This article was downloaded by: [128.36.7.68] On: 18 September 2017, At: 11:56
Publisher: Institute for Operations Research and the Management Sciences (INFORMS)
INFORMS is located in Maryland, USA

Marketing Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Match Your Own Price? Self-Matching as a Retailer's Multichannel Pricing Strategy

Pavel Kireyev, Vineet Kumar, Elie Ofek

To cite this article:
Pavel Kireyev, Vineet Kumar, Elie Ofek (2017) Match Your Own Price? Self-Matching as a Retailer's Multichannel Pricing Strategy. Marketing Science

Published online in Articles in Advance 03 Aug 2017

. https://doi.org/10.1287/mksc.2017.1035

Full terms and conditions of use: http://pubsonline.informs.org/page/terms-and-conditions

This article may be used only for the purposes of research, teaching, and/or private study. Commercial use or systematic downloading (by robots or other automatic processes) is prohibited without explicit Publisher approval, unless otherwise noted. For more information, contact permissions@informs.org.

The Publisher does not warrant or guarantee the article's accuracy, completeness, merchantability, fitness for a particular purpose, or non-infringement. Descriptions of, or references to, products or publications, or inclusion of an advertisement in this article, neither constitutes nor implies a guarantee, endorsement, or support of claims made of that product, publication, or service.

Copyright © 2017, INFORMS

Please scroll down for article—it is on subsequent pages

INFORMS is the largest professional society in the world for professionals in the fields of operations research, management science, and analytics.
For more information on INFORMS, its publications, membership, or meetings visit http://www.informs.org

http://pubsonline.informs.org/journal/mksc/

MARKETING SCIENCE
Articles in Advance, pp. 1–23
ISSN 0732-2399 (print), ISSN 1526-548X (online)

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Match Your Own Price? Self-Matching as a Retailer's Multichannel Pricing Strategy

Pavel Kireyev,[a] Vineet Kumar,[b] Elie Ofek[a]

[a] Harvard Business School, Harvard University, Boston, Massachusetts 02163; [b] Yale School of Management, Yale University, New Haven, Connecticut 06520

Contact: pkireyev@dba2016.hbs.edu (PK); vineet.kumar@yale.edu (VK); eofek@hbs.edu (EO)

Received: July 22, 2015
Revised: June 9, 2016
Accepted: August 9, 2016
Published Online in Articles in Advance: August 3, 2017

https://doi.org/10.1287/mksc.2017.1035

Copyright: © 2017 INFORMS

Abstract. Multichannel retailing has created several new strategic choices for retailers. With respect to pricing, an important decision is whether to offer a "self-matching policy," which allows a multichannel retailer to offer the lowest of its online and store prices to consumers. In practice, we observe considerable heterogeneity in self-matching policies: There are retailers who offer to self-match and retailers who explicitly state that they will not match prices across channels. Using a game-theoretic model, we investigate the strategic forces behind the adoption (or non-adoption) of self-matching across a range of competitive scenarios, including a monopolist, two competing multichannel retailers, as well as a mixed duopoly. Though self-matching can negatively impact a retailer when consumers pay the lower price, we uncover two novel mechanisms that can make self-matching profitable in a duopoly setting. Specifically, self-matching can dampen competition online and enable price discrimination in-store. Its effectiveness in these respects depends on the decision-making stage of consumers and the heterogeneity of their preference for the online versus store channels. Surprisingly, self-matching strategies can also be profitable when consumers use "smart" devices to discover online prices in stores. Our findings provide insights for managers on how and when self-matching can be an effective pricing strategy.

History: Preyas Desai served as the editor-in-chief and Dmitri Kuksov served as associate editor for this article.
Supplemental Material: The online appendix is available at https://doi.org/10.1287/mksc.2017.1035.

Keywords: price self-matching • multichannel retailing • pricing strategy • online shopping • omnichannel • price discrimination

1. Introduction

Many, if not most, major retailers today use a multichannel business model, i.e., they offer products in physical stores and online. These channels tend to attract different consumer segments and allow retailers to cater to distinct buying behaviors and preferences. Consumers are also becoming more savvy in using the various channels during the buying process, i.e., researching products, evaluating fit, comparing prices, and purchasing (Neslin et al. 2006, Grewal et al. 2010, Verhoef et al. 2015).

Retailers must attend to all elements of the marketing mix as they strive to maximize profits. Not surprisingly, pricing has always been an important strategic variable for them to "get right." When retailers were predominantly brick-and-mortar, they had to determine the most effective store price to set for their merchandise. However, having embraced a multichannel selling format, pricing decisions have become much more complex for these retailers to navigate. Not only do they need to price the products in their physical stores, they also need to set prices for products in their online outlets *and* consider how the prices across the various channels should relate to one another. This complexity in devising a comprehensive multichannel pricing strategy is front and center for retailers today, as evidenced by the myriad commentaries in the retail trade press. As Forrester Research reports (Mulpuru 2012), "It is imperative for eBusiness professionals in retail to adopt cross-channel best practices including . . . pricing."

Formulating an effective multichannel pricing strategy can be challenging. A recent survey of leading retailers (eMarketer 2013) revealed that their top two pricing challenges are: (1) increased price sensitivity of consumers, and (2) pricing aggressiveness from competitors. In a world where many consumers buy online or conduct research online before entering a store, these findings suggest that the need to manage the heightened price sensitivity and combat intense competition are becoming even more important. Interestingly, the above study did not find the item "need to provide consistency in price across channels" to be among the top few challenges these retailers face, underscoring that they feel they have flexibility in customizing their price to the specific

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

channel and customer mix that chooses to shop there. Indeed, according to Gartner's Kevin Sterneckert (Reda 2012, p. 6), "Using a single-channel, consistent pricing strategy misses important opportunities in the marketplace..." Consistent with these survey observations, we specifically investigate how retailers can leverage self-matching across channels to set prices flexibly to diminish intense price competition.

With a self-matching policy, the retailer commits to charging consumers the lower of its online and store prices for the same product when consumers furnish appropriate evidence of a price difference. Note that even though self-matching can provide some degree of price consistency, it is fundamentally different from committing to consistent prices and setting exactly the same prices across all channels, as will be clear in our analysis in Section 4. Commonly, this policy features store to online self-matching, allowing consumers to pay the typically lower online prices for store purchases.[1] This policy is a novel marketing instrument that is uniquely available to multichannel retailers and not relevant in the single-channel case. The primary objective of our paper is to understand the strategic consequences of such self-matching policies. We note that competitive price-matching policies have been extensively studied by contrast (and are reviewed in Section 2).

Examining a number of retail markets, there are two distinct self-matching patterns that come to our attention. First, we observe considerable heterogeneity in the adoption of self-matching policies *across retailers* in the United States, including those competing for the same market. For example, Best Buy, Sears, Staples, Office Depot, Toys "R" Us, and PetSmart price match their online channels in-store, whereas JCPenney, Macy's, Urban Outfitters, and Petco explicitly state that they will not match their prices across channels.[2] Second, we observe heterogeneity in self-matching *across industries*. In consumer electronics and home improvement, major players offer self-matching, whereas in low-end department stores and clothing, most or all retailers tend not to adopt self-matching.

We aim to develop insights on when to expect different self-matching patterns for multichannel retailers in a given category, i.e., all self-match, some self-match while others do not, and none self-match. To this end, we examine the use of a self-matching pricing policy by multichannel retailers across a variety of competitive settings, including a monopoly, a duopoly with two competing multichannel retailers, and a mixed duopoly in which a multichannel retailer competes with an e-tailer. More specifically, we address the following research questions:

(1) What strategic mechanisms underpin the decision to implement a self-matching pricing policy?

(2) When do multichannel retailers choose to self-match in equilibrium? How do customer and product characteristics, and the nature of competition, influence a retailer's decision to self-match?

(3) How does self-matching affect the prices charged online and in-store?

(4) Are retailers better or worse off having access to self-matching as a strategic tool?

To investigate these questions, we develop a model that allows us to capture the effects of self-matching on consumer and retailer decisions. We allow for consumer heterogeneity along a number of important dimensions. These dimensions include consumers' channel preferences, their stage in the decision-making process (DMP), and their preference across retailers. As to channel preferences, we allow for "store-only" consumers who have a strong preference to purchase in-store where they can "touch and feel" merchandise and instantly obtain the product. By contrast, "channel-agnostic consumers" do not have a strong preference for any channel from which they purchase. We also distinguish between consumers who know the exact product they want to purchase ("Decided") and consumers who only recognize the need to purchase from a category and require a store visit to shop around and find the specific version or model that best fits their needs ("Undecided"). Finally, consumers have horizontal taste (or brand) preferences across retailers.

Retailers offer unique products of similar value and are at the ends of a Hotelling linear city, with consumer location on the line indicating retailer preference. Retailers first choose a self-matching pricing policy and subsequently and simultaneously set price levels for store and online channels. We analyze the subgame perfect equilibria of the game.

Our analysis reveals several underlying mechanisms that affect the profitability of self-matching in equilibrium. The first effect, termed *channel arbitrage*, is negative and reduces profits, whereas the other effects termed *decision-stage discrimination* and *online competition dampening* increase profits. Thus, the overall profit implications of implementing a self-matching pricing policy depend on the existence and magnitude of these effects.

Consider the pricing incentives faced by a multichannel retailer absent self-matching. In the store channel, it faces two types of consumers; those who researched the product online before choosing a store (decided consumers) and those who visit their preferred store first to identify the product that best matches their needs (undecided consumers). Retailers may want to charge a higher price to the latter type, but are unable to do so because both types purchase in the store channel. Furthermore, consumers who shop online tend to be informed of the online prices at both retailers, which leads to more competitive pricing in the online channel than in-store.

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Now, consider the strategic impact of self-matching policies. With self-matching, consumers who research the product online but purchase in-store can redeem the lower online price; we refer to this profit-reducing effect as channel arbitrage. However, consumers who visit their preferred store first without searching online are unable to obtain evidence of a lower price for their desired product before arriving at the store. These consumers pay the store price even when a self-matching policy is in effect, leading to the *decision-stage discrimination effect*, thus allowing a self-matching retailer to charge different prices to store consumers based on their decision stage, which can increase profits.

If only one retailer self-matches, decided consumers can redeem the lower online price at the self-matching retailer's store but only have access to the store price at the rival. This induces the self-matching retailer to set a higher online price to mitigate the negative impact of channel arbitrage. The rival follows suit due to strategic complementarity of prices and sets a higher online price as well, thus softening online competition. We refer to this profit-increasing mechanism as the *online competition dampening effect*, with self-matching serving as a commitment device to increase online prices from the purely competitive level. It emerges only when one of the retailers offers to self-match: If both retailers self-match, decided consumers have access to the online prices at both stores, and intense competition in the online channel ensues.

We also investigate the equilibrium profitability of the self-matching policy. Our analysis shows that self-matching is not necessarily harmful. In fact, *both retailers can be better off by offering to self-match* when the positive online competition dampening and/or decision-stage discrimination effects dominate the negative channel arbitrage effect.

We investigate several model extensions in Section 5. First, we examine how the presence of consumers equipped with "smart" devices, who can retrieve online price information when in the store, affects retailers' incentives to implement a self-matching policy. Intuitively, when more consumers can retrieve the lower online price, the negative channel arbitrage effect is more pronounced. However, we find that the presence of "smart" consumers can allow retailers to benefit even more from online competition dampening by charging higher online prices. In another extension, we examine the effects of self-matching in a mixed duopoly, in which a multichannel retailer competes with an online-only retailer (i.e., a pure e-tailer). We find that competition is dampened in the online channel when the multichannel retailer chooses to self-match, allowing both retailers to benefit.

Finally, we conducted a consumer survey that allows us to evaluate how customer and market characteristics pertain to our model setup and findings. We find evidence of significant consumer heterogeneity on the dimensions modeled. Mapping the equilibrium predictions of the model to observed self-matching policies chosen by firms is suggestive of the relevance of our approach.

Next, we review the literature (Section 2), describe the model (Section 3), and analyze equilibrium strategies and outcomes (Section 4). We then consider several extensions of the model (Section 5) and conclude by discussing managerial and empirical implications as well as future research opportunities (Section 6).

2. Literature Review

We draw from two separate streams of past research. The first is focused on multichannel retailing, and the second on competitive price-matching in a single channel. Research in multichannel retailing has typically assumed that retailers set the same or different prices across channels, without examining the incentives to adopt a self-matching policy. Liu et al. (2006), for example, study a brick-and-mortar retailer's decision to open an online arm, assuming price consistency, or different prices across channels. Zhang (2009) considers separate prices per channel and studies the retailer's decision to operate an online arm and advertise store prices. Ofek et al. (2011) study retailers' incentives to offer store sales assistance when also operating an online channel, allowing for identical or different pricing across channels. Aside from ignoring self-matching pricing policies, this literature has not considered or modeled heterogeneity in consumers' DMPs, which plays an important role in their channel choice in practice.

The key theoretical mechanisms modeling sales and service were developed by Shin (2007) and investigated further in the literature (e.g. Mehra et al. 2013). While "price-matching has been suggested as a strategy to combat showrooming, to our knowledge, there has not been a careful modeling and evaluation of whether and when such policies can be effective, particularly in a competitive context."

Competitive price-matching is an area that has been well studied. This literature has generally focused on a retailer's incentives to match competitors' prices in a single channel setting, typically brick-and-mortar stores. Salop (1986) argued that when retailers price match each other, this leads to higher prices than otherwise, as they no longer have an incentive to engage in price competition, thus implying a form of tacit collusion (Zhang 1995). However, competitive price-matching has also been found to intensify competition because it encourages consumer search (Chen et al. 2001). Other research in competitive price-matching has explored its role as a signaling mechanism for certain aspects of a retailer's product or service (Moorthy and Winter 2006, Moorthy and Zhang 2006), the impact

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

of hassle costs (Hviid and Shaffer 1999), interaction with product assortment decisions (Coughlan and Shaffer 2009), and the impact of product availability (Nalca et al. 2010).

By contrast, *self-matching* pricing policies represent a phenomenon relevant only for multichannel retailers; recent retailing trends make self-matching an important issue to study. First, the nature of competition is evolving in many categories, from retailers carrying similar products from multiple brands to manufacturers who establish their own retail stores, e.g., Apple, Microsoft, and Samsung. Second, many retailers are moving towards establishing strong private label brands or building exclusive product lines to avoid direct price wars with competitors (Bustillo and Lawton 2009, Mattioli 2011). For instance, 50% or more of products sold by retailers such as JCPenney or health supply retailer GNC are exclusive or private label; electronics retailers such as Brookstone and Best Buy are also increasingly focused on private label products.[3] These trends accentuate the relevance of self-matching relative to competitive price-matching as the product assortments retailers carry become more differentiated.

The mechanisms underlying self-matching are also connected to the broad literature on price discrimination. Cooper (1986) examines pricing in a two-period model, where retailers commit to giving consumers who purchase in the first period the difference between the first and second period prices if the latter price is lower (a form of intertemporal self-matching). The author shows that this policy may increase retailer profits as it reduces the incentive to lower prices in the second period for both retailers. This effect is similar to the online competition dampening effect we identify, whereby a retailer reduces its own incentive to price lower online by inducing channel arbitrage through self-matching. However, whereas both retailers can offer and benefit from a "most-favored-customer" policy in the intertemporal setting, the online competition dampening effect can exist only if one retailer offers to self-match. If both retailers self-match, they reignite competition in the online market and nullify the effect. Cross-channel price-matching is thus driven by different strategic incentives.

