Category Captainship in the Presence of Retail Competition

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Abstract

Category captainship (CC) is a supply chain practice in which a retailer collaborates with a manufacturer to develop and implement a category management strategy. We examine the role of retail competition in CC implementations by analyzing a game-theoretic setting with two competing retailers. We first consider a benchmark model in which both retailers adopt traditional category management. Then, we consider a CC model in which the focal retailer implements CC. Comparing the equilibrium outcomes of these two models leads to the following insights: First, despite preventing the emergence of CC in some cases, retail competition increases the upside potential of CC for the focal retailer. Second, the focal retailer’s CC implementation can increase the competing retailer’s market share and profit. Third, a manufacturer may agree to serve as a captain even though CC decreases the profit it generates through the focal retailer channel because retail competition enables it to recoup its losses through the competing retailer channel. Last, retail competition alleviates concerns about the potential negative impact of CC on consumers. We discuss the implications of our study for retailers, manufacturers, and policymakers.

Key words: category management, category captainship, retail competition, supply chain collaboration, assortment planning

1. Introduction

Building a sustainable competitive advantage is a challenging task for retailers (Levy and Weitz 2004). For example, according to a Booz & Company study (Hodson et al. 2012), remaining competitive in the grocery retailing industry requires “increasing merchandising and marketing expertise, heightened understanding of and attention to a new shopper mind-set, innovation in all dimensions of retailing and manufacturer collaboration, and a renewed focus on operating costs.” The same study also posits that “those in the industry not willing to foster the right capabilities risk the loss of market share, declining profits, and perhaps even extinction.” These risks force retailers to seek ways to improve their marketing and operational capabilities and, in doing so, to create a better match between their offerings and consumer needs in a cost-efficient manner.
One major breakthrough affecting retail competition was the shift from brand management to category management (Dussart 1998). In category management, a retailer treats a product category (i.e., a set of similar products, such as soft drinks, oral care products, and canned vegetables) as a strategic business unit (ACNielsen 2005). Unlike brand management, category management enables retailers to simplify, coordinate, and thereby improve the process of making marketing and operational decisions (Basuroy et al. 2001). Such decisions include, but are not limited to, identification of target market segments, assortment planning, inventory and shelf space optimization, and development of promotional strategies (ACNielsen 2005).

Although category management is beneficial in increasing retail sales and profitability, executing a successful category management strategy is an arduous task for some retailers. This is partly due to the necessity of developing category know-how for tens or even hundreds of categories. By contrast, manufacturers possess deep expertise in a smaller set of categories. The knowledge gap between manufacturers and retailers creates supply chain collaboration opportunities (Blattberg and Fox 1995). As such, some retailers collaborate with one of the leading manufacturers in the category, referred to as the category captain, to develop and implement a category management strategy (e.g., Subramanian et al. 2010, Kurtuluş and Toktay 2011). This practice is referred to as category captainship (CC; Desrochers et al. 2003).

Category management research indicates that assortment (i.e., the set of products a retailer carries) and category presentation play important roles in determining a retailer’s category performance (for a review, see Bauer et al. 2012). Specifically, carrying a large assortment makes it more likely for consumers to find a product that matches their needs (Boatwright and Nunes 2001), but also increases a retailer’s operational costs (Rooderkerk et al. 2013). In addition, factors such as the amount of shelf space devoted to the category, shelf space layout, visual appeal of the category display, category signage, and consumers’ degree of familiarity with the category shape consumers’ perceptions of category presentation, which in turn influences consumer demand (e.g., Dreze et al. 1995, Inman et al. 1997, Broniarczyk et al. 1998, Baker et al. 2002). In line with these findings, CC implementations in practice typically focus on assortment and category presentation decisions. For example, Hormel Foods collaborated with a major retailer in the deli category. Hormel reduced the retailer’s assortment size, which decreased the retailer’s labor and inventory costs. Hormel also improved the category presentation by analyzing consumer needs and redesigning the retailer’s planograms. According to Progressive Grocer (2013, p.94), “Hormel’s innovative work with the retailer invigorated the overall service deli category, both growing the retailer’s market share and improving efficiency in stores.” Similarly, Bayer HealthCare served as a category captain in the upper-respiratory care category. Based on shopper insights (e.g., regional and seasonal occurrences
of allergies), Bayer performed assortment optimization, improved category signage, and introduced a new shelf configuration (Progressive Grocer 2016).

The CC literature has relied on surveys (e.g., Gooner et al. 2011), empirical analyses (e.g., Nijs et al. 2014, Alan et al. 2017), and analytical models (e.g., Subramanian et al. 2010, Kurtuluş and Toktay 2011, Kurtuluş et al. 2014b) to examine the impact of CC on various category stakeholders. In particular, the analytical CC literature has mainly focused on settings in which multiple manufacturers, including the captain, sell their products through a monopolistic retailer. This literature finds that collaborating with a captain helps a retailer better align its product offerings with consumer needs, which in turn leads to an increase in the retailer’s profit (e.g., Kurtuluş and Nakkas 2011). However, an important difference between CC and other supply chain collaboration practices, such as vendor managed inventory, is that the captain can make recommendations regarding its competitors’ products. As such, the captain may use its decision-making power to put the other manufacturers in the category, which we refer to as the non-captain manufacturers, at a disadvantage (Desrochers et al. 2003). Despite this possibility, findings on the impact of the captain’s actions on the non-captain manufacturers are mixed. For example, if the captain’s actions increase category demand, the non-captain manufacturers may benefit; however, if the captain’s actions simply shift demand from some products to others, the non-captain manufacturers may suffer (Subramanian et al. 2010). The captain’s actions also create antitrust concerns about CC because such actions may restrict manufacturer competition and thereby harm consumers (Desrochers et al. 2003, Carameli Jr. 2004).

While the analytical CC literature has generated insights into the impact of CC on a monopolistic retailer, manufacturers, and consumers, it has overlooked the role of retail competition in CC implementations. Accordingly, our goal is to examine CC in the presence of retail competition. We formulate retail competition using a game-theoretic setting in which two retailers compete for consumer demand by strategically selecting their assortments. In our setting, one retailer, which we refer to as the focal retailer, has the option to implement CC, while the other retailer, which we refer to as the competing retailer, makes its own assortment decisions. This setting is motivated by the current retail environment in which some retailers implement CC while others do not use category captains and perform category management on their own (Federal Trade Commission 2001, p.48). When the focal retailer implements CC, the captain not only makes assortment decisions on behalf of that retailer but also exerts effort to improve the retailer’s category presentation.

We examine the role of retail competition in CC implementations by comparing the equilibrium outcomes of a model in which the focal retailer implements CC with a benchmark model in which both retailers adopt traditional category management. Our analysis sharpens the existing
literature’s predictions about the impact of CC on the focal retailer. Specifically, the analytical CC literature identifies two sources of benefits for a monopolistic retailer implementing CC. First, CC may enable a retailer to convert some non-purchasers into purchasers, leading to a category expansion effect (e.g., Subramanian et al. 2010). Second, CC may enable a retailer to lower its category management costs, leading to a cost reduction effect (e.g., Kurtuluş et al. 2014a). While these benefits may also exist in the presence of retail competition, the literature overlooks a third potential benefit that CC may enable a retailer to steal some consumers from its competitors, leading to a share shifting effect. By contrast, our setting with two competing retailers allows us to examine the share shifting effect and its interactions with the other two effects. We find that the share shifting effect prevents the emergence of CC in some cases. Such cases arise when the focal retailer would lose significant market share to the competing retailer as a result of implementing CC. However, there are other cases in which the benefit of CC for the focal retailer is higher in the presence of retail competition compared to a monopolistic retailer setting. Such cases arise when the focal retailer gains significant market share from the competing retailer as a result of implementing CC. These findings suggest that the analytical CC literature, which overlooks retail competition, may have biased predictions about the emergence of CC and its benefits for the focal retailer.

