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Consumer Fit Search, Retailer Shelf Layout, and Channel Interaction

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This study examines the strategic implications of retailer shelf layout decisions in a market characterized by consumer fit uncertainty. A retailer can display competing products in the same location, allowing consumers to inspect various products all at once or in distant locations, which induces consumers to inspect one product first and then decide whether to incur the travel cost to inspect another product. We consider a model in which two competing manufacturers distribute two horizontally differentiated products through a common retailer. Our analysis shows when the two manufacturers offer products of the same fit probabilities, the retailer obtains a greater profit by displaying competing products in distant locations if the products' fit probabilities are not too high; otherwise, the retailer is better off displaying competing products in the same location. When manufacturers offer products of differentiated fit probabilities, a retailer is more likely to benefit from displaying competing products in distant locations with an increased fit difference between products. Finally, a retailer is more likely to benefit from displaying competing products in distant locations when facing less competition from other retailers.

Key words: consumer fit search; shelf layout; distribution channel; retailing; game theory
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1. Introduction

The increasingly information-rich shopping environment provides consumers easy access to product quality information. Nonetheless, for many products such as apparel, electronics, and furniture, consumer purchase decisions largely depend on whether a product fits the consumers' personal taste, and consumers commonly remain uncertain about the product fit before conducting a physical inspection (Ofek et al. 2011). For example, a consumer may have difficulty predicting whether a pair of jeans would fit her body shape before putting them on. Interestingly, consumers' fit search process in a retail store may be affected by the retailer's shelf layout design. For example, in the electronics department of the department store Macy's, all microwave brands are displayed side by side in one place, and with this layout, microwave shoppers can easily inspect various brands and make fully informed choice decisions. In contrast, in Macy's apparel department, a shopper will find one brand's sweaters displayed in one place, together with the brand's other products, and other brands' sweaters are displayed in different places. With this shelf layout, a shopper is likely to first inspect the brand displayed in the prominent location, such as that close to the department entrance, and after the inspection, the consumer has to decide whether to incur a travel cost to inspect the nonprominent brand located farther away. In this study, we examine the strategic incentives behind retailers' shelf layout decisions and investigate the strategic implications of such decisions.

By displaying competing products in distant locations, a retailer induces three changes in consumer demand, compared to displaying competing products in the same location. First, some consumers with high travel costs may terminate the search without purchase after they have made the first inspection and found a bad fit with the product; that is, the retailer suffers a loss in total demand. Second, the demand loss is greater with the product displayed in the nonprominent location than with the product displayed in the prominent location, because consumers are likely to inspect the prominent product first. Third, consumers who find a good fit in the first inspection are likely to buy the product without checking other products; the suppressed product comparison alleviates price competition between the products. These changes in the demand condition further change the interaction between the retailer and its upstream manufacturers. In particular, when the retailer displays competing products in distant locations to induce consumer sequential inspection, the suppressed comparison between competing products lessens manufacturers' incentive to lower wholesale prices in competition for a better retail price. Nonetheless, manufacturers have incentive to compete for the prominent display location and the associated high demand. In summary, by displaying competing products in distant locations and inducing consumer sequential inspection for product fits, a retailer suffers a demand loss but may benefit from its strengthened channel power over the manufacturers. Whether the retailer should adopt such a shelf display format or display competing products in the same location depends on the relative strengths of the two effects.[1]

Manipulating the consumer fit search process via shelf layout designs is important for big retailers such as Macy's and big discount retailers such as Walmart. First, big retailers usually carry a large assortment in a category. If the retailer displays these competing products in distant locations to induce consumer sequential fit inspection, demand loss naturally occurs when a cost is associated with inspecting an additional product, and some consumers terminate the search before inspecting all these products. Second, big retailers usually have a certain local monopoly in the consumer market, which allows it to manipulate the consumer fit search process without worrying too much about losing store traffic. For example, big retailers such as Macy's and Walmart are usually stand-alone stores, with their competitors located at least several miles away. Sometimes two big department stores are located at two far ends of a big shopping mall. But these two department stores usually serve different consumer segments (e.g., JCPenney serves low- to mid-income families, and Macy's serves mid- to high-income families), and they commonly carry different brands with different price levels and qualities in the same category. Third, with their big sales volume, big retailers commonly have large power over manufacturers or suppliers, which allows them to manipulate the shelf display of competing products without much concern about suppliers withdrawing products.

We develop a game-theoretic model to investigate factors that affect the big retailers' shelf layout decisions. In our model, two competing manufacturers distribute two horizontally differentiated products through a common retailer. Consumers are uncertain about the fit with either product before a personal inspection and, when the retailer displays the two products in different locations, incur a cost to travel from one product location to the other. Our analysis shows that a retailer's optimal shelf layout design depends on the fit probabilities of the products manufacturers offer. In particular, when the two products have the same fit probabilities, the retailer obtains a greater profit by displaying competing products in distant locations as long as the two products' fit probabilities are not too high; otherwise, the retailer is better off by displaying competing products in the same location. This result suggests that a retailer may benefit from displaying competing products in distant locations for products with generally low fit probabilities, such as apparel (sweaters, jeans, shirts, etc.), and displaying competing products in the same location for products with generally high fit probabilities, such as home appliances (microwave ovens, refrigerators, etc.). This insight thus may provide an explanation for why Macy's uses different shelf layout designs for different products. Our analysis further shows that when two manufacturers offer products of different fit probabilities, the retailer is more likely to display competing products in distant locations with an increased fit probability difference between the products. We also show that a retailer is more likely to display competing products in distant locations when competition from other retailers is less severe. Collectively, our study reveals that a retailer's shelf layout design plays an important strategic role in manipulating consumer demand and managing its relationship with upstream suppliers.

Our study contributes to the growing literature on consumer fit uncertainty. Researchers have shown that consumer fit uncertainty can be resolved through moneyback guarantees (Davis et al. 1995), demonstrations (Heiman et al. 2001), and secondhand markets (Messinger and Qiu 2007). Recent studies have shown that firms may optimally withhold fit-revealing information in the monopolistic market (Chen and Xie 2008, Sun 2011) and in competitive markets (Gu and Xie 2013) to maintain a more favorable demand condition. Our study contributes to this literature by showing that retailers may strategically manipulate consumers' fit search processes in pursuit of a more favorable channel relationship.

By showing that a retailer's shelf layout design can have the effect of facilitating or hindering consumer fit search, our study is related to the broader literature on consumer information search and firm information revelation. Past research has examined consumer search for the lowest price (e.g., Diamond 1971, Stahl 1989, Chen and Sudhir 2004, Kuksov 2004) or for the best-matched alternative (e.g., Weitzman 1979,

[1] Our study focuses on department store categories such as apparel, electronics, and furniture. These products are big-ticket, high-involvement products; for these products, consumers make purchase decisions based on careful evaluation of product attributes, and therefore their decisions are vulnerable to uncertainties about product attributes. A long stream of literature examines firm information provision strategies that help resolve consumer uncertainty about product attributes (e.g., Bester and Petrakis 1993, Robert and Stahl 1993, Moorthy and Srinivasan 1995, Anderson and Renault 1999, Chen and Xie 2008, Guo and Zhao 2009, Kuksov and Lin 2010).

Wolinsky 1986, Bakos 1997, Anderson and Renault 1999, Villas-Boas 2009, Kuksov and Villas-Boas 2010). Branco et al. (2012) model consumers' knowledge updating process in search. Armstrong et al. (2009) examine the pricing behaviors of a prominent seller and its nonprominent rivals in the consumer market. Complementing these studies, we show that a retailer can strategically manipulate the consumer fit search process through shelf layout design to obtain greater channel power over upstream suppliers. Desai et al. (2010) show that retailer competition critically affects the retailers' incentive to advertise price in a context where consumers incur a cost to travel between retailers in search for price. Different from this study, we focus on examining how consumer fit uncertainty and fit search behavior affects vertical channel relationships.

Our study is also related to literature on store formats (e.g., Baumol and Ide 1956, Messinger and Narasimhan 1997, Lal and Rao 1997, Bell and Lattin 1998, Bhatnagar and Ratchford 2004, Fox et al. 2004, Hansen and Singh 2009). Different from these studies, our work focuses on retailers' shelf layout designs for a particular product category, and a retailer may adopt different shelf layout designs for different product categories with different fit probabilities.[2] Past research has also shown that grocery retailers decide on shelf space allocation based on slotting allowances (e.g., Shaffer 1991, Chu 1992, Lariviere and Padmanabhan 1997, Kim and Staelin 1999, Desai 2000, Sudhir and Rao 2006, Kuksov and Pazgal 2007) or trade promotion (e.g., Lal 1990, Lal et al. 1996, Lal and Villas-Boas 1998). Note that our research context is more relevant to department stores for which slotting allowance is rarely used. In addition, our results suggest that retailers can leverage shelf/store layout to extract more surplus from the manufacturer a la slotting allowances by asking for a higher level of services or some additional payments.

The rest of this paper proceeds as follows. In §§2 and 3, we set up and solve the main model. In §4, we provide several model extensions. Section 5 concludes the paper.

2. Model

We consider two manufacturers distributing two horizontally differentiated products through a common retailer to a consumer market with unit mass. The two manufacturers are denoted by 1 and 2, respectively, and their products are denoted accordingly. The two manufacturers charge wholesale prices, w_1 and w_2, respectively, to maximize their own profits. The retailer charges retail prices p_1 and p_2 to maximize its total profit from selling the two products. The production cost of each manufacturer and the selling cost of the retailer are normalized to 0.

2.1. Demand-Side Specification

Each consumer has a single-unit demand. The consumers' decision sequence is as follows: (a) Before visiting the store, consumers know the shelf layout but not the fit or price of either product. (b) In the store, a consumer visits one display location and observes the prices of any products displayed in this location. (c) Given the observed prices, the consumer decides the product to inspect first and finds its fit. (d) Given the observed product fit, the consumer decides whether to (e) purchase the product, (f) terminate the search without buying, (g) inspect another product displayed in the same location (if available), or (h) incur a travel cost to move to another display location and inspect the other product (if available). We abstract from quality uncertainty and assume that consumers know product qualities before inspection. For example, consumers may learn about product qualities via advertisements, third-party reviews, and word of mouth. Below we detail the demand specification.