Thisse and Vives (1988), Holmes (1989), and Corts (1998) consider cases wherein price discrimination may lead to lower profits for competing retailers in equilibrium. Similarly, retailers may be compelled to self-match in equilibrium even though they would have been better off had self-matching not been an option. In our context, on one hand, a self-matching policy acts as a commitment not to price discriminate decided consumers across channels, which can lead to greater profits for both retailers because this creates an incentive to increase the online price to mitigate the arbitrage effect. On the other hand, a self-matching policy enables price discrimination between undecided and decided consumers who shop in-store. Depending on the relative sizes of these segments, self-matching policies may emerge in equilibrium and lead to greater or lower profits for both retailers.

Desai and Purohit (2004) consider a competitive setting where consumers may haggle over price with retailers. Some form of haggling may occur in the self-matching setting if retailers are not explicit about their policies and consumers must wrangle with managers to obtain a self-match. This interaction may induce additional costs for consumers and for retailers when processing a self-matching policy. In our analysis, we focus on the case of retailers explicitly announcing their self-matching policies and illustrate how self-matching emerges in equilibrium in the absence of consumer haggling or hassle costs. In an extension, we consider the implications of retailer processing costs when a consumer redeems a self-match.

3. Model

3.1. Retailers

Two competing retailers in the same category are situated at the endpoints of a unit consumer interval, or linear city, i.e., $x = 0$ and $x = 1$ (Hotelling 1929). The retailers offer unique and non-overlapping sets of products. Because they carry different products, they do not have the option of offering competitive price-matching guarantees. For example, Gap and Aeropostale sell apparel and operate in the same categories, but the items themselves are not the same and reflect the dedicated designs and logos of each of these retailers.

We model a two-stage game in which the retailers must first decide on self-matching policies and then on prices in each channel. We denote by $SM_i = 0$ the decision of retailer i not to self-match and by $SM_i = 1$ the decision to self-match, leading to four possible subgames, i.e., $(0,0)$, $(1,1)$, $(1,0)$, and $(0,1)$ representing (SM_1, SM_2). In each subgame, p_j^k denotes the price set by retailer $j \in \{1,2\}$ in channel $k \in \{on, s\}$, where on stands for the online or Internet channel and s stands for the physical store channel. With self-matching, consumers who retrieve the match pay the lowest of the two channel prices. In the equilibrium analysis that follows, we find that retailers never set lower prices in-store than online. Hence, the only relevant matching policy to focus on is the store-to-online self-match. All retailer costs are assumed to be zero.

3.2. Consumers

To capture important features of the shopping process in multichannel environments, we model consumers as being heterogeneous along multiple dimensions.

RIGHTS LINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Retailer Brand Preferences: Consumers vary in their preferences for a retailer's product, e.g., a consumer might prefer Macy's clothing lines to those offered at JCPenney. We capture this aspect of heterogeneity by allowing consumers to be distributed uniformly along a unit line segment in the preference space, $x \sim U[0, 1]$. A consumer at preference location x incurs a "misfit cost" θx when purchasing from retailer 1 and a cost $\theta(1-x)$ when purchasing from retailer 2. Note that the parameter θ does *not* involve transportation costs, rather it represents horizontal retailer-consumer "misfit" costs, which are the same across the online and store channels. Misfit costs reflect heterogeneity in taste over differentiated products of similar value, e.g., the collection of suits at Banana Republic compared to those at J. Crew.

Channel Preferences: *Channel-agnostic* (A) consumers do not have an inherent preference for either channel and, for a given retailer, would buy from whichever channel has the lower price for the product they purchase. On the other hand, *Store-only* (S) consumers find the online channel insufficient, e.g., due to waiting times for online purchases, risks associated with online purchases (such as product defects), etc. These consumers purchase only in the store, although they might research products online and obtain online price information for the product they plan to buy. We assume that channel-agnostic consumers form a fraction of size η of the market while store-only consumers form a fraction of size $1-\eta$.

Decision Stage: Consumers can differ in their decision stage, a particularly important aspect of multichannel shopping (Neslin et al. 2006, Mulpuru 2010, Mohammed 2013). *Undecided* (U) consumers of proportion β $(0 < \beta < 1)$ need to go to the store because they do not have a clear idea of the product they wish to purchase. *Decided* (D) consumers of proportion $1-\beta$ are certain about the product they wish to buy and can thus costlessly search for price information from home. Undecided consumers first visit a retailer's store, selecting the store closest to their preference location, to find an appropriate product that fits their needs. After determining fit, they may purchase the product in-store or return home to purchase online, depending on their channel preference. Consumers obtain a value v from purchasing their selected product.

Categories such as apparel, fashion, furniture, and sporting goods are likely to feature more undecided consumers, as styles and sizes of products are important factors that frequently change. Because undecided consumers do not know which product they want before visiting a store, they do not have at their disposal all prices while at the store, since keeping track of a large number of products, models, and versions even within a category would be impractical. Undecided consumers in the model are unaware of the exact product they wish to purchase beforehand (they have limited ability to infer prices under different self-matching configurations before visiting the store).[4]

Table 1. Consumer Segments and Proportions

	Decision stage	
Channel preference	Undecided (U)	Decided (D)
Store (S)	(SU): $(1-\eta)\beta$	(SD): $(1-\eta)(1-\beta)$
Agnostic (A)	(AU): $\eta\beta$	(AD): $\eta(1-\beta)$

We set the travel cost for a consumer's first shopping trip to zero and assume that additional trips are sufficiently costly. Note that if consumers have no cost to visit multiple stores in person, then we obtain a trivial specification wherein there is no distinction between decided and undecided consumers who shop in-store. Throughout the paper, we focus on the more interesting case wherein additional shopping trips are costly enough so that store-only undecided consumers do not shop across multiple physical stores (see proofs of Propositions 2 and 4 in the appendix for formal conditions on the travel cost). However, in all cases, decided consumers research products and prices in advance.[5]

Table 1 depicts the different consumer segments included in the model. We denote the four segments of consumers as SU, AU, SD, and AD, depending on their channel preference and decision stage; the size of each segment is indicated in the corresponding cell of the table. Each of the four segments is uniformly distributed on a Hotelling linear city of unit length, such that consumer location on the line determines retailer preference. In the online appendix, we present examples to illustrate the buying process of a consumer from each segment. Table 2 details the notation used throughout the paper.

3.3. Sequence of Events

Figure 1 details the sequence of events. First, retailers simultaneously decide on a self-matching pricing strategy. Then, after observing each other's self-matching decisions, they determine the price levels in each channel. Consumers, depending on their type (decided or undecided, store or channel-agnostic, and horizontal preference), decide on which channel and retailer at which to shop. Decided consumers, who know the online price before visiting the store, can ask for a price match if the online price is lower *and* the retailer has chosen to self-match. Finally, consumers make purchase decisions and retailer profits are realized.

3.4. Consumer Utility

We now specify the utility consumers derive under different self-matching scenarios. Recall that store-decided (SD) consumers know all prices across both retailers and channels before they make a purchase decision. Channel-agnostic undecided (AU) consumers

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Table 2. Summary of Notation

Notation	Definition
p_j^s	In-store price for retailer j
p_j^{on}	Online price for retailer j
SM_j	Retailer j's self-matching decision
$\Pi_j^{SM_i, SM_j}$	Retailer j's total profit in subgame (SM_i, SM_j)
Consumer	
v	Consumer valuation of the product
θ	Retailer differentiation
$1-\beta$	Fraction of decided segment of consumers
β	Fraction of undecided segment of consumers
η	Fraction of channel-agnostic consumers
$1-\eta$	Fraction of store-only consumers
$\theta \cdot x$ for $x \in [0,1]$	Measure of retailer preference for consumer at location x
u_j^k	Utility for purchasing from retailer j in channel k

have the option of visiting a store to learn what they want and then returning home to make an online purchase, whereas store undecided (SU) consumers purchase in the store they first visit or make no purchase. Consumers obtain zero utility when they do not make a purchase.

Consider the case when neither retailer self-matches, i.e., $(SM_1, SM_2) = (0,0)$. For a consumer who knows the product she wishes to purchase, the utility for each retailer and channel option is as follows:

$$\begin{aligned} u_1^{on} &= v - p_1^{on} - \theta x, \quad & u_1^s &= v - p_1^s - \theta x, \\ u_2^{on} &= v - p_2^{on} - \theta(1-x), \quad & u_2^s &= v - p_2^s - \theta(1-x), \end{aligned} \tag{1}$$

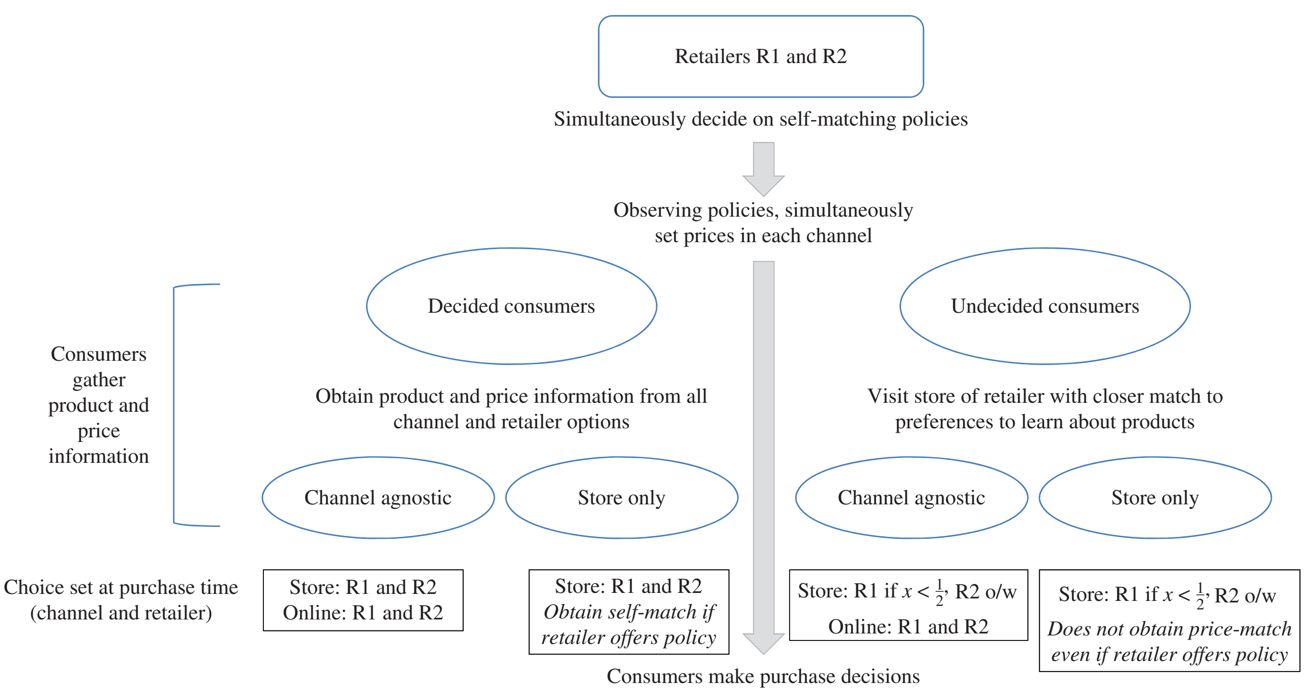
where v is the value of the product, p_1^k and p_2^k ($k =$ on or $k = s$) are the prices set by retailers 1 and 2, respectively, θ measures the degree of consumer preferences for retailers, and $x \in [0,1]$ is the consumer's location (in the preference space) relative to retailer 1.

Whereas these utilities apply to all consumers, not all segments have access to all purchase options. Figure 1 details the choice set available to each segment. For example, the channel-agnostic decided (AD) consumer has access to all four options, whereas the store-only undecided (SU) consumer only has the option of purchasing from his preferred store (e.g., retailer 1). Thus, consumer heterogeneity results in different choice sets available to each segment.

Undecided consumers (both SU and AU), who do not know which specific product they need, first visit the retailer closer to their preference location (i.e., visit retailer 1 if $x < \frac{1}{2}$ and retailer 2, otherwise). After their shopping trip, the store-only undecided (SU) segment must decide whether to buy the product that fits their needs at the store or make no purchase; hence only the corresponding u^s-expression in (1) is relevant for such a consumer. Channel-agnostic undecided (AU) consumers can purchase in the store they first visit and pay the store price, or return home and make an online purchase from either retailer; the utility expressions u_1^s, u_1^{on}, u_2^{on} are thus relevant for AU consumers who prefer retailer 1, and u_2^s, u_1^{on}, u_2^{on} are relevant for AU consumers who prefer retailer 2.

The Impact of Self-Matching Prices. We now examine how self-matching practices by retailers impact con-

Figure 1. (Color online) Sequence of Events in the Model



Note. o/w, otherwise.

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

sumer utilities. Decided consumers know all prices for the specific product they want, and if they shop at the store offering self-matching, they can come armed with the online price and request a price match. Thus, decided consumers can obtain a price match in-store whereas undecided consumers cannot.

When both retailers offer a self-matching pricing policy, i.e., under $(SM_1, SM_2) = (1,1)$, a consumer at $x \in [0,1]$ who *can* obtain a self-match faces the following utilities:

$$u_1^{on} = v - p_1^{on} - \theta x, \quad u_1^s = v - \min(p_1^s, p_1^{on}) - \theta x$$
$$u_2^{on} = v - p_2^{on} - \theta(1-x), \tag{2}$$
$$u_2^s = v - \min(p_2^s, p_2^{on}) - \theta(1-x).$$

Consumers who *cannot* obtain a price self-match (i.e., undecided consumers) continue to face the corresponding utilities specified in Equation (1). Note that although the utility expressions remain the same, retailers may set different prices under different self-matching scenarios. Hence, the equilibrium utilities experienced by consumers will typically differ depending on retailer self-matching policies.

Next, consider consumers' channel preferences. Channel-agnostic decided (AD) consumers have no particular preference for any channel and would choose the lower-priced channel option. Store decided (SD) consumers choose one of the stores based on their preferences and prices. However, they can obtain the lower online price if the retailer offers a self-matching policy. Thus, the expressions for u_j^s for $j = 1, 2$ are different in (2) compared to (1). Undecided (AU and SU) consumers do not know which product they want until they visit the store. They face the same utilities under $(1,1)$ as under $(0,0)$ since they cannot redeem matching policies when they visit a retailer's store without making an additional costly set of trips, i.e., back home to determine online prices and then back to a store to make the purchase.

Utilities in the asymmetric subgame $(1,0)$, where only retailer 1 offers to self-match prices, are defined similar to the $(0,0)$ case, with only u_1^s changing for decided consumers, who can obtain a self-match only from retailer 1 but not retailer 2:[6]

$$u_1^s = v - \min(p_1^s, p_1^{on}) - \theta x.$$

4. Analysis

We begin our analysis by considering the benchmark monopoly case, then the multichannel duopoly setting. All proofs are in the appendix along with the defined threshold values and constants. Note that in all cases, we derive conditions for the market to be covered in the proof; our text discussion will focus on the region of coverage in equilibrium.[7]

4.1. Benchmark Monopoly: A Single Entity Owns Both Retailers

Consider a monopolist that jointly maximizes the profits of two multichannel retailers at the endpoints of a unit segment by choosing a self-matching policy and setting prices.[8] The following holds:

Proposition 1. *A monopolist cannot increase profits by self-matching prices across channels.*

The monopolist will price to extract the greatest surplus from each channel. Because undecided and decided consumers are present in both channels, the prices charged will be the same in both and equal to the monopoly price of $(v - \theta/2)$, regardless of whether the monopolist offers a self-matching policy. The monopolist thus obtains no additional profit when offering the policy and will not offer it when it entails a minimal implementation cost.