Our analysis also generates insights into the impact of CC on the competing retailer, captain, and consumers. First, the analytical CC literature is silent on the impact of a retailer’s CC implementation on its competitors, whereas our model allows us to examine such an impact. We find that despite going up against the focal retailer head-to-head, the competing retailer can actually benefit from the focal retailer’s CC implementation. In other words, there are cases in which the focal retailer’s CC implementation leads to an increase in the competing retailer’s profit. Such cases arise when the competing retailer steals market share from the focal retailer by increasing its assortment size. Second, in a monopolistic retail setting, implementing CC should lead to an increase in the profit the captain generates by selling its products to the retailer so that the captain can at least cover the costs associated with developing a category management strategy for the retailer (Kurtuluş et al. 2014a). While retail competition does not change the notion that CC should not make the captain worse off, the presence of a second retailer creates an additional sales channel for the captain. Accordingly, we analyze how CC affects the profits the captain generates through each sales channel. Our analysis reveals cases in which a manufacturer may agree to serve as a captain even though CC leads to a decrease in the profit it generates through the focal retailer channel. These cases emerge due to retail competition, which enables the captain to cover its shortfall by increasing the profit it generates through the competing retailer. Last, we examine how implementing CC in the presence of retail competition affects consumers. We show that retail competition
alleviates the antitrust concerns about CC because the presence of the competing retailer prevents
the focal retailer from implementing CC when the negative impact of CC on consumers would be
most severe.

In summary, we contribute to the retail operations literature by generating new insights into
the impact of CC on the competing retailer and sharpening the existing literature’s predictions
about the emergence of CC and its impact on the focal retailer, captain, and consumers. The rest
of this article proceeds as follows: Section 2 introduces our supply chain setting. Section 3 presents
our analysis. In particular, Section 3.1 analyzes a benchmark model in which both retailers adopt
traditional category management, and Section 3.2 analyzes a model in which the focal retailer adopts
CC. Sections 4 and 5 present our results and robustness tests, respectively. Section 6 highlights the
implications of our findings for researchers, managers, and policymakers.

2. Supply Chain Setting

We consider a setting with multiple manufacturers and two competing retailers, \( R_1 \) and \( R_2 \). We refer
to \( R_1 \) and \( R_2 \) as the focal retailer and the competing retailer, respectively. The retailers purchase
products from the manufacturers and sell those products to end consumers. Because we focus on a
single category, we assume that all products are substitutes in our setting. For expositional clarity,
we also assume that each manufacturer offers a single product.

Following Anderson and De Palma (1992), we model consumer choice as a two-stage decision
process. In the first stage, a consumer decides which retailer or the no-purchase option to choose.
The consumer moves to the second stage only if she chooses one of the retailers instead of the
no-purchase option in the first stage. In the second stage, she purchases one of the products offered
by the retailer she has chosen in the first stage.

Let \( M_{ij} \) denote the probability that a consumer purchases product \( j \) from retailer \( i = 1, 2 \). We
use backward induction to derive \( M_{ij} \). Let \( \mathcal{N}_i \) denote the assortment (i.e., set of products) offered by
\( R_i \). Furthermore, let \( U_{ij} = u_{ij} - p_{ij} + \mu_2 \epsilon_{ij} \) denote the utility a consumer receives from purchasing
product \( j \in \mathcal{N}_i \). In this formulation, \( u_{ij} \) is a constant representing the deterministic component of
product \( j \)'s utility at retailer \( i \), \( p_{ij} \) is the retail price for product \( j \) at retailer \( i \), and \( \mu_2 \) represents the
degree of product heterogeneity. Furthermore, for retailer \( i = 1, 2 \), \( \epsilon_{ij}, j \in \mathcal{N}_i \) are independent and
identically distributed (i.i.d.) random variables following a standard Gumbel distribution. Suppose
that the consumer chooses retailer \( i \) in the first stage. Then, conditional on that retailer choice, the
probability that she purchases product \( j \) from retailer \( i \) is

\[
Pr(j|i) = \frac{a_{ij} \Pi_{ij}}{\sum_{k \in \mathcal{N}_i} a_{ik}},
\]  

(1)
where \( a_{ij} \equiv \exp \left( (u_{ij} - p_{ij})/\mu_2 \right) \) and \( I_{ij} \) is an indicator variable that takes a value of one if retailer \( i \) carries product \( j \) and zero otherwise. Following the assortment planning literature (e.g., Aydin and Porteus 2008), we refer to \( a_{ij} \) as the attractiveness of product \( j \) offered by retailer \( i \).

As described by Anderson and De Palma (1992), a consumer does not know the realizations of the product-specific random utility terms, \( \epsilon_{ij} \), in the first stage of the process. However, she knows the expected utility of choosing retailer \( i \), \( A_i = \mathbb{E} \left[ \max_{k \in \mathcal{N}_i} U_{ik} \right] = \mu_2 \ln \left( \sum_{k \in \mathcal{N}_i} a_{ik} \right) \). In other words, she knows that once she chooses a retailer, she will pick the best product from that retailer’s assortment. However, she does not know in advance which product will give her the highest utility because \( \epsilon_{ij} \) values are realized in the second stage. Let \( U_i = A_i + \mu_1 \epsilon_i \) denote the utility the consumer receives by choosing retailer \( i = 1, 2 \) in the first stage. Furthermore, let \( U_0 = u_0 + \mu_1 \epsilon_0 \) denote the utility of the no-purchase option, where \( u_0 \) represents the deterministic component of the no-purchase option’s utility. In \( U_i, i = 0, 1, 2, \mu_1 \) captures retailer heterogeneity, and \( \epsilon_i \) are i.i.d. random variables following a standard Gumbel distribution. Accordingly, the probability that the consumer chooses retailer \( i \) in the first stage is

\[
Pr(i) = \frac{\exp(A_i/\mu_1)}{\exp(u_0/\mu_1) + \sum_{l=1}^2 \exp(A_l/\mu_1)}. \tag{2}
\]

Combining (1) and (2) leads to

\[
M_{ij} = Pr(j|i) \times Pr(i) = \frac{a_{ij}I_{ij}}{\sum_{k \in \mathcal{N}_i} a_{ik}} \times \frac{\exp(A_i/\mu_1)}{\exp(u_0/\mu_1) + \sum_{l=1}^2 \exp(A_l/\mu_1)}. \tag{3}
\]

Equation (3) implies that the two-step consumer choice process leads to a nested multinomial logit (NMNL) model in which both nests (i.e., stages) follow a multinomial logit (MNL) model.

We derive the retailers’ and manufacturers’ expected profit functions next. Without loss of generality, we normalize the market size to one. Therefore, the expected demand for product \( j \) offered by retailer \( i \) is \( M_{ij} \). Furthermore, we assume that \( R_i \) incurs a fixed operational cost, \( \alpha_i \), for each product it carries in its assortment. This cost parameter is in line with the category management literature (e.g., Gaur and Honhon 2006, Pan and Honhon 2012, Heese and Martínez-de Albéniz 2018) and captures the notion that offering a large assortment increases a retailer’s operational expenses. Accordingly, retailer \( i \)'s expected profit is

\[
\Pi_i = \sum_{j \in \mathcal{N}_i} (p_{ij} - w_{ij})M_{ij} - \alpha_i n_i, \tag{4}
\]

where \( w_{ij} \) is the wholesale price of product \( j \in \mathcal{N}_i \) and \( n_i = |\mathcal{N}_i| \) is retailer \( i \)'s assortment size. Similarly, manufacturer \( j \)'s expected profit is

\[
\pi_j = \sum_{i=1}^2 (w_{ij} - c_j)M_{ij}, \tag{5}
\]
where $c_j$ denotes the unit production cost for manufacturer $j$.

