Retail Category Management with Slotting Fees

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Abstract

Problem definition: Slotting fees are lump-sum payments retailers demand from manufacturers to include manufacturers' products in their assortments. While retailers regard slotting fees as part of doing business, some manufacturers claim that slotting fees limit their ability to compete on a level playing field with other manufacturers. Considering these conflicting views, we study the role of manufacturer competition in the emergence of slotting fees and how slotting fees affect retailers' category management (i.e., assortment and pricing) decisions. *Methodology/results:* We consider a game-theoretic model with a single retailer and two competing manufacturers, each offering a single product. The retailer makes slotting fee, assortment, and pricing decisions in the presence of an operational cost term that increases in the assortment size. The manufacturers that can afford the slotting fee set the wholesale prices for their products. This study leads to three key findings. First, slotting fees can be suboptimal when their absence would trigger intense wholesale price competition. Second, depending on the retailer's operational cost and the intensity of manufacturer competition, slotting fees create three distinct effects –category expansion, rent extraction, and competitive exclusion under which product variety (i.e., the retailer's assortment size) increases, remains unchanged, and decreases, respectively. Third, slotting fees are most (least) beneficial for the retailer when they lead to a decrease (increase) in product variety. *Managerial implications:* This study not only illustrates that retailers can use slotting fees as a strategic tool to control the intensity of manufacturer competition but also reveals how slotting fees impact retailers' assortment and pricing decisions, with implications for manufacturers and policy makers.

Key words: Slotting fees, category management, retail operations, manufacturer competition, assortment planning

1. Introduction

Slotting fees are lump-sum payments retailers demand from manufacturers in exchange for including manufacturers' products in their assortments. Retailers and manufacturers have conflicting

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views on slotting fees. On the one hand, retailers regard slotting fees as part of doing business and claim that slotting fees allow them to efficiently allocate limited shelf space (e.g., Wilkie et al. 2002). Retailers also assert that slotting fees help them cover at least a portion of their operational costs (Thayer 2015). On the other hand, manufacturers raise concerns about the role of slotting fees in their interactions with retailers and other manufacturers. In general, manufacturers view slotting fees as a tool retailers use to extract more money from them (e.g., Wilkie et al. 2002, Rivlin 2016). Furthermore, some manufacturers claim that they cannot afford to pay slotting fees, which limits not only their ability to compete on a level playing field with other manufacturers but also consumers' access to high-quality products (e.g., Bloom et al. 2000, Thayer 2015). In light of these conflicting views, our first objective is to study the role of manufacturer competition in the emergence of slotting fees.

Slotting fees emerged in the 1980s and have become more prominent over time (Sudhir and Rao 2006, Kuksov and Pazgal 2007). On the one hand, slotting fees are a major expense for manufacturers. For example, in the frozen food category, small retail chains charge \$8,000 to \$9,000 for a single product, while larger chains can charge anywhere from \$20,000 to \$100,000 (Thayer 2015). Indeed, the Federal Trade Commission (2003) estimated that a nationwide distribution of a product would require a slotting fee payment that ranges from a little under \$1 million to more than \$2 million, depending on the product category. On the other hand, slotting fees are a major revenue source for retailers. For example, Thayer (2015) estimates that Safeway, which had a net income of \$113.8 million in 2014, earned approximately \$75 million in slotting fees the same year. Indeed, grocery retailers today are as much about selling shelves to manufacturers as they are about selling products to end consumers (Rivlin 2016). However, it is unclear how a retailer's decision to sell shelves to manufacturers (i.e., collect lump-sum payments from manufacturers) impacts manufacturer competition and consumers' access to products. Accordingly, our second objective is to study the impact of slotting fees on retailers' category management (e.g., assortment and pricing) decisions.

Category management enables a retailer to treat each product category (e.g., ice cream, frozen meals, snacks) as a strategic business unit (ACNielsen 2005). The key category management decisions include determining the size and composition of the assortment (i.e., the set of products offered to consumers) and setting retail prices (Basuroy et al. 2001, ACNielsen 2005). In most categories, retailers manage multiple brands offered by different manufacturers (e.g., Ben & Jerry's, a Unilever brand, and Blue Bell in the ice cream category). As such, adopting category management allows a retailer to maximize the overall category performance by coordinating assortment and pricing decisions among different brands in a category (Zenor 1994, Dhar et al. 2001). Such coordination requires the retailer to take into account several factors, including shelf space constraints (e.g., Rooderkerk et al. 2013), demand substitution patterns among different products in the category (e.g., Besanko et al. 2005), and manufacturers' strategic responses (e.g., wholesale prices) to the retailer's category management decisions (e.g., Heese and Martínez-de Albéniz 2018).

Analytical studies in the category management literature have generated insights into retailers' strategic interactions with manufacturers (e.g., Cachon and Kök 2007, Kök and Xu 2011, Heese and Martínez-de Albéniz 2018, Alan et al. 2019). However, most studies in this stream focus on wholesale price-only contracts and thereby overlook slotting fees. A notable exception is the study of Aydın and Hausman (2009), which explores slotting fees in the category management context. The authors analyze a setting in which a single manufacturer sells multiple products to consumers through a single retailer and show that slotting fees can induce the retailer to increase its assortment size. Although Aydın and Hausman shed light on the role of slotting fees in the strategic interactions between a single retailer and a single manufacturer, it is unclear how slotting fees affect the competitive dynamics in a category with multiple manufacturers.

Given the widespread use of slotting fees in practice, our goal is to better understand (i) the role of manufacturer competition in the emergence of slotting fees and (ii) how slotting fees impact the retailer's broader category management decisions. Specifically, we investigate three main research questions: First, what is the impact of manufacturer competition on the emergence of slotting fees? Second, how do slotting fees affect retail prices and the size and composition of a retailer's assortment? Third, when are slotting fees most and least beneficial for the retailer?

We consider a supply chain in which two competing manufacturers sell their products to end consumers through a common retailer. The first manufacturer offers a high-quality product, while the second manufacturer offers a lower quality product. The manufacturers have different unit production costs. A combination of product quality and unit production cost determines the attractiveness of each product. Both the retailer and the manufacturers aim to maximize their profits. The retailer moves first and announces the assortment size and slotting fee. Then, the manufacturers who can afford to pay the slotting fee set their wholesale prices. Finally, the retailer selects its assortment and sets the retail prices. The retailer has an operational cost term that increases in its assortment size. Consequently, the retailer carries either or both of the two products in its assortment, depending on (i) its operational cost, (ii) slotting fees, and (iii) product characteristics (i.e., the quality and production cost of each product).

Our study leads to three insights. First, there are cases when charging a slotting fee can be suboptimal for the retailer. These cases emerge when foregoing slotting fees create intense wholesale price competition between the manufacturers for the only slot in the retailer's assortment. In such cases, charging a slotting fee makes the retailer worse off by leading to higher wholesale and retail prices at equilibrium. Second, comparison of the equilibrium outcomes of our model with a benchmark model in which the retailer does not collect slotting fees reveals that the emergence of slotting fees creates three distinct effects. The first is a *category expansion* effect under which slotting fees increase product variety in the category (i.e., the retailer's assortment size). The second is a *rent extraction* effect under which slotting fees do not change the retailer's assortment size or composition. The third is a *competitive exclusion* effect under which slotting fees decrease product variety in the category. Cumulatively, these three effects reveal how the retailer's operational cost and the intensity of manufacturer competition jointly determine the impact of slotting fees on product variety in the category. Third, we show that slotting fees are most (least) beneficial for the retailer in the competitive exclusion (category expansion) region.

In summary, we contribute to the literature by (i) showing that a retailer can use slotting fees as a strategic tool to control the intensity of manufacturer competition and (ii) shedding light on the impact of slotting fees on a retailer's category management decisions. Section 2 summarizes the relevant literature. Section 3 provides an overview of our model. Section 4 characterizes the equilibrium outcomes. Section 5 presents our findings, and Section 6 relaxes some of our modeling assumptions to show the robustness of our findings. Finally, Section 7 discusses the implications of our study for supply chain stakeholders (i.e., retailers, manufacturers, and policy makers).

2. Literature Review

Our study is related to the category management and slotting fee research streams. This section provides an overview of these two research streams and explains how they relate to our study.

Coordinating category management decisions among different products in a category can improve the overall category performance (e.g., Zenor 1994, Basuroy et al. 2001). However, retailers face several challenges in their coordination efforts. On the pricing side, they need to consider cross-price effects because a product's demand depends on the retail prices of other products in the category (e.g., Kadiyali et al. 2000, Besanko et al. 2005). Furthermore, manufacturers can strategically adjust the terms of trade (e.g., wholesale prices) in response to the retailer's category management decisions (e.g., Heese and Martínez-de Albéniz 2018). Thus, retailers also need to account for manufacturers' strategic responses to their pricing decisions (e.g., Alan et al. 2019). Accordingly, we construct a demand model that captures not only the manufacturers' strategic responses but also the cross-price effects that emerge when the retailer carries both manufacturers' products in its assortment. Consequently, our model sheds light on the pricing dynamics in the presence of slotting fees.

Determining the right product variety (i.e., assortment size) poses another challenge for retailers. On the one hand, offering more variety is tempting because a broader assortment allows a retailer to better meet consumers' needs (Boatwright and Nunes 2001). On the other hand, operational costs typically increase as product variety increases (e.g., Gaur and Honhon 2006, Dukes et al. 2009). A stream of assortment studies captures this trade-off by imposing a constraint (e.g., limited shelf space) on the retailer's assortment size (e.g., Kurtuluş and Toktay 2011, Martínez-de Albéniz and Roels 2011, Rooderkerk et al. 2013). Another stream captures the same trade-off with an operational cost term that increases as the retailer's assortment size increases (e.g., Gaur and Honhon 2006, Kök and Xu 2011, Pan and Honhon 2012). We follow the latter approach in our study and thereby generate insights into the impact of slotting fees on the relationship between the retailer's operational cost and product variety.

Finding the right assortment composition is also challenging for retailers, even for a fixed assortment size. To this end, some assortment studies focus on reducing the complexity of a retailer's assortment optimization problem. These studies consider an arbitrary number of products a retailer can include in its assortment and rely on structural properties and/or heuristics to find the optimal assortment or a near-optimal one (e.g., Kök and Xu 2011, Rooderkerk et al. 2013). See Kök et al. (2015) for an extensive review of this research stream. Another research stream uses more stylized models and focuses on the strategic interactions between retailers and manufacturers in the assortment context (e.g., Dukes et al. 2009, Aydın and Heese 2015, Alan et al. 2019). Our study falls in the latter stream and investigates the role of slotting fees in the strategic interactions between retailers and manufacturers.

The literature on slotting fees offers a variety of reasons for their emergence, including (i) imperfect (asymmetric) demand information, (ii) sharing retailing costs with manufacturers, (iii) retail competition, and (iv) supply chain coordination. In the new product introduction context, slotting fees can serve as a signaling or screening device to mitigate the information asymmetry between manufacturers and retailers about the demand prospects of a product. For example, Chu (1992) shows that charging a slotting fee allows a retailer to screen products with poor demand prospects. Similarly, Lariviere and Padmanabhan (1997) show that when a manufacturer is better informed of a new product's demand, it can offer a slotting fee to the retailer to signal its demand information and partly cover the retailer's operational costs.