4.2. Multichannel Duopoly

We now consider the case of two competing multichannel retailers who make decisions according to the timeline in Figure 1. We examine each of the possible self-matching policy subgames and conclude with a result highlighting the conditions under which self-matching emerges in equilibrium.

For notational convenience, we define the function $\Phi(p_1^k, p_2^k; \theta) := \frac{1}{2} + (p_2^k - p_1^k)/(2\theta)$ to represent the proportion of demand obtained by retailer 1 from a specific segment of consumers who face prices p_1^k and p_2^k from the two retailers.

No Self-Matching— $(0,0)$. In the $(0,0)$ subgame wherein neither retailer self-matches, store-only consumers (SD and SU segments) purchase from the store channel and pay the store price. Channel-agnostic (AD and AU) consumers can also purchase from either retailer's online channel. AD consumers will begin their search process online, whereas AU consumers will first visit their preferred retailer to browse products, then return home to purchase online after they discover the specific product they wish to purchase. Retailers compete for these two consumer segments in the online channel.

SU consumers visit the retailer closest in preference to them to learn about products. Recall that these consumers do not purchase online and do not switch stores because of travel costs associated with multiple store visits. Each retailer effectively has a subset $(\beta/2)$ of such consumers.

On the other hand, SD consumers know the product they want and are informed of all prices. They purchase in-store, given their channel preference, but make a decision on which store to visit after factoring in their retailer preferences and prices. Thus, there is intense competition among retailers for this segment, since by reducing store price, a retailer can attract more SD consumers.

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

The profit functions of retailers 1 and 2 can be written as

$$\begin{aligned}\Pi_1^{0,0} = &\underbrace{\eta\Phi(p_1^{on}, p_2^{on})p_1^{on}}_{\text{Channel-Agnostic Decided and Undecided}}\\ &+(1-\eta)\big(\underbrace{(1-\beta)\Phi(p_1^s, p_2^s)}_{\text{Store-Only Decided}}+\underbrace{\beta/2}_{\text{Store-Only Undecided}}\big)p_1^s,\\ \Pi_2^{0,0} &= \eta(1-\Phi(p_1^{on}, p_2^{on}))p_2^{on}\\ &\quad+(1-\eta)\big((1-\beta)(1-\Phi(p_1^s, p_2^s))+\beta/2\big)p_2^s.\end{aligned}$$

In the $(0,0)$ case, the online situation is similar to retailers competing in a horizontally differentiated market comprised of only channel-agnostic consumers. The resulting equilibrium prices, therefore, reflect the strength of consumers' preferences for retailers, with $\hat{p}_1^{on} = \hat{p}_2^{on} = \theta$. We refer to a price of θ as the "competitive" price level to reflect the fact that this would be the price charged in a standard Hotelling duopoly model with one retail channel.

Next, we turn to the store channel, where we obtain symmetric equilibrium prices of

$$\hat{p}_1^s = \hat{p}_2^s = \begin{cases} v - \dfrac{\theta}{2}, & \dfrac{v}{\theta} \le \dfrac{1}{2} + \dfrac{1}{1-\beta}, \\[2ex] \dfrac{\theta}{1-\beta}, & \dfrac{v}{\theta} > \dfrac{1}{2} + \dfrac{1}{1-\beta} \end{cases}. \tag{3}$$

There are a few useful observations to be made here. First, for $v/\theta \le \frac{1}{2} + 1/(1-\beta)$, retailers serve the entire market even though they charge the monopoly price in-store. This is possible because of the existence of SU consumers: Retailers prefer to charge the monopoly price to extract all surplus from SU consumers if the ratio of product value to retailer differentiation is sufficiently low. Second, if $v/\theta > \frac{1}{2} + 1/(1-\beta)$, then retailers charge a store price of $\theta/(1-\beta)$, which is larger than the competitive price of θ. When v/θ is sufficiently large, retailers can no longer maintain monopoly prices in-store and prefer to compete for SD consumers. However, the existence of SU consumers enables retailers to charge more in-store than online, and the retailers extract more surplus from both SU and SD segments.

Symmetric Self-Matching—(1,1). In this case, both retailers implement a self-matching policy. The first and most obvious result of self-matching is the *channel arbitrage effect*, and the intuition here is straightforward. Recall that SD consumers shop in-store and pay $\hat{p}_j^s$ as in Equation (3) absent a self-matching policy. However, with a self-match they pay the lower online price while shopping in-store, resulting in less profit for the retailer due to arbitrage across channels.

Although this arbitrage intuition is correct, it is incomplete in determining whether in equilibrium a self-matching pricing policy will be adopted. When a multichannel retailer chooses to self-match, there emerges an important distinction between the store-only decided (SD) and undecided (SU) consumers. Whereas the SD consumers can obtain a price match, SU consumers only know which product they desire *during* a store visit. Because they lack evidence of a lower online price, they always pay the store price. Thus, even though the two segments of store consumers obtain the product in-store, they effectively pay different prices. Self-matching thus enables the retailer to price discriminate consumers based on their decision stage.

Retailers' profits in this self-matching setting are thus

$$\Pi_1^{1,1} = \underbrace{(1-\beta(1-\eta))\Phi_1(p_1^{on}, p_2^{on})p_1^{on}}_{\text{Channel-Agnostic and Store-Only Decided}} + \underbrace{(1-\eta)\frac{\beta}{2}p_1^s}_{\text{Store-Only Undecided}},$$

$$\Pi_2^{1,1} = (1-\beta(1-\eta))(1-\Phi_1(p_1^{on}, p_2^{on}))p_2^{on} + (1-\eta)\frac{\beta}{2}p_2^s.$$

In the pricing sub-game, retailers set equilibrium online prices $\hat{p}_1^{on} = \hat{p}_2^{on} = \theta$, since there is no force to prevent online prices from dropping to their competitive level. However, retailers set store prices $\hat{p}_1^s = \hat{p}_2^s = (v - \theta/2)$ to extract surplus from their respective "captive" sets of SU customers, who pay the store price. We refer to the ability to extract additional surplus from SU consumers through self-matching as the *decision-stage discrimination effect*.

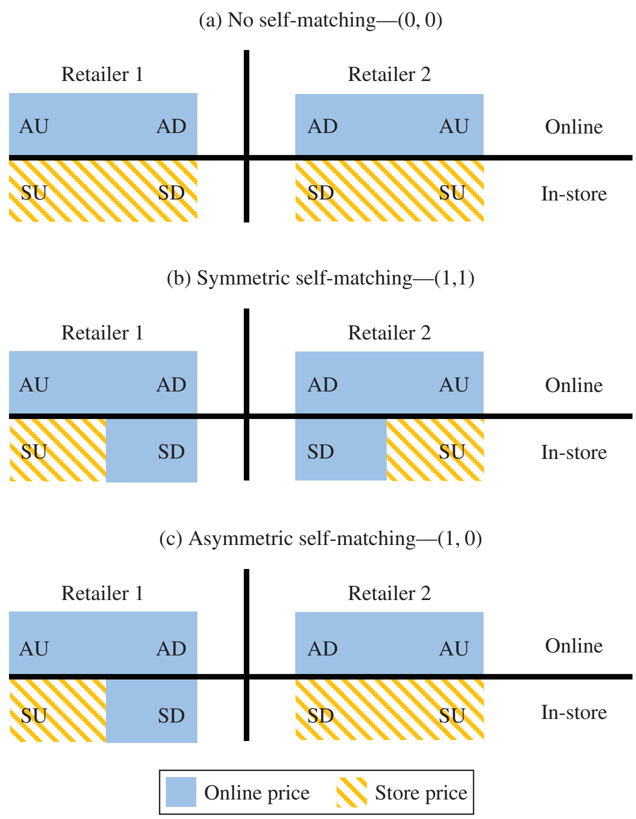
Figure 2 illustrates pricing and purchase outcomes across the $(0,0)$ and $(1,1)$ subgames. The dashed regions cover the segments that pay the store price, whereas the solid-filled regions show the segments that pay the online price. In the $(0,0)$ subgame, SU and SD consumers purchase in-store and pay the same store price, whereas AU and AD consumers purchase online and pay the online price. In the $(1,1)$ subgame, SU and SD consumers purchase in-store, but SD consumers now pay the online price. Thus, self-matching allows a retailer to simultaneously price discriminate consumers across decision stages in the store and de-segment decided consumers across channels.

Asymmetric Self-Matching—(1,0). Next, we explore the case wherein retailer 1 offers a self-matching policy while retailer 2 does not, i.e., the $(1,0)$ self-matching subgame. By symmetry (or relabeling), similar results follow in the $(0,1)$ subgame. Observe that SD consumers who visit retailer 1's store can purchase there and pay the lower of the online and store price, i.e., $\min(p_1^{on}, p_1^s)$. However, if an SD consumer visits retailer 2's store instead, she faces a price of p_2^s and cannot obtain the online price in-store (since retailer 2 does not self-match). Moreover, by offering a self-matching policy, and as long as its online price satisfies $p_1^{on} < p_2^s$, retailer 1 attracts some SD consumers who are closer in

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Figure 2. The Effects of Self-Matching



preference to the competing retailer 2 but who choose to visit retailer 1's store in anticipation of paying the lower online price through a self-match.

For SD consumers, under $p_1^{on} < p_1^s$, the store price of retailer 1 is irrelevant (since they retrieve the price match); the retailer can set a store price level to capture the highest possible surplus from the SU consumers who are closer to its location. Thus, decision-stage price discrimination persists in the asymmetric subgame.

We obtain the following profit functions:

$$\Pi_1^{1,0} = \underbrace{\eta\Phi_1(p_1^{on}, p_2^{on})p_1^{on}}_{\text{Channel-Agnostic}} + (1-\eta)\Big(\underbrace{(1-\beta)\Phi_1(p_1^{on}, p_2^{s})p_1^{on}}_{\text{Store-Only Decided}} + \underbrace{\beta/2p_1^s}_{\text{Store-Only Undecided}}\Big),$$

$$\Pi_2^{1,0} = \eta(1-\Phi_1(p_1^{on}, p_2^{on}))p_2^{on} + (1-\eta)\big((1-\beta)(1-\Phi_1(p_1^{on}, p_2^{s})) + \beta/2\big)p_2^s.$$

Solving for the second-stage pricing subgame, we find that the online price levels chosen by the retailers are *higher* than the Hotelling competitive price of θ *in both channels* and critically depend on the ratio of product value v to the retailer differentiation parameter θ as follows. For $v/\theta \le (\frac{4}{3} + 1/(6(1-\beta(1-\eta))) + \beta/(2(1-\beta)))$, both retailers will extract all surplus from SU consumers and set prices

$$\hat{p}_1^{on} = \theta + \frac{(1-\beta)(1-\eta)(2v-3\theta)}{4(1-\beta(1-\eta))-\eta},$$

$$\hat{p}_2^{on} = \theta + \frac{(1-\beta)(1-\eta)(2v-3\theta)}{8(1-\beta(1-\eta))-2\eta}, \quad \hat{p}_1^s = \hat{p}_2^s = v - \frac{\theta}{2}.$$

For $v/\theta > (4/3 + 1/(6(1-\beta(1-\eta))) + \beta/(2(1-\beta)))$, we find that retailers set prices

$$\hat{p}_1^{on} = \theta\left(\frac{2}{3} + \frac{1}{3(1-\beta(1-\eta))}\right),$$

$$\hat{p}_2^{on} = \theta\left(\frac{5}{6} + \frac{1}{6(1-\beta(1-\eta))}\right),$$

$$\hat{p}_1^s = v - \frac{\theta}{2}, \quad \hat{p}_2^s = \hat{p}_2^{on} + \frac{\beta\theta}{2(1-\beta)}.$$

Interestingly, equilibrium online prices in the asymmetric self-matching $(1,0)$ case are greater than those set in the no self-matching $(0,0)$ case and the symmetric self-matching $(1,1)$ case. The intuition follows from the idea that although self-matching retailer 1 loses profit from the SD segment of consumers who can invoke the price self-match, the policy effectively acts like a "commitment device" to prevent online prices from going all the way down to the competitive level. More important, when only one retailer self-matches online competition softens, which results in channel-agnostic AD and AU consumers paying a higher price (relative to the competitive online price of θ they were paying under no self-matching or symmetric self-matching cases). Thus, self-matching has a positive effect on profits through this third mechanism, which we term the *online competition dampening effect*.

Note that the situation in the asymmetric $(1,0)$ case differs from the case when both retailers self-match. Under $(1,1)$, SD consumers can redeem the online price at both retailers' stores, which forces online prices down to their competitive level θ. By contrast, Figure 2 illustrates how, in the asymmetric $(1,0)$ case, SD consumers can only redeem the match from retailer 1. Retailer 2 will price higher in-store relative to retailer 1's online price, as SD consumers and its captive segment of SU consumers pay its store price, whereas retailer 1 fully segments out its store consumers through the self-matching policy invoked by its SD consumers (while retailer 1's SU consumers continue to pay its store price). However, to mitigate the downside effect of channel arbitrage, retailer 1 does not set its online price as low as θ; this move also allows it to extract greater surplus from the channel agnostic segments. Because online prices are strategic complements across retailers, retailer 2's best response is to increase its online price as well. This results in online

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Table 3. Effects of Self-Matching for Retailer 1 in a Multichannel Duopoly

Effect	Relevant Subgames
(−) *Channel Arbitrage*: SD consumers redeem lower online price in the store, reducing profits from SD.	(1,0) (1,1)
(+) *Decision-Stage Discrimination*: Retailer avoids competing for SD segment on store prices; instead letting them obtain lower online prices. This allows higher store prices to captive SU segment.	(1,0) (1,1)
(+) *Online Competition Dampening*: Retailer charges higher online price to mitigate arbitrage, increasing profit from AD, AU, and SD segments.	(1,0)

prices at both retailers being higher than the competitive level, leading to online competition dampening.

The results detailed in this section are based on the pricing subgame, taking the self-matching policies as given. The pricing equilibria depend on the magnitudes of the three effects induced by self-matching. Table 3 presents a summary of the effects we have identified. Note that the negative channel arbitrage effect and the positive decision-stage discrimination effect always occur for a self-matching retailer, while online competition dampening occurs only when one self-matches but the rival does not. We now examine the full equilibrium results of the game beginning with the self-matching strategy choices.

4.3. Self-Matching Policy Equilibria in a Multichannel Duopoly

For a self-matching policy configuration to emerge in equilibrium, it must be the case that neither retailer would be better off by unilaterally deviating to offer a different policy. Proposition 2 details the equilibrium conditions and the resulting choices of self-matching policies. Across all regions of the parameter space, we restrict our focus to Pareto-dominant equilibria.