In our main analysis, we make three assumptions. First, we normalize the production costs, $c_j$, to zero and assume exogenous retail and wholesale prices. Second, we assume that all model parameters (i.e., $p_{ij}, w_{ij}, u_{ij}, \alpha_i$) are identical across products and retailers. Admittedly, a setting in which each retailer jointly optimizes its assortment and prices in the presence of asymmetric model parameters and strategic manufacturers would be more realistic. Indeed, the retail competition literature analyzes variants of such a setting (e.g., Cachon et al. 2008, Kök and Xu 2011, Caro and Martínez-de Albéniz 2012). However, the captain’s strategic interactions with $R_1$ and $R_2$ make the analysis of such a setting intractable in our CC model. Thus, we assume exogenous prices and symmetric model parameters for analytical tractability. Nevertheless, we numerically relax both assumptions to demonstrate that our managerial insights continue to hold when (i) the model parameters vary across products (see Section 5.2.3) and (ii) the retailers and manufacturers strategically optimize their prices (see Section 5.2.4).

Third, we assume $\mu_1 = \mu_2 = 1$ for analytical tractability. Setting $\mu_1 = \mu_2 = 1$ reduces an NMNL model to an MNL model. While this assumption facilitates analytical tractability, such tractability comes at the expense of losing some model realism because an MNL model may not fully capture consumer choice behavior in the presence of competing retailers with potentially overlapping assortments. Indeed, the existing literature (e.g., Kök and Xu 2011, Besbes and Sauré 2016) indicates that an NMNL model provides a more reasonable approximation of consumer choice behavior in the presence of retail competition. In our setup, the same product may be offered by both retailers, so there might be some correlation among utilities across nests. Hence, the NMNL model remains an approximation, as it assumes that utilities for offerings in different nests are independent. As described by Anderson and De Palma (1992) and Kök and Xu (2011), the two-step process we consider captures consumer choice in cases in which $\mu_1 \geq \mu_2$. Accordingly, we check the robustness of our insights by analyzing an alternative (NMNL) model with $\mu_1 > \mu_2$. Our numerical analysis suggests that our main insights continue to hold when $\mu_1 > \mu_2$. We present our NMNL analysis in Section 5.2.1.

These assumptions allow us to capture retail competition with a single decision variable, assortment size (also referred to as product variety), as follows. Setting $\mu_1 = \mu_2 = 1$, $p_{ij} = p$, and $u_{ij} = u$, we can rewrite $M_{ij}$ as

$$M_{ij} = \frac{a_0}{a_0 + (n_1 + n_2)a},$$

where $a = \exp(u - p)$ represents the attractiveness of each product on the market, $a_0 = \exp(u_0)$ represents the attractiveness of the no-purchase option. Furthermore, setting $w_{ij} = w$ and $\alpha_i = \alpha$, 

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we can rewrite retailer i’s expected profit as

$$\Pi_i(n_i|n_{3-i}) = (p - w) \frac{n_ia}{a_0 + (n_1 + n_2)a} - \alpha n_i. \quad (7)$$

Last, setting \( c_j = 0 \), we can rewrite manufacturer j’s expected profit as

$$\pi_j(n_1, n_2) = w(M_{1j} + M_{2j}) = w \frac{a(I_{1j} + I_{2j})}{a_0 + (n_1 + n_2)a}. \quad (8)$$

Note that \( n_i = 0 \) is a feasible solution leading to zero profit for retailer \( i = 1, 2 \). Thus, a special case of our formulation with \( n_2 = 0 \) can be interpreted as a setting with a monopolistic retailer.

3. Analysis

In this section, we analyze two models. First, we consider a benchmark model in which each retailer sets its own assortment size. Second, we consider a CC model in which \( R_1 \) delegates the assortment decision to a category captain. We generate our managerial insights by comparing the equilibrium outcomes of the benchmark and CC models.

3.1. Benchmark Model

In this section, we analyze a benchmark model in which both retailers adopt traditional category management. In the benchmark model, the focal retailer, \( R_1 \), and the competing retailer, \( R_2 \), simultaneously determine their assortment sizes \((n_1, n_2)\) to maximize their expected profits. That is, \( R_i \) solves the following problem:

$$\max_{n_i \geq 0} (p - w) \frac{n_ia}{a_0 + (n_1 + n_2)a} - \alpha n_i. \quad (9)$$

Although the assortment size is a non-negative integer in practice, we treat \( n_1 \) and \( n_2 \) as continuous variables. This is in line with Cachon et al. (2008) and Kurtuluş and Nakkas (2011), who also focus on assortment size optimization, and enables us to work with differentiable profit functions instead of performing discrete optimization.

Retailer \( i \)'s objective function in Equation (9) is concave in \( n_i \). Thus, for retailer \( i = 1, 2 \), combining the non-negativity constraint with the first-order condition leads to the following best response function

$$n_i^*(n_{3-i}) = \left( \sqrt{X_R (A_0 + n_{3-i} - (A_0 + n_{3-i})} \right)^+, \quad (10)$$

where \( (\cdot)^+ = \max\{0, \cdot\} \), \( A_0 = a_0/a \), and \( X_R \equiv (p - w)/\alpha \). Here, \( A_0 \) denotes the relative attractiveness of the no-purchase option with respect to \( a \), and \( X_R \) denotes the ratio of a retailer’s profit margin, \( p - w \), to its operational cost, \( \alpha \). Hereinafter, we refer to \( X_R \) as the operational efficiency
of a retailer because, all else being equal, a larger $X_R$ (i.e., a higher operational efficiency) enables a retailer to generate a higher return on its assortment investment.

Proposition 1 characterizes the equilibrium outcomes of the benchmark model by jointly solving the two retailers’ best response functions, $n^*_1(n_2)$ and $n^*_2(n_1)$. We present all proofs in Section B in the appendix.

**Proposition 1.** Let $\Phi \equiv 1 + \sqrt{1 + 8 \frac{A_0}{X_R}}$. If $X_R < A_0$, the benchmark model’s equilibrium assortment sizes are $n^*_1 = n^*_2 = 0$, and the corresponding equilibrium expected profits are $\Pi^*_1 = \Pi^*_2 = 0$. If $X_R \geq A_0$, then $n^*_1 = n^*_2 = \frac{1}{2} \left( \frac{X_R}{4} \Phi - A_0 \right)$ and $\Pi^*_1 = \Pi^*_2 = \alpha \frac{X_R}{4} \left( 1 - \frac{4A_0}{X_R\Phi} \right) \left( 1 - \frac{\Phi}{4} \right)$.

Proposition 1 shows that the benchmark model has a symmetric equilibrium. Specifically, when the retailers are inefficient (i.e., when $X_R < A_0$), they do not offer the category because doing so would lead to losses. When the retailers have relatively high operational efficiencies (i.e., when $X_R \geq A_0$), both retailers offer the category and select the same assortment size (i.e., $n^*_1 = n^*_2$). Figure 1 shows the retailers’ equilibrium assortment sizes, market shares, and profits as a function of $X_R$. Figure 1(a) reveals that improving $X_R$ allows both retailers to increase their assortment sizes, which in turn enables them to convert some non-purchasers into purchasers. That is, as Figure 1(b) shows, $M^*_1$ and $M^*_2$ increase in $X_R$. Figure 1(c) illustrates that a higher efficiency enables both retailers to generate higher profits.

**Figure 1 Equilibrium Outcomes of the Benchmark Model**

Notes. We generate these figures by setting $u_0 = 1$, $u = 1$, $p = 3$, and $w = 1$. We vary $\alpha$ between 0.025 and 0.5, which in turn varies $X_R$ between between 4 and 80. The retailers offer the category only when $X_R > A_0 = \exp(u_0 - u + p) = \exp(3) \approx 20.09$.