Although models with asymmetric information can capture the emergence of slotting fees for new products, retailers in practice also charge slotting fees for established products for which the demand prospects are much more certain (Kolay and Shaffer 2022). As such, the slotting fee studies with complete information shed light on the emergence of slotting fees for established products.

In particular, Desai (2000) and Kuksov and Pazgal (2007) show that a combination of retail competition and fixed retailing costs can lead to the emergence of slotting fees even in the absence of asymmetric information. Intuitively, when there is retail competition, slotting fees can be a more efficient cost-sharing mechanism than a wholesale price reduction. This is because a wholesale price reduction induces competing retailers to reduce their retail prices, limiting their ability to cover their fixed costs through higher sales revenues, whereas slotting fees provide a lump-sum cost subsidy to retailers (Desai 2000). In addition, Kolay and Shaffer (2022) show that a manufacturer can offer a menu of contracts to two competing retailers, where the large retailer prefers the contract with the lower wholesale price, while the smaller retailer picks the contract with the largest slotting fee. A common feature of most studies that show the emergence of slotting fees under information asymmetry and/or retail competition is that the manufacturer sets the slotting fee to maximize its profit. By contrast, we study a setting in which the retailer strategically determines the slotting fee based on its operational costs and the degree of manufacturer competition in the category.

Slotting fees can also enable supply chain coordination. For example, Aydın and Hausman (2009) study a supply chain setting in which a single manufacturer sells multiple products through a single retailer under exogenous wholesale and retail prices. In their setting, the retailer's optimal assortment can differ from the assortment that maximizes the total supply chain profit because of double marginalization. However, the manufacturer can induce the retailer to carry the supply-chain-optimal assortment by paying an identical slotting fee for every product the retailer carries in excess of an assortment size threshold. Martínez-de Albéniz and Roels (2011) consider a supply chain setting in which multiple suppliers (manufacturers) sell their products through a single retailer. In their setting, the retailer has a given assortment (i.e., all manufacturers enter the assortment), and the manufacturers compete for limited shelf space, where a product's demand increases in its shelf space. Martínez-de Albéniz and Roels (2011) show that under exogenous retail prices, charging a slotting fee proportional to the shelf space allocated to each product can achieve supply chain coordination and make the retailer better off. While Aydın and Hausman (2009) and Martínez-de Albéniz and Roels (2011) demonstrate how retailers can use slotting fees to restore supply chain efficiency, our study focuses on the impact of slotting fees on the retailer's assortment and pricing decisions in a setting in which slotting fees can prevent a manufacturer from entering the retailer's assortment.

3. Model

We consider a supply chain with one retailer and two competing manufacturers. The manufacturers sell their products to end consumers through the retailer. The first manufacturer offers a high-quality product, while the second manufacturer offers a low-quality product. We use indices 1 and 2 to refer to the first manufacturer and second manufacturer, respectively. We also use the same indices to refer to their respective product offerings. Let $\mathbb{A}$ denote the set of products (i.e., assortment) the retailer carries. If the retailer chooses to offer the category, it has three assortment choices: (i) the retailer can carry both products in its assortment (i.e., $\mathbb{A} = \{1, 2\}$), (ii) the retailer can carry only the first manufacturer's product (i.e., $\mathbb{A} = \{1\}$), (iii) the retailer can carry only the second manufacturer's product (i.e., $\mathbb{A} = \{2\}$).

Consumers are heterogeneous in their valuations of product quality. Let θ, which is uniformly distributed between 0 and 1, denote the consumer heterogeneity parameter. This parameter captures consumers' willingness to pay for quality. In addition, let q_i and p_i denote the quality and retail price of the product offered by manufacturer i, respectively. Consistent with the indexing of the two manufacturers, we assume without loss of generality that $q_1 > q_2$. Consumer type θ derives the following utility from purchasing product $i = 1, 2$:

$$u_i(\theta) = \theta q_i - p_i. \tag{1}$$

When the retailer carries both products in its assortment (i.e., when $\mathbb{A} = \{1, 2\}$), consumer type θ purchases product i if $u_i(\theta) \geq 0$ and $u_i(\theta) \geq u_j(\theta)$, where $i = 1, 2$ and $j \neq i$. Consumer type θ does not make a purchase if both products lead to a negative utility (i.e., if $u_1(\theta) < 0$ and $u_2(\theta) < 0$). Without loss of generality, we normalize the market size to one (Pan and Honhon 2012, Heese and Martínez-de Albéniz 2018). Accordingly, when $\mathbb{A} = \{1, 2\}$, the unit sales (i.e., demands) for the first and second products are $z_1 = Pr(\theta q_1 - p_1 \geq \theta q_2 - p_2, \theta q_1 - p_1 \geq 0)$ and $z_2 = Pr(\theta q_2 - p_2 \geq \theta q_1 - p_1, \theta q_2 - p_2 \geq 0)$, respectively. When the retailer carries only one product in its assortment, consumer type θ purchases that product if it leads to a non-negative utility. Accordingly, when $\mathbb{A} = \{i\}$, the unit sales for products i and j ($j \neq i$) are $z_i = Pr(\theta q_i - p_i \geq 0)$ and $z_j = 0$, respectively. The category management literature uses this consumer choice model, referred to as the vertical differentiation model, to characterize demands for products with different quality levels (e.g., Pan and Honhon 2012, Amaldoss and Shin 2015, Alan et al. 2019). In addition, the industrial organization literature relies on the vertical differentiation model to capture quality competition at the firm-level (e.g., Tirole 1988, chapter 7). In our setting, the vertical differentiation model allows us to parsimoniously capture the price and quality aspects of manufacturer competition, which in turn enables us to test the validity of some manufacturers' claims that slotting fees limit consumers' access to high-quality products (e.g., Bloom et al. 2000, Rivlin 2016).

We focus on lump-sum payments manufacturers make to retailers in exchange for securing a slot in the retailer's assortment. Some practitioners refer to such lump-sum payments as slotting fees for new products and pay-to-stay fees for existing products (e.g., Bloom et al. 2000), while others use the term slotting fees more generically to refer to any payment a manufacturer makes for space inside a store (e.g., Rivlin 2016). Similarly, academic studies generally use slotting fees as an *umbrella term* for lump-sum payments retailers demand for both new products (e.g., Lariviere and Padmanabhan 1997) and existing ones (e.g., Kolay and Shaffer 2022). Following this convention, we also refer to the lump-sum payments in our setting as slotting fees (see Bloom et al. 2000 and Rivlin 2016 for various forms of payments retailers demand from manufacturers).

Previous studies (e.g., Federal Trade Commission 2003, Elberg and Noton 2023) document that the magnitude of slotting fees depends on several factors, including product category (e.g., slotting fees are typically higher in frozen food categories), number of retail stores carrying a product (e.g., a nationwide distribution requires higher slotting fees compared to a smaller scale distribution), and the extent of the retailer-manufacturer relationship (e.g., whether a manufacturer offers products in multiple categories). Because our model focuses on a single category, where each manufacturer offers one product, we do not consider such factors and assume that the retailer demands the same slotting fee from both manufacturers. To this end, let S denote the slotting fee the retailer demands to carry a manufacturer's product in its assortment. In addition, let c_i and w_i denote the per unit production cost and wholesale price for product i, respectively. Then, manufacturer i's profit for a given assortment $\mathbb{A}$ is

$$\Pi_i(\mathbb{A}) = \begin{cases} (w_i - c_i)z_i(\mathbb{A}) - S & \text{if } i \in \mathbb{A}, \\ 0 & \text{otherwise}, \end{cases} \tag{2}$$

where $(w_i - c_i)z_i(\mathbb{A})$ is the gross profit manufacturer i generates by selling its product to the retailer.

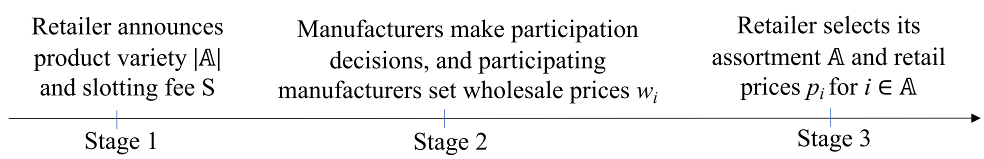
We follow the literature (e.g., Pan and Honhon 2012, Heese and Martínez-de Albéniz 2018, Alan et al. 2019) and assume that the retailer incurs a fixed operational cost, denoted by K, for every product it carries in its assortment. The inclusion of K allows us to parsimoniously capture the costs associated with offering a broader assortment (i.e., more product variety), including the opportunity cost of shelf space and operational expenses related to carrying a product in the assortment. Hereinafter, we refer to K as the retailer's operational cost. Let $|\mathbb{A}|$ denote product variety (i.e., the number of products the retailer carries in its assortment). Then, the retailer's profit for a given assortment $\mathbb{A}$ is

$$\Pi_r(\mathbb{A}) = \underbrace{\sum_{i \in \mathbb{A}} (p_i - w_i) z_i(\mathbb{A})}_{\text{Gross profit}} + \underbrace{S|\mathbb{A}|}_{\substack{\text{Revenue from} \\ \text{slotting fees}}} - \underbrace{K|\mathbb{A}|}_{\substack{\text{Total} \\ \text{operational} \\ \text{cost}}}, \tag{3}$$

where the first term is the retailer's gross profit, the second term is the revenue the retailer generates by collecting slotting fees from the manufacturers, and the third term is the retailer's total operational cost. Consistent with the literature (e.g., Lariviere and Padmanabhan 1997, Desai 2000), Equation (3) suggests that slotting fees can at least partially cover the retailer's operational cost and thereby enable the retailer to carry a product it would not carry without slotting fees.

We model the strategic interactions between the retailer and the two manufacturers as a three-stage game. All three players aim to maximize their profits, and all model parameters and objective functions are common knowledge. Figure 1 illustrates the sequence of events. In the first stage, the retailer announces product variety, $|\mathbb{A}|$, and the slotting fee, S, to the manufacturers. That is, the retailer decides on how many products it will carry in its assortment and the slotting fee it demands from the manufacturers. If the retailer offers the category, it has two product variety choices: $|\mathbb{A}| = 1$ and $|\mathbb{A}| = 2$. In the second stage, manufacturers make participation and wholesale price decisions. Specifically, if a manufacturer can afford the slotting fee, it participates in the game and sets a wholesale price for its product. By contrast, if a manufacturer is unable to pay the slotting fee, it does not participate in the game. Finally, in the third stage, the retailer selects its assortment, $\mathbb{A}$, and sets the retail prices for the products it carries in its assortment, p_i, for $i \in \mathbb{A}$.

Figure 1 Sequence of Events



Our sequence of events is consistent with the hierarchical category management approach used in practice (ACNielsen 2005). That is, retailers in practice first determine how much shelf space they should allocate to each category. The first stage mimics this decision because $|\mathbb{A}| = 1$ implies that the retailer introduces the category with limited shelf space (i.e., low product variety) and $|\mathbb{A}| = 2$ implies that the retailer introduces the category with abundant shelf space (i.e., high product variety). In addition, the retailer's slotting fee decision captures the possibility that the retailer might create *a barrier to entry* for manufacturers by setting a relatively high slotting fee (e.g., Rivlin 2016). The second stage captures the challenges manufacturers may face in entering a retailer's assortment in practice, including high slotting fees and manufacturer competition for a limited number of slots (e.g., Bloom et al. 2000, Wilkie et al. 2002), while the third stage captures that the retailer has the ultimate power in determining its assortment and retail prices (Corstjens and Corstjens 1995).