Proposition 2. *In a duopoly featuring two multichannel retailers, self-matching policies are determined by the following mutually exclusive regions*:

- *Asymmetric equilibrium* (1,0). *One retailer will offer to self-match its prices while the other will not when product values are relatively low or retailer differentiation is high.*
- *Symmetric non-matching equilibrium* (0,0). *Neither retailer will self-match its prices when product values and retailer differentiation are at intermediate levels.*
- *Symmetric matching equilibrium* (1,1). *Both retailers will self-match prices when product values are high or retailer differentiation is low.*

The above result indicates that all three types of joint strategies can emerge in equilibrium depending on the nature of the product and degree of competitive interaction. To understand the intuition behind the emergence of the different equilibria, it is critical to examine how the focal retailer's *best response function* evolves as the ratio of product value to retailer differentiation (v/θ) changes. We translate best response functions into equilibria in Figure 3. The top arrow depicts retailer 1's best response if retailer 2 does not self-match. The middle arrow depicts retailer 1's best response if retailer 2 self-matches. The dominant effects for retailer 1 are listed below the arrows. The bottom arrow shows the emergent Pareto-dominant equilibria. The best response of the focal retailer depends on the competitor's self-matching strategy as well as the three effects we have previously described, i.e., *channel arbitrage, decision-stage discrimination*, and *online competition dampening*.

Retailer 1's Best Response to Retailer 2 Not Self-Matching. For low v/θ, the retailer's store price ($v-\theta/2$) is relatively close to its competitive online price θ because there is little additional surplus the retailer can extract from its captive SU consumers by pricing higher in-store. As a result, effects that have an impact on the store channel, i.e., the negative channel arbitrage effect and the positive decision-stage discrimination effect are negligible. However, online prices can increase with self-matching due to the online competition dampening effect. This leads retailer 1 to offer a self-matching policy to take advantage of the additional profits from the online channel.

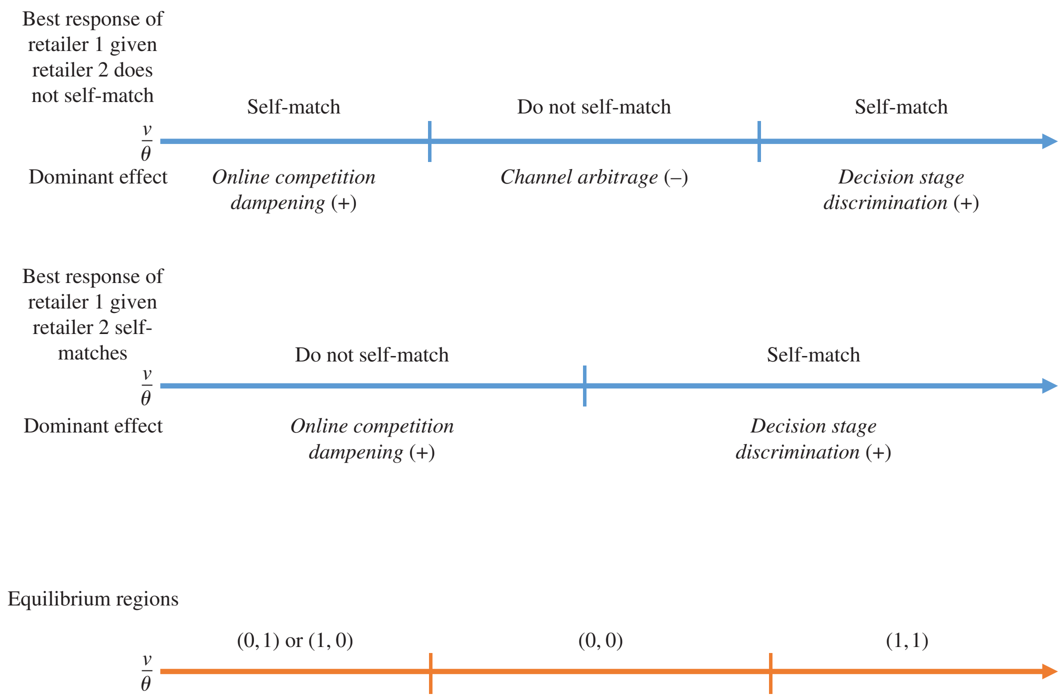
As v/θ increases, so does the difference in prices across channels. For intermediate values of v/θ, the retailer can extract more surplus from SU consumers, driving it to price higher in-store even if it does not self-match, thus reducing the benefits of decision-stage discrimination. Because a self-matching policy allows SD consumers to redeem the lower online price, the channel arbitrage effect increases. As competition in the online channel is more intense than in the store channel, the positive online competition dampening effect can no longer overcome the negative channel arbitrage effect. Consequently, the channel arbitrage effect dominates the other two effects, and the retailer no longer finds it profitable to self-match as a best response.

At high v/θ levels, retailer 1 is compelled to compete more intensely for SD consumers closer to retailer 2 in preference, resulting in a store price of $\theta/(1-\beta)$ that no longer grows in v, if the retailer does not self-match. Thus, the negative impact due to channel arbitrage is limited. However, if the retailer were to offer a self-matching policy, decision-stage discrimination would allow it to charge the monopoly price ($v-\theta/2$) to captive SU consumers, which increases as v/θ increases. This creates a strong positive impact on profits, resulting in retailer 1 choosing to offer self-matching.

Retailer 1's Best Response to Retailer 2 Self-Matching. We now turn to the case wherein retailer 2 decides to offer a self-matching policy.

RIGHTSLINK

Figure 3. (Color online) Retailer Best Responses



Recall that when both retailers self-match, the online competition dampening effect ceases to exist. Because retailer 2 is self-matching, its actions will result in online competition dampening only if retailer 1 does *not* self-match. This creates an incentive for retailer 1 to refrain from self-matching at low values of v/θ, to benefit from online competition dampening through strategic complementarity in prices. Furthermore, at low values of v/θ, the decision-stage discrimination effect is small as retailer 1 cannot extract a substantial amount of surplus from SU consumers.

As v/θ increases, the benefit of decision-stage discrimination grows because the retailer can extract greater surplus from SU consumers if it can charge them a different price than SD consumers. This leads retailer 1 to adopt self-matching for high values of v/θ.

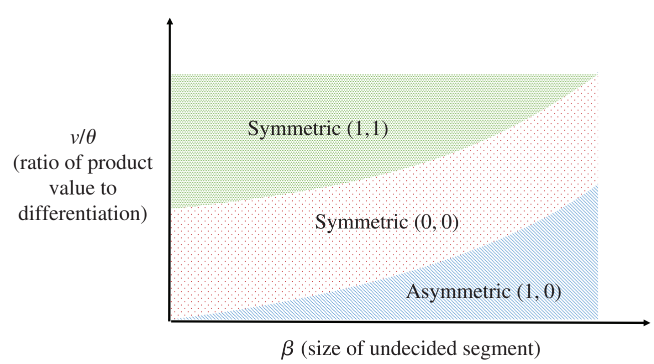
Strategic Substitutes or Complements. We integrate the best responses to obtain equilibrium strategies and focus on whether self-matching strategies across retailers are strategic complements or substitutes. We find from the best responses that at low product values, and/or at high levels of retailer differentiation, the self-matching strategies act like *strategic substitutes*, so that a retailer will choose the strategy opposite to that of its competitor. As v/θ increases to an intermediate level, we obtain a symmetric equilibrium where no retailer self-matches and strategies are *strategic complements*. Finally, when v/θ is above a high threshold, the strong impact of decision-stage discrimination leads to self-matching *being a dominant strategy* regardless of what the competitor chooses. Figure 4 shows the equilibrium regions that emerge in the $v/\theta \leftrightarrow \beta$ space for a fixed value of $\eta \in (0, 1)$ based on Proposition 2.

Next, we turn to how the equilibrium regions are affected by β and η.

Corollary 1. *An increase in the fraction of undecided consumers β will grow the asymmetric equilibrium region and shrink the symmetric equilibrium regions.*

According to the corollary, retailer 1 has more of an incentive to offer a self-matching policy as β increases, implying that the v/θ-region for which we can sustain the $(1, 0)$ equilibrium expands. To understand the intuition for Corollary 1, consider the case of focal retailer 1's best response when retailer 2 does not self-match. As the fraction of undecided consumers increases, the

Figure 4. Equilibrium Regions



Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

retailers stand to gain more from online competition dampening (because of the greater fraction of AU consumers). Thus, if retailer 1 self-matches, retailer 2 will refrain from doing so (because when both self-match, the online competition dampening effect is nullified).

The next corollary examines the effect of η on the equilibrium regions.

Corollary 2. *An increase in the fraction of channel-agnostic consumers η will grow the region where retailers choose not to self-match.*

The profitability of self-matching largely depends on the existence of SU consumers. When the fraction of store-only consumers decreases (i.e., η grows), retailers can no longer benefit as much from decision-stage discrimination. Thus, the profitability of offering a self-matching policy decreases as η increases.

4.4. Profitability of Self-Matching

We have thus far analyzed how retailers decide whether to adopt self-matching policies and characterized the strategies that can be sustained in equilibrium. Here, we examine the profit impact of having self-matching available as a strategic option. The key issue we seek to understand is whether retailers are compelled by competitive forces to adopt self-matching, even though it might not be beneficial and could result in lower equilibrium profits were self-matching not an option. The result in Proposition 3 addresses this issue.

Proposition 3. *The profit implications of self-matching, compared to the baseline case where self-matching is not available as an option, are as follows*:

(a) *In the asymmetric equilibrium* $(1,0)$. *The retailer offering to self-match earns greater profits, but the competing retailer earns lower profits.*

(b) *In the symmetric self-matching equilibrium* $(1,1)$. *Both retailers earn higher profits when product valuation is high or retailer differentiation is low. Otherwise, they both earn lower profits.*

We find that at low values of v/θ, the profit impact of self-matching is asymmetric, with the self-matching retailer obtaining higher profits.

We find that in the region of v/θ where symmetric self-matching occurs in equilibrium, when v/θ is close to its lower bound, self-matching reduces profits for both retailers because of the lower positive impact of decision-stage discrimination and the increasing negative impact of channel arbitrage. This interaction results in a situation wherein both retailers would have benefitted had self-matching not been an option. However, when v/θ is high, both retailers choose to self-match and earn higher profits. This occurs because at high v/θ, decision-stage discrimination overtakes the negative impact of channel arbitrage. Overall, we find that the availability of self-matching as a strategy may enhance profits for at least one retailer and can also do so for both retailers for a range of parameters, highlighting the importance of self-matching as a strategic option.

5. Extensions

The base model analyzed in Section 4 focused on developing an understanding of the mechanisms underlying the effectiveness of self-matching and the conditions for retailers to implement the policy in equilibrium. Here, we have two main objectives. First, we will examine additional settings that are relevant to retailers as they contemplate whether to offer a self-matching pricing policy. Second, we relax a few key assumptions in the baseline model, with a view towards increasing the range of applicability of the findings. Proofs for results presented in this section are provided in Appendix B and the Electronic Supplement.

5.1. Impact of "Smart-Device" Enabled Consumers

The baseline model characterized undecided consumers as not knowing what specific product they want until they visit a store to evaluate which item from the many available options best fits their needs. They could not invoke a self-matching policy because they were in-store at the time of their final decision, and there was no way for them to access the Internet to produce evidence of a lower online price.

Here, we recognize the increasing importance of mobile devices to alter this dynamic and examine the implications for self-matching policies. Retail TouchPoints (Fiorletta 2013) notes that, "Amplified price transparency—due to the instant availability of information via the web and mobile devices—has encouraged retailers to rethink their omnichannel pricing strategies." Intuitively, one might expect that the greater the proportion of consumers who carry smart devices and take the trouble to check online when in-store, the less profitable self-matching should be (because of the increased threat of cross-channel arbitrage). We show that this need not be the case.

Suppose that a fraction μ $(0 < \mu < 1)$ of consumers has access to the Internet while shopping in-store. We refer to these consumers as "smart" to reflect the notion that with the aid of Internet-enabled smartphone devices these consumers can easily obtain online price information while in-store. Store-only undecided smart consumers can now invoke a self-matching policy if the online price offered by a retailer is lower than its store price. Channel-agnostic undecided smart consumers will effectively behave as we have already modeled in the baseline model.

An increase in smart consumers can be understood as increasing the fraction of store-only undecided (SU) consumers who redeem the online price. However, these consumers can only purchase from the retailer

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

they first visit, by contrast to store-only decided (SD) consumers who have the option of buying from other retailers at the outset. To see how the existence of smart consumers impacts retailers' strategies, consider the profits retailers earn if they both offer to self-match

$$\begin{aligned}\Pi_1^{1,1} &= (1-\beta(1-\eta))\Phi_1(p_1^{on}, p_2^{on})p_1^{on}\\ &\quad + (1-\eta)\frac{\beta}{2}((1-\mu)p_1^s + \mu p_1^{on}),\\ \Pi_2^{1,1} &= (1-\beta(1-\eta))(1-\Phi_1(p_1^{on}, p_2^{on}))p_2^{on}\\ &\quad + (1-\eta)\frac{\beta}{2}((1-\mu)p_2^s + \mu p_2^{on}).\end{aligned}$$

Solving for the equilibrium reveals that retailers will set $p_1^{on} = p_2^{on} = \theta(1-\mu) + \mu\theta/(1-\beta(1-\eta))$ and $\hat{p}_1^s = \hat{p}_2^s = v - \theta/2$. Note that the online prices are increasing in μ. We detail how smart consumers impact retailers' equilibrium incentives to self-match in Proposition 4.

Proposition 4. *In a duopoly with two multichannel retailers, where some consumers can use a smart device in-store to obtain online price information*:

(a) *As the fraction of smart consumers increases, the asymmetric equilibrium region grows, whereas the symmetric self-matching equilibrium region shrinks.*

(b) *Retailer profits can increase in the fraction of smart consumers.*

At low product values, holding fixed the other model parameters, more smart consumers enhance the online competition dampening effect in the asymmetric equilibrium, which allows retailers to price higher online when offering to self-match. On the other hand, the conditions for symmetric self-matching policies to emerge in equilibrium for high product values become more stringent as μ grows. That is, as $\mu \to 1$, the symmetric self-matching region for high v shrinks in size to zero. This happens because the existence of smart consumers greatly erodes the positive decision-stage discrimination effect of self-matching, as there are fewer SU consumers who will still pay the high store price, while more consumers pay the lower online price, thereby reducing retailers' incentives to self-match.

Thus, and somewhat counterintuitively, the presence of smart consumers need not decrease the profitability of a self-matching retailer (see proof of Proposition 4 in Appendix B for details of the profit enhancing case). On the contrary, smart consumers can enable retailers to charge higher online prices, increasing the profitability of self-matching policies. This suggests that given current technology trends, horizontally differentiated retailers would find it worthwhile to more carefully examine whether self-matching is an appropriate strategic option.

5.2. Mixed Duopoly: Multichannel Retailer and E-Tailer

We consider the case of a multichannel retailer facing a pure online e-tailer, i.e., a "mixed duopoly market." This market structure is becoming more important for a number of multichannel retailers, e.g., several retailers find that Amazon and potentially other e-tailers are their primary rivals. Past research has considered the strategic implications of direct sellers, such as e-tailers, competing with traditional retail channels (Balasubramanian 1998). Motivation for mixed channel structures and a different type of consumer heterogeneity across channels has been studied by Yoo and Lee (2011). However, to our knowledge, decision-stage heterogeneity and self-matching policies have not been examined in this setting.

We denote the focal multichannel retailer as retailer 1 and the online-only e-tailer as retailer 2. In this setting, only retailer 1 can offer a self-matching policy in stage 1 of the game. Subsequently, both retailers set prices and compete for demand per the timeline in Figure 1.