Having characterized the equilibrium solution for the benchmark model, we analyze the CC model next. In our subsequent analysis, we focus on a set of parameters that ensures positive profits for both retailers in the benchmark model (i.e., $\left\{ (p, w, \alpha, u, u_0) : X_R = \frac{p-w}{\alpha} \geq A_0 = \frac{\exp(u_0)}{\exp(u-p)} \right\}$) to rule out the uninteresting cases in which the retailers do not offer the category.
3.2. Category Captainship Model

In this section, we analyze a model in which the focal retailer delegates its assortment decision, $n_1$, to a category captain. In addition to making assortment decisions, captains in practice also seek to improve category presentation, as the CC examples in the introduction (i.e., Hormel Foods and Bayer HealthCare) show. We capture the captain’s effort to improve category presentation with an additional decision variable, $v$. Specifically, we assume that the captain’s effort changes the attractiveness of each product from $a$ to $va$ for $R_1$. Modeling the captain’s category presentation decision with an effort parameter is consistent with the CC literature (e.g., Subramanian et al. 2010, Kurtuluş et al. 2014a) and allows us to parsimoniously capture the notion that improving category presentation makes the category more attractive for consumers (Bauer et al. 2012).

Although the captain sets both $v$ and $n_1$, the captain incurs the cost of $v$, while $R_1$ incurs the cost of $n_1$. Splitting category management costs between $R_1$ and the captain is consistent with practice wherein captains incur merchandising-related costs and retailers incur assortment-related costs despite delegating assortment decisions to captains. For example, Alan et al. (2017) empirically examine a CC implementation in which the captain makes assortment decisions on behalf of a retailer without covering the retailer’s assortment-related costs (e.g., inventory, replenishment, shelf management). In our setting, $\alpha n_1$ captures such costs. By contrast, captains in practice incur costs associated with their category presentation efforts, such as designing an innovative category display (planogram), sponsoring a consumer education program, and finding the optimal location for the category within a retailer’s store. Following Kurtuluş et al. (2014a), we model the captain’s effort cost using a quadratic cost function, $\beta v^2$.

For ease of exposition, we assume that the retailers do not have the ability to improve category presentation by exerting costly effort on their own. In our robustness checks, however, we consider an alternative setting in which the retailers can exert costly effort. This alternative setting has two new decision variables (i.e., both retailers’ effort variables) in the benchmark model and one new decision variable (i.e., the competing retailer’s effort variable) in the CC model. Our analysis reveals that retailer effort does not change our main insights. We present our retailer effort analysis in Section 5.2.2.

In practice, leading manufacturers in each category (e.g., E&J Gallo Winery in the wine category, The Coca-Cola Co. in the soft drinks category) typically serve as category captains, and such manufacturers sell their products through multiple retailers. Accordingly, we assume that both retailers offer the category and carry the captain’s product. Thus, the captain’s expected profit
equals

\[ \pi_C(v, n_1|n_2) = w \frac{n_1 v a}{a_0 + n_1 v a + n_2 a} \left( \frac{1}{n_1} \right) + w \frac{n_2 a}{a_0 + n_1 v a + n_2 a} \left( \frac{1}{n_2} \right) - \beta v^2 \]

\[ = w \frac{1 + v}{A_0 + n_1 v + n_2} - \beta v^2. \tag{11} \]

Note that the captain’s effort does not affect the attractiveness of its product in \( R_2 \) because only the products sold through \( R_1 \) benefit from such an effort. Let \( X_C \equiv w/\beta \) denote the captain’s operational efficiency. Prior research has shown that the retailer usually selects a manufacturer that can bring a unique category management perspective as a category captain (e.g., Kurtuluş et al. 2014a). Accordingly, we assume that the captain in our context is the most efficient manufacturer (i.e., the one with the lowest \( \beta \)).

Retailers in practice set performance targets for their captains to ensure that they benefit from CC. Although retailers strive to maximize their category profits, they typically refrain from specifying a profit target because of anti-trust concerns (Federal Trade Commission 2003). Such concerns arise because a profit target requires a retailer to share the competing manufacturers’ terms of trade (e.g., wholesale prices) with its captain. Indeed, the CC literature contends that retailers typically specify their performance targets in terms of category sales (Alan et al. 2017). Following this literature, we assume that \( R_1 \) sets the terms of the CC agreement such that it not only delegates category management to the captain but also sets a sales target \( T \) to ensure that its unit sales do not fall below \( T \).

We formulate the CC model as a three-stage game. In stage 1, \( R_1 \) decides whether it should implement CC by comparing the expected profit it can obtain under CC with the expected profit it can obtain under traditional category management (i.e., the benchmark model). In stage 2, \( R_1 \) sets its sales target, \( T \), to maximize its expected profit. In stage 3, \( R_2 \) and the captain simultaneously make category management decisions. Specifically, the competing retailer sets its assortment size, \( n_2 \), to maximize its expected profit. Meanwhile, the captain chooses its effort level, \( v \), and \( R_1 \)’s assortment size, \( n_1 \). When choosing \( v \) and \( n_1 \), the captain aims to maximize its expected profit subject to the target sales constraint imposed by \( R_1 \). Note that the second and third stages of the game emerge only when \( R_1 \) decides to implement CC in the first stage (i.e., only when CC leads to a higher expected profit than traditional category management for \( R_1 \)). We incorporate the necessary participation constraint into the second stage to ensure that implementing CC does not make the captain worse off compared to the benchmark model.

We solve the model through backward induction. In stage 3, given \((n_1, v)\), \( R_2 \) solves

\[ \max_{n_2 \geq 0} \left( p - w \right) \frac{n_2}{A_0 + n_1 v + n_2} - \alpha n_2. \tag{12} \]
The competing retailer’s best response is
\[ n_2^*(n_1v) = \left( \sqrt{X_R (A_0 + n_1v)} - (A_0 + n_1v) \right)^+ , \] (13)

Note that Equation (13) has the same functional form as the best response function we derived in Equation (10) in the benchmark model. The only difference is that instead of responding to \( n_1, R_2 \) now responds to \( n_1v \). Let \( z \equiv n_1v \). Then, we can write the captain’s problem as
\[
\begin{align*}
\max_{v \geq 0, z \geq 0} & \quad w \frac{1 + v}{A_0 + z + n_2} - \beta v^2, \\
\text{s.t.} & \quad z \geq \frac{T}{1 - T} (A_0 + n_2).
\end{align*}
\] (14)
(15)

The captain’s objective function decreases in \( z \). Hence, the target sales constraint is binding at the optimal solution (i.e., \( z = \frac{T}{1 - T} (A_0 + n_2) \)). Furthermore, the captain’s objective function is concave in \( v \). As such, substituting \( z = \frac{T}{1 - T} (A_0 + n_2) \) into the captain’s objective function and solving the first-order condition with respect to \( v \) leads to
\[ v^*(n_2|T) = X_C \frac{1 - T}{2(A_0 + n_2)}. \] (16)

Furthermore, replacing \( v \) with \( X_C \frac{1 - T}{2(A_0 + n_2)} \) in the equality that \( n_1v = \frac{T}{1 - T} (A_0 + n_2) \) leads to
\[ n_2^*(n_2|T) = 2T \left( \frac{A_0 + n_2}{1 - T} \right)^2 . \] (17)

Lemma 1 characterizes the equilibrium outcomes of the category management sub-game played between the competing retailer and the captain by jointly solving the best response functions, \( n_2^*(n_1v), v^*(n_2|T) \), and \( n_2^*(n_2|T) \).