Heese and Martínez-de Albéniz (2018) analyze a setting without slotting fees and show that committing to product variety before interacting with the manufacturers makes the retailer better off by allowing the retailer to control the intensity of manufacturer competition. That said, it might be tempting for the retailer to deviate from the announced product variety after observing the manufacturers' wholesale price decisions (e.g., announcing $|\mathbb{A}| = 1$ and setting $\mathbb{A} = \{1, 2\}$). However, such a deviation would have a detrimental impact on the retailer because the retailer would lose its commitment ability (i.e., the manufacturers would find future product variety announcements non-credible). Indeed, under mild assumptions, Heese and Martínez-de Albéniz (2018) show that "losing such ability would be detrimental to the retailer, so honoring her commitment is ex post rational and, thus, ex ante credible." Hence, following Heese and Martínez-de Albéniz (2018), we assume that the retailer's product variety announcement in the first stage is credible.

4. Analysis

In this section, we first analyze the two subgames in which the retailer sets $|\mathbb{A}| = 1$ and $|\mathbb{A}| = 2$. After deriving the retailer's profit in each subgame, we characterize the full equilibrium by comparing the retailer's profits in the two subgames.

4.1. Retailer Offers the Category with Low Product Variety

We use backward induction to solve the subgame in which the retailer commits to offering the category with low product variety. In the last stage of the subgame, the retailer determines whether it should set $\mathbb{A} = \{1\}$ or $\mathbb{A} = \{2\}$. The retailer also sets the retail price for the product it carries in its assortment. Formally, for a given assortment $\mathbb{A} = \{i\}$, slotting fee S, and wholesale price w_i, the retailer solves

$$\max_{0 \le p_i \le q_i} \quad (p_i - w_i) z_i(p_i) + S - K, \tag{4}$$

where $z_i(p_i) = Pr(\theta q_i - p_i \ge 0) = 1 - p_i/q_i$ for $p_i \in [0, q_i]$. Let $\tilde{p}_i(w_i)$ denote the solution of Equation (4). Then, a combination of $\tilde{p}_i(w_i)$ and whether one or both manufacturers participate and set wholesale prices for their products shapes the retailer's assortment decision. Lemma 1 characterizes the retailer's pricing and assortment decisions when $|\mathbb{A}| = 1$. We present all proofs in Section B of the online supplement.

Lemma 1. *When $\mathbb{A} = \{i\}$, the retail price for product i is $\tilde{p}_i(w_i) = (q_i + w_i)/2$. If manufacturer $i = 1, 2$ participates and manufacturer $j \neq i$ does not, the retailer sets $\mathbb{A} = \{i\}$. If both manufacturers participate, the retailer sets $\mathbb{A} = \{i\}$ if $w_i \le q_i - (q_j - w_j)\sqrt{q_i/q_j}$, where $i = 1, 2$ and $j \neq i$.*

Lemma 1 reveals that if only one manufacturer participates, the retailer simply carries that manufacturer's product. If both manufacturers participate, manufacturer i needs to set its wholesale price below a threshold (i.e., $q_i - (q_j - w_j)\sqrt{q_i/q_j}$) to enter the retailer's assortment. Setting w_i

below that threshold, which captures the retailer's incentive compatibility constraint, ensures that product i leads to a higher gross profit for the retailer than product j ($j \neq i$).

In the second stage, each manufacturer makes a participation decision, depending on whether it can earn a non-negative profit after paying the slotting fee. If a manufacturer decides to participate, it sets the wholesale price for its product. A participating manufacturer's wholesale price decision depends on whether its competitor also participates. Formally, if manufacturer $i = 1, 2$ participates and manufacturer j ($j \neq i$) does not, manufacturer i knows that it will enter the retailer's assortment. Accordingly, manufacturer i acts as an upstream monopoly and solves

$$\max_{w_i \geq c_i} \quad (w_i - c_i)\tilde{z}_i(w_i) - S, \tag{5}$$

where $\tilde{z}_i(w_i) = 1 - \frac{\tilde{p}_i(w_i)}{q_i} = \frac{q_i - w_i}{2q_i}$. If both manufacturers participate, the manufacturers engage in wholesale price competition to enter the retailer's assortment. Specifically, for $i = 1, 2$, Lemma 1 implies that if the retailer sets $\mathbb{A} = \{i\}$ with $\tilde{p}_i = (q_i + w_i)/2$, the retailer's profit in the third stage is $\tilde{\Pi}_r^{\{i\}}(w_i) = \frac{(q_i - w_i)^2}{4q_i} + S - K$. Because the retailer's profit increases as the wholesale price decreases, manufacturer j, which cannot enter the retailer's assortment, sets its wholesale price on the basis of its *zero-profit condition*. That is, manufacturer j selects the lowest wholesale price it can offer to the retailer without losing money. Accordingly, manufacturer i, which enters the retailer's assortment, solves

$$\max_{w_i \geq c_i} \quad (w_i - c_i)\tilde{z}_i(w_i) - S \tag{6}$$

$$\text{s.t.} \quad w_i \leq q_i - (q_j - w_j)\sqrt{\frac{q_i}{q_j}} \tag{7}$$

$$(w_j - c_j)\left(\frac{q_j - w_j}{2q_j}\right) - S = 0. \tag{8}$$

In this formulation, Equation (7) follows from Lemma 1 and ensures that the retailer sets $\mathbb{A} = \{i\}$ in the last stage. In addition, Equation (8) captures manufacturer j's zero-profit condition, determining w_j.

Let $v_l \equiv \frac{(q_l - c_l)^2}{q_l}$ denote the *attractiveness* of product $l = 1, 2$. Lemma 2 relies on the attractiveness of each product to characterize the manufacturers' participation and wholesale price decisions.

Lemma 2. *Without loss of generality, suppose $v_i \geq v_j$, where $i = 1, 2$ and $j \neq i$. When $|\mathbb{A}| = 1$, the manufacturers have the following participation and wholesale price decisions:*

(i) If $0 \leq S \leq v_j/8$, both manufacturers participate, where

$$(\tilde{w}_i(S), \tilde{w}_j(S)) = \left(\min\left\{\frac{q_i + c_i}{2}, q_i - \frac{\sqrt{q_i}}{2}\left(\sqrt{v_j} + \sqrt{v_j - 8S}\right)\right\}, c_j + \frac{\sqrt{q_j}}{2}\left(\sqrt{v_j} - \sqrt{v_j - 8S}\right)\right).$$

(ii) If $v_j/8 < S \leq v_i/8$, only manufacturer i participates and sets $\tilde{w}_i(S) = \frac{q_i+c_i}{2}$.

Lemma 2 indicates that both manufacturers participate only when the retailer's slotting fee, S, is relatively low (i.e., when $0 \leq S \leq v_j/8$). When both manufacturers participate, solving manufacturer j's zero-profit condition (i.e., Equation 8) leads to $\tilde{w}_j(S) = c_j + \frac{\sqrt{q_j}}{2}\left(\sqrt{v_j} - \sqrt{v_j - 8S}\right)$. Furthermore, replacing w_j with $\tilde{w}_j(S)$ in Equation (7) allows us to rewrite the same constraint as $w_i \leq q_i - \frac{\sqrt{q_i}}{2}\left(\sqrt{v_j} + \sqrt{v_j - 8S}\right)$. At the optimal solution, either this constraint is binding or manufacturer i sets $\tilde{w}_i(S) = (q_i + c_i)/2$, which solves the first order condition of Equation (6). When the slotting fee is relatively high (i.e., when $v_j/8 < S \leq v_i/8$), manufacturer j cannot find a wholesale price that leads to a non-negative profit upon participation. Consequently, manufacturer j does not participate, and manufacturer i acts as an upstream monopoly and sets $\tilde{w}_i(S) = (q_i + c_i)/2$.

Corollary 1 builds on Lemma 2 and characterizes the retailer's objective function in the first stage of the subgame in which $|\mathbb{A}| = 1$.

Corollary 1. *For a given S and $v_i \geq v_j$ for $i = 1, 2$ and $j \neq i$, the retailer's profit is*

$$\tilde{\Pi}_r(S) = \begin{cases} \max\left\{\frac{v_i}{16}, \frac{\left(\sqrt{v_j}+\sqrt{v_j-8S}\right)^2}{16}\right\} + S - K & \text{if } 0 \leq S \leq v_j/8, \\ \frac{v_i}{16} + S - K & \text{if } v_j/8 < S \leq v_i/8, \end{cases} \tag{9}$$

where $\frac{d\tilde{\Pi}_r(S)}{dS} \leq 0$ if $S \leq v_j/8$ and $\sqrt{v_i} \leq \sqrt{v_j} + \sqrt{v_j - 8S}$ and $\frac{d\tilde{\Pi}_r(S)}{dS} \geq 0$ otherwise.

In the first stage of the subgame, the retailer solves $\max_{0 \leq S \leq v_i/8} \tilde{\Pi}_r(S)$. Corollary 1 indicates that when manufacturer j's participation poses a credible threat to manufacturer i (i.e., when $S \leq v_j/8$ and $\sqrt{v_i} \leq \sqrt{v_j} + \sqrt{v_j - 8S}$), the retailer's profit decreases as the slotting fee, S, increases. Intuitively, manufacturer j's wholesale price offer, $\tilde{w}_j(S)$, increases as S increases. Such an increase relieves the wholesale price pressure on manufacturer i. Consequently, manufacturer i charges a higher wholesale price, leading to a decrease in the retailer's profit as S increases. By contrast, when manufacturer j does not pose a credible threat, the retailer's profit increases as S increases. Collectively, these findings indicate that the retailer faces a tradeoff between foregoing slotting fees to ensure intense wholesale price competition between the manufacturers and charging a slotting fee, resulting in a higher wholesale price. Proposition 1 characterizes the retailer's slotting fee decision and the subgame equilibrium profit for $|\mathbb{A}| = 1$. We provide the remaining subgame equilibrium outcomes (i.e., retail prices, wholesale prices, demands, and manufacturers' profits) in the proof of Proposition 1 for ease of exposition.