A consumer's utility from product i ($i = 1, 2$) is given by $U_i = v_i - p_i$, where v_i is the consumer's value from her perceived fit with product i. Consumers are endowed with heterogeneous fits with the two products. For product i ($i = 1, 2$), a proportion α_i ($0 \le \alpha_i \le 1$) of consumers perceive a good fit, $v_i = G$; and the rest of the proportion $(1 - \alpha_i)$ of consumers perceive a bad fit, $v_i = B$. A larger α_i indicates a higher fit probability of product i. For example, home appliances (e.g., microwave ovens) may generally have higher fit probabilities than apparel (e.g., jeans). Products in the same category may also differ in fit probabilities. For example, designer brands may generally have lower fit probabilities than mass market brands owing to their peculiar styles. In the main model, we consider the case in which the two products have the same fit probabilities, $\alpha_1 = \alpha_2 = \alpha$, and we will relax this assumption in model extension.

Before inspecting a product, a consumer remains uncertain about the product fit and rationally forms her fit expectation ex ante, $Ev_i = \alpha_i G + (1 - \alpha_i)B$. Without loss of generality, we set $B = 0$, and therefore $Ev_i = \alpha_i G$. Clearly, no consumer will buy a product priced higher than her willingness to pay for a good fit product, and therefore we focus on the case of $0 \le p_i \le G$

[2] Our study is also related to the literature on retailer store design. Past research has demonstrated that store environmental factors can influence shoppers' information-seeking process (Russo 1977, Russo et al. 1986, Titus and Everett 1995), physiological state (Bitner 1992), emotional responses (Donovan and Rossiter 1982, Bellizzi and Hite 1992), and cognitive process (Ward et al. 1992, Hui et al. 1997), and they can eventually affect store sales (e.g., Rogers 1992, Kumar and Karande 2000). Our research complements these studies by revealing that retailer shelf layout affects channel relationship.

in our analysis. We further assume that a consumer's perceived fits with the two products, v_1 and v_2, are independent. That is, finding the fit with one product does not resolve a consumer's fit uncertainty regarding the other product. We identify consumers using their perceived fits with the two products, (v_1, v_2). For example, (G, B) refers to consumers who perceive a good fit with manufacturer 1's product and a bad fit with manufacturer 2's; (E, G) refers to consumers who have fit uncertainty with product 1 and a good fit with product 2. Fit inspection is cost free.

We assume that a consumer observes the product price only after seeing the product. That is, a consumer does not observe a product's price before entering the store or visiting the product's display location. Before observing the price of product i ($i = 1, 2$), consumers hold price belief, $Ep_i \le G$. For the two products with the same value G, consumers believe their prices are the same at a retailer store, $Ep_1 = Ep_2$. When products are displayed in the same location, consumers observe the prices of the two products at the same time. When products are displayed in distant locations, we assume that after observing the first product's price, consumers update their beliefs on the other product's price to be equal to the observed one. Furthermore, we assume that consumers travel to the other display location if and only if the expected utility of doing so is nonnegative and strictly higher than that of buying the first product. Note that we do not use the notion of the perfect Bayesian equilibrium and instead use the assumptions above to restrict consumer beliefs and gain equilibrium uniqueness. Specifically, the first assumption (expectation of equal prices) postulates how beliefs are formed and updated, and the second one (further search only if expected utility is strictly higher) rules out the possibility that consumers with zero travel cost inspect both products before making purchase decisions even when they find fit with the first product and do not expect a higher utility from purchasing the second one. The latter assumption helps eliminate the equilibrium in which the retailer, conceptually, charges the price of the distant product infinitesimally lower than the prominent one. These assumptions made in lieu of the ones imposed by the perfect Bayesian equilibrium simplify the analyses but could be viewed as a limitation of our model.

We assume that a consumer visits a retailer store if her expected utility from doing so is nonnegative. Since $Ep_i \le G$, all consumers visit the store. In a retailer store, consumers' fit search behavior depends on the retailer's shelf layout design. If the retailer displays two products in the same location, consumers can inspect the two products without incurring extra cost, which facilitates easy comparison of the two products' fits. We label this fit inspection process as *simultaneous inspection*. Alternatively, if the retailer displays the two products in distant locations, consumers have to inspect one product first and then travel to the next location to inspect the other product. Such a shelf layout design forces consumers to inspect one product first and later decide whether to inspect the other product; we label this fit inspection process as *sequential inspection*. Below we discuss the two inspection processes in detail.

Case 1. *Consumer Fit Search When Competing Products Are Displayed in the Same Location (Consumer Simultaneous Inspection).* When the two products are displayed in the same location, consumers observe the prices of the two products at the same time. A consumer will then inspect the product with the lower price first and will inspect the other product only if a bad fit is found in the first inspection. This is technically equivalent to the case when a consumer finds her fits with the two products at the same time and then decides which product to buy based on price. Depending on the perceived fits with the two products, consumers can be divided into four segments, (G, G), (G, B), (B, G), and (B, B). Letting z_g denote the size of segment g, we summarize the size of each segment and consumer utilities in each segment in Table 1. Consumers in segment (G, G) will buy product i if $p_i < p_{-i}$; if $p_i = p_{-i}$, consumers randomly choose between the two products. Segment (G, B) consumers will always buy product 1 with $p_1 \le G$, segment (B, G) consumers will always buy product 2 with $p_2 \le G$, and segment (B, B) consumers will buy neither product.

Case 2. *Consumers Fit Search When Competing Products Are Displayed in Distant Locations (Consumer Sequential Inspection).* In this case, a consumer first visits one product display location. Observing the product price, the consumer inspects the product fit. The consumer then decides whether to travel to the other location to inspect the other product. We assume that consumers incur a cost $k \in \{k_L, k_H\}$ to travel between the two products' locations, which may capture the physical effort involved as well as psychological costs such as those associated with time pressure. Consumers are endowed with heterogeneous travel costs; for example, a consumer with a busy work schedule may have a higher travel cost than a consumer at leisure. We assume that half of the consumers have

Table 1 Segment Sizes and Consumer Utilities When Consumers Conduct Simultaneous Inspection

Segment	Size	Consumer utility
(G, G)	$z_{GG} = \alpha^2$	$U_1 = G - p_1,\ U_2 = G - p_2$
(G, B)	$z_{GB} = \alpha(1-\alpha)$	$U_1 = G - p_1,\ U_2 = 0 - p_2$
(B, G)	$z_{BG} = \alpha(1-\alpha)$	$U_1 = 0 - p_1,\ U_2 = G - p_2$
(B, B)	$z_{BB} = (1-\alpha)^2$	$U_1 = 0 - p_1,\ U_2 = 0 - p_2$

a low travel cost $k_L = 0$ and the other half have a high travel cost $k_H = 1$. This two-point distribution of travel costs is sufficient to demonstrate the mechanism behind our results, and we will discuss other specifications of the travel cost in model extension. A consumer's travel cost is independent of her perceived fit with either product.

Consider the case when consumers inspect product i first. Observing p_i, the consumer updates her price belief to $Ep_i = p_i$ and then, given her belief that the prices of the two products with the same value have the same price, updates $Ep_{-i} = Ep = p_i \le G$. If a consumer finds a good fit with product i in her first inspection, she makes the second inspection only if $G - p_i < \alpha(G - Ep_{-i}) - k = \alpha(G - p_i) - k$, which is never satisfied. A consumer with low travel cost who finds a bad fit in the first inspection always continues to make the second inspection. We constrain $G \le 1$ to focus on the interesting case when the high travel cost prohibits consumers from making the second inspection after finding a bad fit in the first inspection.

Consumers may start the fit search from either product. For example, in a department store, consumers may enter the apparel department from different directions depending on where they park or which other department they have just visited. We let s_1 denote the proportion of consumers who inspect product 1 first, and we let $s_2 = 1 - s_1$ denote the proportion of consumers who inspect product 2 first. Consider consumers who start the search from product 1. After inspecting product 1, consumers may find a good or bad fit. The size αs_1 of consumers who find a good fit buy product 1 and terminate the search. Among the size $(1 - \alpha)s_1$ of consumers who find a bad fit, half have low travel costs and continue to inspect product 2, whereas the other half have high travel costs and terminate the search.[3] In the end, the proportion $s_1/2$ of consumers with low travel cost is divided into segments (G, E), (B, G), and (B, B), and the proportion $s_1/2$ of consumers with high travel cost is divided into segments (G, E) and (B, E). Similarly, among consumers who inspect product 2 first, those who find a good fit buy the product immediately, and those who find a bad fit either continue to inspect product 1 or terminate the search without purchases, depending on the travel cost. The market is thus split into seven distinct segments, and we summarize the market size and consumer utilities in each segment in Table 2. It is easy to see that the demand of product 1 comes from segments (G, E) and (G, B) and the demand of product 2 comes from segments (E, G) and (B, G).

[3] The demand loss in a sequential search when a cost is associated with searching an additional item is well documented in the literature (e.g., Villas-Boas 2009, Kuksov and Villas-Boas 2010, Branco et al. 2011). These studies focus on examining factors that affect consumers' termination rules in a sequential search process and commonly model more than two products. Given our research focus on demonstrating the implications of different consumer fit search processes for channel interaction, we model only two products offered by two manufacturers to facilitate analysis.