**Lemma 1.** Let \( A(T) \equiv \frac{X_R}{2} \left( T + \sqrt{T^2 + 4A_0} \right) \) and suppose that \( T \in [0, 1 - A_0/X_R] \). Then, the captain’s effort is \( \bar{v}(T) = \frac{X_C}{2A(T)} \left( \frac{A(T)^2}{X_R} - A_0 \right) \) and the assortment sizes for the focal and the competing retailers are \( \bar{n}_1(T) = \frac{2A(T)}{X_C} \left( \frac{A(T)^2}{X_R} - A_0 \right) \) and \( \bar{n}_2(T) = A(T) - \frac{A(T)^2}{X_R} \), respectively.

In Lemma 1, focusing on \( T \in [0, 1 - A_0/X_R] \) ensures that both retailers offer the category.

Lemma 1 implies that for a given \( T \), the expected profits for \( R_1 \) and the captain are
\[ \bar{\Pi}_1(T) = (p - w) \frac{n_1(T)v(T)}{A_0 + n_1(T)v(T) + n_2(T)} - \alpha \bar{n}_1(T) = (p - w) \frac{\bar{v}(T)n_1(T)}{A(T)} - \alpha \bar{n}_1(T) \] and
\[ \bar{\Pi}_C(T) = w \frac{T + \bar{v}(T)n_1(T) + \bar{n}_1(T)}{A(T)} - \beta \bar{v}(T) \overline{\bar{n}_1(T)} = \frac{w}{A(T)} \left( 1 + \frac{X_C}{2A(T)} \right) , \] respectively. In stage 2, \( R_1 \) sets the sales target, \( T \), to maximize its expected profit subject to the captain’s participation constraint. This constraint ensures that the captain’s expected profit in the CC model is no less than its expected profit in the benchmark model, which is \( \pi_C^B = \frac{2w}{A_0 + n_1^T + n_2} = \frac{4w}{X_R \Phi} \). Thus, \( R_1 \) solves
\[
\begin{align*}
\max_{T \geq 0} & \quad (p - w) \frac{\bar{v}(T)n_1(T)}{A(T)} - \alpha \bar{n}_1(T), \\
\text{s.t.} & \quad \frac{X_R}{A(T)} \left( 1 + \frac{X_C}{4A(T)} \right) \geq \frac{8}{\Phi} .
\end{align*}
\] (18)
(19)
where we obtain the participation constraint expression by rearranging the terms of \( \pi_C(T) \geq \pi_C^B \).

Proposition 2 characterizes the equilibrium sales target set by the focal retailer (i.e., the solution of Equations (18)-(19)) and the corresponding equilibrium outcomes for the retailers.

**Proposition 2.** Let \( \Theta \equiv \min \left\{ \left( \frac{X_C + 2A \Phi}{X_R} + \sqrt{\left( \frac{X_C + 2A \Phi}{X_R} \right)^2 + \frac{8A \Phi X_C}{3X_R^2}} \right)^{1/2}, \frac{1}{8} \left( \Phi + \sqrt{\Phi \left( \Phi + 8 \frac{X_C}{X_R} \right)} \right) \right\} \), \( X_C^C = 4X_R \left( \frac{8A \Phi}{4X_R} - \frac{1}{X_R} \right) \), and \( X_C \equiv 4X_R \left( \frac{8A \Phi}{4X_R} \right) \). Suppose that \( X_C \in [X_C^L, \bar{X}_C] \). In the CC equilibrium, the focal retailer sets \( T^C = \left( \frac{\Theta}{2} - \frac{\Phi}{X_C^\Theta} \right) \). Consequently, \( v^C = \frac{X_C^\Theta}{X_C^\Theta}, n_1^C = \frac{X_C^\Theta (X_C^\Theta - A)}{X_C^\Theta}, \) and \( n_2^C = \frac{X_C^\Theta (2 - \Theta)}{4} \). Furthermore, \( \Pi_1^C = \frac{\Phi - \Theta (2 - \Theta)}{4} \left( \Theta - \frac{4A \Phi}{X_C^\Theta} \right) \) and \( \Pi_2^C = \frac{\Phi - \Theta (2 - \Theta)}{4} \).

In Proposition 2, focusing on \( X_C \in [X_C^L, \bar{X}_C] \) ensures that both retailers offer the category. The proof of Proposition 2 reveals that when \( X_C \in [X_C^L, \bar{X}_C] \), \( R_1 \)'s objective function is concave in \( T \) and the left-hand side of the captain’s participation constraint, \( \frac{X_R}{A(T)} \left( 1 + \frac{X_C}{A(T)} \right) \), decreases in \( T \). Thus, the optimal \( T \) either solves the objective function’s first-order condition or is such that the captain’s participation constraint is binding.

Figure 2 shows the retailers’ equilibrium assortment sizes, market shares, and profits as a function of \( X_C \). Figure 2(a) illustrates that \( R_2 \)'s assortment size, \( n_2^C \), is greater than \( R_1 \)'s assortment size, \( n_1^C \), for small \( X_C \) values. Conversely, \( n_1^C > n_2^C \) for large \( X_C \) values. Figure 2(a) also illustrates that the captain’s effort, \( v^C \), increases in its efficiency. Indeed, Figure 2(b) shows that \( R_1 \)'s market share, \( M_1^C \), increases and \( R_2 \)'s market share, \( M_2^C \), decreases as the captain becomes more efficient. Consequently, \( R_1 \)'s expected profit, \( \Pi_1^C \), increases and \( R_2 \)'s expected profit, \( \Pi_2^C \), decreases in \( X_C \), as Figure 2(c) shows. This finding implies that among a set of manufacturers with varying efficiency levels, it would be optimal for the focal retailer to choose the most efficient manufacturer as the category captain.

In the first stage, the focal retailer compares the expected profit it can generate under CC, \( \Pi_1^C = \frac{\Phi - \Theta (2 - \Theta)}{4} \left( \Theta - \frac{4A \Phi}{X_C^\Theta} \right) \), with the expected profit it can generate under traditional category management, \( \Pi_1^T = \frac{\Phi - \Theta (2 - \Phi)}{4} \left( \Phi - \frac{4A \Phi}{X_C^\Phi} \right) \), to decide whether it should implement CC. Proposition 3 formalizes the focal retailer’s category management choice.

**Proposition 3.** There exists a threshold \( X_C \in [X_C^L, \bar{X}_C] \) such that the focal retailer prefers traditional category management when \( X_C \in [X_C^L, X_C^T] \) and CC when \( X_C \in [X_C, \bar{X}_C] \).

Proposition 3 reveals that \( R_1 \) does not implement CC when the captain has a relatively low efficiency. Revisiting Figure 2, both \( v^C \) and \( n_1^C \) are small when \( X_C < X_C^T \). As a result, the focal retailer’s market share is also small, which in turn leads to an outcome in which \( \Pi_1^C < \Pi_1^T \). Consequently, \( R_1 \) prefers traditional category management when \( X_C < X_C^T \). When \( X_C \geq X_C^T \), the captain is able to increase \( R_1 \)'s expected profit. Consequently, \( R_1 \) prefers CC.
4. Results

In this section, we compare the equilibrium outcomes of the benchmark and CC models to explore how CC affects the category stakeholders in the presence of retail competition.

4.1. Impact of CC on the Focal Retailer

The analytical CC literature explores the benefits of CC for retailers in settings in which a monopolistic retailer interacts with multiple manufacturers (e.g., Subramanian et al. 2010, Kurtuluş et al. 2014a). To create a contrast with this literature, we start our analysis with a special case of our model in which the competing retailer does not offer the category. This special case mimics a monopolistic retailer setting, and comparing it with our main model with two retailers enables us to delineate our contribution. We characterize the equilibrium outcomes of the monopolistic retailer case by setting the competing retailer’s assortment size to zero in the benchmark and CC models. Proposition 4 characterizes the equilibrium outcomes of the monopolistic retailer setting.