Proposition 1. *When $|\mathbb{A}| = 1$, the retailer sets $\mathbb{A} = \{1\}$ if $v_1/(v_1 + v_2) \in [0.5, 1]$ and $\mathbb{A} = \{2\}$ if*

$v_1/(v_1+v_2) \in [0, 0.5)$. *In addition, the retailer sets*

$$S^{|1|} = \begin{cases} v_2/8 & \text{if } \frac{v_1}{v_1+v_2} \in [0, 3/7), \\ 0 & \text{if } \frac{v_1}{v_1+v_2} \in [3/7, 4/7], \\ v_1/8 & \text{if } \frac{v_1}{v_1+v_2} \in (4/7, 1]. \end{cases} \tag{10}$$

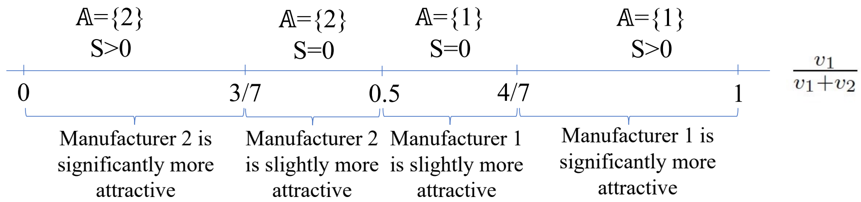
Consequently, the retailer's profit is

$$\Pi_r^{|1|} = \begin{cases} v_2/16 + S^{|1|} - K & \text{if } \frac{v_1}{v_1+v_2} \in [0, 3/7], \\ v_1/4 - K & \text{if } \frac{v_1}{v_1+v_2} \in (3/7, 1/2), \\ v_2/4 - K & \text{if } \frac{v_1}{v_1+v_2} \in [1/2, 4/7), \\ v_1/16 + S^{|1|} - K & \text{if } \frac{v_1}{v_1+v_2} \in [4/7, 1]. \end{cases} \tag{11}$$

Figure 2 illustrates Proposition 1, where $v_1/(v_1+v_2)$ captures the relative attractiveness of the first (high-quality) manufacturer with respect to the second (low-quality) manufacturer. Specifically, when $v_1/(v_1+v_2) \geq 0.5$, the first manufacturer offers a more attractive product. Consequently, the first manufacturer enters the retailer's assortment. Indeed, when the first manufacturer's product is significantly more attractive (i.e., $v_1/(v_1+v_2) \in [4/7, 1]$), the retailer sets $S^{|1|} = v_1/8$, and the second manufacturer cannot afford to pay that amount. Consequently, the second manufacturer does not participate, which allows the first manufacturer to charge the wholesale price it would charge if it were a monopoly (i.e., $w_1^{|1|} = (q_1 + c_1)/2$). However, the retailer extracts the first manufacturer's full surplus by setting the slotting fee to the first manufacturer's gross profit, $v_1/8$. Consequently, the retailer's profit is $\Pi_r^{|1|} = \left(q_1 - w_1^{|1|}\right)^2/(4q_1) + S - K = 3v_1/16 - K$. When the first manufacturer's product is slightly more attractive (i.e., $v_1/(v_1+v_2) \in [1/2, 4/7)$), the retailer does not charge a slotting fee (i.e., $S^{|1|} = 0$). Both manufacturers participate, leading to wholesale price competition. The second manufacturer offers its product to the retailer at cost (i.e., $w_2^{|1|} = c_2$), and the wholesale price constraint in Equation (7) becomes binding for the first manufacturer. Consequently, the first manufacturer sets $w_1^{|1|} = q_1 - \left(q_2 - w_2^{|1|}\right)\sqrt{q_1/q_2} = q_1 - \sqrt{q_1 v_2}$, leading to $\Pi_r^{|1|} = \left(q_1 - w_1^{|1|}\right)^2/(4q_1) + S - K = v_2/4 - K$. The dynamics are reversed when $v_1/(v_1+v_2) < 0.5$. That is, the second manufacturer enters the retailer's assortment without paying a slotting fee when its product is slightly more attractive than the first manufacturer's product (i.e., $v_1/(v_1+v_2) \in [3/7, 1/2]$) and by paying a slotting fee when its product is significantly more attractive (i.e., $v_1/(v_1+v_2) \in [0, 3/7)$).

In summary, when one manufacturer's product is only slightly more attractive than the other's, the retailer does not charge a slotting fee to create wholesale price competition between the two

Figure 2 Retailer's Assortment Choice and Slotting Fee Revenue When Product Variety Is Low



manufacturers for the single slot in its assortment. In such cases, the manufacturer that is unable to enter the retailer's assortment poses a credible threat to the one that enters the retailer's assortment. Hence, the retailer does not charge a slotting fee to ensure the participation of both manufacturers. By contrast, when one manufacturer's product is significantly more attractive than the other's, the participation of the less attractive product's manufacturer would not allow the retailer to receive a lower wholesale price from the manufacturer of the more attractive product. In other words, the manufacturer of the less attractive product would not pose a credible threat to that of the more attractive one. Consequently, the retailer foregoes wholesale price competition and charges a slotting fee to extract more surplus from the manufacturer that enters the assortment.

4.2. Retailer Offers the Category with High Product Variety

When the retailer commits to offering high product variety (i.e., when $|\mathbb{A}| = 2$), it sets the slotting fee such that both manufacturers participate and enter the assortment. Accordingly, for a given slotting fee, S, and wholesale prices, w_1 and w_2, the last stage of the subgame requires the retailer to set $\mathbb{A} = \{1, 2\}$ and solve

$$\max_{(p_1,p_2)\geq 0} \quad (p_1 - w_1)z_1(p_1, p_2) + (p_2 - w_2)z_2(p_1, p_2) + 2S - 2K, \tag{12}$$

where $z_1(p_1, p_2) = Pr(\theta q_1 - p_1 \geq \theta q_2 - p_2, \theta q_1 - p_1 \geq 0)$ and $z_2(p_1, p_2) = Pr(\theta q_2 - p_2 \geq \theta q_1 - p_1, \theta q_2 - p_2 \geq 0)$. Let $\tilde{p}_1(w_1, w_2)$ and $\tilde{p}_2(w_1, w_2)$ denote the solution of Equation (12).

In the second stage of the subgame, anticipating the retailer's pricing response and the impact of that response on the unit sales of each product, the manufacturers simultaneously solve

$$\max_{w_1\geq c_1} \quad (w_1 - c_1)\tilde{z}_1(w_1, w_2) - S \quad \text{and} \quad \max_{w_2\geq c_2} \quad (w_2 - c_2)\tilde{z}_2(w_1, w_2) - S, \tag{13}$$

where $\tilde{z}_1(w_1, w_2) = Pr(\theta q_1 - \tilde{p}_1 \geq \theta q_2 - \tilde{p}_2, \theta q_1 - \tilde{p}_1 \geq 0)$ and $\tilde{z}_2(w_1, w_2) = Pr(\theta q_2 - \tilde{p}_2 \geq \theta q_1 - \tilde{p}_1, \theta q_2 - \tilde{p}_2 \geq 0)$. This stage can lead to two cases. First, the wholesale prices can be such that both products have strictly positive unit sales (i.e., $\tilde{z}_1(w_1, w_2) > 0$ and $\tilde{z}_2(w_1, w_2) > 0$). Second, the wholesale prices can be such that one of the products has zero demand. The latter case arises when one of the manufacturers has a strong product offering, preventing the other manufacturer from generating demand for its product. Let $\tilde{w}_1$ and $\tilde{w}_2$ denote the subgame equilibrium wholesale prices, which solve Equation (13).

In the first stage of the subgame, anticipating the manufacturers' wholesale price responses, $\tilde{w}_i$, the retailer solves

$$\max_{S\geq 0} \quad (\tilde{p}_1 - \tilde{w}_1)\tilde{z}_1(\tilde{w}_1, \tilde{w}_2) + (\tilde{p}_2 - \tilde{w}_2)\tilde{z}_2(\tilde{w}_1, \tilde{w}_2) + 2S - 2K \tag{14}$$

$$\text{s.t.} \quad (\tilde{w}_1 - c_1)\tilde{z}_1(\tilde{w}_1, \tilde{w}_2) - S \geq 0, \tag{15}$$

$$(\tilde{w}_2 - c_2)\tilde{z}_2(\tilde{w}_1, \tilde{w}_2) - S \geq 0. \tag{16}$$

In this formulation, Equations (15) and (16) are the manufacturers' *participation constraints*, ensuring that they do not lose money upon entering the retailer's assortment. Proposition 2 characterizes the retailer's slotting fee decision and the subgame equilibrium profit for $|\mathbb{A}| = 2$. We provide the remaining subgame equilibrium outcomes in the proof of Proposition 2 for ease of exposition.

Proposition 2. *Let* $\bar{v} \equiv \frac{(2q_1-q_2)^2}{q_1q_2+(2q_1-q_2)^2}$ *and* $v_{12} \equiv \frac{q_1^2(4q_1-3q_2)(v_1+v_2)-2q_1q_2\sqrt{q_1v_1q_2v_2}}{4(q_1-q_2)(4q_1-q_2)^2}$. *When* $|\mathbb{A}| = 2$, *the retailer sets*

$$S^{|2|} = \begin{cases} \frac{\min\{((2q_1-q_2)\sqrt{q_1v_1}-q_1\sqrt{q_2v_2})^2, ((2q_1-q_2)\sqrt{q_1v_2}-q_1\sqrt{q_2v_1})^2\}}{2(q_1-q_2)(4q_1-q_2)^2} & \text{if } \frac{v_1}{v_1+v_2} \in (1-\bar{v}, \bar{v}), \\ 0 & \text{otherwise.} \end{cases} \tag{17}$$

Consequently, the retailer's profit is

$$\Pi_r^{|2|} = \begin{cases} \frac{v_2}{16} - 2K & \text{if } \frac{v_1}{v_1+v_2} \in \left[0, \frac{q_2}{4q_1+q_2}\right], \\ \frac{q_1v_1}{4q_2} - 2K & \text{if } \frac{v_1}{v_1+v_2} \in \left(\frac{q_2}{4q_1+q_2}, 1-\bar{v}\right], \\ v_{12} + 2S^{|2|} - 2K & \text{if } \frac{v_1}{v_1+v_2} \in (1-\bar{v}, \bar{v}), \\ \frac{q_1v_2}{4q_2} - 2K & \text{if } \frac{v_1}{v_1+v_2} \in \left[\bar{v}, \frac{4q_1}{4q_1+q_2}\right), \\ \frac{v_1}{16} - 2K & \text{if } \frac{v_1}{v_1+v_2} \in \left[\frac{4q_1}{4q_1+q_2}, 1\right]. \end{cases} \tag{18}$$

The proof of Proposition 2 shows that the retailer sets its slotting fee to the gross profit of the manufacturer that offers the less attractive product. In other words, the first manufacturer's participation constraint (i.e., Equation 15) is binding when $\frac{v_1}{v_1+v_2} \in [0, 0.5]$, and the second manufacturer's participation constraint (i.e., Equation 16) is binding when $\frac{v_1}{v_1+v_2} \in [0.5, 1]$. Both products have positive demand when $\frac{v_1}{v_1+v_2} \in (1-\bar{v}, \bar{v})$. The retailer charges a slotting fee in this range because both manufacturers have a positive gross profit. The first (high-quality) product has zero demand when $\frac{v_1}{v_1+v_2} \in [0, 1-\bar{v}]$, and the second (low-quality) product has zero demand when $\frac{v_1}{v_1+v_2} \in [\bar{v}, 1]$.

When one of the products has zero demand, the retailer does not charge a slotting fee (i.e., $S^{|2|} = 0$) to ensure the participation of the manufacturer with zero demand, leading to zero gross profit for that manufacturer.