Table 2 Segment Sizes and Consumer Utilities When Consumers Conduct Sequential Inspection

Segment	Size	Consumer utility
(G, E)	$z_{GE} = s_1\alpha$	$U_1 = G - p_1$, $U_2 = \alpha(G - Ep_2) - k$
(B, E)	$z_{BE} = s_1(1-\alpha)/2$	$U_1 = 0 - p_1$, $U_2 = \alpha(G - Ep_2) - k$
(E, G)	$z_{EG} = s_2\alpha$	$U_1 = \alpha(G - Ep_1) - k$, $U_2 = G - p_2$
(E, B)	$z_{EB} = s_2(1-\alpha)/2$	$U_1 = \alpha(G - Ep_1) - k$, $U_2 = 0 - p_2$
(G, B)	$z_{GB} = s_2\alpha(1-\alpha)/2$	$U_1 = G - p_1$, $U_2 = 0 - p_2$
(B, G)	$z_{BG} = s_1\alpha(1-\alpha)/2$	$U_1 = 0 - p_1$, $U_2 = G - p_2$
(B, B)	$z_{BB} = (1-\alpha)^2/2$	$U_1 = 0 - p_1$, $U_2 = 0 - p_2$

2.2. Supply-Side Specification

The retailer can design its shelf layout to display competing products in the same location or in distant locations, and in the latter case, the retailer also decides which product to display in the prominent location. We assume that when the retailer displays the two products in distant locations, a proportion r $(0 \le r \le 1)$ of consumers first inspect the prominent product; the remaining proportion $1 - r$ of consumers randomly pick the product to inspect first. Therefore, if the retailer sets up product i in the prominent location, a size $s_i = r + (1 - r)/2 = (1 + r)/2$ of consumers inspects product i first, and the remaining $s_{-i} = (1 - r)/2$ of consumers inspects product $-i$ first. That is, more consumers inspect the prominent product first, $s_i > s_{-i}$. The parameter r captures the retailer's control over store traffic, where a larger r indicates that the retailer can force more consumers to start the fit search from the prominent product. In particular, when $r = 1$, all consumers inspect the prominent product first; when $r = 0$, consumers inspect the two products in random order. A retailer's control over the store traffic is typically imperfect and often depends on the general design of the store, such as the location of entrances and exits, the shape of the shopping space, and the width of the aisle. For example, in a department store, consumers who have just visited the cosmetics department and who have just visited the electronics department may naturally enter the apparel department from different directions. Therefore, a retail store's traffic control can be viewed as having a longer strategic span than its shelf layout decision or price decision in a particular department.

The game involves four stages. In the first stage, the retailer decides the shelf layout design—that is, whether to display competing products in the same location or distant locations. In the second stage, given the shelf layout, the two manufacturers decide their wholesale prices simultaneously. In the third stage, given the wholesale prices, the retailer determines the retail prices for the two products and, if displaying two products in distant locations, also determines which product to set up in the prominent location. In the last stage, consumers make purchase decisions.[4]

3. Analysis

We solve the model through backward induction. We first solve the equilibrium strategies of the manufacturers and the retailer when the retailer displays competing products in the same location and in distant locations, and then we compare the retailer's payoffs in the two subgames to derive its optimal shelf layout strategy.

3.1. Channel Strategies Under Different Shelf Layout Formats

3.1.1. Subgame 1: Retailer Displays Competing Products in the Same Location. When the retailer displays competing products in the same location, we derive product i's demand ($i = 1, 2$) in the fourth stage from Table 1 as

$$D_i^{SM} = \begin{cases} \alpha(1-\alpha) & \text{if } p_i > p_{-i}, \\ \alpha(1-\alpha) + \dfrac{\alpha^2}{2} = \alpha\left(1-\dfrac{\alpha}{2}\right) & \text{if } p_i = p_{-i}, \\ \alpha(1-\alpha)+\alpha^2 = \alpha & \text{if } p_i < p_{-i}. \end{cases} \tag{1}$$

As shown in Equation (1), consumer demand is greater for the product with the lower retail price. The total demand the retailer obtains is $\Lambda^{SM} = D_1^{SM} + D_2^{SM} = \alpha(2-\alpha)$, which increases with α, the fit probability of the products.

In the third stage of the game, the retailer chooses the optimal prices p_1 and p_2 to maximize its total profit $\pi_R^{SM} = D_1^{SM}(p_1 - w_1) + D_2^{SM}(p_2 - w_2)$, taking the wholesale prices w_1 and w_2 as given. Note that π_R^{SM} always increases with p_1 and p_2 and always decreases with w_1 and w_2. Therefore, if $w_i < w_{-i}$ $(i = 1, 2)$, the optimal retailer strategy is to set $p_i = G - \varepsilon$ and $p_{-i} = G$, where ε is infinitesimal; this strategy allows the retailer to generate a larger demand for product i, from which it obtains a greater profit margin. If $w_i = w_{-i}$, the retailer optimally sets $p_i = p_{-i} = G$. The retailer's maximized profit is thus

$$\pi_R^{SM*}(w_i, w_{-i}) = \begin{cases} \alpha(G-\varepsilon-w_i) + \alpha(1-\alpha)(G-w_{-i}) \\ \quad \text{if } w_i < w_{-i}, \\ \alpha\left(1-\dfrac{\alpha}{2}\right)(G-w_i) + \alpha\left(1-\dfrac{\alpha}{2}\right)(G-w_{-i}) \\ \quad \text{if } w_i = w_{-i}. \end{cases} \tag{2}$$

In the second stage, the two manufacturers choose their optimal wholesale prices simultaneously to maximize their own profits of

$$\pi_{Mi}^{SM} = \begin{cases} \alpha(1-\alpha)w_i & \text{if } w_i > w_{-i}, \\ \alpha\left(1-\dfrac{\alpha}{2}\right)w_i & \text{if } w_i = w_{-i} \\ \alpha w_i & \text{if } w_i < w_{-i}. \end{cases} \quad i = 1, 2, \tag{3}$$

Equation (3) shows that when a manufacturer offers a wholesale price lower than its rival's, it obtains a more favorable retail price and an additional demand of $d^{SM} = \alpha^2$, which comes from consumers who find a good fit with both products (segment (G, G)). Each manufacturer has incentive to undercut its rival's wholesale price to compete for this demand, and such incentive becomes stronger with an increased fit probability α and an expanded segment (G, G). Manufacturer competition in the segmented market leads to a mixed strategy equilibrium in wholesale prices (Narasimhan 1988). The retailer's expected equilibrium profit is thus $E\pi_R^{SM*} = \pi_R^{SM*}(w_1 \le w_2) \cdot \Pr(w_1 \le w_2) + \pi_R^{SM*}(w_1 > w_2)\Pr(w_1 > w_2)$. We summarize the market equilibrium in the following lemma.

Lemma 1. *When the retailer displays competing products in the same location, in equilibrium,* (1) *manufacturers implement mixed pricing strategies with each manufacturer's wholesale price* w_i^{SM*} $(i = 1, 2)$ *ranging over* $[(1-\alpha)G, G]$, *and manufacturers' equilibrium profits are* $\pi_{M1}^{SM*} = \pi_{M2}^{SM*} = \alpha(1-\alpha)G$; (2) *the equilibrium retail price is* $\{p_i^{SM*} = G, p_{-i}^{SM*} = G - \varepsilon\}$ *if* $w_i > w_{-i}$ *and* $p_i^{SM*} = p_{-i}^{SM*} = G$ *if* $w_i = w_{-i}$, *and the retailer's expected profit is* $E\pi_R^{SM*} = \alpha^2 G$; (3) *consumers' expected prices for the two products are* $Ep_1^{SM*} = Ep_2^{SM*} \cong G$; *and* (4) *the total channel surplus is* $\Pi^{SM*} = \alpha(2-\alpha)G$.

Proof. See the appendix.

As shown in Lemma 1, with an increased fit probability α, the retailer always obtains a greater profit; each manufacturer's profit first increases and then declines after α reaches $\frac{1}{2}$. This is because an increased fit probability (a larger α) brings two effects. First, more consumers find a good fit with at least one product, allowing the retailer to obtain a greater demand;

[4] This game sequence allows us to examine retailer shelf layout as a long-term strategy. Certain store layout decisions can be temporary. For example, a retailer at the request of the manufacturer or as part of the store promotion campaign may display a product at the prominent location for a holiday weekend. Such temporary store layout decisions are beyond the scope of this paper.

the maximum demand a manufacturer can obtain also increases. Second, more consumers find a good fit with both products, which intensifies competition between manufacturers for a more favorable retail price. This notion is reflected in that the midpoint of the manufacturers' price range decreases with α. The intensified price competition increases retailer margin but hurts manufacturer profitability. The retailer thus benefits from both effects. For manufacturers, when α is already large ($\alpha > \frac{1}{2}$) and further increases, its negative effect of intensifying manufacturer competition dominates the favorable effect in expanding demand, leading to reduced manufacturer profits. Finally, the total channel surplus always increases with α, which is natural, given the expanded total market demand.

3.1.2. Subgame 2: Retailer Displays Competing Products in Distant Locations. When the retailer displays competing products in distant locations, a proportion $(1+r)/2$ of consumers inspects the prominent product first, and the remaining proportion $(1-r)/2$ of consumers inspects the nonprominent product first. From Table 2, we derive the total demand for product i ($i=1,2$) as

$$D_i^{SE} = \begin{cases} \dfrac{\alpha(3-\alpha)+\alpha(1+\alpha)r}{4} \\ \quad \text{if product } i \text{ is prominent,} \\ \dfrac{\alpha(3-\alpha)-\alpha(1+\alpha)r}{4} \\ \quad \text{if product } i \text{ is nonprominent.} \end{cases} \tag{4}$$

As shown in Equation (4), the prominent product obtains a greater demand than the nonprominent product. The retailer's total market demand is $\Lambda^{SE} = D_1^{SE} + D_2^{SE} = \alpha(3-\alpha)/2$, which increases with the fit probability of products, α.

In the third stage of the game, the retailer chooses the optimal prices p_1 and p_2 to maximize its total profit of $\pi_R^{SE} = D_1^{SE}(p_1 - w_1) + D_2^{SE}(p_2 - w_2)$. It is straightforward that the retailer's optimal strategy is to charge the $p_i = p_{-i} = G$ and make product i prominent if $w_i < w_{-i}$ so that it obtains a greater demand from product i. When the two manufacturers offer the same wholesale price, the retailer randomly selects a product to display in the prominent location. The retailer's maximized profit is thus

$$\pi_R^{SE*}(w_i < w_{-i}) = \frac{\alpha(3-\alpha)+\alpha(1+\alpha)r}{4}(G-w_i) + \frac{\alpha(3-\alpha)-\alpha(1+\alpha)r}{4}(G-w_{-i}). \tag{5}$$

In the second stage, the manufacturers simultaneously choose the optimal wholesale prices to maximize their own profits:

$$\pi_{Mi}^{SE} = \begin{cases} \dfrac{\alpha(3-\alpha)-\alpha(1+\alpha)r}{4} w_i & \text{if } w_i > w_{-i}, \\ \dfrac{\alpha(3-\alpha)}{4} w_i, & \text{if } w_i = w_{-i} \\ \dfrac{\alpha(3-\alpha)+\alpha(1+\alpha)r}{4} w_i & \text{if } w_i < w_{-i}. \end{cases} \quad i=1,2, \tag{6}$$

As shown in Equation (6), a manufacturer that offers a lower wholesale price obtains a demand greater by $d^{SE} = \alpha(1+\alpha)r/2$ than its rival. This is because by occupying the prominent location, a manufacturer attracts more consumers to inspect its product first; consequently, more consumers find a good fit with its product and make purchases. With an increased retailer traffic control r, more consumers start the fit search from the prominent location; with an increased fit probability α, more consumers find a good fit with the product they first inspect. In both cases, the increased d^{SE} motivates the manufacturers to undercut each other's wholesale price to compete for the prominent display location. In equilibrium, manufacturers conduct mixed strategy competition in wholesale prices; the retailer's expected equilibrium profit is $E\pi_R^{SE*} = \pi_R^{SE*}(w_1 \le w_2)\Pr(w_1 \le w_2) + \pi_R^{SE*}(w_1 > w_2) \cdot \Pr(w_1 > w_2)$. We summarize the market equilibrium in the following lemma.