First, consider the case wherein the multichannel retailer does not self-match its prices. Store-only consumers can only consider retailer 1's store channel and are captive to this retailer, whereas channel-agnostic consumers have the option of shopping across the two retailers' online sites. Profits for both retailers can be expressed as follows:

$$\begin{aligned}\Pi_1^{0,0} &= \underbrace{\eta\Phi_1(p_1^{on}, p_2^{on})p_1^{on}}_{\text{Channel-Agnostic Decided and Undecided}}\\ &\quad + \underbrace{(1-\eta)p_1^s}_{\text{Store-Only Decided and Undecided}},\\ \Pi_2^{0,0} &= \underbrace{\eta(1-\Phi_1(p_1^{on}, p_2^{on}))p_2^{on}}_{\text{Channel-Agnostic Decided and Undecided}}.\end{aligned} \tag{4}$$

Retailer 1 serves as an effective monopolist for store-only consumers (SD and SU segments), who comprise a combined segment of size $1-\eta$, and will attempt to extract surplus from them by setting a store price of $\hat{p}_1^s = v - \theta$. Note that by contrast to the multichannel duopoly, store-only decided consumers do not drive down prices in the mixed duopoly case because the e-tailer does not have a store that serves as a competitive option. Both retailers compete online for the channel-agnostic consumers, who form a segment of size η. We allow for channel-agnostic undecided consumers who are closer in preference to retailer 2, the e-tailer, to browse the product category at retailer 1's store and then purchase online from the e-tailer. The equilibrium online prices are at the competitive level, with $\hat{p}_1^{on} = \hat{p}_2^{on} = \theta$.

Next, consider the (1, 0) subgame where the multichannel retailer offers a self-matching policy. SD consumers can now retrieve the multichannel retailer's

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

online price in-store. Consider the retailers' profits as given below

$$\Pi_1^{1,0} = \underbrace{\eta\Phi(p_1^{on}, p_2^{on})p_1^{on}}_{\text{Channel-Agnostic Decided and Undecided}} + \underbrace{(1-\eta)(1-\beta)p_1^{on}}_{\text{Store-Only Decided}} + \underbrace{(1-\eta)\beta p_1^{s}}_{\text{Store-Only Undecided}}, \quad (5)$$
$$\Pi_2^{1,0} = \eta(1-\Phi(p_1^{on}, p_2^{on}))p_2^{on}.$$

As in the no self-matching case, online competition places downward pressure on the price levels p_1^{on} and p_2^{on} in the $(1,0)$ case. However, a portion of store consumers, i.e., the $(1-\eta)(1-\beta)$-sized SD segment, now receive the online price by invoking the self-match policy instead of paying the store price. As in the multichannel duopoly case, retailer 1 thus faces a *channel arbitrage effect* when it allows consumers to obtain a price match. We might intuitively expect self-matching to be unprofitable, especially since the SD consumers, regardless of retailer preferences, cannot defect to the e-tailer due to their preference for the store channel. However, once again, the *online competition dampening effect* can act to increase profitability when the multichannel retailer chooses to self-match. The following proposition reflects the net impact of these effects.

Proposition 5. *In a mixed duopoly featuring a multichannel retailer and a pure e-tailer, the multichannel retailer adopts a self-matching policy when product value is relatively low or retailer differentiation is high. Otherwise, the retailer will not adopt a self-matching policy.*

The intuition for Proposition 5 follows naturally from the implications of the online competition dampening effect in the asymmetric case of the multichannel duopoly scenario. When retailer 1 decides to self-match, there is a cross-channel arbitrage externality. In a bid to reduce the negative impact of channel arbitrage, the multichannel retailer who implements a self-match has an incentive to raise its online price relative to the no self-matching case. Strategic complementarity in prices leads both retailers to set higher online prices than under no self-matching. Note that there is no decision-stage discrimination effect. SU consumers pay the same price regardless of whether there is self-matching because the e-tailer has no rival store to induce competition for the SD segment and lower the multichannel retailer's store price.

The trade-off between the channel arbitrage and competition dampening effects depends on v/θ. For low enough v (or high θ), the self-matching multichannel retailer prices similarly across channels; thus channel arbitrage is low. In this case, the online competition dampening effect dominates and grows in v/θ. However, the negative channel arbitrage effect also increases in v/θ (as SD consumers redeem the lower online price) and eventually dominates the online competition dampening effect. As a result, self-matching emerges as an equilibrium outcome only for low values of v/θ.

Turning to the profit impact of self-matching on the e-tailer, we find the following:

Corollary 3. *In a mixed duopoly, the e-tailer makes higher profits when the multichannel retailer uses a self-matching policy.*

Thus, a self-matching policy has a positive externality on the e-tailer due to reduced competition in the online channel, which allows the e-tailer to increase prices. This holds even though the e-tailer's price level is lower than that of the multichannel retailer; the latter internalizes a higher benefit of raising its online price because of the positive impact on its store channel.

5.3. Additional Analyses

5.3.1. Markets with a Possibility of Expanding Demand. To relax the assumption that all markets are fully covered, we focus on a scenario where retailers compete in a linear city and also face markets that are not fully covered but can expand as retailers reduce prices.[9] Specifically, retailers are at $x=0$ and $x=1$ on a Hotelling line of length $\frac{1}{5}(3+6v/\theta)$ such that the distance between retailers is still equal to 1 but they face additional monopoly (captive) consumer segments outside of the unit interval ($x<0$ and $x>1$).

We conduct equilibrium analysis for high levels of v/θ and find that both retailers will choose to offer self-matching policies. This result coincides with Proposition 2, where we found that symmetric self-matching emerges in equilibrium at high levels of v/θ. However, by contrast to the profitability results in Proposition 3, retailers earn lower profits when self-matching than in the case where self-matching is not available as a strategic option. This is because retailers now have an incentive to keep store prices low, even when self-matching, to attract consumers outside of the unit interval. As a result, the decision-stage discrimination effect is reduced, and the profitability of self-matching suffers. The following proposition summarizes our finding:

Proposition 6. *In a market with demand that can expand (characterized by the existence of consumer segments beyond the Hotelling unit interval on both sides), both retailers offer self-matching policies if the product value is high or the level of differentiation is low. However, both retailers earn lower profits than had self-matching not existed as a strategic option.*

5.3.2. Retailer Processing Costs. Retailers may incur a processing cost when dealing with consumers who redeem a self-matching policy, for example, the staff time for verifying the evidence and entering it into the

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

system. The idea here is somewhat analogous to that of hassle costs developed in Desai and Purohit (2004). In fully covered markets, an increase in retailer processing costs will reduce the profitability of self-matching by, in effect, increasing the magnitude of the channel arbitrage effect. As a result, self-matching is more difficult to sustain in equilibrium and the region labeled $(1,1)$ in Figure 4 shrinks as retailer processing costs grow. In the Electronic Supplement, we illustrate the impact a small but non-zero retailer cost of servicing consumers who redeem a self-matching policy has on retailer prices and profits to highlight the greater channel arbitrage effect and the reduced profitability of self-matching.

5.3.3. Different Structure of Consumer Heterogeneity in a Monopoly Setting. Proposition 1 establishes that self-matching will never be adopted by a monopolist and provides a benchmark for the duopoly analysis. However, the monopolist may choose to self-match in models that allow for a different structure of consumer heterogeneity. To illustrate how self-matching may be profitable for a monopolist, in the Electronic Supplement we develop an alternative model where consumers exhibit heterogeneity in their travel costs and product valuations. All consumers are at first undecided and must visit the retailer's store to identify their preferred product. Consumers have heterogeneous product valuations that are perfectly correlated with their travel costs, i.e., consumers with a high product valuation have a high travel cost, and consumers with a low product valuation have a low travel cost. A self-matching policy may enable the monopolist to price discriminate by charging a higher store price and selling to store-only consumers with a high travel cost and a high product valuation as these consumers may find it costly to visit the store multiple times to redeem a self-matching policy.

5.4. Consumer Survey

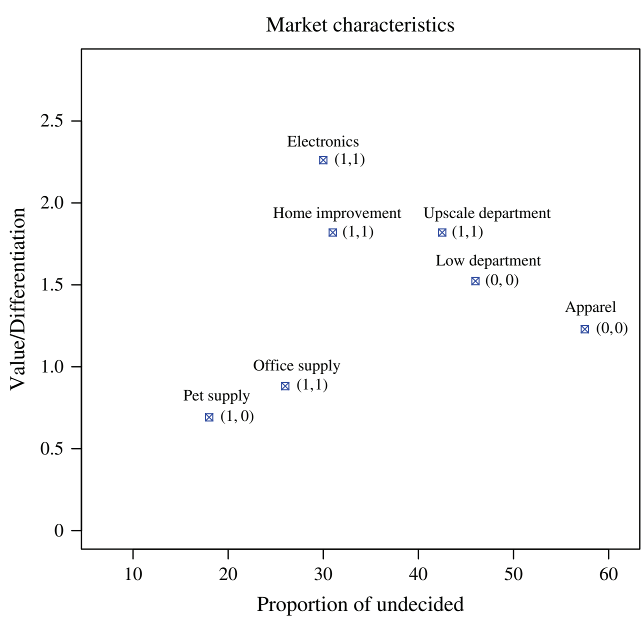
We conducted a consumer survey to characterize market conditions across a range of retail product categories. Our primary goal is to evaluate whether consumers exhibit heterogeneity along the dimensions incorporated in the model, off-line versus online channel preference, horizontal preference across retailers within a category, and decision-stage heterogeneity (decided versus undecided). We also want to examine observed market outcomes, in terms of firm behavior, to assess the degree to which our model analysis corresponds to these outcomes. Full details on the survey and its results are provided in Appendix C, and survey questions are detailed in the Electronic Supplement. Broadly, the survey findings point to substantial consumer heterogeneity and lend support to our model tenets.

Connection to Market Outcomes. We discuss how the insights from our theoretical model, when combined with the survey findings, compared with the observed self-matching policies of firms across a range of product categories (from pet supplies to electronics). Observed Policies are detailed in Appendix D. We emphasize that to empirically establish a causal connection between our hypothesized forces and observed market outcomes, a more thorough empirical investigation is required. The survey results are intended to provide us with preliminary evidence that may encourage such subsequent research.

Here, we focus on Figure 5 and the model predictions per Proposition 2. Figure 5 shows a scatter of product categories and indicates the self-matching outcomes of major players above each category label observed in the market. The ratio of value to differentiation is indicated on the vertical axis and the proportion of undecided consumers is indicated on the horizontal axis, as measured by the survey.

First, we observe that the pet supply market, which was found to have few undecided consumers and low relative product value, reflects an asymmetric $(1,0)$ outcome in practice, consistent with what the model predicts. Second, the apparel and low-end department stores markets, characterized by intermediate relative value and medium to high levels of undecided consumers, demonstrate a no-self-matching, or $(0,0)$ outcome in practice, again consistent with model predictions. Finally, we examine the markets with all firms self-matching in practice $(1,1)$, i.e., electronics, upscale department stores, home improvement, and office supplies. We find (with the exception of office supply

Figure 5. (Color online) Market Characteristics and Outcomes



RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

products) that they have a high relative value and an intermediate proportion of undecided consumers, which is consistent with our analysis. As for office supply firms, they may view their primary competition as coming from pure e-tailers such as Amazon rather than from multichannel rivals.[10]

Whereas this offers suggestive and initial evidence of the connection between market characteristics and self-matching strategic choices in accordance with our model predictions, we expect further careful examination across other product categories to be valuable. An empirical investigation of this phenomenon would also be useful and complementary to our theoretical analysis.

6. Discussion, Limitations, and Conclusion

The self-matching pricing policy has become an important strategic aspect of multichannel retailing and is used in a variety of markets, including consumer electronics, discount retail, and home improvement. Our paper is, to our knowledge, the first attempt to model this strategic pricing policy and investigate how a company's self-matching decision is determined by consumer behavior and the competitive landscape.

Retailers in our model choose whether to offer a self-matching pricing policy in the first stage and then set price levels in the second stage. The retailers' products are horizontally differentiated, with consumers having heterogeneous preferences over retailers. We further allow for consumer heterogeneity along two additional dimensions, decision stage and channel preference. Thus, we explicitly capture a wide variety of DMPs for consumers enabled by the multichannel setting.

The analysis illustrates how retailers in a multichannel setting face downward price pressure in-store from competition induced by the presence of store-only decided consumers. By self-matching, a retailer relinquishes its ability to charge different prices to decided consumers across channels (desegmentation). Channel desegmentation induces channel arbitrage, but produces another effect: It can act as a commitment device to increase online prices when only one retailer chooses to self-match. We refer to this as the online competition dampening effect. Self-matching may also enable the retailer to charge store-only undecided consumers a higher store price, which we call the decision-stage discrimination effect; this can result in both retailers self-matching.

Self-matching is thus profitable when the positive effects of online competition dampening and/or decision-stage discrimination overcome the negative effects of channel arbitrage. We further find that the profitability of self-matching is determined by product value (relative to retailer differentiation), as well as consumer heterogeneity across different dimensions, such as decision stage and channel preference.

Beyond the baseline model, we consider several extensions, one of which explicitly models a setting with smart-device enabled ("smart") consumers, who can look up online prices while in-store, an increasingly prevalent phenomenon. We find that self-matching can increase retailer profitability as the proportion of smart consumers increases. This consumer trend may prove to be an important issue for retailers to consider when making pricing policy decisions going forward.

Our model yields results that are empirically testable. First, retailers offering to self-match will have a larger online to store price discrepancy relative to those that do not self-match. Second, we should find asymmetric self-matching equilibrium configurations in markets with relatively low-valued products (or highly differentiated retailers). Third, as the penetration of smart devices among consumers increases, online prices set by retailers offering to self-match are expected to rise. A consumer survey we conducted provides suggestive evidence of face validity as to how the equilibrium predictions of the model broadly correspond to the emergent self-matching configurations in practice across a number of industries.

Although we believe this to be the first research to rigorously examine the idea of self-matching as a pricing strategy, the present paper has several limitations that could be addressed in future research. First, we do not model *competitive* price-matching policies. Such policies have been extensively studied in the literature, and our focus is retailers with differentiated product assortments, where competitive price-matching does not play a role. It would be interesting to examine whether self-matching complements or substitutes competitive matching policies in settings where rival retailers sell identical products. Second, by assuming sufficiently large consumer travel costs for store visits beyond the initial visit, we ensure that retailers can price-discriminate their captive consumers who find it too costly to search additional stores for product information. We incorporated a variety of consumer DMPs and preference dimensions. However, it would be useful to consider a richer model of consumer search, for example, where consumers could visit a retailer's store and then decide whether to visit a second based on expectations of price as well as the benefits they may obtain. Such an effort would connect with the search literature, and it would be useful to examine whether self-matching then leads to more search and larger consideration sets in the spirit of Diamond (1971) and Liu and Dukes (2013). Third, the dimensions of consumer heterogeneity might be correlated, e.g., consumers who prefer store shopping may also be more undecided. While we do not expect this to change our

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

primary findings, careful modeling of these dependencies might reveal additional effects. Fourth, it would be interesting to investigate how new types of competition could feature self-matching, e.g., such as Amazon competing with other sellers on its platform (Jiang et al. 2011). Finally, although we expect the mechanisms detailed here to apply to the case wherein there are ex ante differences among retailers (based on costs or customer loyalty) beyond horizontal differentiation, there may be additional insights obtained in modeling the more general case.