**Proposition 4.** In the benchmark model, the monopolistic retailer’s equilibrium assortment size is \( n_{1}^{MB} = \sqrt{X_{R}A_{0}} - A_{0} \). In the CC model, the retailer’s sales target is \( T^{MC} = 1 - \frac{2A_{0}}{X_{R} \theta^{M}} \), where \( \theta^{M} = \sqrt{\frac{X_{C}}{X_{R}}} \sqrt{\frac{X_{R}}{X_{R}}} \). The corresponding equilibrium effort level and assortment size are \( v^{MC} = \frac{X_{C}}{X_{R} \theta^{M}} \) and \( n_{1}^{MC} = \frac{X_{R} \theta^{M}}{X_{C}} \left( \frac{X_{R} \theta^{M}}{2} - A_{0} \right) \), respectively. Last, there exists a threshold \( X_{C}^{M} \geq X_{C}^{L} \) such that the retailer prefers traditional category management when \( X_{C} \in [X_{C}^{L}, X_{C}^{M}] \) and CC when \( X_{C} \geq X_{C}^{M} \).

The proof of Proposition 4 provides the details of the monopolistic retailer setting and demonstrates that CC emerges only when the captain’s efficiency level exceeds \( X_{C}^{M} \). Comparing this
threshold with the one we obtain in Proposition 3 allows us to examine how retail competition influences the emergence of CC. Proposition 5 formalizes this comparison.

**Proposition 5.** $X_C \geq X^M_C$, which implies that when $X_C \in [X^M_C, X_C)$, CC emerges in the absence, but not in the presence, of retail competition.

Proposition 5 reveals that when the captain has a relatively low efficiency, the competing retailer’s strategic response makes CC unattractive for the focal retailer. That is, retail competition prevents the emergence of CC when $X_C \in [X^M_C, X_C)$. This result arises because retail competition affects the levers through which CC generates value for the focal retailer. Specifically, let $\Delta \Pi_1 \equiv \Pi_1^C - \Pi_1^B$ denote the expected profit difference between the CC and benchmark models for $R_1$ in the presence of retail competition. We decompose $\Delta \Pi_1$ into three components as follows:

$$\Delta \Pi_1 = \Pi_1^C - \Pi_1^B = [(p - w) M_1^C - \alpha n_1^C] - [(p - w) M_1^B - \alpha n_1^B] = [(p - w)(1 - M_0^C - M_2^C) - \alpha n_1^C] - [(p - w)(1 - M_0^B - M_2^B) - \alpha n_1^B] = \begin{cases} \text{Category expansion, } \Delta \Pi_{11} & \text{Share shifting, } \Delta \Pi_{12} \\ \text{Cost reduction, } \Delta \Pi_{13} \end{cases} .$$

In Equation (20), $\Delta \Pi_{11} \equiv (p - w)(M_0^B - M_0^C)$ captures the category expansion effect CC generates by converting some non-purchasers to purchasers. Similarly, $\Delta \Pi_{12} \equiv (p - w)(M_2^B - M_2^C)$ captures the share shifting effect CC generates by enabling $R_1$ to steal some market share from $R_2$. Last, $\Delta \Pi_{13} \equiv \alpha(n_1^B - n_1^C)$ captures the cost reduction effect CC generates by facilitating a cost-sharing mechanism between $R_1$ and the captain.

Figure 3 demonstrates these three effects. The share shifting effect is zero in the absence of retail competition, as Figure 3(a) shows. Hence, only the category expansion and cost reduction effects are present for a monopolistic retailer. Figure 3(a) also shows that a moderately efficient captain generates value for a monopolistic retailer through the cost reduction effect. That is, the cost reduction effect is positive, and the market expansion effect is negative when the captain is moderately efficient. By contrast, a highly efficient captain enables a monopolistic retailer to increase its market share without increasing its operational cost. In other words, both the cost reduction and category expansion effects are positive when a monopolistic retailer works with a highly efficient captain.

Comparing Figures 3(a) and 3(b) reveals that retail competition affects the magnitudes of the cost reduction and market expansion effects. Nonetheless, these two effects remain qualitatively unchanged as the cost reduction effect decreases and the market expansion effect increases in the captain’s efficiency both in the absence and presence of retail competition. By contrast, the share
Notes. We generate these figures by setting $u_0 = 1$, $u = 1$, $p = 3$, $w = 1$, and $\alpha = 0.04$. We vary $\beta$ to vary the captain’s efficiency, $X_C$. In the monopolistic retailer setting depicted in Figure 3(a), CC emerges when $X_C \geq 80$ (i.e., $X_M = 80$). In the presence of retail competition depicted in Figure 3(b), CC emerges when $X_C \geq 109$ (i.e., $X_r = 109$). When $X_C \leq 234$ ($X_C > 234$), the benefit of CC for the focal retailer is higher in the absence (presence) of retail competition. In both figures, $\bar{X}_C = 324$.

The share shifting effect is negative when the captain has a relatively low efficiency. Consequently, as Proposition 5 formalizes, there is a range of $X_C$ values in which CC emerges in the absence, but not in the presence, of retail competition. (This range is $X_C \in \{80, 109\}$ in Figure 3.) Intuitively, retail competition prevents $R_1$ from implementing CC in this range because working with a relatively inefficient captain would result in a large market share loss to $R_2$.

The share shifting effect amplifies the benefit of CC when the captain is highly efficient. Specifically, Figure 3(b) shows that for large $X_C$ values, the magnitude of the share shifting effect is larger than the sum of the magnitudes of the category expansion and cost reduction effects. Indeed, when the captain is highly efficient, CC may generate more value for the focal retailer in the presence of retail competition. For example, when $X_C = 300$, the total benefit of CC is 0.54 in the absence and 0.65 in the presence of retail competition.

In summary, our model enables us to decompose the impact of CC on the focal retailer’s category profitability into three components. While previous CC studies analytically examined the cost reduction and category expansion effects in various forms, the absence of retail competition prevented those studies from exploring the share shifting effect and its interaction with the other two effects. We show that despite preventing the emergence of CC in some cases, the share shifting effect increases the upside potential of CC for the focal retailer. These findings imply that overlooking retail competition in analytical CC studies may lead to biased predictions regarding the emergence
of CC and its impact on a retailer’s profitability.

4.2. Impact of CC on the Competing Retailer

The analytical CC literature is silent on the impact of a retailer’s CC implementation on its competitors. By contrast, our model with two retailers enables us to examine (i) how the competing retailer adjusts its assortment size in response to the focal retailer’s CC implementation and (ii) how such an implementation affects the competing retailer’s profitability. Let $\Delta \Pi_2 \equiv \Pi^C_2 - \Pi^B_2$ denote the expected profit difference between the CC and benchmark models for the competing retailer. We decompose $\Delta \Pi_2$ into two components as follows:

$$\Delta \Pi_2 = \Pi^C_2 - \Pi^B_2 = [(p - w)M^C_2 - \alpha n^C_2] - [(p - w)M^B_2 - \alpha n^B_2]$$

$$= (p - w)(M^C_2 - M^B_2) + \alpha(n^B_2 - n^C_2).$$

(21)

In Equation (21), the share shifting effect, $\Delta \Pi_{21} \equiv (p - w)(M^C_2 - M^B_2)$, captures the impact of $R_1$’s CC implementation on $R_2$’s market share. Note that $\Delta \Pi_{21} = -\Delta \Pi_{12}$, which implies that $\Delta \Pi_{12}$ and $\Delta \Pi_{21}$ capture the impact of consumer switching between the two retailers from $R_1$’s and $R_2$’s perspectives, respectively. In addition, the cost reduction effect, $\Delta \Pi_{22} \equiv \alpha(n^B_2 - n^C_2)$, captures the impact of $R_1$’s CC implementation on $R_2$’s operational cost. Proposition 6 formalizes how the captain’s efficiency affects $\Delta \Pi_2$ and its components, $\Delta \Pi_{12}$ and $\Delta \Pi_{22}$.