Lemma 2. *When the retailer displays competing products in distant locations, in equilibrium,* (1) *manufacturers implement mixed pricing strategies with each manufacturer's wholesale price* w_i^{SE*} ($i=1,2$) *ranging over* $[((\alpha(3-\alpha)-\alpha(1+\alpha)r)/(\alpha(3-\alpha)+\alpha(1+\alpha)r)) \cdot G, G]$, *and manufacturers' equilibrium profits are* $\pi_{M1}^{SE*} = \pi_{M2}^{SE*} = ((\alpha(3-\alpha)-\alpha(1+\alpha)r)/4)G$; (2) *the retailer makes product* i *prominent and sets* $p_i^{SE*} = p_{-i}^{SE*} = G$ *if* $w_i < w_{-i}$ *and randomly chooses the product to make prominent if* $w_i = w_{-i}$, *and the retailer's expected profit is* $E\pi_R^{SE*} = (\alpha(1+\alpha)r/2)G$; (3) *consumers' expected prices for the two products are* $Ep_i^{SE*} = Ep_{-i}^{SE*} = G$; *and* (4) *the total channel surplus is* $\Pi^{SE*} = (\alpha(3-\alpha)/2)G$.

Proof. See the appendix.

Lemma 2 shows that the retailer's expected profit and the total channel surplus both increase with α, but the manufacturers' profits first increase with α and then decline, similar to when the retailer displays competing products in the same location. In addition, Lemma 2 shows that an increased retailer traffic control r enhances retailer profit but reduces manufacturer profits. This is because when the retailer has a stronger control over the store traffic, more consumers start the sequential inspection from the prominent product, leading to a greater demand gain for the manufacturer occupying the prominent location (d^{SE} increases with r). In this case, each manufacturer has stronger incentive to cut its wholesale price to compete for the prominent location, which is reflected in that the midpoint of manufacturers' price range decreases with r. As a result, the retailer obtains a greater channel power over the manufacturers and ends up with an enhanced profit.[5]

Note that the support of equilibrium as in Lemma 2 relies on two assumptions: first, the assumption that consumers believe the prices of the two products are the same before observing the true prices helps simplify consumers' belief updating process; and second, the assumption that consumers make a second inspection only if the utility of doing so is strictly higher rules out the case that consumers with low travel cost inspect both products before making a purchase decision, which helps eliminate the equilibrium that the retailer charges the price of one product to be infinitesimally lower than the other.

3.2. Retailer's Optimal Shelf Layout Strategy

In this section, we compare the retailer's market payoffs under different shelf layout designs to derive its optimal layout strategy. Note that under consumer sequential inspection, a size $(1-\alpha)/2$ of consumers with high travel costs exits the market without purchases after they have made the first inspection and found a bad fit. Also note that a proportion α of these consumers would have found a good fit with the other product that they failed to inspect. Therefore, the retailer suffers a demand loss of $\Lambda^{SM} - \Lambda^{SE} = (\alpha(1-\alpha))/2$ by displaying competing products in distant locations rather than in the same location. We summarize the retailer's optimal shelf layout strategy in the following proposition.

Proposition 1 (Retailer Optimal Shelf Layout Strategy). *In equilibrium, the retailer displays competing products in distant locations* ($E\pi_R^{SE*} > E\pi_R^{SM*}$) *if the fit probability of products is sufficiently low,* $\alpha < \alpha_R = r/(2-r)$; *otherwise, the retailer displays competing products in the same location* ($E\pi_R^{SE*} \le E\pi_R^{SM*}$).

Proposition 1 is interesting because it shows that despite its loss in demand, the retailer may benefit from displaying competing products in distant locations. This is because by inducing consumer sequential inspection of product fits, the retailer may acquire greater channel power over manufacturers. Below we discuss this intuition in detail. When the retailer displays competing products in the same location, consumers find the fits of the two products at the same time and make fully informed decisions. In this case, manufacturers have incentive to lower the wholesale price to compete for demand from segment (G, G) consumers who find a good fit with both products. In contrast, when the retailer displays competing products in distant locations, it optimally charges the same price for competing products, and therefore consumers who find a good fit after making the first inspection have no incentive to inspect the second product. The disappearance of segment (G, G) alleviates manufacturer competition. Such alleviation in competition pressure, however, may be offset by manufacturers' additional incentive to compete for the prominent display location and the associated high demand. In particular, when products' fit probability is small, $\alpha < \alpha_R$, few consumers find a good fit with both products, and therefore the alleviation in manufacturer competition for segment (G, G) under sequential inspection is also limited. In this case, the retailer enjoys a greater margin by displaying competing products in distant location and inducing manufacturer competition for the prominent location, and the increased margin more than compensates for the retailer's loss in demand.

On the other hand, when the fit probability is large, $\alpha \ge \alpha_R$, many consumers find a good fit with both products and sequential inspection brings great alleviation in manufacturers' competition pressure for segment (G, G) consumers. In this case, the retailer is better off by displaying competing products in the same location. Also note that if $\alpha < (3 - r - \sqrt{9-14r+9r^2})/(2(1-r))$, the midpoint of manufacturers' wholesale price range when the retailer displays competing products in distant locations is lower than that when the retailer displays competing products in the same location. Therefore, if the fit probability is not too large, $\alpha_R \le \alpha < (3 - r - \sqrt{9-14r+9r^2})/(2(1-r))$, by displaying competing products in the same location, the retailer obtains a lower margin than displaying them in distant locations, but its gain in demand more than compensates for the reduced margin. When the fit probability is

[5] Our results suggest that when the cost is not a concern, it is to the retailer's benefit to have better control of the store traffic (a larger r). Nonetheless, consumers' search sequence can be affected by many factors in their shopping practices that are out of the retailer's control. For example, while visiting a department store, some consumers may want to shop electronics first, and some may want to shop cosmetics first. When these consumers go to the apparel section, they will naturally enter from different entrances and thus have different search sequences. Also note that our setup is about the shelf display of a category or a department. The managers may have full control of consumers' search sequences by imposing a one-way shopping route—say, consumers have to go to the electronics department first, then the apparel department, and then the cosmetics department. This arrangement, however, may hurt the sales of other departments. When the cost of obtaining higher traffic control is taken into consideration, the retailer's traffic control can be endogenously determined.

very large, $\alpha \geq (3 - r - \sqrt{9 - 14r + 9r^2})/(2(1 - r)) > \alpha_R$, the retailer, by displaying competing products in the same location, benefits from both the expanded demand and the enhanced margin.

Proposition 1 also shows that the threshold α_R increases with r, suggesting that a retailer is more likely to display competing products in distant locations when it has a better control of the store traffic. This is because when r is larger, more consumers start the sequential inspection from the prominent product, motivating the manufacturers to compete for the prominent location. In particular, when the retailer has perfect control over the store traffic, $r = 1$, under sequential inspection, all consumers inspect the prominent product first. The manufacturers have strong incentive to compete for the prominent location, and the retailer always generates a greater profit by displaying competing products in distant locations; $\pi_R^{SE*}(r = 1) = (\alpha(1 + \alpha)/2)G > \pi_R^{SM*}$. On the other hand, when the retailer has no control over the store traffic, $r = 0$, under sequential inspection, consumers check out product fits in random orders. The manufacturers have no incentive to compete for the prominent location, and the retailer obtains a greater profit from displaying competing products in the same location; $\pi_R^{SE*}(r = 0) = 0 < \pi_R^{SM*}$.

We further compare the manufacturers' profits under different retailer layout formats and find that the manufacturers earn greater profits when the retailer displays competing products in distant locations than when the retailer displays in the same location if the fit probability is sufficiently large, $\alpha > \alpha_M = (1 + r)/(3 - r)$. As discussed earlier, when α is larger, more consumers find a good fit with both products (segment (G, G)), and manufacturers benefit considerably from the lessened competition for these consumers when the retailer facilitates consumer sequential inspection. When α is sufficiently large, this benefit dominates manufacturers' loss in margin owing to the competition for the prominent location together with the loss in demand. In addition, stronger retailer traffic control intensifies manufacturer competition for the prominent location, offsetting the benefit of lessened competition pressure for segment (G, G) consumers (α_M increases with r). Furthermore, note that $\alpha_M > \alpha_R$ is always satisfied, and thus we obtain the following proposition.

Proposition 2 (Product Fit Probability and Channel Interaction). (1) *When $\alpha < \alpha_R$, the manufacturers prefer competing products to be displayed in the same location, but the retailer displays competing products in distant locations* ($\pi_{Mi}^{SE*} < \pi_{Mi}^{SM*}$, $E\pi_R^{SE*} > E\pi_{Mi}^{SM*}$). (2) *When $\alpha_R \leq \alpha \leq \alpha_M$, the manufacturers prefer competing products to be displayed in the same location, and the retailer displays competing products in the same location* ($\pi_{Mi}^{SE*} \leq \pi_{Mi}^{SM*}$, $E\pi_R^{SE*} \leq E\pi_{Mi}^{SM*}$). (3) *When $\alpha > \alpha_M$, the manufacturers prefer competing products to be displayed in distant locations, but the retailer displays competing products in the same location* ($\pi_{Mi}^{SE*} > \pi_{Mi}^{SM*}$, $E\pi_R^{SE*} < E\pi_{Mi}^{SM*}$).