When a product has zero demand, there are two different equilibrium regimes. For example, when $\frac{v_1}{v_1+v_2} \in \left[\bar{v}, \frac{4q_1}{4q_1+q_2}\right)$, the second manufacturer's presence in the assortment creates a price pressure on the first manufacturer. Consequently, the retailer's gross profit $\frac{q_1 v_2}{4q_2}$ increases in the attractiveness of the second manufacturer's product, v_2. By contrast, when $\frac{v_1}{v_1+v_2} \in \left[\frac{4q_1}{4q_1+q_2}, 1\right]$, the second manufacturer's product is not attractive enough to create a credible threat to the first manufacturer. Consequently, the first manufacturer acts as a monopoly, where the retailer's gross profit is $v_1/16$. Indeed, Proposition 1 indicates that when $\frac{v_1}{v_1+v_2} \in \left[\frac{4q_1}{4q_1+q_2}, 1\right]$, setting $|\mathbb{A}| = 1$ would allow the retailer to lower its assortment cost (from $2K$ to K) and increase its slotting fee revenue (from 0 to $v_1/8$) while retaining the same gross profit, $v_1/16$. In other words, $\Pi_r^{|1|} > \Pi_r^{|2|}$ when $\frac{v_1}{v_1+v_2} \in \left[\frac{4q_1}{4q_1+q_2}, 1\right]$. The next section formally compares $\Pi_r^{|1|}$ and $\Pi_r^{|2|}$ to find the retailer's optimal assortment size.

4.3. Full Equilibrium Characterization

In this section, we characterize the full equilibrium by analyzing the first stage of the game in which the retailer selects product variety. We make two assumptions. First, we assume that $K \leq \min\{v_1/16, v_2/16\}$. This assumption suffices to eliminate cases in which the retailer cannot profitably offer the category. Consequently, the retailer compares $\Pi_r^{|1|}$ and $\Pi_r^{|2|}$ to select the product variety that maximizes its profit. Second, we assume that $\frac{q_1}{2q_1-q_2} < \frac{q_1-c_1}{q_2-c_2} < \frac{2q_1-q_2}{q_2}$ (equivalently, $1 - \bar{v} < \frac{v_1}{v_1+v_2} < \bar{v}$). This assumption suffices to eliminate cases in which the retailer offers high product variety (i.e., sets $|\mathbb{A}| = 2$) and carries a zero-demand product to exert price pressure on the manufacturer that offers a more attractive product. We make this assumption for ease of exposition as characterizing the full equilibrium in the absence of this assumption would require us to compare two piecewise functions, $\Pi_r^{|1|}$ and $\Pi_r^{|2|}$. Furthermore, the calibrated numerical study we present in Section 5.3 reveals that retailers in practice are unlikely to carry zero-demand products in their assortments. Thus, this assumption not only eases exposition but also allows us to focus on more realistic equilibrium outcomes.

Let $\Omega \equiv \{(q_1, q_2, c_1, c_2, K) \in \mathbb{R}^5 | 0 \leq K \leq \min\{\frac{(q_1-c_1)^2}{16q_1}, \frac{(q_2-c_2)^2}{16q_2}\}, q_1 > c_1 \geq 0, q_2 > c_2 \geq 0, \frac{q_1}{2q_1-q_2} < \frac{q_1-c_1}{q_2-c_2} < \frac{2q_1-q_2}{q_2}\}$ denote the set of feasible parameter values. In the definition of Ω, $q_i > c_i \geq 0$ for $i = 1, 2$ ensures that manufacturer i can make a positive gross profit when $\mathbb{A} = \{i\}$. We use $\omega = (q_1, q_2, c_1, c_2, K)$ to refer to an element of Ω. We partition Ω into non-empty subsets to capture different equilibrium outcomes. Specifically, $\Omega_{\mathbb{A}}^k$ denotes a subset of Ω where the subscript $\mathbb{A}$ represents the equilibrium assortment and the superscript k captures whether the retailer earns a slotting fee revenue or not ($k = +$ in the former outcome, and $k = 0$ in the latter outcome). Proposition 3 characterizes the equilibrium outcomes for each non-empty subset of Ω. For expositional clarity, we illustrate these sets in Figure 3 and provide their definitions in the proof of Proposition 3.

Proposition 3. *The parameter set Ω has five mutually exclusive and exhaustive subsets: $\Omega^0_{\{1\}}$, $\Omega^+_{\{1\}}$, $\Omega^0_{\{2\}}$, $\Omega^+_{\{2\}}$, and $\Omega^+_{\{1,2\}}$. At equilibrium, the retailer sets its assortment size to one (i.e., $|\mathbb{A}^*| = 1$) if $\omega \in \left(\Omega^0_{\{1\}} \cup \Omega^+_{\{1\}} \cup \Omega^0_{\{2\}} \cup \Omega^+_{\{2\}}\right)$ and two (i.e., $|\mathbb{A}^*| = 2$) if $\omega \in \Omega^+_{\{1,2\}}$. The retailer's slotting fee at equilibrium is*

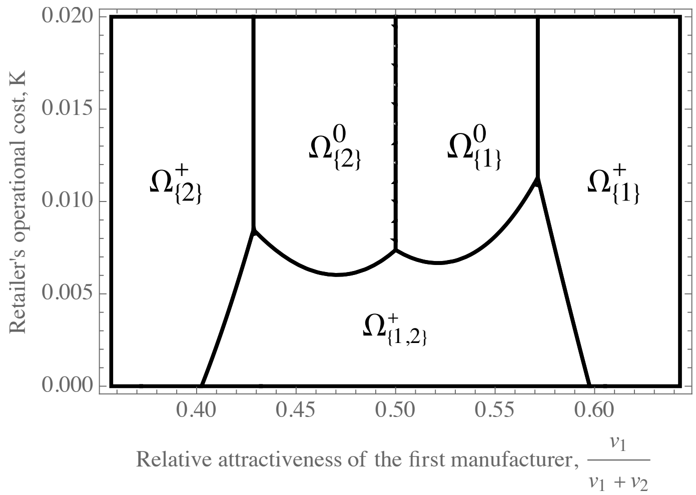
$$S^* = \begin{cases} 0 & \text{if } \omega \in \Omega^0_{\{1\}} \cup \Omega^0_{\{2\}}, \\ v_1/8 & \text{if } \omega \in \Omega^+_{\{1\}}, \\ v_2/8 & \text{if } \omega \in \Omega^+_{\{2\}}, \\ \frac{\min\{((2q_1-q_2)\sqrt{q_1v_1}-q_1\sqrt{q_2v_2})^2,((2q_1-q_2)\sqrt{q_1v_2}-q_1\sqrt{q_2v_1})^2\}}{2(q_1-q_2)(4q_1-q_2)^2} & \text{if } \omega \in \Omega^+_{\{1,2\}}. \end{cases} \tag{19}$$

Consequently, the retailer's assortment at equilibrium is $\mathbb{A}^* = \{1\}$ if $\omega \in \left(\Omega^0_{\{1\}} \cup \Omega^+_{\{1\}}\right)$, $\mathbb{A}^* = \{2\}$ if $\omega \in \left(\Omega^0_{\{2\}} \cup \Omega^+_{\{2\}}\right)$, and $\mathbb{A}^* = \{1, 2\}$ if $\omega \in \Omega^+_{\{1,2\}}$, and the retailer's equilibrium profit is

$$\Pi^*_r = \begin{cases} v_2/4 - K & \text{if } \omega \in \Omega^0_{\{1\}}, \\ v_1/16 + S^* - K & \text{if } \omega \in \Omega^+_{\{1\}}, \\ v_1/4 - K & \text{if } \omega \in \Omega^0_{\{2\}}, \\ v_2/16 + S^* - K & \text{if } \omega \in \Omega^+_{\{2\}}, \\ v_{12} + 2S^* - 2K & \text{if } \omega \in \Omega^+_{\{1,2\}}. \end{cases} \tag{20}$$

Figure 3 illustrates the sets $\Omega^0_{\{1\}}$, $\Omega^+_{\{1\}}$, $\Omega^0_{\{2\}}$, $\Omega^+_{\{2\}}$, and $\Omega^0_{\{1,2\}}$ as a function of $v_1/(v_1+v_2)$, which captures the relative attractiveness of the first manufacturer's product, and K, which captures the retailer's operational cost. The retailer offers high product variety only when K is relatively small and the manufacturers offer products with comparable attractiveness levels (i.e., $v_1/(v_1 + v_2)$ is close to 0.5). When the retailer carries a single product, it charges a slotting fee only when one of the products is significantly more attractive than the other (i.e., when $v_1/(v_1 + v_2) < 3/7$ or $v_1/(v_1+v_2) > 4/7$). Cumulatively, these findings suggest that the retailer does not charge a slotting fee when K is relatively large and the manufacturers offer products with comparable attractiveness levels, leading to aggressive wholesale price competition between the manufacturers for the single slot in the retailer's assortment. In the next section, we generate insights into the emergence of slotting fees and their implications for retailers.

Figure 3 Illustration of Proposition 3



Notes. We generate this figure by setting $q_1 = 1.25$, $q_2 = 1$, and $c_2 = 0.2$, and varying K between 0 and 0.02 and c_1 between 0.05 and 0.5833 so that $v_1/(v_1 + v_2)$ varies between $(1 - \bar{v}, \bar{v}) = (0.3571, 0.6429)$. See the proof of Proposition 3 for the definitions of $\Omega^k_{\mathbb{A}}$.

5. Results

5.1. Emergence of Slotting Fees

In this section, we take a closer look at the role of manufacturer competition in the emergence of slotting fees. Corollary 2 decomposes Ω into two subsets depending on whether the retailer charges a slotting fee at equilibrium.

Corollary 2. *Let* $\Omega^0 \equiv \left\{\omega \in \Omega : \frac{3}{7} \leq \frac{v_1}{v_1+v_2} \leq \frac{4}{7}, K \geq v_{12} + 2S^{|2|} - \min\{v_1/4, v_2/4\}\right\}$. *At equilibrium, the retailer does not charge a slotting fee (i.e.,* $S^* = 0$*) when* $\omega \in \Omega^0$ *and charges a slotting fee (i.e.,* $S^* > 0$*) when* $\omega \in \Omega \setminus \Omega^0$.

Corollary 2 relies on Propositions 1 and 3 to characterize the set of parameters in which charging a slotting fee is suboptimal for the retailer. Specifically, Proposition 3 shows that the retailer charges a slotting fee when it offers high product variety at equilibrium (i.e., when $\mathbb{A}^* = \{1, 2\}$). Thus, charging a slotting fee can be suboptimal only when the retailer offers low product variety. When the retailer commits to low product variety, foregoing slotting fees to create wholesale price competition for the only slot in its assortment allows the retailer to earn a higher gross profit. This is because receiving a lower wholesale price enables the retailer to sell more units at a higher per-unit margin. Accordingly, when the retailer commits to low product variety, it faces a tradeoff between charging a slotting fee accompanied by a low gross profit and foregoing a slotting fee accompanied by a higher gross profit. Proposition 1 shows that foregoing slotting fees under low product variety makes the retailer better off only when $\frac{3}{7} \leq \frac{v_1}{v_1+v_2} \leq \frac{4}{7}$. This is the first condition in the definition of Ω^0 in Corollary 2.

When $\frac{3}{7} \leq \frac{v_1}{v_1+v_2} \leq \frac{4}{7}$, the retailer faces another tradeoff. On the one hand, the retailer can offer low product variety and have a single revenue stream, revenue from sales, accompanied by a low operational cost, K. On the other hand, the retailer can offer high product variety and have two revenue streams, revenues from sales and slotting fees, accompanied by a higher operational cost, $2K$. Comparing the retailer's profits for $|\mathbb{A}| = 1$ and $|\mathbb{A}| = 2$ leads to an operational cost threshold above which it is optimal for the retailer to offer low product variety. The second condition in the definition of Ω^0, $K \geq v_{12} + 2S^{|2|} - \min\{v_1/4, v_2/4\}$, captures this threshold. Intuitively, these two conditions suggest that the retailer charges a slotting fee unless there is intense manufacturer competition for limited shelf space.