**Proposition 6.** Let $\hat{X}_C \equiv X_{R_1}$. In the presence of retail competition, $\Delta \Pi_2 \geq 0$ when the captain is moderately efficient (i.e., when $X_C \in [\hat{X}_C, \tilde{X}_C]$) and $\Delta \Pi_2 < 0$ when the captain is highly efficient (i.e., when $X_C \in (\hat{X}_C, \tilde{X}_C]$). Furthermore, there exists a threshold $\hat{X}_C$ such that $\hat{X}_C \leq \tilde{X}_C$. If $\hat{X}_C \leq X_C$, then $\Delta \Pi_{22} \leq 0 \leq \Delta \Pi_{21}$ when $X_C \in [\hat{X}_C, \tilde{X}_C]$. If $\hat{X}_C > X_C$, then $\Delta \Pi_{21} > 0$ and $\Delta \Pi_{22} > 0$ when $X_C \in (\hat{X}_C, \tilde{X}_C)$ and $\Delta \Pi_{22} \leq 0 \leq \Delta \Pi_{21}$ when $X_C \in [\hat{X}_C, \tilde{X}_C]$. Last, $\Delta \Pi_{22} > 0 > \Delta \Pi_{21}$ when $X_C \in (\hat{X}_C, \tilde{X}_C)$.

Proposition 6 indicates that the captain’s efficiency level determines whether $R_2$ benefits or suffers from $R_1$’s CC implementation. It also reveals that the share shifting and cost reduction effects can work in opposite directions for $R_2$. Figure 4 complements Proposition 6 by illustrating how $\Delta \Pi_2$ and its components vary as a function of the captain’s efficiency. When $R_1$ works with a highly efficient captain (i.e., when $X_C \in [\hat{X}_C, \tilde{X}_C]$), $R_2$ shrinks its assortment size and, in doing so, loses some market share to $R_1$. While lowering the assortment size creates a positive cost reduction effect (i.e., $\Delta \Pi_{22} > 0$), the share shifting effect is more dominant. Consequently, $R_2$’s expected profit declines.
Notes. We generate this figure by setting $u_0 = 1, u = 1, p = 3, w = 1$, and $\alpha = 0.04$. We vary $\beta$ to vary the captain’s efficiency, $X_C$. The resulting thresholds are $X_C = 109, \hat{X}_C = 153$, and $\bar{X}_C = 324$.

Unlike a highly efficient captain, a moderately efficient captain makes $R_2$ better off. When $R_1$ works with a moderately efficient captain (i.e., when $X_C \in [X_C, \hat{X}_C]$), $R_2$ increases its assortment size and thereby steals market share from $R_1$. Consequently, the cost reduction effect is negative and the share shifting effect is positive for $R_2$. Notably, the combination of these two effects is positive, which implies that the competing retailer benefits from the focal retailer’s CC implementation with a moderately efficient captain.

In summary, our findings suggest that the captain’s efficiency level determines whether the competing retailer increases or decreases its assortment size as a response to the focal retailer’s CC implementation. The captain’s efficiency also determines whether the competing retailer benefits or suffers from the focal retailer’s CC implementation. It is important to note that the focal retailer’s CC implementation does not always hurt the competing retailer. Indeed, our findings suggest that despite competing head-to-head with the focal retailer, the competing retailer can actually benefit from the focal retailer’s CC implementation.

4.3. Impact of CC on the Captain

Previous analytical studies on CC focus on settings in which the captain can sell its product only through a monopolistic retailer (e.g., Subramanian et al. 2010, Kurtuluş and Toktay 2011). However, captains in practice sell their products through multiple retailers. Thus, it is of interest to examine how the presence of the competing retailer influences the captain’s profitability. Let $\Delta \pi_C \equiv \pi_C^C - \pi_C^B$ denote the expected profit difference between the CC model and the benchmark model for the captain. We decompose $\Delta \pi_C$ into the changes in profits the captain generates through
the focal retailer and the competing retailer ($\Delta \pi_{C1}$ and $\Delta \pi_{C2}$, respectively) as follows:

$$\Delta \pi_C = \pi^C_C - \pi^R_C$$

$$= \left( w \frac{1 + v^C}{A_0 + n_1^C v^C + n_2^C} - 2 \frac{1 - \beta (v^C)^2}{A_0 + n_1^B + n_2^B} \right)$$

$$= w \left( \frac{v^C}{A_0 + n_1^C v^C + n_2^C} - 2 \frac{1}{A_0 + n_1^B + n_2^B} - \beta (v^C)^2 \right) - \beta (v^C)^2$$

$$\Delta \pi_{C1} = w \left( \frac{1}{A_0 + n_1^C v^C + n_2^C} - \frac{1}{A_0 + n_1^B + n_2^B} \right).$$

The focal retailer channel, $\Delta \pi_{C1}$

$$\Delta \pi_{C2} = w \left( \frac{1}{A_0 + n_1^C v^C + n_2^C} - \frac{1}{A_0 + n_1^B + n_2^B} \right).$$

The competing retailer channel, $\Delta \pi_{C2}$

(22)

In a monopolistic retailer setting, $\Delta \pi_{C2}$ would not exist due to the absence of the competing retailer channel. As such, $\Delta \pi_{C1}$ would never be negative because of the captain’s participation constraint. Likewise, $\Delta \pi_C$ can never be negative in the presence of retail competition. However, it is difficult to predict the sign and magnitude of $\Delta \pi_{C1}$ and $\Delta \pi_{C2}$. Proposition 7 formalizes the link between the captain’s efficiency and the change in the expected profit it generates through each retailer.

**Proposition 7.** *In the presence of retail competition, $\Delta \pi_{C1} \leq 0 \leq \Delta \pi_{C2}$ when the captain is moderately efficient (i.e., when $X_C \in [X_C, \tilde{X}_C]$), and $\Delta \pi_{C1} > 0 > \Delta \pi_{C2}$ when the captain is highly efficient (i.e., when $X_C \in (\tilde{X}_C, \bar{X}_C]$).*

Proposition 7 reveals that a highly efficient captain increases the expected profit it generates through the focal retailer channel. Meanwhile, a highly efficient captain also leads to a decrease in the competing retailer’s market share. Consequently, the expected profit the captain generates from $R_2$ decreases because fewer customers purchase the captain’s product through that channel. The dynamics reverse for a moderately efficient captain. Specifically, a moderately efficient captain experiences a decline in the expected profit it generates through $R_1$ (i.e., $\Delta \pi_{C1} \leq 0$ when $X_C \in [X_C, \tilde{X}_C]$). Nevertheless, the captain offsets its losses by increasing the expected profit it generates through $R_2$ (i.e., $\Delta \pi_{C2} \geq 0$ when $X_C \in [X_C, \tilde{X}_C]$). Intuitively, $R_2$ increases its market share when $R_1$ works with a moderately efficient captain. Consequently, the expected profit the captain generates from $R_2$ increases because more customers purchase the captain’s product through $R_2$. By contrast, a combination of the CC implementation costs and the decrease in $R_1$’s market share leads to a decline in the expected profit a moderately efficient captain generates through $R_1$.

In summary, our analysis of the captain’s profit reveals that a manufacturer may agree to serve as a captain even though CC leads to a decline in the profit it generates through the focal retailer channel. It does so because of retail competition, which enables the captain to increase its profit.
through the competing retailer channel. This finding suggests that the captain should pay attention to the competing retailer channel to fully assess the costs and benefits of serving as a captain.