Proposition 2 shows that the retailer's optimal shelf layout strategy is in line with the manufacturers' interests only when the products' fit probabilities are not too high or too low; otherwise, the retailer's shelf layout decision conflicts with the manufacturers' interests and hurts manufacturer profits. This result suggests that by strategically designing the shelf layout and manipulating consumers' fit inspection processes, the retailer steers the channel relationship toward its own benefit. In particular, when the fit probability of products is large ($\alpha \geq \alpha_M$), the retailer designs its shelf layout to facilitate consumer simultaneous inspection, with the purpose of forcing manufacturers to compete for a favorable retail price. On the other hand, when the fit probability of products is small ($\alpha < \alpha_R$), the retailer designs its shelf layout to facilitate consumer sequential inspection, which impedes consumers from making fully informed decisions, so that it can motivate manufacturers to compete for the prominent location; in this case, the retailer squeezes a sufficiently large profit from the manufacturers that more than compensates for its loss in demand. Our result thus implies that the retailer's decision to assist or suppress consumers' fit seeking through shelf layout design is associated with its intention to manipulate the channel relationship. This insight makes a unique contribution to the literature on information provision (e.g., Chen and Xie 2008, Sun 2011), which mostly focuses on the demand market implications. Our analysis thus reveals the important strategic role of retail shelf layout design in asserting control over the supplier market as well as in the consumer market.

Finally, note that the total channel surplus is lower when the retailer displays competing products in distant locations than when the retailer displays in the same location, $\Pi^{SE*} < \Pi^{SM*}$. This result implies that by facilitating consumer sequential inspection, the strategic retailer hurts channel efficiency.

4. Model Extensions

We examine several model extensions to obtain further insights regarding retailers' strategic shelf layout decisions and also discuss several robustness issues.

4.1. Manufacturers Offer Products with Different Fit Probabilities

In the main model, we assume that consumers find a good fit with each of the two products with equal probabilities. We now consider the case in which competing manufacturers offer products with differentiated fit probabilities. Without loss of generality, we assume that product 1 has a higher fit probability than product 2; $\alpha_1 = \alpha + \delta$ and $\alpha_2 = \alpha$, $0 < \delta \le 1 - \alpha$. Focusing on the case in which consumers' perceived value G from a good fit product is not too low and the fit probability difference δ is not too large, we solve the model in the appendix and summarize the main findings in the following proposition.

Proposition 3. *When the two manufacturers offer products of differentiated fit probabilities, if consumers' perceived value G from a good fit product is not too low and the fit probability difference δ is not too large,* (1) *the retailer profit does not change with δ if it displays the two products in the same location, and it increases with δ if it displays the two products in distant locations* ($\partial \pi_R^{SM*}/\partial \delta = 0$, $\partial \pi_R^{SE*}/\partial \delta > 0$)*; and* (2) *the retailer is more likely to benefit from displaying competing products in distant locations.*

Proof. See the appendix.

Proposition 3 suggests that an increased fit probability difference δ between competing products motivates the retailer to display the products in distant locations. This is because an increased fit probability of product 1 always leads to increased demand in the consumer market but induces different manufacturer competition conditions under different shelf layout formats. In particular, when the retailer displays products in the same location, consumers make fully informed decisions. The retailer always obtains the same total demand no matter which product has a lower retail price and sells more, and therefore the retailer's optimal strategy is to set a lower retail price for the product with the lower wholesale price. And a manufacturer obtains the more favorable retail price as long as it offers a slightly lower wholesale price than its rival's. In this case, the increased fit probability of product 1 induces a greater channel surplus without affecting manufacturer competition. Manufacturer 1 is able to collect all the extra channel surplus induced by its increased fit probability, and the market payoffs of manufacturer 2 and the retailer remain unchanged.

On the other hand, when the retailer displays the two products in distant locations, consumers who find a good fit with the first product they inspect make immediate purchases without inspecting the other product. In this case, the retailer generates a greater demand by displaying the high fit product in the prominent location than displaying the low fit product and therefore is willing to make the high fit product prominent even if its wholesale price is slightly higher than the low fit product's. The low fit manufacturer in pursuit of the prominent location has to offer a wholesale price much lower than that of the high fit product. With an increased fit probability of product 1, manufacturer 2 is forced to cut its wholesale price even further to compete for the prominent location. The retailer, benefiting from the increased demand as well as intensified manufacturer competition, ends up with an increased profit. In the end, the retailer is more likely to benefit from displaying competing products in distant locations.

4.2. Retailer Competition

In the main model, we consider the shelf layout decision of a monopolistic retailer. We extend the model to examine shelf layout decisions of retailers operating in a competitive market. We consider two retailers, 1 and 2, each selling the two manufacturers' products in the consumer market of unit mass. We assume that a proportion l_1 of consumers is loyal to retailer 1 and a proportion l_2 is loyal to retailer 2; the remaining consumers are switchers who visit the store that provides the higher expected utility. A consumer randomly chooses a store to visit if she perceives the same expected utility from visiting the two stores. We focus on symmetric retailers and assume that $l_1 = l_2 = l$, $0 \le l \le 0.5$. A larger size of switchers, or a smaller l, indicates greater competition between retailers. We assume that consumers' store loyalty is independent of their travel costs or perceived product fit.

Following the main model, we assume that before visiting a store consumers already know product qualities and hold beliefs about product prices. We also restrict that before visiting either store, consumers believe the prices of the same product are the same at the two symmetric retail stores; this assumption allows us to abstract out the impact of price competition and focus on their competition based on shelf layout format. Letting Ep_{jr} denote consumers' expected price for product j sold through store r, we have $Ep_{j=1,2,\,r=1,2} = Ep$, $0 \le Ep \le G$. A consumer's expected utility from visiting a store depends on her expected probability of finding a good fit product. Clearly, a switcher with low travel cost is indifferent between stores with different shelf layouts, but a switcher with high travel cost prefers to visit a store that displays competing products in the same location. The game sequence is the same as in the main model. We derive retailers' equilibrium profits under each of the four scenarios in Table 3. Solving the game as shown in Table 3, we obtain the following proposition.

Proposition 4 (Shelf Layout Decisions of Competitive Retailers). (1) *If the fit probability of the two products is small, $\alpha \le (r + 2lr)/(4 - r - 2lr)$, in equilibrium, both retailers display the two products in distant locations.* (2) *If the fit probability of the two products is in the intermediate range, $(r + 2lr)/(4 - r - 2lr) < \alpha \le r/(3 - 2l - r)$, in equilibrium, one retailer displays the two products in the same location and the other retailer displays in distant locations.* (3) *If the fit probability of the two products is large, $\alpha > r/(3 - 2l - r)$, in equilibrium, both retailers display the two products in the same location.*

Table 3 Payoffs of Competitive Retailers by Shelf Layout of Competing Products

Retailer 1	Retailer 2: In the same location	Retailer 2: In distant locations
In the same location	$E\pi_{R1}^* = \frac{1}{2}\alpha^2 G$, $E\pi_{R2}^{MM*} = \frac{1}{2}\alpha^2 G$	$E\pi_{R1}^* = \frac{3-2l}{4}\alpha^2 G$, $E\pi_{R2}^* = \frac{1+2l}{4}\frac{\alpha(1+\alpha)r}{2}G$
In distant locations	$E\pi_{R1}^* = \frac{1+2l}{4}\frac{\alpha(1+\alpha)r}{2}G$, $E\pi_{R2}^* = \frac{3-2l}{4}\alpha^2 G$	$E\pi_{R1}^* = \frac{1}{2}\frac{\alpha(1+\alpha)r}{2}G$, $E\pi_{R2}^* = \frac{1}{2}\frac{\alpha(1+\alpha)r}{2}G$

Proof. See the appendix.

Proposition 4 shows that with a lower fit probability of products, more retailers display competing products in distant locations. Interestingly, we find that the two symmetric retailers may adopt asymmetric shelf layout formats in equilibrium. In this case, the retailer that displays competing products in the same locations attracts a greater demand, whereas the other retailer that displays competing products in different locations obtains a greater margin. In addition, we show that with an expanded switcher segment, the intensified competition motivates retailers to display competing products in the same location ($(r+2lr)/(4-r-2lr)$ and $r/(3-2l-r)$ both decrease with a smaller l) to facilitate consumer simultaneous fit inspection.

4.3. Other Robustness Issues

4.3.1. Inspection Cost and Consumer Loyalty. Now we demonstrate that our main results hold in a more general model framework by incorporating the inspection cost and consumer product loyalty.[6] We consider the existence of a loyal segment with size y, among which half will only buy product 1 and the other half only buy product 2. Loyal consumers incur zero cost for inspecting either product. We also assume that nonloyal consumers incur an inspection cost $e \in \{e_H, e_L\}$ to inspect each product, with $e_H > e_L \geq 0$. We assume that a proportion τ $(0 \leq \tau \leq 1)$ of nonloyal consumers incur a low inspection cost, $e = e_L = 0$, and the proportion $1-\tau$ of the remaining consumers incur a high inspection cost, $e = e_H \geq 1$. A consumer's travel cost is independent of her inspection cost or product loyalty. Other assumptions in the main model apply. Our analysis shows that it is optimal for the retailer to facilitate consumer sequential inspection for fit if the fit probability of the products is sufficiently small; that is, $E\pi_R^{SM*} > E\pi_R^{SE*}$ if

$$\alpha < \alpha_{GR} = \frac{2r - r\tau}{2(2-r\tau)} + \frac{1}{2(2-r\tau)} \cdot \sqrt{\frac{r(r(2-\tau)^2\tau + y(4 - r\tau(6-4\tau+\tau^2)))}{(1-y)\tau}}.$$

This result is consistent with Proposition 1. Also note that the threshold α_{GR} decreases with τ, $\partial\alpha_{GR}/\partial\tau < 0$. That is, when more (fewer) consumers have a low inspection cost, the retailer is less (more) likely to benefit from displaying competing products in distant locations. This is because when a larger size of consumers have a high inspection cost, more consumers terminate the fit search without inspecting the second product, causing a greater demand loss and a greater demand asymmetry between the product occupying the prominent location and the product occupying the nonprominent location. Such an increased demand asymmetry motivates manufacturers to engage in price competition and benefits the retailer. In addition, it can be proven that $\partial\alpha_{GR}^2/(\partial\tau\partial y) < 0$. That is, the impact of consumer inspection cost on retailer shelf layout decisions is alleviated when there is a larger segment of loyal consumers who do not inspect the product. A detailed proof is in the online appendix (available at http://dx.doi.org/10.1287/mksc.2013.0778).[7]

4.3.2. Alternative Specification of the Travel Cost. Below we examine a modification of the specification for the inspection cost to demonstrate the robustness of our results. We let t denote the proportion of consumers with low travel cost and allow t to range between 0 and 1. It can be proven that the retailer's expected profit is $\pi_R^{SM*} = \alpha^2 G$ when it displays competing products in the same location and $\pi_R^{SE*} = \alpha r(1-(1-\alpha)t)G$ when it displays competing products in distant locations. In equilibrium, the retailer displays competing products in distant locations if the fit probability of the two products is small, $\alpha < (r-rt)/(1-rt)$, which is consistent with that in the main model. In addition, $(r-rt)/(1-rt)$ decreases with t, indicating that the retailer is more likely to facilitate consumer sequential fit inspection

[6] We thank the reviewers for indicating the inspection cost and consumer product loyalty as two very important factors to be considered in a realistic and more general model framework.

