Proposition 2: First, we examine the case in which there is no Internet channel (the BO case). Each consumer will compare U_{S_1} with U_{S_2} (see (1)). Only consumer heterogeneity in terms of retailer preferences matters because shopping trip costs cancel out. The demand of each retailer can be calculated by finding the consumer located at x that is indifferent between the two stores. For purposes of the proofs, from this point we will drop the S subscript and use λ_1 and λ_2 to denote the store assistance levels. Then, the indifferent consumer can be found by solving

$$v - p_1 - tx - c(1 - \lambda_1) = v - p_2 - t(1 - x) - c(1 - \lambda_2). \tag{A1}$$

Rearranging terms in (A1), the profit function of retailer 1 is:

$$\pi_1 = \frac{p_2 - p_1 + (\lambda_1 - \lambda_2)c + t}{2t}(p_1 - r(1 - \lambda_1)) - \frac{1}{2}h\lambda_1^2. \tag{A2}$$

A similar expression exists for retailer 2. Taking first order conditions with respect to prices (holding SA levels constant) and solving the system, one obtains:

$$p_i = t + r + \frac{c(\lambda_i - \lambda_j) - r(2\lambda_i + \lambda_j)}{3}, \quad i \neq j. \tag{A3}$$

Substituting back into the profit functions and differentiating with respect to SA levels we get the best response SA levels

$$b_i(\lambda_j) = \frac{3t(c + r) - (c + r)^2\lambda_j}{9ht - (c + r)^2}, \quad i \neq j. \tag{A4}$$

Solving the resulting system provides the subgame-perfect equilibrium expressions in the left hand column of Table 3. Uniqueness follows from the strict concavity of the profit functions guaranteed under (A13).

Now we examine the Bricks & Clicks case in which consumers can shop both offline and online. Clearly, k_L types will never shop on the Internet and only compare physical stores (as in the proof of the BO duopoly case). For the k_H type consumers, because their shopping trip costs are higher than the expected returns costs, they only need to compare U_{N_1} with U_{N_2}. On the Internet, the indifferent consumer satisfies: $v - p_1 - tx - c = v - p_2 - t(1 - x) - c$. Thus, firm 1's profit will be:

$$\pi_1 = \mu\frac{p_2 - p_1 + (\lambda_1 - \lambda_2)c + t}{2t}(p_1 - (1 - \lambda_1)r) + (1 - \mu)\frac{p_2 - p_1 + t}{2t}(p_1 - r) - \frac{1}{2}h\lambda_1^2. \tag{A5}$$

Following the same steps as in the proof of the BO duopoly case, the best response functions are

$$b_i(\lambda_j) = \frac{\lambda_j(2\mu^2c^2 - 5\mu^2cr + 9\mu cr) - 6t(c + r)}{2(\mu^2c^2 + \mu^2r^2 - 9ht - 7\mu^2cr + 9c\mu r)}, \quad i \neq j. \tag{A6}$$

Solving the system we get the equilibrium results stated in the right hand column of Table 3. The equilibrium is unique because the profit functions are concave. Also, note that firms cannot profitably deviate to change the qualitative behavior of the two segments. Condition (A13) below ensures that $0 \leq \hat{\lambda}_{BC} < 1$, and in particular that the denominator of $\hat{\lambda}_{BC}$ is always positive.

Finally, we compare the result we obtained with and without the online channel. Straightforward calculations comparing the expressions in the left and right hand columns of Table 3 yields that $\hat{\lambda}_{BC} > \hat{\lambda}_{BO}$ and $\hat{\pi}_{BC} < \hat{\pi}_{BO}$ hold if and only if $t < \frac{\mu cr}{2h}$. We note that $\hat{p}_{BC} > \hat{p}_{BO}$ is equivalent to