Broadly, our findings suggest that although a self-matching policy may initially appear to be an unprofitable but necessary evil, it has more subtle and positive competitive implications. Indeed, self-matching can be profitably used as a strategic lever and can result in higher profits for all retailers in the industry. Multichannel retailers should therefore treat their self-matching decisions as an important element of their overall cross-channel strategy, taking into account the products they sell, consumer characteristics, as well as the competitive landscape.

Acknowledgments
The authors thank participants at the 2012 Marketing Science conference for comments and helpful feedback. All errors are the authors'.

Appendix A. Proofs of Propositions
Proof of Proposition 1
First, we determine interior and corner solutions without self-matching. At price p, consumer demand is $D(p) = \min(2(v-p)/\theta, 1)$. For an interior optimal price, we have the first-order condition (FOC) $0 = -p/\theta + (v-p)/\theta \implies \hat{p} = v/2$. The condition for an interior solution is $v < \theta$. When we have a corner solution, i.e., under $v > \theta$, the monopolist sets a price of $\hat{p} = v - \theta/2$. In the rest of the proof, we focus on the case wherein the markets are covered, i.e., $v > \theta$.

The monopolist's profit is determined as follows:

$$\Pi_1^{SM=0} = (1-\beta)(\eta p_1^{on} + (1-\eta)p_1^s) + \beta(\eta p_1^{on} + (1-\eta)p_1^s),$$
$$\Pi_1^{SM=1} = (1-\beta)(\eta p_1^{on} + (1-\eta)\min(p_1^{on}, p_1^s)) + \beta(\eta p_1^{on} + (1-\eta)p_1^s),$$

so the demand from all segments is equal to 1.[11]

To solve for prices, the consumer farthest from the monopolist must be indifferent between purchasing or not. This yields $v - p_1^s - \theta/2 = 0$ and $v - p_1^{on} - \theta/2 = 0$ in the case of no self-matching policy. Prices are then $\hat{p}_1^s = \hat{p}_1^{on} = v - \theta/2$. Similarly, for when the retailer self-matches, we solve $v - p_1^s - \theta/2 = 0$, $v - \min(p_1^{on}, p_1^s) - \theta/2 = 0$, and $v - p_1^{on} - \theta/2 = 0$. Regardless of whether SD consumers choose to redeem the self-matching policy, the multichannel retailer will set identical prices across channels, equal to those set had it not self-matched: $\hat{p}_1^s = \hat{p}_1^{on} = v - \theta/2$. As the profits under the two conditions are equal, the monopolist will always prefer $SM = 0$, which weakly dominates $SM = 1$.

Below, we refer to m as the cost of undertaking a second shopping trip for store-only undecided consumers. We derive bounds on m that ensure the consumer behavior specified in our assumptions.

Proof of Proposition 2
First, we separately consider each subgame. Then, we compare the profits from each subgame to derive the bounds for the equilibrium results. The following constraints must be imposed:

- $v > 3\theta/2$ ensures that all markets are fully covered,
- $\beta < 5/8$ ensures that no retailer sets such a high online price to earn zero demand from decided consumers in the $(1, 0)$ subgame;
- $v < \theta(1/\beta + 1/(4(1-\beta)) - \eta/(36(1-\beta(1-\eta))^2) + (7-11\eta)/(36(1-\beta(1-\eta))) + 7/18)$ ensures that no retailer wants to exclusively price for its captive segment of store-only undecided consumers and forgo all demand for store-only decided consumers;
- $m > v - 3\theta/2$ ensures that no store-only undecided consumers switch stores after their first visit, and that no consumer returns home and visits the store a second time to redeem a self-matching policy.

We focus on the case wherein $\beta > 0$, so that there are at least some undecided consumers.

No Matching—$(0, 0)$. Channel-agnostic consumers will purchase online. Store-only consumers will buy in-store. All consumers will pay the price set in the channel from which they buy. The retailers will earn profits

$$\Pi_1^{0,0} = \eta\Phi_1(p_1^{on}, p_2^{on})p_1^{on} + (1-\eta)\left((1-\beta)\Phi_1(p_1^s, p_2^s) + \frac{\beta}{2}\right)p_1^s,$$
$$\Pi_2^{0,0} = \eta(1-\Phi_1(p_1^{on}, p_2^{on}))p_2^{on} + (1-\eta)\left((1-\beta)(1-\Phi_1(p_1^s, p_2^s)) + \frac{\beta}{2}\right)p_2^s.$$

We solve for the FOCs $\partial\Pi_j^{0,0}/\partial p_j^s = 0$ and $\partial\Pi_j^{0,0}/\partial p_j^{on} = 0$ for $j \in \{1, 2\}$, and check for corner solutions. We find an interior solution with equilibrium prices at $\hat{p}_1^{on} = \hat{p}_2^{on} = \theta$ and $\hat{p}_1^s = \hat{p}_2^s = \theta/(1-\beta)$ for $v/\theta > \frac{1}{2} + 1/(1-\beta)$, and a corner solution in store prices with $\hat{p}_1^s = \hat{p}_2^s = v - \theta/2$ for $v/\theta \le \frac{1}{2} + 1/(1-\beta)$. The store price is higher than the online price in all cases as retailers have an incentive to price higher for their captive segment of store-only consumers. The binding condition for an interior solution requires that all SU consumers purchase in equilibrium. For retailer 1, this can be written as $v - p_1^s - \theta/2 > 0$ (the utility for the SU consumer farthest away from store 1 is greater than zero). When this condition fails (i.e., $v/\theta \le \frac{1}{2} + 1/(1-\beta)$), we have a corner solution where retailers set local monopoly prices $v - \theta/2$ in-store. No other constraints apply and there are no other corner solutions. The equilibrium profits earned by retailers are

$$\Pi_1^{0,0} = \Pi_2^{0,0} = \begin{cases} \frac{1}{4}[2v(1-\eta) - \theta(1-3\eta)], & \frac{v}{\theta} \le \frac{1}{2} + \frac{1}{1-\beta}, \\ \frac{\theta}{2}\left(1 + \frac{\beta(1-\eta)}{1-\beta}\right), & \frac{v}{\theta} > \frac{1}{2} + \frac{1}{1-\beta}. \end{cases}$$

Symmetric Self-Matching—$(1, 1)$. Channel-agnostic consumers will purchase online and pay the online price.

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Store-only decided consumers will buy in-store, but will redeem the online price of the store they purchase from. Store-only undecided consumers will buy in the store they first visit and will pay the store price. The retailers will earn profits

$$\Pi_1^{1,1} = (1-\beta(1-\eta))\Phi(p_1^{on}, p_2^{on})p_1^{on} + (1-\eta)\frac{\beta}{2}p_1^s,$$
$$\Pi_2^{1,1} = (1-\beta(1-\eta))(1-\Phi(p_1^{on}, p_2^{on}))p_2^{on} + (1-\eta)\frac{\beta}{2}p_2^s,$$

and set prices $\hat{p}_1^{on} = \hat{p}_2^{on} = \theta$ online and $\hat{p}_1^s = \hat{p}_2^s = v - \theta/2$ in-store. The online price is the familiar competitive price θ and is an interior solution to the FOCs $\partial\Pi_j^{1,1}/\partial p_j^{on} = 0$ for $j \in \{1,2\}$. Differentiating with respect to store prices yields $\partial\Pi_j^{1,1}/\partial p_j^s = (1-\eta)(\beta/2) > 0$, implying a corner solution. The retailers will set the highest store price they can, ensuring that all SU consumers purchase, which is $v - \theta/2$. There are no other corner solutions. The equilibrium profits earned by retailers are

$$\Pi_1^{1,1} = \Pi_2^{1,1} = \frac{1}{2}\left[\theta(1-\beta(1-\eta)) + \beta(1-\eta)\left(v - \frac{\theta}{2}\right)\right].$$

Asymmetric Self-Matching—(1, 0). Channel-agnostic consumers will purchase online and pay the online price. Store-only decided consumers will buy in-store, but will redeem the online price (as it will be lower) if they buy from the self-matching retailer. They will pay the store price if they buy from the non-self-matching retailer. Store-only undecided consumers will buy from the store they first visit and pay the store price. The retailers profits are then

$$\Pi_1^{1,0} = \eta\Phi(p_1^{on}, p_2^{on})p_1^{on} + (1-\eta)\left((1-\beta)\Phi(p_1^{on}, p_2^s)p_1^{on} + \frac{\beta}{2}p_1^s\right),$$
$$\Pi_2^{1,0} = \eta(1-\Phi(p_1^{on}, p_2^{on}))p_2^{on} + (1-\eta)\left((1-\beta)(1-\Phi(p_1^{on}, p_2^s)) + \frac{\beta}{2}\right)p_2^s.$$

The FOCs can be written as

$$\frac{\partial\Pi_2^{1,0}}{\partial p_2^s} = 0, \quad \frac{\partial\Pi_j^{1,0}}{\partial p_j^{on}} = 0 \quad \text{for } j \in \{1,2\}, \quad \text{and} \quad \frac{\partial\Pi_1^{1,0}}{\partial p_1^s} = (1-\eta)\frac{\beta}{2} > 0.$$

In equilibrium, there is an interior solution for online prices and for the store price of retailer 2 and a corner solution for the store price of retailer 1, for large v. The retailers set online prices $\hat{p}_1^{on} = \theta(\frac{2}{3} + 1/(3(1-\beta(1-\eta))))$ and $\hat{p}_2^{on} = \theta(\frac{5}{6} + 1/(6(1-\beta(1-\eta))))$ and store prices $\hat{p}_1^s = v - \theta/2$ and $\hat{p}_2^s = \hat{p}_2^{on} + \beta\theta/(2(1-\beta))$ for $v/\theta > \frac{4}{3} + 1/(6(1-\beta(1-\eta))) + \beta/(2(1-\beta))$.

Otherwise, if v is small, we have a corner solution for p_2^s which yields prices $\hat{p}_1^{on} = \theta + ((1-\beta)(1-\eta)(2v-3\theta))/(4(1-\beta(1-\eta)) - \eta)$, $\hat{p}_2^{on} = \theta + ((1-\beta)(1-\eta)(2v-3\theta))/(8(1-\beta(1-\eta)) - 2\eta)$ online and $\hat{p}_1^s = \hat{p}_2^s = v - \theta/2$ in-store. The binding threshold on v for an interior solution requires that all of retailer 2's SU consumers purchase in equilibrium. In other words, $v - p_2^s - \theta/2 > 0$. Substituting the interior solution equilibrium store price for retailer 2 into the inequality shows that the corner solution holds for $v/\theta \le \frac{4}{3} + 1/(6(1-\beta(1-\eta))) + \beta/(2(1-\beta))$.

The equilibrium profits earned by retailers are

$$\Pi_1^{1,0} = \frac{v\beta}{2}(1-\eta) + \frac{\theta}{9}\left[4(1-\beta) - \frac{\beta}{4}(1-17\eta) + \frac{1}{2(1-\beta(1-\eta))}\right],$$
$$\Pi_2^{1,0} = \frac{\theta}{72}\left[\frac{9\beta^2(1-\eta)}{1-\beta} + \beta(34-5\eta) + 29(1-\beta) + \frac{7}{1-\beta(1-\eta)}\right],$$

for $v/\theta > (\frac{4}{3} + 1/(6(1-\beta(1-\eta))) + \beta/(2(1-\beta)))$. The expression for $v/\theta \le (\frac{4}{3} + 1/(6(1-\beta(1-\eta))) + \beta/(2(1-\beta)))$ can be similarly obtained by substituting equilibrium prices into the profit functions and is available on request.

Equilibrium Analysis. A self-matching configuration is a Subgame perfect Nash equilibrium (SPNE) if no retailer has the incentive to unilaterally deviate. Equivalently, for $(0,0)$ to be an SPNE, retailer 1 must not have the incentive to deviate to $(1,0)$. For $(1,1)$ to be an SPNE, retailer 2 must not have the incentive to deviate to $(1,0)$. For $(1,0)$ or $(0,1)$ to be an SPNE the self-matching retailer must not prefer $(0,0)$ and the non-self-matching retailer must not prefer $(1,1)$. By comparing the profits at the equilibrium prices defined above, we can construct equilibrium regions.

Let $\beta' = (27 - \sqrt{25\eta^2 + 448\eta + 256})/(32(1-\eta)) + 5/32$. The results in Proposition 2 focus on the region where $\beta < \beta'$ for clarity of exposition. In this proof, we provide an extended analysis, including the region where $\beta \ge \beta'$. Define

- $z_1 = \min((27-17\beta)/(18(1-\beta)) + \beta/(9(1-\beta)(1-\beta(1-\eta))), 7/(36(1-\beta(1-\eta))) + 1/(4(1-\beta)) + 25/18, 3\eta/(8\beta(1-\eta) - 8 - \eta) + \frac{5}{2})$,
- $z_2 = \max((27-17\beta)/(18(1-\beta)) + \beta/(9(1-\beta)(1-\beta\cdot(1-\eta))), 7/(36(1-\beta(1-\eta))) + 1/(4(1-\beta)) + 25/18)$,
- $z_3 = 1/(1-\beta) - 1/(9(1-\beta(1-\eta))) + 17/18$.

We calculate equilibrium profits and the applicable thresholds under all subgames. Then, for $v/\theta < z_1$, the incremental profit from self-matching for retailer 1 is positive: $\Pi_1^{1,0} - \Pi_1^{0,0} > 0$; retailer 2 prefers not to deviate as $\Pi_2^{1,1} - \Pi_2^{1,0} < 0$, so $(1,0)$ and $(0,1)$ are SPNE. For $z_1 < v/\theta < z_2$, $(0,0)$ is the unique equilibrium for $\beta < \beta'$, as $\Pi_1^{1,0} - \Pi_1^{0,0} < 0$ while $\Pi_2^{1,1} - \Pi_2^{1,0} < 0$, and $(1,1)$ is the unique equilibrium for $\beta > \beta'$ as $\Pi_1^{1,0} - \Pi_1^{0,0} > 0$ while $\Pi_2^{1,1} - \Pi_2^{1,0} > 0$. For $z_2 < v/\theta < z_3$, both $(0,0)$ and $(1,1)$ are SPNE as $\Pi_1^{1,0} - \Pi_1^{0,0} < 0$ while $\Pi_2^{1,1} - \Pi_2^{1,0} > 0$, so no retailer prefers to unilaterally deviate from either symmetric setup. For $v/\theta > z_3$, $(1,1)$ is the unique SPNE as $\Pi_1^{1,0} - \Pi_1^{0,0} > 0$ while $\Pi_2^{1,1} - \Pi_2^{1,0} > 0$.

Note that for sufficiently large β, retailers prefer to offer symmetric self-matching policies at intermediate v. This is because as β grows, retailer 1 has an incentive to match for lower v given that retailer 2 also matches. As the critical threshold of v becomes lower, it may cross the threshold at which the other retailer no longer prefers to match, yielding an equilibrium where both retailers match for intermediate v.

To summarize, for low β, as v increases, there will first be an asymmetric solution, then $(0,0)$, then both $(0,0)$ and $(1,1)$, and then uniquely $(1,1)$. For high β, as v increases, there will first be an asymmetric solution, then $(1,1)$, then both $(0,0)$ and $(1,1)$, and then uniquely $(1,1)$.

Proof of Proposition 3

A comparison of profits in the $(1,0)$ subgame reveals that $\Pi_{1,0}^1 > \Pi_{1,0}^2$ everywhere. A comparison of profits earned by retailer 1 in the $(1,1)$ subgame and in the $(0,0)$ subgame reveals that $\Pi_{1,1}^1 > \Pi_{0,0}^1$ if $v/\theta > \frac{3}{2} + 1/(1-\beta) = z_4$, which is strictly greater than z_3.