[7] We have analyzed two alternative specifications of the inspection cost to demonstrate the robustness of our results. In the first specification, we maintain the two-point distribution of the inspection cost and assume that consumers incur no inspection cost to inspect the first product and an inspection cost to inspect the second product. This way, we eliminate the effect that the inspection cost simply reduces the total size of the market and focus on the impact of the inspection cost in deterring consumer from making the second inspection. In the second specification, we assume consumers incur an inspection cost for making the first and the second inspection and allow the inspection cost to be in the intermediate range. Under both specifications, our main results remain unchanged. Details are in the online appendix.

when there are more consumers with low travel cost. A detailed proof is included in the online appendix.

5. Conclusion

This study examines how a retailer's shelf layout design is determined by its incentive to manipulate the shopping process of fit uncertain consumers and the pricing behavior of the upstream manufacturers. Our analysis shows that a retailer makes its shelf layout decision by considering the impact of such a decision on market demand as well as its channel power over the manufacturers. In particular, when manufacturers offer products of the same fit probabilities, the retailer optimally displays competing products in distant locations if the products' fit probabilities are not too large and otherwise displays competing products in the same location. The retailer's optimal shelf layout strategy is in line with the manufacturers' interests only if the products' fit probabilities are not too high or too low and otherwise hurts manufacturer profits. When the fit probability difference between competing products becomes larger, the retailer is more likely to display competing products in distant locations. Finally, a retailer is more likely to display competing products in distant locations when facing less severe competition from other retailers.

Our results suggest that retailers may optimally adopt different shelf layout formats for product categories with different fit probabilities. For example, retailers may be willing to display competing products in distant locations for products with generally low fit probabilities such as apparel (jeans, shirts, etc.) and to display competing products in the same location for products with generally high fit probabilities such as home appliances (microwave ovens, refrigerators, etc.). This insight may explain why in a department store such as Macy's, a consumer can find all different brands of microwave ovens or refrigerators at the same place but has to travel the entire floor for different brands of shirts or jeans. Our result can also explain why different retailers in the same category adopt different shelf display formats. For example, Sears organizes its furniture by product, displaying all different brands of bookcases in one place and all desks in another place, whereas Bloomingdale's organizes its furniture by brand, displaying all home office furniture from one brand in one room and that from another brand in a different room. This could be because Sears carries mass market brands with generally high fit probabilities, whereas Bloomingdale's carries designer brand furniture characterized by peculiar styles, suggesting low fit probabilities. At last, our results may also provide an explanation for Carrefour's shelf layout change from displaying all brands of toothbrushes side by side in one place in its stores to displaying different brands in different places (Agrawal and Smith 2009). The toothbrush industry has experienced rapid technology advancement in recent years, and today different toothbrush makers typically offer products with different (and often patented) bristle and head configurations, tongue scrapers, gum massagers, grip controls, and color strips. The increased product differentiation alleviates product competition based on retail price and consequently reduces manufacturers' incentive to lower wholesale prices to compete for a better retail price in a store. Threatened by the reduced channel power, the retailer benefits from changing the shelf layout design to display competing products in distant locations and inducing manufacturer competition for the prominent display location.

Our study aims to provide explanations for some intriguing retailing practice in markets characterized by consumer fit uncertainty and therefore is not in the position of providing a general theory on store layout. In the analysis, we focus on the impact of consumer fit uncertainty and abstract out price uncertainty and quality uncertainty. This approach is reasonable in our research context as retailers typically carry products with similar qualities and prices that match their store images (e.g., Walmart carries products of low quality/price and JCPenney carries products of medium quality/price), and consumers also expect so. Our study models product fit probabilities as exogenous, and it could be interesting to examine how retailer shelf layout decisions affect manufacturers' product design. We do not model retailers' selling costs in the model, and it is easy to see that a higher marginal cost motivates retailers to enhance margin by displaying competing products in distant locations so as to induce manufacturer competition for the prominent display location. Finally, it would be interesting to investigate manufacturers' roles in retailer shelf layout decisions (e.g., Zhang and Jerath 2010, Subramanian et al. 2010). For example, our analysis suggests that in the case where the category captain makes the shelf layout decision for the retailer, the category captain will advise the retailer to display competing products in distant locations if the fit probability of products is sufficiently high. Because the channel surplus is always greater when the retailer displays competing products in the same location, this insight suggests that having the category captain decide the retailer shelf layout does not resolve the channel conflict but shifts the channel power from the retailer to the manufacturers. It would be interesting to examine how a retailer can effectively use a category captain to its own benefit. We leave these interesting issues to future research.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/mksc.2013.0778.

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Appendix

A1. Proof of Lemma 1

The highest wholesale price manufacturer 1 can charge is G, in which case it obtains a demand of $\alpha(1-\alpha)$ from (G, B) consumers; therefore, the lowest price manufacturer 1 is willing to charge to obtain demand from both (G, B) and (G, G) consumers is $\alpha(1-\alpha)G/\alpha = (1-\alpha)G$; manufacturer 2 can thus charge a price slightly lower than $(1-\alpha)G$ to obtain demand from both (B, G) and (G, G). In equilibrium, the two manufacturers implement mixed pricing strategies, with each manufacturer's wholesale price distributed over the interval $[(1-\alpha)G, G]$. The equilibrium profit for manufacturer i $(i=1,2)$ is $\pi_{Mi}^{SM*} = \alpha(1-\alpha)G$. We proceed to solve for the distribution function. We have

$$\alpha(1-\alpha)w + [1-F_i(w)]\alpha^2 w = \alpha(1-\alpha)G, \quad (1-\alpha)G \le w \le G. \tag{7}$$

Solving Equation (7), we obtain

$$F_i = \begin{cases} 0 & \text{if } w < (1-\alpha)G, \\ \dfrac{G\alpha + w - G}{\alpha w} & \text{if } (1-\alpha)G \le w \le G, \\ 1 & \text{if } w > G. \end{cases} \tag{8}$$

The retailer's expected equilibrium profit can thus be solved as

$$E\pi_R^{SM*} = 2\int \big[\alpha(1-\alpha)(G-w_1) + \alpha^2(G-w_1)(1-F_2(w_1))\big]\,dF_1(w_1) = \alpha^2 G. \tag{9}$$

Consumers' expected prices for the two products in the fulfilled equilibrium are $Ep_i^{SM*} = \Pr(w_i \ge w_{-i})G + \Pr(w_i < w_{-i}) \cdot (G-\varepsilon) = G - \varepsilon/2 \cong G$ as ε is infinitesimal. The equilibrium total channel surplus is $\Pi^{SM*} = E\pi_R^{SM*} + \pi_{M1}^{SM*} + \pi_{M2}^{SM*} = (2-\alpha)\alpha G$. It is straightforward that $\partial\pi_{Mi}^{SM*}/\partial\alpha \ge 0$ if and only if $\alpha \le \frac{1}{2}$, $\partial E\pi_R^{SM*}/\partial\alpha > 0$, and $\partial\Pi^{SM*}/\partial\alpha > 0$.

A2. Proof of Lemma 2

The lowest profit manufacturer 1 expects to obtain is when it charges a wholesale price of G and gets the nonprominent position, that is, $((\alpha(3-\alpha) - \alpha(1+\alpha)r)/4)G$. Therefore, the lowest price manufacturer 1 is willing to charge to get the prominent location and the demand of $(\alpha(3-\alpha) + \alpha(1+\alpha)r)/4$ is $((\alpha(3-\alpha) - \alpha(1+\alpha)r)/(\alpha(3-\alpha) + \alpha(1+\alpha)r))G$. Manufacturer 2 can thus charge a price slightly lower than $(\alpha(3-\alpha) - \alpha(1+\alpha)r)/(\alpha(3-\alpha) + \alpha(1+\alpha)r)$ to get the prominent location. In equilibrium, both manufacturers implement mixed pricing strategies, with each manufacturer's wholesale price distributed over the interval $[((\alpha(3-\alpha)-\alpha(1+\alpha)r)/(\alpha(3-\alpha)+\alpha(1+\alpha)r))G, G]$; each manufacturer obtains an equilibrium profit of $\pi_{Mi}^{SE*} = ((\alpha(3-\alpha) - \alpha(1+\alpha)r)/4)G$. We proceed to derive the distribution function. We have

$$\frac{\alpha(3-\alpha)-\alpha(1+\alpha)r}{4}w + [1-F_i(w)]\frac{\alpha(1+\alpha)r}{2}w = \frac{\alpha(3-\alpha)-\alpha(1+\alpha)r}{4}G, \quad \frac{\alpha(3-\alpha)-\alpha(1+\alpha)r}{\alpha(3-\alpha)+\alpha(1+\alpha)r}G \le w \le G. \tag{10}$$

Solving Equation (10), we obtain

$$F_i = \begin{cases} 0 & \text{if } w < \dfrac{\alpha(3-\alpha)-\alpha(1+\alpha)r}{\alpha(3-\alpha)+\alpha(1+\alpha)r}G, \\ \dfrac{w(3+r-\alpha+r\alpha)+G(-3+r+\alpha+r\alpha)}{2rw(1+\alpha)} & \text{if } \dfrac{\alpha(3-\alpha)-\alpha(1+\alpha)r}{\alpha(3-\alpha)+\alpha(1+\alpha)r}G \le w \le G, \\ 1 & \text{if } w > G. \end{cases} \tag{11}$$