$h > \frac{\mu cr}{(1+\mu)2t}$. Since $\frac{\mu}{(1+\mu)} < \frac{1}{2}$ and $4cr \leq (c+r)^2$, the condition on h follows from $h > \frac{(c+r)^2}{9t}$ in (A13). That is, prices in the B&C case are higher than in the BO case in the parameter region we examine. $\square$

Explicit Comparison of Direct and Strategic Effects Given in (6):

$$\frac{\partial \pi_{BO_i}}{\partial \lambda_{BO_i}} = \frac{c}{2t}(p_i - r(1-\lambda_{BO_i})) + \frac{r}{2t}(p_j - p_i + (\lambda_{BO_i} - \lambda_{BOj})c + t) - h\lambda_{BO_i}, \tag{A7}$$

$$\frac{\partial \pi_{BC_i}}{\partial \lambda_{BC_i}} = \mu\left[\frac{c}{2t}(p_i - r(1-\lambda_{BC_i})) + \frac{r}{2t}(p_j - p_i + (\lambda_{BC_i} - \lambda_{BCj})c + t)\right] - h\lambda_{BC_i}. \tag{A8}$$

Clearly, if evaluated at the same SA level, the direct effect given in (A7) is greater than that in (A8) (note that both effects must be positive in equilibrium).

$$\frac{\partial \pi_{BO_i}}{\partial p_{BO_j}}\frac{\partial \hat{p}_{BO_j}}{\partial \lambda_{BO_i}} = -\left(\frac{p_{BO_i} - r(1-\lambda_{BO_i})}{2t}\right)\frac{c+r}{3}, \tag{A9}$$

$$\frac{\partial \pi_{BC_i}}{\partial p_{BC_j}}\frac{\partial \hat{p}_{BC_j}}{\partial \lambda_{BC_i}} = -\left(\frac{\mu(p_{BC_i} - r(1-\lambda_{BC_i}))}{2t} + \frac{(1-\mu)(p_{BC_i} - r)}{2t}\right)\frac{\mu(c+r)}{3}. \tag{A10}$$

Both strategic effects are negative and it is clear by inspection that, when evaluated at the same SA level, (A10) is smaller than (A9) in absolute terms (this evident by two factors: (i) the last term in (A10) is multiplied by μ relative to (A9), (ii) $\mu(p_{BC_i} - r(1-\lambda_{BC_i})) + (1-\mu)(p_{BC_i} - r)) < (p_{BC_i} - r(1-\lambda_{BC_i}))$; plugging in the equilibrium values for $\hat{p}_{BC_i}$ and $\hat{p}_{BC_j}$ confirms these relationships). $\square$

Proof of Corollary 1: The derivative of $\hat{\lambda}_{BC}$ with respect to μ is zero when $\mu = \underline{\mu} = \sqrt{\frac{2ht}{rc}}$. Note that $0 < \underline{\mu} < 1$ when $t < \frac{cr}{2h}$. Further examining the derivative shows that $\hat{\lambda}_{BC}$ is increasing for $0 < \mu < \underline{\mu}$ and decreasing for $\underline{\mu} < \mu < 1$. $\square$

Proof of Proposition 3: To simplify notation, we will use $\pi_{00} = \hat{\pi}_{BO}$, $\pi_{11} = \hat{\pi}_{BC}$, $\pi_{10} = \hat{\pi}^1_{BC,BO} = \hat{\pi}^2_{BO,BC}$, and $\pi_{01} = \hat{\pi}^2_{BC,BO} = \hat{\pi}^1_{BO,BC}$. Further to (A13), we assume that $h > 2\mu\frac{(c+r)^2}{9t}$ to ensure an interior solution in the asymmetric case. In order to prove the proposition, we identify the criteria that each type of equilibrium requires.

- (BO,BO): In this case, both firms make π_{00} profits. They do not have an incentive to unilaterally deviate iff $\pi_{00} \geq \pi_{10} - F_N$.
- (BC,BC): In this case, firms do not have an incentive to deviate iff $\pi_{11} - F_N \geq \pi_{01}$.
- (BO, BC): Firm 1 does not have an incentive to deviate iff $\pi_{01} \geq \pi_{11} - F_N$. Firm 2 does not want to deviate iff $\pi_{10} - F_N > \pi_{00}$.