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Appendix B. Proofs for Extensions

Proof of Proposition 4

The proof of Proposition 4 proceeds just as in Proposition 2, except with an extra parameter μ representing the fraction of "smart" consumers, or consumers who can costlessly search for online information while in-store. The μ segment will be relevant for store-only undecided consumers, as they can only claim a self-matching policy if they have access to the Internet in-store. The remaining store-only undecided consumers will be unable to claim a self-matching policy and will have to pay the store price. We require the following restrictions:

- $v > 3\theta/2 + (\beta\mu\theta(1-\eta))/(1-\beta(1-\eta))$ ensures that all markets are fully covered;
- $\beta < 1 - 3/(2(4-\mu))$ ensures that no retailer sets such a high online price to earn zero demand from decided consumers in the $(1,0)$ subgame;
- Restriction

$$v < \theta\Bigg(\frac{1-\beta}{\beta} + \frac{4\mu+16\eta-4\mu\eta+2}{12\eta} + \frac{3\beta\eta}{12(1-\beta)\eta} - \frac{(1+2\mu)^2(1-\beta)^2(1-\eta)^2}{36\eta(1-\beta(1-\eta))^2)} + \frac{(1+2\mu)(1-\beta)(1-\eta)(2\mu+11\eta-2\mu\eta-5)}{36\eta(1-\beta(1-\eta))}\Bigg)$$

ensures that no retailer wants to price exclusively for its captive segment of store-only undecided consumers and forego all demand for store-only decided consumers;

- $m > v - 3\theta/2 + \mu\theta - \mu\theta/(1-\beta(1-\eta))$ ensures that no store-only undecided consumers switch stores after their first visit, and that no consumer returns home and visits the store a second time to redeem a self-matching policy.

No Retailers Self-Match—(0, 0). The equilibrium prices under $(0,0)$ emerge just as in Proposition 2, as mobile consumers behave just as the rest of the consumers.

One Retailer Self-Matches—(1, 0). Store-only undecided consumers who are mobile will redeem the self-matching policy if they first visit the store that offers the policy. Profits are

$$\Pi_1^{1,0} = \eta\Phi(p_1^{on}, p_2^{on})p_1^{on} + (1-\eta)\cdot\left((1-\beta)\Phi(p_1^{on}, p_2^{s})p_1^{on} + \frac{\beta}{2}((1-\mu)p_1^{s} + \mu p_1^{on})\right),$$
$$\Pi_2^{1,0} = \eta(1-\Phi(p_1^{on}, p_2^{on}))p_2^{on} + (1-\eta)\left((1-\beta)(1-\Phi(p_1^{on}, p_2^{s})) + \frac{\beta}{2}\right)p_2^{s}.$$

In equilibrium, the retailers set online prices $\hat{p}_1^{on} = \theta((1+2\mu)/(3(1-\beta(1-\eta))) + 2(1-\mu)/3)$ and $\hat{p}_2^{on} = \theta((1+2\mu)/(6(1-\beta(1-\eta))) + (5-2\mu)/6)$ and store prices $\hat{p}_1^{s} = v - \theta/2$ and $\hat{p}_2^{s} = \hat{p}_2^{on} + \beta\theta/(2(1-\beta))$ for $v/\theta > ((1+2\mu)/(6(1-\beta(1-\eta))) + 1/(2(1-\beta)) - \mu/3 + \frac{5}{6})$. Otherwise, $\hat{p}_1^{on} = v/2 + \theta/4 - \theta\mu/2 - (8\theta\mu + 9\theta\eta - 6v\eta - 2\theta\eta\mu)/(4(4\beta(1-\eta)+\eta-4))$, $\hat{p}_2^{on} = \hat{p}_1^{on} - \theta(\beta(6\eta - 4 + \mu\eta) + 4 - 3\eta)/(4\beta(1-\eta)+\eta-4)$, and $\hat{p}_1^{s} = \hat{p}_2^{s} = v - \theta/2$. The FOCs and the binding constraint are just as in the proof for $(1,0)$ in Proposition 2, except for the addition of an extra parameter μ.

Both Retailers Self-Match—(1, 1). The retailers will earn profits

$$\Pi_1^{1,1} = (1-\beta(1-\eta))\Phi(p_1^{on}, p_2^{on})p_1^{on} + (1-\eta)\frac{\beta}{2}((1-\mu)p_1^{s} + \mu p_1^{on}),$$
$$\Pi_2^{1,1} = (1-\beta(1-\eta))(1-\Phi(p_1^{on}, p_2^{on}))p_2^{on} + (1-\eta)\frac{\beta}{2}((1-\mu)p_2^{s} + \mu p_2^{on}),$$

and set prices $p_1^{on} = p_2^{on} = \theta(1-\mu) + \mu\theta/(1-\beta(1-\eta))$ online and $p_1^{s} = p_2^{s} = v - \theta/2$ in-store.

Equilibrium Analysis. To prove the existence of the result, we provide an example with $\eta = \frac{1}{5}$ and $\beta = \frac{1}{3}$. Let

$$y_0 = \frac{2{,}385\mu - 41(529\mu^2 + 1{,}408\mu + 1936)^{1/2} + 7{,}810}{4{,}004},$$
$$y_1 = \frac{32\mu + 331}{198} + \frac{4}{11(2+\mu)},$$
$$y_2 = \frac{64\mu + 395}{198} + \frac{3}{88(1-\mu)}, \quad y_3 = \frac{32\mu + 427}{198} + \frac{3}{22(1-\mu)}.$$

Comparing profits when $v/\theta < y_0$, $(1,1)$ is the unique SPNE. For $y_0 < v/\theta < y_1$, $(1,0)$ and $(0,1)$ are SPNE. For $y_1 < v/\theta < y_2$, $(0,0)$ is the unique equilibrium. For $y_2 < v/\theta < y_3$, $(0,0)$ and $(1,1)$ are SPNE. For $v/\theta > y_3$, $(1,1)$ is the unique SPNE. To prove the associated proposition, note that y_0, y_1, y_2, and y_3 are all increasing in μ, so that holding constant v/θ, an increase in mobile consumers shrinks the equilibrium region that admits self-matching policies.

Increasing Profits with Mobile Consumers. In the $(1,1)$ equilibrium for large v, $\eta = \frac{1}{5}$ and $\beta = \frac{1}{3}$, the retailers' profits are increasing in μ if $v/\theta < \frac{5}{2} + 8\mu/11$, which is possible if $\mu < 0.83$. Furthermore, the retailers' profits are larger than when $\mu = 0$ if $v/\theta < 5/2 + 4\mu/11$, which is possible if $\mu < 0.72$. This shows that retailer profits may increase as the fraction of mobile consumers increases.

Proof of Proposition 5

Suppose that a multichannel retailer competes with an online-only e-tailer. Assume $v > 2\theta$ to ensure that all markets are fully covered. Assume $v < 4\theta$ and $\beta > \frac{5}{2} - 3/(2(1-\eta))$ to ensure that the multichannel retailer has positive online sales. Under $(0,0)$ the retailers earn profits

$$\Pi_1^{0,0} = \eta\Phi(p_1^{on}, p_2^{on})p_1^{on} + (1-\eta)p_1^{s}, \quad \Pi_2^{0,0} = \eta(1-\Phi(p_1^{on}, p_2^{on}))p_2^{on}.$$

Taking the FOCs with respect to the prices, we solve

$$\frac{\partial\Pi_1^{0,0}}{\partial p_1^{on}} = \eta\left[\Phi(p_1^{on}, p_2^{on}) + p_1^{on}\frac{\partial\Phi(p_1^{on}, p_2^{on})}{\partial p_1^{on}}\right] = 0,$$
$$\frac{\partial\Pi_1^{0,0}}{\partial p_1^{s}} = (1-\eta) > 0, \quad \text{implying a corner solution.}$$

We obtain the corresponding FOCs for retailer 2 and solve for the equilibrium corresponding to the best responses of both retailers. All channel-agnostic consumers will purchase online, whereas store-only consumers will buy from the multichannel retailer's store. The retailers will set competitive prices online $\hat{p}_1^{on} = \hat{p}_2^{on} = \theta$, and retailer 1 will set monopoly price in-store $\hat{p}_1^{s} = (v - \theta)$. That is, we obtain an interior solution for online pricing, but a corner solution for the store

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

price where the multichannel retailer maximizes profits from all captive SU consumers.

Under the $(1,0)$ subgame of competition between a self-matching multichannel retailer with an e-tailer, retailers earn profits

$$\Pi_1^{1,0} = \eta\Phi(p_1^{on}, p_2^{on})p_1^{on} + (1-\eta)((1-\beta)p_1^{on} + \beta p_1^s),$$
$$\Pi_2^{1,0} = \eta(1-\Phi(p_1^{on}, p_2^{on}))p_2^{on}.$$

As under $(0,0)$, channel-agnostic consumers will purchase online and store-only consumers will purchase from the multichannel retailer's store. Store-only decided consumers redeem the matching policy and pay the online price, whereas store-only undecided consumers fail to redeem the policy and pay the store price. The retailers will set prices $\hat{p}_1^{on} = \theta + (4\theta(1-\beta)(1-\eta))/(3\eta)$, $\hat{p}_2^{on} = \theta + (2\theta(1-\beta)(1-\eta))/(3\eta)$, $\hat{p}_1^s = v - \theta$ for $v > 2\theta + (4\theta(1-\beta)\cdot(1-\eta))/(3\eta)$. Once again, there is an interior solution in online pricing for v sufficiently large and a corner monopoly solution for the store price. The threshold for v is derived from the condition that in equilibrium $p_1^{on} < v - \theta$ for an interior solution. That is, the online price charged by retailer 1 cannot exceed the monopoly price for SD consumers, or equivalently, $v - p_1^{on} - \theta > 0$, ensuring that the SD consumer farthest away from store 1 purchases in equilibrium for the market to remain covered. For $v \le 2\theta + 4\theta(1-\beta)\cdot(1-\eta)/(3\eta)$, this condition fails, and retailers will set prices $\hat{p}_1^{on} = v - \theta$, $\hat{p}_2^{on} = v/2$, $\hat{p}_1^s = v - \theta$ which corresponds to a corner solution.

Now we substitute prices into profits for the appropriate v and identify the parameter ranges for which $\Pi_{1,0}^1 > \Pi_{0,0}^1$ to see when retailer 1 would prefer to self-match. Suppose that $\beta > \frac{7}{4} - 3/(4(1-\eta))$. Then, $\Pi_{1,0}^1 > \Pi_{0,0}^1$ if $v < z_1 = \theta(\frac{7}{3} + (8(1-\beta)\cdot(1-\eta))/(9\eta))$. Otherwise, if $\beta \le \frac{7}{4} - 3/(4(1-\eta))$, then $\Pi_{1,0}^1 > \Pi_{0,0}^1$ if $v < z_2 = 3\theta$. Hence, there exists a $z_0 = \min\{z_1, z_2\}$, such that for $v < z_0$, the multichannel retailer will prefer to self-match.

Proof of Corollary 3

A comparison of the e-tailer's profits, $\Pi_2^{1,0} - \Pi_2^{0,0}$ reveals that it earns greater profits when the multichannel retailer offers a self-matching policy. To see this, note that the e-tailer's price under $(1,0)$ is $\hat{p}_2^{on} = \theta + (2\theta(1-\beta)(1-\eta))/(3\eta)$, which is greater than θ, the price it would charge under $(0,0)$. Also in $(1,0)$, the e-tailer's price is less than $\hat{p}_1^{on} = \theta + (4\theta(1-\beta)(1-\eta))/(3\eta)$, the online price charged by the multichannel retailer. Under $(1,0)$ the e-tailer sets a higher price and earns a greater fraction of demand than under $(0,0)$. As a result, its profits are greater.

Suppose $v \le 2\theta + (4\theta(1-\beta)(1-\eta))/(3\eta)$. Then $\Pi_2^{1,0} = v^2\eta/(8\theta)$ and $\Pi_2^{0,0} = \theta\eta/2$. The difference $\Pi_2^{1,0} - \Pi_2^{0,0} = (v^2 - 4\theta^2)\eta/(8\theta)$ which is positive when $v > 2\theta$, which is the lower bound required for markets to be fully covered. Now, suppose $v > 2\theta + (4\theta(1-\beta)(1-\eta))/(3\eta)$. Then $\Pi_2^{1,0} = \theta(2\beta(1-\eta) - 2 - \eta)^2/(18\eta)$ and $\Pi_2^{0,0} = \theta\eta/2$. The difference $\Pi_2^{1,0} - \Pi_2^{0,0} = (2\theta(1-\beta)(1-\eta)(1+2\eta-\beta(1-\eta)))/(9\eta)$ is greater than zero whenever $\beta/(1-\beta) > -(1+2\eta)/(3\eta)$, which is always the case as $\beta > 0$. Hence, the e-tailer always makes higher profits when the multichannel retailer matches.

Appendix C. Consumer Survey Across Product Categories

We conducted a survey among $N = 499$ individuals in the United States using Amazon's Mechanical Turk (mTurk) service to identify the degree of consumer heterogeneity across a wide range of product categories.[12] Our model and analysis depend on consumer value for a product (v), retailer differentiation (θ), and the dimensions of consumer heterogeneity leading to multiple segments, i.e., decided $(1-\beta)$ versus undecided (β), and store-only $(1-\eta)$ versus channel-agnostic (η).

Operationalizing Model Characteristics

We detail how model constructs are operationalized in the survey.

(1) *Value*: To operationalize the value of the product, we asked participants to estimate how much they spent on a typical single item in this product category. We used the median value of the responses.

(2) *Retailer Differentiation*: To operationalize the extent of retailer differentiation, we asked participants to estimate how similar specific firms within a product category are with respect to the merchandise they offer.

(3) *Undecided vs. Decided Consumers*: We computed the proportion of undecided consumers by asking participants to indicate on a 0–100 scale the extent to which they were undecided (about specific products in a category) across a variety of product categories and taking the average across all responses within a category.

(4) *Store vs. Channel Agnostic Consumers*: To operationalize consumer preference across channels, we asked participants to indicate on a 0–100 scale the extent to which they would prefer to shop in-store or online for each product category.

In Table C.1, we classify the *empirically observed* outcome to the closest possible equilibrium of our model. Thus, each market outcome is associated with one of three outcomes, i.e., $(1,0)$—Asymmetric Self-Matching, $(0,0)$—Symmetric No Self-Matching or $(1,1)$—Symmetric Self-Matching.