From the manufacturers' perspective, Corollary 2 implies that the attractiveness of a competing manufacturer's product can affect a focal manufacturer's profit, even when the competing manufacturer does not enter the retailer's assortment. For example, suppose $v_1 > v_2$ for a sufficiently high operational cost, leading to low product variety at equilibrium. When the first manufacturer is significantly more attractive (i.e., when $v_2 < 0.75v_1$, leading to $\frac{v_1}{v_1+v_2} > \frac{4}{7}$), the retailer charges a slotting fee. The second manufacturer cannot participate, allowing the first manufacturer to set a high wholesale price, $w_1^* = (q_1 + c_1)/2$. As a result, the first manufacturer earns a high gross profit, $(w_1^* - c_1)z_1^* = v_1/8$. However, in this case, the retailer extracts the first manufacturer's entire surplus by setting $S^* = v_1/8$, leading to $\Pi_1^* = (w_1^* - c_1)z_1^* - S^* = 0$. When the first manufacturer is slightly more attractive (i.e., when $v_2 \in [0.75v_1, v_1)$, leading to $\frac{v_1}{v_1+v_2} \in \left(\frac{1}{2}, \frac{4}{7}\right]$), the retailer foregoes slotting fees, forcing the first manufacturer to lower its wholesale price to $w_1^* = q_1 - \sqrt{q_1 v_2}$. In this case, the first manufacturer's equilibrium profit, $\Pi_1^* = (w_1^* - c_1)z_1^* = (\sqrt{v_1} - \sqrt{v_2})\sqrt{v_2}/2$, is positive. That is, for a given v_1, facing a stronger competitor makes the first manufacturer better off, as its equilibrium total profit is higher when $v_2 \in [0.75v_1, v_1)$. This is because the retailer's decision to waive slotting fees to trigger wholesale price competition between the manufacturers prevents it from extracting the entire surplus from the first manufacturer.

Retailers in practice use the opportunity cost of limited shelf space and operational expenses associated with carrying a product (captured by K in our model) to justify charging slotting fees (e.g., Thayer 2015). The academic literature also emphasizes the role of operational costs in the emergence of slotting fees (e.g., Lariviere and Padmanabhan 1997, Desai 2000). By contrast, we show that overlooking the role of manufacturer competition and charging a slotting fee to fully or partially cover opportunity costs and operational expenses can be suboptimal for the retailer. This finding suggests that retailers should carefully manage the tradeoff between charging a slotting fee, which provides a lump-sum payment for the use of limited shelf space, and foregoing it, which may result in lower wholesale prices. We further find that a manufacturer may prefer to interact with a stronger competitor because a stronger competitor can lead to a setting in which the retailer foregoes slotting fees, allowing the manufacturer to make a higher profit. Collectively, these results illustrate the role of manufacturer competition in the emergence of slotting fees.

5.2. Impact of Slotting Fees on Product Variety

In this section, we investigate the impact of slotting fees on product variety (i.e., the retailer's assortment size). To do so, we first consider a *benchmark model* in which the retailer does not charge slotting fees. This benchmark model is a special case of our main model in which the retailer sets the slotting fee to zero in the first stage of the game. Proposition 4 characterizes the equilibrium assortment and the retailer's profit in the benchmark model.

Proposition 4. *Let* $\bar{\Omega}_{\{1\}} \equiv \{\omega \in \Omega : v_1 \geq v_2, K \geq v_{12} - \max\{v_1/16, v_2/4\}\}$, $\bar{\Omega}_{\{2\}} \equiv \{\omega \in \Omega : v_1 < v_2, K \geq v_{12} - \max\{v_1/4, v_2/16\}\}$, *and* $\bar{\Omega}_{\{1,2\}} \equiv \Omega \setminus \left(\bar{\Omega}_{\{1\}} \cup \bar{\Omega}_{\{2\}}\right)$. *In the benchmark model, the retailer sets* $\bar{\mathbb{A}} = \{1\}$ *when* $\omega \in \bar{\Omega}_{\{1\}}$, $\bar{\mathbb{A}} = \{2\}$ *when* $\omega \in \bar{\Omega}_{\{2\}}$, *and* $\bar{\mathbb{A}} = \{1,2\}$ *when* $\omega \in \bar{\Omega}_{\{1,2\}}$. *Consequently, the retailer's profit is*

$$\bar{\Pi}_r = \begin{cases} \max\{v_1/16, v_2/4\} - K & \text{if } \omega \in \bar{\Omega}_{\{1\}}, \\ \max\{v_1/4, v_2/16\} - K & \text{if } \omega \in \bar{\Omega}_{\{2\}}, \\ v_{12} - 2K & \text{if } \omega \in \bar{\Omega}_{\{1,2\}}. \end{cases} \tag{21}$$

Comparison of Propositions 3 and 4 reveals the similarities and differences between the main model and the benchmark model. In particular, all three assortments (i.e., $\{1\}$, $\{2\}$, and $\{1,2\}$) are feasible in both models. Indeed, in some cases, the main model and the benchmark model lead to the same assortment. Nevertheless, the two models can lead to different equilibrium outcomes because of the absence of slotting fees in the benchmark model. Proposition 5 formally characterizes the impact of slotting fees on product variety.

Proposition 5. *Slotting fees have the following impacts on the equilibrium product variety and assortment composition:*

(a) When $\omega \in \Phi_{\uparrow} \equiv \{\omega \in \Omega : v_1 \geq v_2, v_{12} - \max\{v_1/16, v_2/4\} \leq K < v_{12} + 2S^{|2|} - \max\{3v_1/16, v_2/4\}\} \cup \{\omega \in \Omega : v_1 < v_2, v_{12} - \max\{v_1/16, v_2/4\} \leq K < v_{12} + 2S^{|2|} - \max\{v_1/4, 3v_2/16\}\}$, *slotting fees increase product variety. Specifically, when* $\omega \in \Phi_{\uparrow}$, *the equilibrium assortment in the benchmark model is either* $\bar{\mathbb{A}} = \{1\}$ *or* $\bar{\mathbb{A}} = \{2\}$, *and the equilibrium assortment in the main model is* $\mathbb{A}^* = \{1,2\}$.

(b) *When* $\omega \in \Phi_{\downarrow} = \{\omega \in \Omega : v_1 \geq v_2, v_{12} + 2S^{|2|} - 3v_1/16 \leq K < v_{12} - \max\{v_1/16, v_2/4\}\} \cup \{\omega \in \Omega : v_1 < v_2, v_{12} + 2S^{|2|} - 3v_2/16 \leq K < v_{12} - \max\{v_1/4, v_2/16\}\}$*, slotting fees decrease product variety. Specifically, when* $\omega \in \Phi_{\downarrow}$*, the equilibrium assortment in the benchmark model is* $\bar{\mathbb{A}} = \{1, 2\}$*, and the equilibrium assortment in the main model is either* $\mathbb{A}^* = \{1\}$ *or* $\mathbb{A}^* = \{2\}$*.*

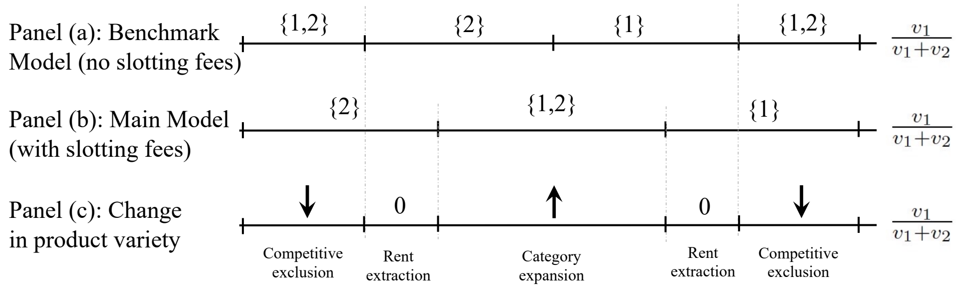
(c) *When* $\omega \in \Phi_0 \equiv \Omega \setminus \left(\Omega^{\downarrow} \cup \Omega^{\uparrow}\right)$*, slotting fees do not change product variety. Specifically, when* $\omega \in \Phi_0$*, the benchmark model and the main model have the same equilibrium assortment, which is* $\mathbb{A}^* = \bar{\mathbb{A}} = \{1\}$*,* $\mathbb{A}^* = \bar{\mathbb{A}} = \{2\}$*, or* $\mathbb{A}^* = \bar{\mathbb{A}} = \{1, 2\}$*.*

Part (a) of Proposition 5 identifies the set of parameters $\Phi_{\uparrow}$ in which slotting fees create a *category expansion* effect by allowing the retailer to increase its assortment size. Part (b) of Proposition 5 identifies the set of parameters $\Phi_{\downarrow}$ in which slotting fees create a *competitive exclusion* effect. Specifically, when $\omega \in \Phi_{\downarrow}$, the retailer carries both products in its assortment in the benchmark model. In the main model, the retailer commits to low product variety to collect a slotting fee payment from the more attractive manufacturer. Such a commitment creates a competitive exclusion effect by preventing the less attractive manufacturer from entering the retailer's assortment. Finally, part (c) of Proposition 5 identifies the set of parameters Φ_0 in which slotting fees create a *rent extraction* effect. Specifically, when $\omega \in \Phi_0$, slotting fees allow the retailer to extract more surplus from the manufacturers without changing its assortment.

Figure 4 illustrates Proposition 5 for a special case in which $K = 0$. In this figure, setting $K = 0$ and varying $v_1/(v_1 + v_2)$ allows us to demonstrate the role of manufacturer competition in the retailer's product variety decision. Notably, the retailer may offer low product variety both in the absence and presence of slotting fees, even when offering high product variety does not increase the retailer's operational cost (i.e., even when $K = 0$). That said, comparing the retailer's product variety choices in the benchmark and main models in Figure 4 reveals that slotting fees reverse the conditions under which the retailer offers low product variety at equilibrium. Specifically, Panel (a) of Figure 4 shows that in the benchmark model, the retailer offers low product variety when $v_1/(v_1 + v_2) \in (0.35, 0.65)$. Intuitively, in the absence of slotting fees, the retailer commits to low product variety when the two products have comparable attractiveness levels, leading to intense wholesale price competition for the only slot in its assortment. In such cases, carrying the more attractive product and receiving a relatively low wholesale price from its manufacturer is more profitable than carrying both products.