Now let $\underline{F}(c,r,h,t,\mu) = \pi_{11} - \pi_{01}$ and $\overline{F}(c,r,h,t,\mu) = \pi_{10} - \pi_{00}$. Combining the three cases, one can obtain the different types of equilibria that are possible under different parameter values, as described in the proposition. Note that $\underline{F}$ can be negative. Yet there are parameter regions in which $\underline{F}$ is positive and the only equilibrium is (BC, BC). For example, if $\mu = 1/50, c = 3, r = 1, h = 1, t = \frac{10}{11}\frac{\mu rc}{2h}$ then $\pi_{11} > \pi_{01}$.[24]$\square$

Proof of Corollary 2:

One can check in (8) that $\hat{\pi}^2_{BC,BO} > \hat{\pi}^1_{BC,BO}$ holds if and only if

$$t < \tilde{t} := \frac{\mu}{72h}\left(\begin{array}{c} 4c^2 + 44rc + (13+27\mu)r^2 \;\; + \\ \sqrt{16c^4 - 224rc^3 + 24c^2(49-27\mu)r^2 + 8c(143+81\mu)r^3 + (457+81\mu(9\mu-2))r^4} \end{array}\right).$$

$\square$

Proof of Proposition 4: We show in the Technical Appendix that if shopping trip costs (which here are effectively $k_H - k_W$) are less than $\frac{c(c+r)}{3h}$ then even high shopping trip cost consumers buy offline. Therefore, firms deciding to open an online arm have to anticipate that consumers would not buy online, just learn. Let us compare the decision between the BO and BLC options. If

$$F_N < \tilde{F}(c,r,h,t,\mu) := \frac{(1-\mu)k_W}{9ht - 2(c+r)^2}\left(2 - \frac{(1-\mu)k_W}{9ht - 2(c+r)^2}\right), \tag{A12}$$

then $F_N < \hat{\pi}_{BO} - \hat{\pi}^2_{BLC,BO}$ and a firm is better off setting up an online arm if the rival does so. Furthermore, since

$$\frac{(1-\mu)k_W}{9ht - 2(c+r)^2}\left(2 - \frac{(1-\mu)k_W}{9ht - 2(c+r)^2}\right) \leq \frac{(1-\mu)k_W}{9ht - 2(c+r)^2}\left(2 + \frac{(1-\mu)k_W}{9ht - 2(c+r)^2}\right),$$

$F_N < \hat{\pi}_{BO} - \hat{\pi}^2_{BLC,BO} \leq \hat{\pi}^1_{BLC,BO} - \hat{\pi}_{BO}$. Thus, a firm is also better off setting up an online arm if the rival firm does not do so. Therefore, if F_N is lower than $\tilde{F}$ then both firms choose the BLC option. If, however, $F_N > \tilde{F}$ then firms do not have an incentive to open an online arm, thus the unique equilibrium is (BO, BO). $\square$

Lower bound on the SA cost factor: Throughout the analysis we require that $\hat{\lambda}_{S_i} \in (0,1)$ and that the profit functions are strictly concave. This means that we need

$$h > Max\left\{(c+r)^2/(9t), \;\; (c+r)/3, \;\mu(3rc(1-\mu) + 2t(c+r))/(6t)\right\}. \tag{A13}$$

The first term in the curly brackets comes from the second order conditions of profit functions in Proposition 2. The second term comes from the requirement that $\hat{\lambda}_{BO} < 1$, and the third term from $\hat{\lambda}_{BC} < 1$.

[24]In this example, and consistent with Proposition 2, for small t values profits are smaller than if both firms could commit to staying Bricks-Only.

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Figure 3: Meijer Does Not Sell Clothing Goods Online (Only Sold in Stores)