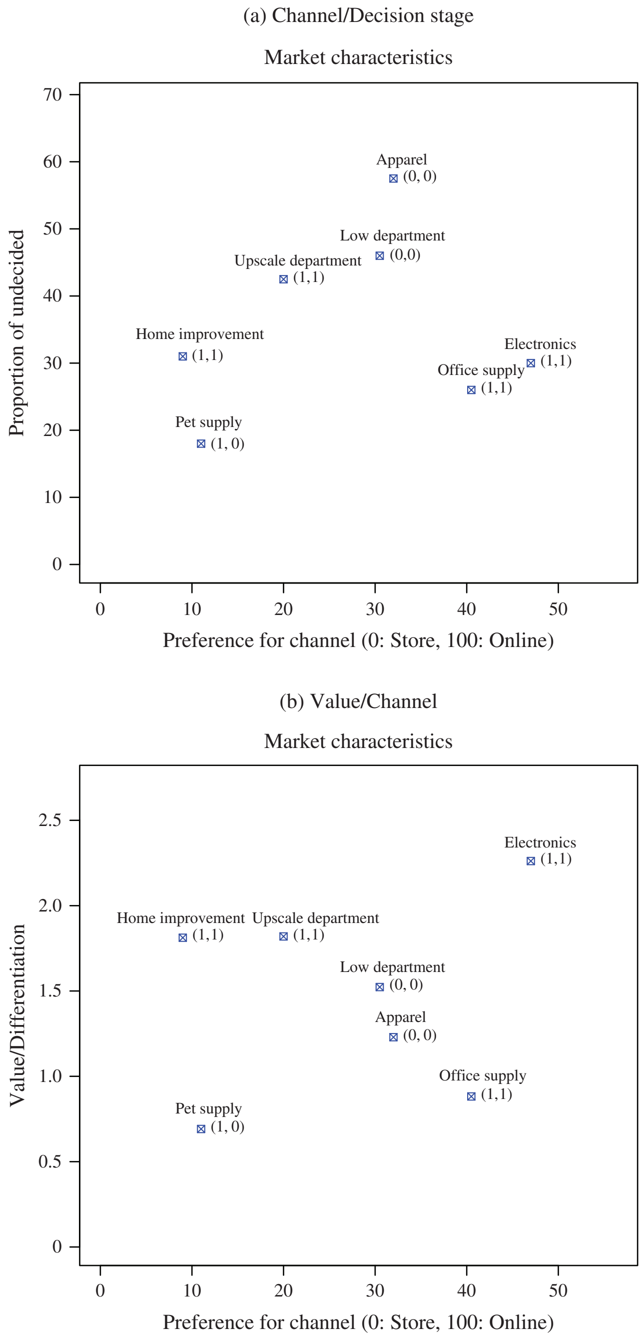
Figure C.1 illustrates a plot of multichannel retail categories based on how survey participants characterized them along the various heterogeneity dimensions. The values in parentheses in Figure C.1 are taken from Table C.1. There are a few observations that deserve attention here. First, the proportion of undecided participants displays a considerable range, from ≈20% for pet supply products to almost 60% for apparel. Second, we find that participants also display a range of channel preferences, from home improvement, where a large majority prefer to shop in store, to electronics, where about half prefer to shop online. Third, when

Table C.1. Self-Matching Outcomes

Market	Empirical outcome
Pet supply	$(0,1)$
Apparel	$(0,0)$
Department (low)	$(0,0)$
Department (upscale)	$(1,1)$
Office supply	$(1,1)$
Home improvement	$(1,1)$
Electronics	$(1,1)$

RIGHTSLINK
Copyright Clearance Center

Figure C.1. (Color online) Consumer Characteristics and Market Outcomes



we plot channel preference versus the proportion of undecided consumers (participants) for each category, we find that there is a significant variation along both dimensions, with home improvement and pet supplies featuring more consumers who prefer store purchases, while being relatively more decided than undecided. The apparel product category, on the other hand, is characterized by significantly more undecided consumers (≈60%), and demonstrates a moderate preference for shopping in store. Based on the survey, we find evidence of significant heterogeneity in consumer (participant) preferences and behavior across a wide range of product categories, lending credibility to our model tenets. Furthermore, in the value/differentiation versus channel preference plot (Figure C.1(b)), the equilibrium regions obtained in Proposition 2 are largely consistent with the policies observed in practice.

Appendix D. Self-Matching Policies in Practice

Below we list the self-matching policies of several popular retailers. We obtained these from retailers' websites on January 14, 2016 and verified them by calling store locations to inquire about matching the website price (if lower).

Self-Matching Retailers[13]

Best Buy: "We match BestBuy.com prices on in-store purchases"

- Also matches online and local competitors.
- http://www.bestbuy.com/site/help-topics/best-buy-low-price-guarantee/pcmcat297300050000.c?id=pcmcat297300050000.

Sears: "If you find a lower price on an identical brand and model number from another Sears branded non-outlet retail format or website, Sears will match that price for up to 7 days after the date of your purchase."

- Also matches online and local competitors.
- http://www.sears.com/cspricematch/nb-100000000022522.

Staples: "If you purchase an item from Staples and tell us within 14 days that you found that item at a lower price in our stores or at staples.com, we'll refund the difference."

- Also matches Amazon.com and any retailer who sells products in retail stores and online under the same brand name.
- http://www.staples.com/sbd/content/help-center/pricing-and-promotions.html.

Office Depot: "If you find a lower price on a new identical item on OfficeDepot.com or OfficeMax.com at the time of purchase or within 14 days of your purchase, show us the lower price and Office Depot or OfficeMax stores will match the price or refund you the difference."

- Also matches Amazon.com and any retailer who sells products in retail stores and online under the same brand name.
- http://www.officedepot.com/renderStaticPage.do?file=/customerservice/lowPrice.jsp.

Toys "R" Us: "We will match Toysrus.com and Babiesrus.com online pricing in our stores."

- Also matches online and local competitors.
- http://www.toysrus.com/shop/index.jsp?categoryId=11949070.

Petsmart: Website price will be honored in store.

- Obtained from customer service at 203-937-2749.

Lowe's: Website price will be honored in store.

- Obtained from customer service at 1-800-445-6937.

Home Depot: Website price will be honored in store.

- Obtained from customer service at 1-800-466-3337.

Retailers who do not Self-Match

JCPenney: "All online and mobile pricing, promotions, advertisements, or offers, including from jcp, are excluded from our price matching policy."

- Matches local competitors.

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

RIGHTSLINK Copyright Clearance Center

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

- http://www.jcpenney.com/dotcom/jsp/customerservice/serviceContent.jsp?pageId=pg40014800010.

Macy's: "macys.com and Macy's stores operate separately. This means that the products and prices offered at each may be different."

- Does not match competitors.
- https://customerservice.macys.com/app/answers/detail/a_id/14/~/pricing-policy-for-online-merchandise.

Urban Outfitters: "While merchandise offered on-line at UrbanOutfitters.com will usually be priced the same as merchandise offered at our affiliate Urban Outfitters stores, in some cases, Urban Outfitters stores may have different prices or promotional events at different times."

- Does not state whether it matches competitors.
- http://www.urbanoutfitters.com/urban/help/terms_of_use.jsp.

Petco: "...Petco and Unleashed by Petco stores do not match the prices of unleashedbypetco.com, petco.com or other online sellers and/or websites."

- Does not match competitor websites but does match local competitor stores.
- https://www.petco.com/content/petco/PetcoStore/en_US/pet-services/help/help-policies-terms.html#price-matching.

Endnotes

[1] A webpage printout or a mobile screenshot of the webpage usually suffices as appropriate evidence. Policies allowing self-matching in the other direction, i.e., allowing web customers to match store prices, are rarely observed in practice as prices online are typically lower than in-store (Reda 2012, Mulpuru 2013).

[2] See Appendix D for examples of self-matching policies from retailer websites.

[3] See Wahba (2014).

[4] More generally, the product category is sufficiently large and varied to make forming accurate expectations of prices more costly than simply visiting the preferred store.

[5] In the baseline model, consumers cannot access online prices at the store, although we examine this possibility in Section 5 by modeling a segment of consumers with mobile Internet access.

[6] The other asymmetric equilibrium $(0, 1)$ is obtained by relabeling the retailers.

[7] Formally, we require bounds on v and β, which are detailed in the appendix. In the Electronic Supplement we explore a setting where the market is not fully covered but can expand.

[8] Note that qualitatively similar results hold if a single retailer is located at the center of the unit segment.

[9] If v/θ is sufficiently low in the main model, retailers no longer compete for consumers at the center, and act essentially like monopolists. The results of Proposition 1 apply and no retailer will choose to self-match.

[10] We also acknowledge that the competitive market forces in some of these industries, e.g., office supplies, may be evolving.

[11] To see this, consider the case of an AD consumer. A consumer at x purchases online if $v - p_1^{on} - \theta|x - \frac{1}{2}| \geq 0$. In other words, consumers at $x \geq \frac{1}{2} - (v - p_1^{on})/\theta$ for $x \leq \frac{1}{2}$ and at $x \leq \frac{1}{2} + (v - p_1^{on})/\theta$ for $x \geq \frac{1}{2}$ purchase and the remainder do not, leading to a total demand of $2((v - p_1^{on})/\theta)$ for the monopolist from AD consumers. For an interior solution to exist (the market is not completely served) it must be the case that $2((v - p_1^{on})/\theta) < 1$, or $p_1^{on} > v - \theta/2$. However, solving the optimization problem for the monopolist (maximizing $2((v - p_1^{on})/\theta)p_1^{on}$) will yield a price of $\frac{v}{2}$, and $v/2 > v - \theta/2$ if and only if $v < \theta$. A similar logic follows for the other segments. Hence, the condition $v > \theta$ ensures that the monopolist serves the entire market.

[12] We filtered out participants who did not pass a number of standard validation checks including multiple attention checks and minimum time to complete the survey, for a final sample of $N = 430$ individual responses.

[13] All links were accessed in January 2016.

References

Balasubramanian S (1998) Mail versus mall: A strategic analysis of competition between direct marketers and conventional retailers. *Marketing Sci.* 17(3):181–195.

Bustillo M, Lawton C (2009) Best Buy expands private-label brands. *Wall Street Journal* (April 27), http://online.wsj.com/article/SB124078866665357525.html.

Chen Y, Narasimhan C, Zhang Z (2001) Consumer heterogeneity and competitive price-matching guarantees. *Marketing Sci.* 20(3):300–314.

Cooper T (1986) Most-favored-customer pricing and tacit collusion. *RAND J. Econom.* 17(3):377–388.

Corts K (1998) Third-degree price discrimination in oligopoly: All-out competition and strategic commitment. *RAND J. Econom.* 29(2):306–323.

Coughlan A, Shaffer G (2009) Price-matching guarantees, retail competition, and product-line assortment. *Marketing Sci.* 28(3):580–588.

Desai PS, Purohit D (2004) Let me talk to my manager: Haggling in a competitive environment. *Marketing Sci.* 23(2):219–233.

Diamond PA (1971) A model of price adjustment. *J. Econom. Theory* 3(2):156–168.

eMarketer (2013) Dynamic pricing helps keep pace with savvy consumers. (May 17), https://www.emarketer.com/Article/Dynamic-Pricing-Helps-Keep-Pace-with-Savvy-Consumers/1009897.

Fiorletta A (2013) Inconsistent pricing across channels remains a key challenge for retailers. *Retail Touchpoints* (January 28), http://www.retailtouchpoints.com/shopper-engagement/2245-inconsistent-pricing-across-channels-remains-a-key-challenge-for-retailers.

Grewal D, Janakiraman R, Kalyanam K, Kannan P, Ratchford B, Song R, Tolerico S (2010) Strategic online and offline retail pricing: A review and research agenda. *J. Interactive Marketing* 24(2):138–154.

Holmes T (1989) The effects of third-degree price discrimination in oligopoly. *Amer. Econom. Rev.* 79(1):244–250.

Hotelling H (1929) Stability in competition. *Econom. J.* 39(153):41–57.

Hviid M, Shaffer G (1999) Hassle costs: The achilles' heel of price-matching guarantees. *J. Econom. Management Strategy* 8(4):489–521.

Jiang B, Jerath K, Srinivasan K (2011) Firm strategies in the "mid tail" of platform-based retailing. *Marketing Sci.* 30(5):757–775.

Liu L, Dukes A (2013) Consideration set formation with multiproduct firms: The case of within-firm and across-firm evaluation costs. *Management Sci.* 59(8):1871–1886.

Liu Y, Gupta S, Zhang Z (2006) Note on self-restraint as an online entry-deterrence strategy. *Management Sci.* 52(11):1799–1809.

Mattioli D (2011) Retailers try to thwart price apps. *Wall Street Journal* (December 23), http://online.wsj.com/article/SB10001424052970203686204577114901480554444.html.

Mehra A, Kumar S, Raju J (2013) "Showrooming" and the competition between store and online retailers. Working paper, Indian School of Business, Hyderabad, India.

Mohammed R (2013) Is Target's price matching policy a mistake? *Harvard Bus. Rev.* (January 15), http://blogs.hbr.org/cs/2013/01/is_targets_price_matching_poli.html.

RIGHTSLINK

Downloaded from informs.org by [128.36.7.68] on 18 September 2017, at 11:56 . For personal use only, all rights reserved.

Moorthy S, Winter R (2006) Price-matching guarantees. *RAND J. Econom.* 37(2):449–465.

Moorthy S, Zhang X (2006) Price matching by vertically differentiated retailers: Theory and evidence. *J. Marketing Res.* 43(2): 156–167.

Mulpuru S (2010) The state of retailing online 2010: Key metrics and multichannel and global strategies. *Forrester Res.* (October 28), https://www.forrester.com/report/The+State+Of+Retailing+Online+2010+Key+Metrics+And+Multichannel+And+Global+Strategies/−/E-RES57389.

Mulpuru S (2012) Our cross-channel numbers show "showrooming" could be overblown. *Forrester Res.* (June 12), http://blogs.forrester.com/sucharita_mulpuru/12-06-12-our_cross_channel_numbers_show_showrooming_could_be_overblown.

Mulpuru S (2013) U.S. cross-channel retail forecast, 2012 to 2017. *Forrester Res.* (October 29), https://www.forrester.com/report/US+CrossChannel+Retail+Forecast+2012+To+2017/-/E-RES105461.

Nalca A, Boyaci T, Ray S (2010) Competitive price-matching guarantees under imperfect store availability. *Quant. Marketing Econom.* 8(3):275–300.

Neslin S, Grewal D, Leghorn R, Shankar V, Teerling M, Thomas J, Verhoef P (2006) Challenges and opportunities in multichannel customer management. *J. Service Res.* 9(2):95–112.

Ofek E, Katona Z, Sarvary M (2011) Bricks and clicks: The impact of product returns on the strategies of multichannel retailers. *Marketing Sci.* 30(1):42–60.

Reda S (2012) Pricing transparency. *NRF* (January 31), https://nrf.com/news/retail-trends/pricing-transparency.

Salop S (1986) Practices that (credibly) facilitate oligopoly coordination. Stiglitz J, Mathewson F, eds. *New Developments in the Analysis of Market Structure* (MIT Press, Cambridge, MA), 265–290.

Shin J (2007) How does free riding on customer service affect competition? *Marketing Sci.* 26(4):488–503.

Thisse J, Vives X (1988) On the strategic choice of spatial price policy. *Amer. Econom. Rev.* 78(1):122–137.

Verhoef PC, Kannan P, Inman JJ (2015) From multi-channel retailing to omni-channel retailing: Introduction to the special issue on multi-channel retailing. *J. Retailing* 91(2):174–181.

Wahba P (2014) J.C. Penney's secret comeback sauce? Its own brands. *Fortune* (December 22), http://fortune.com/2014/12/22/jc-penney-private-label/.

Yoo WS, Lee E (2011) Internet channel entry: A strategic analysis of mixed channel structures. *Marketing Sci.* 30(1):29–41.

Zhang X (2009) Retailers' multichannel and price advertising strategies. *Marketing Sci.* 28(6):1080–1094.

Zhang Z (1995) Price-matching policy and the principle of minimum differentiation. *J. Indust. Econom.* 43(3):287–299.

RIGHTSLINK