The retailer's expected equilibrium profit can be solved as

$$E\pi_R^{SE*} = 2\int \bigg[\frac{\alpha(3-\alpha)-\alpha(1+\alpha)r}{4}(G-w_1) + \frac{\alpha(1+\alpha)r}{2}(G-w_1)(1-F_2(w_1))\bigg]\,dF_1(w_1) = \frac{\alpha(1+\alpha)r}{2}G.$$

Consumers' expected prices for the two products in the fulfilled equilibrium are $Ep_i^{SM*} = \Pr(w_i \ge w_{-i})G + \Pr(w_i < w_{-i}) \cdot (G-\varepsilon) \cong G$. In equilibrium, the total channel surplus is $\Pi^{SE*} = E\pi_R^{SE*} + \pi_{M1}^{SE*} + \pi_{M2}^{SE*} = (\alpha(3-\alpha)/2)G$. It is straightforward that $\partial\pi_{Mi}^{SE*}/\partial\alpha \ge 0$ if and only if $\alpha \le (3-r)/(2(1+r))$; in addition, $\partial E\pi_R^{SE*}/\partial\alpha > 0$ and $\partial\Pi^{SE*}\partial\alpha > 0$. We also obtain that $\partial\pi_{Mi}^{SE*}/\partial r < 0$, $\partial E\pi_R^{SE*}/\partial r > 0$, and $\partial\Pi^{SE*}/\partial r = 0$.

A3. Proof of Proposition 3

We first solve for channel members' equilibrium pricing strategies and market payoffs when the retailer displays competing products in the same location and in distant locations separately. Then we compare the retailer's payoffs under the two subgames to derive its optimal shelf layout strategy.

A3.1. Optimal Channel Strategies Under Different Shelf Layout Formats. We solve the pricing strategies and market payoffs for each scenario.

Subgame 1. The retailer displays competing products in the same location:

In the fourth stage of the game, the consumer demand for product i is

$$D_i^{SM} = \begin{cases} \alpha_i(1-\alpha_{-i}) & \text{if } p_i > p_{-i}, \\ \alpha_i(1-\alpha_{-i}/2) & \text{if } p_i = p_{-i}, \\ \alpha_i & \text{if } p_i < p_{-i}. \end{cases} \tag{12}$$

Therefore, we have

$$D_1^{SM} = \begin{cases} (\alpha+\delta)(1-\alpha) & \text{if } p_1 > p_2, \\ (\alpha+\delta)(1-\alpha/2) & \text{if } p_1 = p_2, \\ \alpha+\delta & \text{if } p_1 < p_2, \end{cases} \tag{13}$$

and

$$D_2^{SM} = \begin{cases} \alpha & \text{if } p_1 > p_2, \\ \alpha(1-(\alpha+\delta)/2) & \text{if } p_1 = p_2, \\ \alpha(1-\alpha-\delta) & \text{if } p_1 < p_2. \end{cases} \quad (14)$$

The total demand is $\Lambda^{SM} = D_1^{SM} + D_2^{SM} = 2\alpha + \delta - \alpha^2 - \alpha\delta$, which increases with α and with δ.

In the third stage, the retailer chooses the optimal prices p_1 and p_2 to maximize its total profit from the two products $\pi_R^{SM} = D_1^{SM}(p_1 - w_1) + D_2^{SM}(p_2 - w_2)$, taking the wholesale prices w_1 and w_2 as given. If $w_i < w_{-i}$ $(i = 1, 2)$, the optimal retailer strategy is to set $p_i^{SM*} = G - \varepsilon$ and $p_{-i}^{SM*} = G$. The retailer's maximized profit is thus

$$\pi_R^{SM*}(w_1, w_2) = \begin{cases} (\alpha+\delta)(G-\varepsilon-w_1) + \alpha(1-\alpha-\delta)(G-w_2) \\ \quad \text{if } w_1 < w_2, \\ (\alpha+\delta)\left(1-\dfrac{\alpha}{2}\right)(G-w_1) + \alpha\left(1-\dfrac{\alpha+\delta}{2}\right)(G-w_2) \\ \quad \text{if } w_1 = w_2, \\ (\alpha+\delta)(1-\alpha)(G-w_1) + \alpha(G-\varepsilon-w_2) \\ \quad \text{if } w_1 > w_2. \end{cases} \quad (15)$$

In the second stage, the two manufacturers choose their optimal wholesale prices simultaneously to maximize their own profits. The highest wholesale price manufacturer 1 can charge is G, in which case it obtains a demand of $(\alpha+\delta)\cdot(1-\alpha)$ from (G, B) consumers; therefore, the lowest price manufacturer 1 is willing to charge to obtain demand from both (G, B) and (G, G) consumers is $((\alpha+\delta)(1-\alpha)/\alpha+\delta)G = (1-\alpha)G$; manufacturer 2 can thus charge a price slightly lower than $(1-\alpha)G$ to obtain a total demand of α from segments (B, G) and (G, G). In equilibrium, the two firms implement mixed pricing strategies, with each manufacturer's wholesale price randomizing over the interval $[(1-\alpha)G, G]$. Manufacturer 1's equilibrium profit is $\pi_{M1}^{SM*} = (\alpha+\delta)(1-\alpha)G$; manufacturer 2's equilibrium profit is $\pi_{M2}^{SM*} = \alpha(1-\alpha)G$.

We proceed to solve for the distribution functions. We have for manufacturer 2 that

$$\alpha(1-\alpha-\delta)w + [1-F_1(w)]\alpha(\alpha+\delta)w = \alpha(1-\alpha)G, \quad (1-\alpha)G \le w \le G \quad (16)$$

and for manufacturer 1 that

$$(\alpha+\delta)(1-\alpha)w + [1-F_2(w)]\alpha(\alpha+\delta)w = (\alpha+\delta)(1-\alpha)G, \quad (1-\alpha)G \le w \le G. \quad (17)$$

Solving Equations (16) and (17) simultaneously, we obtain

$$F_1 = \begin{cases} 0 & \text{if } w < (1-\alpha)G, \\ \dfrac{G\alpha + w - G}{(\alpha+\delta)w} & \text{if } (1-\alpha)G \le w \le G, \\ 1 & \text{if } w > G, \end{cases} \quad (18)$$

and

$$F_2 = \begin{cases} 0 & \text{if } w < (1-\alpha)G, \\ \dfrac{G\alpha + w - G}{\alpha w} & \text{if } (1-\alpha)G \le w \le G, \\ 1 & \text{if } w > G. \end{cases} \quad (19)$$

In equilibrium, the total channel surplus is $\Pi^{SM*} = (D_1^{SM} + D_2^{SM})G = (2\alpha + \delta - \alpha^2 - \alpha d)G$; the retailer's expected profit can be obtained as $E\pi_R^{SM*} = \Pi^{SM*} - \pi_{M1}^{SM*} - \pi_{M2}^{SM*} = \alpha^2 G$. Consumers' expected prices for the two products are $Ep_i^{SM*} = \Pr(w_i \ge w_{-i})G + \Pr(w_i < w_{-i})(G-\varepsilon) \cong G$ as ε is infinitesimal.

Subgame 2. The retailer displays competing products in distant locations:

In the fourth stage of the game, suppose a proportion s_1 of consumers starts sequential inspection from product 1 and a proportion $s_2 = 1 - s_1$ of consumers starts sequential inspection from product 2. Consumers who start from product 1 can be divided into four segments, as summarized in Table A.1. Consumers who start from product 2 can also be divided into four segments, as summarized in Table A.2.

If product 1 is prominent, we have $s_1 = (1+r)/2$ and $s_2 = (1-r)/2$. Therefore, we can obtain that $z_{GE} = (\alpha+\delta)\cdot(1+r)/2$, $z_{BE} = (1-\alpha-\delta)(1+r)/4$, $z_{EG} = \alpha(1-r)/2$, $z_{EB} = (1-\alpha)(1-r)/4$, $z_{GB} = (\alpha+\delta)(1-\alpha)(1-r)/4$, $z_{BG} = \alpha(1-\alpha-\delta)(1+r)/4$, and $z_{BB} = (1-\alpha)(1-\alpha-\delta)/2$. In this case, consumer demands for products 1 and 2 are, respectively,

$$D_1^{SE} = z_{GE} + z_{GB} = \frac{(\alpha+\delta)(3-\alpha+(1+\alpha)r)}{4} \quad \text{and} \quad (20)$$

$$D_2^{SE} = z_{EG} + z_{BG} = \frac{\alpha(3-\alpha-\delta-(1+\alpha+\delta)r)}{4}. \quad (21)$$

On the other hand, if product 2 is prominent, we have $s_1 = (1-r)/2$ and $s_2 = (1+r)/2$; in this case, consumer demand for products 1 and 2 are, respectively,

$$D_1^{SE} = z_{GE} + z_{GB} = \frac{(\alpha+\delta)(3-\alpha-(1+\alpha)r)}{4} \quad \text{and} \quad (22)$$

$$D_2^{SE} = z_{EG} + z_{BG} = \frac{\alpha(3-\alpha-\delta+(1+\alpha+\delta)r)}{4}. \quad (23)$$

Table A.1 Segment Sizes Among Consumers Who First Inspect Product 1

Segment	Size
(G, E)	$s_1(\alpha+\delta)$
(B, E)	$s_1(1-\alpha-\delta)/2$
(B, G)	$s_1\alpha(1-\alpha-\delta)/2$
(B, B)	$s_1(1-\alpha)(1-\alpha-\delta)/2$

Table A.2 Segment Sizes Among Consumers Who First Inspect Product 2

Segment	Size
(E, G)	$s_2\alpha$
(E, B)	$s_2(1-\alpha)/2$
(G, B)	$s_2(\alpha+\delta)(1-\alpha)/2$
(B, B)	$s_2(1-\alpha)(1-\alpha-\delta)/2$

The total market demand is thus

$$D_1^{SE}+D_2^{SE}=\begin{cases}\dfrac{\delta(3+r-2\alpha)}{4}+\dfrac{(3-\alpha)\alpha}{2} & \text{if product 1 is prominent,}\\[2ex] \dfrac{\delta(3-r-2\alpha)}{4}+\dfrac{(3-\alpha)\alpha}{2} & \text{if product 2 is prominent.}\end{cases}\tag{24}$$

The total retailer demand increases when δ is larger. Note that the total retailer demand is always greater when it makes product 1 prominent than when it makes product 2 prominent, and the demand difference $(r\delta)/2$ increases with δ and r.