In the presence of slotting fees, offering high product variety requires the retailer to set its slotting fee to the gross profit of the manufacturer that offers the less attractive product, whereas offering low product variety allows the retailer to set its slotting fee to the gross profit of the manufacturer that offers the more attractive product. When one product is slightly more attractive

Figure 4 Impact of Slotting Fees on Product Variety When $K = 0$



Notes. We generate this illustrative example by setting $K = 0$, $q_1 = 2$, and $q_2 = 1$, which leads to $(1-\bar{v}, \bar{v}) = (0.1818, 0.8181)$. We set $v_1+v_2 = 1$ and vary c_1 and c_2 to show the equilibrium assortments in the benchmark and main models for $v_1/(v_1+v_2) \in (1-\bar{v}, \bar{v})$. The symbols $\uparrow$, 0, and $\downarrow$ in the last line graph represent cases in which the assortment size increases, remains unchanged, and decreases, respectively.

than the other, the two manufacturers have comparable gross profits under high product variety, so carrying both products leads to a relatively high slotting fee revenue for the retailer. By contrast, when one product is significantly more attractive than the other, offering high product variety would be less lucrative because the manufacturer with the less attractive product would have a relatively low gross profit. Consequently, in the presence of slotting fees, the retailer offers low product variety when one product is significantly more attractive than the other. Indeed, Panel (b) of Figure 4 shows that in the main model, the retailer offers low product variety when $v_1/(v_1+v_2) \leq 0.4$ or $v_1/(v_1+v_2) \geq 0.6$. Panel (c) of Figure 4 compares the retailer's product variety choices in the benchmark and main models. This figure shows that product variety may increase, decrease, or remain unchanged when the retailer charges slotting fees.

In summary, we show that slotting fees can create a category expansion, a competitive exclusion, or a rent extraction effect under which product variety increases, decreases, and remains unchanged, respectively. The emergence of these three effects in the same model reconciles different views documented in the literature about slotting fees. For example, both Lariviere and Padmanabhan (1997) and Desai (2000) identify the high opportunity cost of shelf space (captured by K in our setting) as one of the key drivers of slotting fees. In contrast with Lariviere and Padmanabhan (1997) and Desai (2000), our findings suggest that the retailer can use slotting fees to increase product variety, even in the absence of an operational cost. As another example, several practitioner articles (e.g., Thayer 2015, Rivlin 2016) have argued that slotting fees not only put some manufacturers at a disadvantage but also limit consumer choice by reducing product variety in the assortment. Our finding regarding the emergence of the competitive exclusion effect conforms to this line of thought. Indeed, the retailer's transition from $\bar{A} = \{1, 2\}$ to $\mathbb{A}^* = \{2\}$ is consistent with some manufacturers' claims that slotting fees prevent consumers from having access to high-quality products (e.g., Bloom et al. 2000). Nevertheless, we also identify cases when slotting fees can increase product variety offered to consumers. For example, there are cases when slotting fees allow the high-quality manufacturer to enter the retailer's assortment (i.e., when $\bar{A} = \{2\}$ and $\mathbb{A}^* = \{1, 2\}$).

Our model's ability to capture the different effects of slotting fees stems from the presence of manufacturer competition. That is, our model shows that keeping the retailer's operational cost fixed, changing the relative attractiveness of a manufacturer's product can change the retailer's motivation to collect slotting fees from one effect (e.g., competitive exclusion) to another (e.g., category expansion or rent extraction). The main implication of this observation is that understanding the impact of slotting fees on supply chain stakeholders (e.g., retailers, manufacturers) requires a case-by-case approach, in which a crucial step is to decipher why slotting fees emerge in each case.

5.3. Impact of Slotting Fees on Retailer Profitability

In this section, we design and analyze a calibrated numerical study to assess the impact of slotting fees on the retailer's equilibrium profit in the three regions introduced in Section 5.2 (i.e., category expansion, competitive exclusion, and rent extraction). We design our study in three steps. In the first step, we generate unique scenarios (parameter combinations) as follows: We vary q_2 between 1 and 10 in increments of 1. For a given q_2, we set $q_1 = \gamma q_2$ and vary γ between 1.1 and 2 in increments of 0.1. For a given (q_1, q_2), We vary v_1 between $1 - \bar{v}$ and $\bar{v}$ in increments of 0.01. Furthermore, we set $v_1 + v_2 = 1$ so that v_2 also varies between $1 - \bar{v}$ and $\bar{v}$ in increments of 0.01. For a given (v_1, v_2), we vary K between 0 and $\min\{v_1/16, v_2/16\}$ in increments of 0.001. Because $v_l = (q_l - c_l)^2/q_l$ for $l = 1, 2$, a given (q_l, v_l) implies that we set $c_l = q_l - \sqrt{q_l v_l}$. These parameter combinations lead to 105,700 unique scenarios, where the ranges we pick for v_1, v_2, and K ensure that each scenario is an element of our parameter set, Ω.

We perform calibration in the second step. Specifically, Pauwels (2007) reports that across 25 product categories, the average market shares of the top two brands were 45% and 24%, respectively, indicating an approximatively two-to-one ratio in their sales volumes. Indeed, the same study documents that the first quartile of the market share of the brand with the second highest sales volume was 19%. In light of these statistics, we remove the instances in which the less attractive manufacturer has less than 20% market share in the category when the retailer carries both products in its assortment. Removing such instances reduces the number of scenarios to 80,734 and ensures that our numerical results are not driven by a relatively large imbalance between the market shares of the two competing manufacturers.

We establish face validity in the third step. That is, we compare the prevalence and relative magnitude of slotting fees in our numerical study with their counterparts in an empirical study conducted by Elberg and Noton (2023) to ensure that our model leads to realistic equilibrium outcomes. In particular, Elberg and Noton (2023) report that 73% of manufacturers in their sample pay slotting fees, where manufacturers spend 10% and 11.2% of their gross revenues to pay slotting fees in two different retail chains, on average. By contrast, in our numerical study, 69.5% of the manufacturers pay slotting fees, where a manufacturer pays 10.6% of its gross revenue (i.e., $w_i^* z_i^*$) as a slotting fee to the retailer, on average. Thus, we conclude that the prevalence and magnitude of slotting fees in our calibrated numerical study align well with practice.

We define the difference between the retailer's equilibrium profits in the main and benchmark models as $\Delta\Pi_r \equiv \Pi_r^* - \bar{\Pi}_r$. Table 1 focuses on the scenarios in which slotting fees emerge at equilibrium and summarizes their impact on the retailer's profit. As Panel (a) of Table 1 shows, the average changes in the retailer's profit due to slotting fees in the competitive exclusion, rent extraction, and category expansion regions are 0.0382, 0.02082, and 0.0057, respectively. In addition, Panel (b) of Table 1 shows that the average percentage increases in the competitive exclusion, rent extraction, and category expansion regions are 49.19%, 27.54%, and 5.18%, respectively. Given these averages, we conclude that slotting fees are most beneficial for the retailer in the competitive exclusion region and least beneficial in the category expansion region. Other summary statistics we report in Table 1 support this conclusion as the competitive exclusion (category expansion) region has the highest (lowest) values in each quartile.

Table 1 Impact of Slotting Fees on the Retailer's Profit

Panel (a): Absolute Change in the Retailer's Profit, $\Delta\Pi_r$

Region	Min.	25th percentile	Median	Mean	75th percentile	Max.
Competitive exclusion	0.00546	0.02939	0.03921	0.03820	0.04797	0.06537
Rent extraction	0.00177	0.01250	0.01688	0.02082	0.03000	0.06063
Category expansion	0.00003	0.00263	0.00544	0.00570	0.00851	0.01415

Panel (b): Relative Change in the Retailer's Profit, $\Pi_r^*/\bar{\Pi}_r - 1$

Region	Min.	25th percentile	Median	Mean	75th percentile	Max.
Competitive exclusion	5.11%	32.78%	47.03%	49.19%	63.50%	114.23%
Rent extraction	1.51%	12.50%	22.65%	27.54%	38.46%	111.24%
Category expansion	0.02%	2.42%	4.94%	5.18%	7.57%	14.15%

Notes. We generate the summary statistics for the competitive exclusion, rent extraction, and category expansion regions based on the 5,484, 30,180, and 15,740 scenarios in which slotting fees emerge at equilibrium, respectively.

Why does the retailer benefit the most (least) from slotting fees in the competitive exclusion (category expansion) region? We answer this question by decomposing $\Delta\Pi_r \equiv \Pi_r^* - \bar{\Pi}_r$ into two components as follows:

$$\Delta\Pi_r = \left(\sum_{i\in\mathbb{A}^*}(p_i^* - w_i^*)z_i^* + S^*|\mathbb{A}^*| - K|\mathbb{A}^*|\right) - \left(\sum_{i\in\bar{\mathbb{A}}}(\bar{p}_i - \bar{w}_i)\bar{z}_i - K|\bar{\mathbb{A}}|\right) \tag{22}$$

$$= \underbrace{S^*|\mathbb{A}^*|}_{\Delta\Pi_r^{(1)}} + \underbrace{\sum_{i\in\mathbb{A}^*}(p_i^* - w_i^*)z_i^* - \sum_{i\in\bar{\mathbb{A}}}(\bar{p}_i - \bar{w}_i)\bar{z}_i - K\left(|\mathbb{A}^*| - |\bar{\mathbb{A}}|\right)}_{\Delta\Pi_r^{(2)}}. \tag{23}$$

In Equation (23), $\Delta\Pi_r^{(1)}$ and $\Delta\Pi_r^{(2)}$ capture the *direct* and *indirect* impacts of slotting fees on the retailer's profit, respectively. Specifically, $\Delta\Pi_r^{(1)} = S^*|\mathbb{A}^*|$ captures the retailer's slotting fee revenues. By contrast, $\Delta\Pi_r^{(2)}$ reflects the impact of slotting fees on the retailer's gross profit and operational costs.

Table 2 revisits the scenarios summarized in Table 1 and shows the median and mean values of $\Delta\Pi_r^{(1)}$ and $\Delta\Pi_r^{(2)}$ in each region. Notably, both the median and mean $\Delta\Pi_r^{(2)}$ are negative in all three regions. In other words, the indirect impact of slotting fees on the retailer's gross profit and operational costs can dampen the profitability benefits of slotting fees for the retailer in all three regions. The retailer benefits the most in the competitive exclusion region for two reasons. First, the retailer carries low product variety and collects a relatively large slotting fee from the manufacturer that offers the more attractive product (i.e., $\Delta\Pi_r^{(1)}$ is relatively large) in this region. Second, reducing product variety lowers the retailer's operational cost from $2K$ to K. Although the indirect impact of slotting fees is still negative because of a decrease in the retailer's gross profit, combining a relatively high slotting fee with a lower operational cost leads to a relatively large increase in the retailer's profit. The retailer's gains are moderate in the rent extraction region in part because slotting fees do not lower the retailer's operational cost in this region. The retailer benefits the least in the category expansion region because of a combination of relatively low slotting fee revenues and relatively high operational costs. Specifically, the retailer carries both products and sets the slotting fee to the gross profit of the manufacturer that offers the less attractive product. That manufacturer's gross profit is relatively low, leading to a relatively low slotting fee revenue for the retailer. In addition, expanding product variety increases the retailer's operational cost from K to $2K$. Combining these two forces leads to a relatively low increase in the retailer's gross profit.

Table 2 Decomposition of the Impact of Slotting Fees on the Retailer's Profit

	Direct Impact, $\Delta\Pi_r^{(1)}$		Indirect Impact, $\Delta\Pi_r^{(2)}$		Total Impact, $\Delta\Pi_r$	
Region	Median	Mean	Median	Mean	Median	Mean
Competitive exclusion	0.08500	0.08426	−0.04544	−0.04606	0.03921	0.03820
Rent extraction	0.07625	0.07693	−0.05625	−0.05611	0.01688	0.02082
Category expansion	0.03040	0.02964	−0.02437	−0.02394	0.00544	0.00570

In summary, our numerical analysis shows that the retailer benefits the most (least) from slotting fees when they lead to a decrease (increase) in product variety. Furthermore, we find that the profitability impact of slotting fees goes beyond creating an additional revenue stream for the retailer. This is because slotting fees affect the retailer's assortment and the wholesale and retail prices in the category. Indeed, we show that the indirect impact of slotting fees on the retailer's gross profit and operational costs can dampen the profitability benefits of slotting fees for the retailer. Combining these findings with the suboptimality of slotting fees when there is intense manufacturer competition for a single slot in the retailer's assortment, we conclude that it is important for a retailer to understand the indirect impact of slotting fees on its profit to obtain a more complete picture regarding the advantages and disadvantages of slotting fees.

6. Robustness Tests

Our study leads to three key insights. First, charging a slotting fee can be suboptimal for the retailer when there is intense manufacturer competition for limited shelf space. Second, when slotting fees emerge at equilibrium, they can create a category expansion, a competitive exclusion, or a rent extraction effect under which product variety increases, decreases, and remains unchanged, respectively. Third, the retailer benefits the most (least) from slotting fees in the competitive exclusion (category expansion) region, where the indirect impact of slotting fees on the retailer's gross profit and operational costs can dampen the benefit of slotting fees for the retailer in all three regions. We generate these insights from a stylized model with two manufacturers competing for one or two slots in the retailer's assortment. Furthermore, our modeling assumptions lead to cases in which charging a slotting fee allows the retailer to extract the full surplus from one of the manufacturers. In this section, we relax some of our modeling assumptions to test the robustness of our key insights.

6.1. Manufacturers With Outside Options

In our model, a manufacturer participates (i.e., offers a wholesale price) only when it can make a non-negative profit at equilibrium. Consequently, our model setup leads to cases when the retailer sets its slotting fee such that a manufacturer makes zero profit upon entering the retailer's assortment. For example, when $\mathbb{A}^* = \{1, 2\}$ with $v_1 > v_2$, the retailer sets its slotting fee such that the second manufacturer makes zero profit at equilibrium. In Section A.1 in the online supplement, we study a model extension with more powerful manufacturers. Specifically, we assume that manufacturer $i = 1, 2$ has an outside option, $\hat{\pi}_i$. Consequently, manufacturer i participates only when its equilibrium profit is no less than its outside option. Our approach of capturing the role of manufacturer power with outside options is similar to Kolay and Shaffer's (2022) approach of capturing the role of retailer power by studying a setting in which a single manufacturer's slotting fee payments to two competing retailers depend on the outside option of each retailer.

We set $\hat{\pi}_i = \lambda v_i$, where $\lambda \geq 0$ allows us to capture manufacturer power with a single parameter. Specifically, $\lambda = 0$ reduces to our main model, while increasing λ gives more power to the manufacturers by improving their outside options. Our analysis reveals that both the prevalence and magnitude of slotting fees decrease as manufacturer power increases. In other words, the set of parameters in which slotting fees emerge at equilibrium and the retailer's slotting fee revenue shrink as λ increases. Nevertheless, our managerial insights continue to hold when $\lambda > 0$. See Section A.1 in the online supplement for details.

6.2. Category With Three Manufacturers

In our main model, the retailer interacts with two manufacturers, where the equilibrium assortment is $\mathbb{A}^* = \{1\}$, $\mathbb{A}^* = \{2\}$, or $\mathbb{A}^* = \{1, 2\}$. In Section A.2 in the online supplement, we study an alternative model with three manufacturers. For ease of exposition, we assume that the unit production cost is zero for all three manufacturers. This assumption leads to $v_i = (q_i - c_i)^2/q_i = q_i$, where $q_1 > q_2 > q_3$. Consequently, the equilibrium assortment can be $\{1\}$, $\{1, 2\}$, or $\{1, 2, 3\}$, depending on the model parameters, q_1, q_2, q_3, and K. In other words, for a given assortment size, the equilibrium assortment includes the most attractive (i.e., highest quality) products because in the absence of production costs, a higher quality product can dominate a lower quality one by matching the lower quality product's wholesale price.

Although the setting with three manufacturers leads to new product variety comparisons between the benchmark and main models (e.g., $\bar{\mathbb{A}} = \{1, 2, 3\}$ in the benchmark model and $\mathbb{A}^* = \{1\}$ in the main model), our main insights into the emergence of slotting fees and their impact on the retailer's assortment size and profit continue to hold. In addition, a model with three manufacturers unveils that a manufacturer can benefit from slotting fees. In particular, we find that the retailer's decision to introduce slotting fees can lead to an increase in the first manufacturer's profit by softening the wholesale price competition in the category. See Section A.2 in the online supplement for details.

6.3. Category With a Store Brand

Many retailers in practice include store brand (SB) products in their assortments. Retailers own and market such products, which enable them to exert more pressure on manufacturers (e.g., Pauwels and Srinivasan 2004). In Section A.3 in the online supplement, we study an alternative model in which the retailer interacts with two manufacturers when it can carry an SB product in its assortment. A key feature of this alternative model is that the retailer does not earn a slotting fee revenue from its own SB. We use indices 1, 2, and s to represent the first manufacturer's product, the second manufacturer's product, and the SB product, respectively. In line with Section 6.2, we assume that the unit production cost is zero for all three products. Following Alan et al. (2019), we also assume that the SB has the lowest quality (i.e., $q_1 > q_2 > q_s$) and that the retailer acquires the SB at zero cost.

In this model, the equilibrium assortment can be $\{1\}$, $\{1, 2\}$, $\{1, s\}$, or $\{1, 2, s\}$, depending on the model parameters, q_1, q_2, q_s, and K. Revisiting Section 6.2, when $|\mathbb{A}^*| = 2$, the third manufacturer cannot enter the retailer's assortment at equilibrium (i.e., $\mathbb{A}^* = \{1, 2\}$) because of its quality disadvantage. By contrast, $\mathbb{A} = \{1, s\}$ can be the equilibrium assortment in this setting. This is because there are scenarios when carrying $\mathbb{A} = \{1, s\}$ and setting S to extract the full surplus from the first manufacturer makes the retailer better off compared to carrying $\mathbb{A} = \{1, 2\}$ and setting a smaller S to ensure the second manufacturer's participation. More generally, comparing the equilibrium outcomes of the models we study in Sections A.2 and A.3 reveals that the SB presence increases the prevalence and magnitude of slotting fees. This result is consistent with the notion that SBs allow retailers to receive better terms of trade from manufacturers (e.g., Pauwels and Srinivasan 2004, Alan et al. 2019). Although the SB presence in the category leads to new equilibrium outcomes (e.g., $\mathbb{A}^* = \{1, s\}$), our main insights remain valid. See Section A.3 in the online supplement for details.

6.4. Other Robustness Tests

We analyze three additional settings to further test the robustness of our key insights. First, we expand the set of feasible parameter values to consider the possibility that the retailer carries a zero-demand product in its equilibrium assortment. Second, we analyze an alternative setting in which the retailer does not commit to an assortment size in the first stage of the game. Third, we consider an alternative setting in which we use the multinomial logit model to formulate consumer demand. Our key insights continue to hold in these three alternative settings. See the supplemental file, which is available at http://tinyurl.com/bdz267tn, for details.

7. Discussion and Conclusions

We study the role of slotting fees in a retailer's strategic interactions with two competing manufacturers. In our model, the retailer moves first and announces its assortment size and the slotting fee it demands from the manufacturers. The manufacturers then make participation and wholesale price decisions. Finally, the retailer determines its assortment and retail prices. Our findings reveal that a retailer can use slotting fees as a strategic tool to control the intensity of manufacturer competition. Furthermore, comparing our main model with a benchmark model in which the retailer does not charge slotting fees allows us to demonstrate the impact of slotting fees on the retailer's broader category management strategy (i.e., assortment and pricing decisions) and profitability.

In our model, the retailer has a strong first-mover advantage because of its ability to set the assortment size and slotting fee in the first stage. As such, our model captures a supply chain setting in which the manufacturers interact with a relatively powerful retailer. We relax some of our modeling assumptions to test the robustness of our main insights. Specifically, studying an alternative model in which the manufacturers have outside options reveals that the prevalence and magnitude of slotting fees decrease as the manufacturers' outside options improve (i.e., as the manufacturers become powerful). In addition, we study a model in which the retailer interacts with two manufacturers when it can carry an SB product. Having the option to carry an SB product makes the retailer more powerful and thereby increases the prevalence and magnitude of slotting fees. Collectively, our robustness tests indicate that the prevalence and magnitude of slotting fees decrease (increase) as manufacturers (retailers) become more powerful. More importantly, our robustness tests show that our main insights into the role of manufacturer competition in the emergence of slotting fees and the impact of slotting fees on the retailer's assortment and pricing decisions continue to hold under alternative modeling assumptions.

Our findings have important implications for retailers, manufacturers, and policy makers. For retailers, our study provides partial support for their claim that they use slotting fees to cover the operational costs associated with offering a larger assortment (e.g., Thayer 2015). That is, the retailer in our setting does indeed use slotting fees to cover its operational cost in the category expansion region. However, we also demonstrate that slotting fees can emerge even when offering high product variety is costless. Thus, operational costs do not fully explain the emergence of slotting fees. Indeed, our analysis reveals that retailers should pay attention to the tradeoff between charging a slotting fee, which provides a lump-sum payment, and foregoing it, which may result in lower wholesale prices. Keeping this tradeoff in mind, retailers should be aware that slotting fees can be suboptimal when foregoing them can create intense wholesale price competition for limited shelf space.

Our study also provides partial support for the manufacturers' claims that slotting fees reduce product variety (e.g., Wilkie et al. 2002). In particular, we show that slotting fees do indeed reduce product variety in the competitive exclusion region. Nevertheless, we also identify cases when slotting fees increase product variety in the category. Indeed, our robustness tests reveal that the retailer's decision to charge slotting fees can lead to an increase in a strong manufacturer's profit. Collectively, our findings about the impact of slotting fees on the retail and wholesale prices and the retailer's assortment size and composition imply that the strategic role of slotting fees in retailer-manufacturer interactions extends beyond a simple lump-sum payment from manufacturers and retailers. As such, it is important for retailers and manufacturers to assess the indirect impact of slotting fees on their operational decisions and profits.

Our study also has implications for policy makers. In particular, we identify cases in which slotting fees can decrease product variety, limit consumers' access to a high-quality product, and/or increase retail prices. However, we also identify cases in which slotting fees lead to an increase in product variety (i.e., the category expansion region). Cumulatively, these findings provide an operational perspective for the ongoing debate regarding whether regulators should ban slotting fees because of their anticompetitive effects (e.g., Federal Trade Commission 2003). In particular, our results imply that a case-by-case analysis would be more reasonable than an outright ban on slotting fees because the impact of slotting fees on product variety and retail prices depends on the retailer's operational cost structure and the intensity of manufacturer competition in the category.

It is worth noting that the retailer sets slotting fees in our main model and robustness checks. Studying alternative settings in which manufacturers set slotting fees or manufacturers and retailers bargain over slotting fees can lead to new insights. For example, a setting in which manufacturers make slotting fee offers to a retailer to maximize their profits may change the conditions under which slotting fees emerge and provide the highest profitability benefit to the retailer. We hope that our study generates more interest in studying the operational drivers and implications of slotting fees.

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