In the third stage, the retailer chooses the optimal prices p_1 and p_2 to maximize its total profit of $\pi_R^{SE}=D_1^{SE}(p_1-w_1)+D_2^{SE}(p_2-w_2)$. The retailer's optimal strategy is to charge $p_1^{SE*}=p_2^{SE*}=G$ and make product 1 prominent if and only if $w_1<w_2+(\delta/((1+\alpha)(\alpha+\delta)))(G-w_2)$, or $w_2>w_1-\delta/(\alpha(1+\alpha+\delta))(G-w_1)$. The retailer's maximized profit is thus

$$\pi_R^{SE*}(w_1,w_2)=\begin{cases}\dfrac{(\alpha+\delta)(3-\alpha+(1+\alpha)r)(G-w_1)}{4}+\dfrac{\alpha(3-\alpha-\delta-(1+\alpha+\delta)r)(G-w_2)}{4} & \text{if } w_1<w_2+\dfrac{\delta(G-w_2)}{(1+\alpha)(\alpha+\delta)},\\[2ex] \dfrac{(\alpha+\delta)(3-\alpha)(G-w_1)}{4}+\dfrac{\alpha(3-\alpha-\delta)(G-w_2)}{4} & \text{if } w_1=w_2+\dfrac{\delta(G-w_2)}{(1+\alpha)(\alpha+\delta)},\\[2ex] \dfrac{(\alpha+\delta)(3-\alpha-(1+\alpha)r)(G-w_1)}{4}+\dfrac{\alpha(3-\alpha-\delta+(1+\alpha+\delta)r)(G-w_2)}{4} & \text{if } w_1>w_2+\dfrac{\delta(G-w_2)}{(1+\alpha)(\alpha+\delta)}.\end{cases}\tag{25}$$

In the second stage, the two manufacturers choose their optimal wholesale prices simultaneously to maximize their own profits. The lowest profit manufacturer 1 expects to obtain is when it charges a wholesale price of G and gets the nonprominent position; that is, $\hat{\pi}_{M1}^{SE}=((\alpha+\delta)(3-\alpha-(1+\alpha)r))/4$. Therefore, the lowest price manufacturer 1 is willing to charge to get the prominent location and a demand of $((\alpha+\delta)(3-\alpha+(1+\alpha)r))/4$, or an additional demand of $((a+\delta)(1+\alpha)r)/2$, is $\hat{w}_1=((3-\alpha-(1+\alpha)r)/(3-\alpha+(1+\alpha)r))G$.

On the other hand, the lowest profit manufacturer 2 expects to obtain is when it charges a wholesale price of G and gets the nonprominent position; that is, $\hat{\pi}_{M2}^{SE}=(\alpha(3-\alpha-\delta-(1+\alpha+\delta)r))/4$. Therefore, the lowest price manufacturer 2 is willing to charge to get the prominent location and a demand of $(\alpha(3-\alpha-\delta+(1+\alpha+\delta)r))/4$, or an additional demand of $\alpha(1+\alpha+\delta)/2$, is $\hat{w}_2=((3-\alpha-\delta-(1+\alpha+\delta)r)/(3-\alpha-\delta+(1+\alpha+\delta)r))G$, which decreases with δ.

We focus on the case when $\delta<(-3-r+2\alpha-2r\alpha+5\alpha^2-r\alpha^2)/(-1+r-5\alpha+r\alpha)$. In this case, $\hat{w}_1\le\hat{w}_2+(\delta/((1+\alpha)\cdot(\alpha+\delta)))(G-\hat{w}_2)$. The lowest price that manufacturer 2 is willing to charge is $\underline{w}_2=\hat{w}_2$, and the lowest price that manufacturer 1 can charge to obtain the prominent display location is $\underline{w}_1=\hat{w}_2+(\delta/((1+\alpha)(\alpha+\delta)))(G-\hat{w}_2)>\hat{w}_1$. In both cases, manufacturers' equilibrium profits are

$$\pi_{M1}^{SE*}=\frac{(\alpha+\delta)(3-\alpha+(1+\alpha)r)}{4}\cdot\left(\frac{3-\alpha-\delta-(1+\alpha+\delta)r}{3-\alpha-\delta+(1+\alpha+\delta)r}+\frac{\delta}{(1+\alpha)(\alpha+\delta)}\cdot\left(G-\frac{3-\alpha-\delta-(1+\alpha+\delta)r}{3-\alpha-\delta+(1+\alpha+\delta)r}\right)\right)>\hat{\pi}_{M1}^{SE}$$

and $\pi_{M2}^{SE*}=\hat{\pi}_{M2}^{SE}$. It is easy to see that π_{M2}^{SE*} decreases with δ; it can also be proven that $0<\partial\pi_{M1}^{SE*}/\partial\delta<\partial\hat{\pi}_{M1}^{SE}/\partial\delta$ when G is not too small.

We can derive the distribution functions of the two manufacturers' wholesale prices by solving for manufacturer 2:

$$\frac{\alpha(3-\alpha-\delta-(1+\alpha+\delta)r)}{4}w+\left[1-F_1\left(w+\frac{\delta}{(1+\alpha)(\alpha+\delta)}(G-w)\right)\right]\frac{\alpha(1+\alpha+\delta)r}{2}w=\pi_{M2}^{SE*},\quad \underline{w}_2\le w\le G.\tag{26}$$

From Equation (26), we can solve for

$$F_1\left(w+\frac{\delta(G-w)}{(1+\alpha)(\alpha+\delta)}\right)=\frac{w(3-\alpha-\delta+r(1+\alpha+\delta))+G(-3+\alpha+\delta+r(1+\alpha+\delta))}{2rw(1+\alpha+\delta)},\tag{27}$$

which increases with δ. And for manufacturer 1, we have

$$\frac{(\alpha+\delta)(3-\alpha-(1+\alpha)r)}{4}w+\left[1-F_2\left(w-\frac{\delta}{(1+\alpha+\delta)\alpha}(G-w)\right)\right]\frac{(\alpha+\delta)(1+\alpha)r}{2}w=\pi_{M1}^{SE*},\quad \underline{w}_1\le w\le G.\tag{28}$$

In equilibrium, the total channel surplus is

$$\begin{aligned}\Pi^{SE*}&=\left(\frac{\delta(3+r-2\alpha)}{4}+\frac{(3-\alpha)\alpha}{2}\right)\cdot G\Pr\left(w_1<w_2+\frac{\delta}{(1+\alpha)(\alpha+\delta)}(G-w_2)\right)\\&\quad+\left(\frac{\delta(3-r-2\alpha)}{4}+\frac{(3-\alpha)\alpha}{2}\right)\cdot G\left(w_1\ge w_2+\frac{\delta}{(1+\alpha)(\alpha+\delta)}(G-w_2)\right)\\&=\frac{\delta(3-r-2\alpha)}{4}+\frac{(3-\alpha)\alpha}{2}+\frac{\delta r}{2}\Pr\left(w_1<w_2+\frac{\delta}{(1+\alpha)(\alpha+\delta)}(G-w_2)\right).\end{aligned}$$

Consumers' expected prices for the two products are $Ep_i^{SE*}=G$.

The total retailer profit is $E\pi_R^{SE*}=\Pi^{SE*}-\pi_{M1}^{SE*}-\pi_{M2}^{SE*}$. It can be proven that $\partial E\pi_R^{SE*}/\partial\delta>\partial(\Pi^{SE*}-\hat{\pi}_{M1}^{SE}-\pi_{M2}^{SE*})/\partial\delta>0$.

A3.2. Retailer Optimal Shelf Layout Decision. As shown above, $E\pi_R^{SM*}$ does not change with δ, and $E\pi_R^{SE*}$ increases with δ. Also, when $\delta = 0$, the model reduces to the main model, and the retailer displays competing products in distant locations when $\alpha < r/(2-r)$. Therefore, when δ becomes larger, the retailer is more likely to display competing products in distant locations.

A4. Proof of Proposition 4

To derive Table 3, note that when a retail store displays competing products in the same location, a consumer's expected probability of finding a good fit with at least one product is $1-(1-\alpha)^2 = \alpha(2-\alpha)$, and therefore her expected utility from visiting the store is $EU^{SM} = \alpha(2-\alpha)(G-Ep)$. When a retailer displays competing products in distant locations, a consumer with low travel cost will inspect both products before finding a fit, and thus her expected utility from visiting the store is $EU^{SE} = \alpha(2-\alpha)(G-Ep)$; a consumer with high travel cost expects to inspect one product only, and therefore her expected utility of visiting the store is $EU^{SE} = \alpha(G-Ep)$. Clearly, a switcher with low travel cost is indifferent between stores with different shelf layouts, but a switcher with high travel cost prefers to visit a store that displays competing products in the same location. The game sequence is the same as in the simplified model. In the first stage, the two retailers make shelf layout decisions simultaneously. There are four possible scenarios: (1) both retailers display competing products in the same location, (2) retailer 1 displays competing products in the same location but retailer 2 displays in distant locations, (3) retailer 1 displays competing products in distant locations but retailer 2 displays in the same location; and (4) both retailers display competing products in distant locations. Note that consumer traffic does not affect the pricing behavior of either the retailer or its suppliers under any given shelf layout.

From Table 3, it is easy to see that when retailer 1 displays competing products in the same location, retailer 2 obtains a greater profit by displaying competing products in distant locations if $\alpha < (r+2lr)/(4-r-2lr)$; when retailer 1 displays competing products in distant locations, retailer 2 obtains a greater profit by displaying competing products in distant locations if $\alpha < r/(3-r-2l)$. We can further prove that $r/(3-r-2l) - (r+2lr)/(4-r-2lr) = ((1-2l)^2 r)/((3-r-2l)(4-r-2lr)) > 0$. Summarizing the above discussion, we obtain Proposition 4.

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