4.4. Impact of CC on Consumers

The CC literature points out the possibility that CC may restrict manufacturer competition in ways that harm consumers (e.g., Desrochers et al. 2003). Motivated by this possibility, we examine how retail competition influences the impact of CC on consumers. Because we assume that all products have the same retail price, we assess the impact of CC on consumers by analyzing the market penetration of the category (i.e., the proportion of consumers who shop in the category).

Let $\Delta \pi_S \equiv (M_{C1} + M_{C2}) - (M_{B1} + M_{B2})$ denote the difference between the proportion of consumers who shop in the category in the CC and benchmark models. Proposition 8 formalizes how the captain's efficiency affects $\Delta \pi_S$ in the presence of retail competition.

**Proposition 8.** In the presence of retail competition, $\Delta \pi_S \leq 0$ when the captain is moderately efficient (i.e., when $X_C \in [\hat{X}_C, \bar{X}_C]$), and $\Delta \pi_S > 0$ when the captain is highly efficient (i.e., when $X_C \in (\hat{X}_C, \bar{X}_C]$).

Proposition 8 reveals that consumers benefit when the focal retailer works with a highly efficient captain. By contrast, a moderately efficient captain hurts consumers by leading to a decrease in the market penetration of the category. This finding suggests that antitrust concerns persist in the presence of retail competition. But then how does retail competition affect the magnitude of $\Delta \pi_S$? Note that $\Delta \pi_S = (M_{C1} + M_{C2}) - (M_{B1} + M_{B2}) = M_B^0 - M_C^0$ is a linear function of the category expansion effect, $\Delta \Pi_{11} = (p - w)(M_B^0 - M_C^0)$, we analyzed in Section 4.1. Also, recall from Proposition 5 that there exists a range of $X_C$ values in which CC emerges in the absence, but not in the presence, of retail competition. Figure 3(a) shows that $\Delta \Pi_{11}$ (and, therefore, $\Delta \pi_S$) attains its smallest values in this range. In other words, implementing CC would be most harmful for consumers in this range because this is the range in which the market penetration of the category shrinks the most. By preventing the emergence of CC in this range, retail competition preempts large drops in the market penetration of the category.

In summary, we find that the antitrust concerns raised in the literature persist in the presence of retail competition. Nonetheless, retail competition alleviates the antitrust concerns because it prevents a retailer from implementing CC in cases in which the negative impact of CC on consumers would be most severe. This finding suggests that the analytical CC literature, which overlooks retail competition, may be overstating the potential negative impact of CC on consumers.
5. Discussion of Competitive Dynamics and Robustness Tests

Sections 4.1–4.4 generate results on the role of retail competition in CC implementations by comparing the equilibrium outcomes of the benchmark and CC models. In this section, we first provide an alternative perspective on our results by focusing on the competitive dynamics between $R_1$ and $R_2$. Then, we test the robustness of such dynamics and our managerial insights by numerically relaxing some of our modeling assumptions.

5.1. Discussion of Competitive Dynamics

We use the difference between the two retailers’ market shares as a proxy for $R_1$’s competitive strength with respect to $R_2$. Figure 5(a) shows the market share dynamics between the two retailers, while Figure 5(b) shows the two retailers’ equilibrium profits. In the benchmark model, $\Delta M^B = M^B_1 - M^B_2 = 0$, which implies that $R_1$ and $R_2$ are equally competitive. When the captain has low or moderate efficiency, CC weakens the competitive position of the focal retailer. That is, $\Delta M^C = M^C_1 - M^C_2 < 0$ when $X_C < \tilde{X}_C$. In such situations, $R_1$ faces the following tradeoff: On the one hand, $R_1$’s weak competitive position means lower revenues. On the other hand, it means lower operational expenses due to the reduction in $R_1$’s assortment size. Hence, when CC weakens $R_1$’s competitive position, $R_1$’s CC implementation decision depends on whether its operational expenses fall more than its revenues.

When the captain’s efficiency is low (i.e., when $X_C < \bar{X}_C$), $R_1$’s weak competitive position would be too detrimental for its revenues, leading to a decline in $R_1$’s profit. Consequently, $R_1$ does not implement CC. When the captain is moderately efficient (i.e., when $X_C \in [\bar{X}_C, \tilde{X}_C]$), $R_1$ implements CC despite losing market share to $R_2$. This is because when the captain is moderately efficient, the decline in $R_1$’s revenues is smaller than the decline in its operational expenses. When the captain is highly efficient (i.e., when $X_C \geq \tilde{X}_C$), CC enables $R_1$ to strengthen its competitive position, which in turn translates into a sizable increase in its profit.

The competitive dynamics between $R_1$ and $R_2$ also impact the captain and consumers. Namely,
when the captain is moderately efficient, $R_2$’s strong competitive position has two conflicting implications for the captain. On the one hand, the captain has access to more consumers through $R_2$. On the other hand, the proportion of $R_2$’s consumers that purchase the captain’s product is smaller compared to the benchmark model because $R_2$ carries a larger assortment. It turns out that the first effect is more dominant, implying that it is better for the captain to receive a smaller portion of a larger pie than a larger portion of a smaller pie. In other words, $R_1$’s CC implementation increases (decreases) the profit the captain generates through $R_2$ in cases in which CC strengthens (weakens) $R_2$’s competitive position. Last, when CC weakens $R_1$’s competitive position, it also lowers the overall market penetration of the category (i.e., $M_{C1} + M_{C2} < M_{B1} + M_{B2}$ when $\Delta M^C < 0$). In other words, consumers benefit (suffer) from CC in cases in which CC strengthens (weakens) $R_1$’s competitive position.

5.2. Robustness Tests

5.2.1. Nested Logit Structure

In our main model, we normalize the retailer and product heterogeneity parameters ($\mu_1$ and $\mu_2$, respectively) to one. In Section A.1 in the appendix, we explore a more general model in which $\mu_1/\mu_2 \geq 1$. Specifically, following Kök and Xu (2011), we set $\mu_2 = 1$ but allow $\mu_1 > 1$ so that the retailer-specific random utility term, $\epsilon_i$, becomes relatively more important than the product-specific random utility term, $\epsilon_{ij}$. Allowing $\mu_1 > 1$ influences the equilibrium outcomes. For example, we find that the efficiency thresholds $X_C$, above which $R_1$ implements CC, and $\tilde{X}_C$, above which the captain is considered highly efficient, decrease in $\mu_1$. Consequently, a captain that is considered
to have low efficiency when \( \mu_1 = 1 \) maybe considered to have high efficiency when \( \mu_1 > 1 \).

Our numerical analysis suggests that despite influencing the equilibrium outcomes, setting \( \mu_1 > 1 \) does not change our main managerial insights. Recall from Section 5.1 that the competitive dynamics between the two retailers determine the impact of CC on the focal retailer, competing retailer, captain, and consumers. Figure 6(a) illustrates those competitive dynamics under an NMNL model with \( \mu_1 > 1 \). When the captain’s efficiency is low, \( R_1 \) does not implement CC because doing so would severely weaken its competitive position with respect to \( R_2 \). When the captain is moderately efficient, \( R_1 \) implements CC. In this region, \( R_1 \)’s CC implementation strengthens \( R_2 \)’s competitive position, so \( R_2 \)’s profit increases. Last, when the captain is highly efficient, CC weakens \( R_2 \)’s competitive position and thereby lowers \( R_2 \)’s profit. Note that these dynamics are qualitatively the same as the ones we discussed in Section 5.1. As a result, our managerial insights continue to hold when \( \mu_1 > 1 \). See Section A.1 in the appendix for details.

5.2.2. Retailer Effort

In our main model, the captain has the ability to exert effort and thereby change the attractiveness of each product in the focal retailer’s assortment, whereas the retailers are unable to exert such effort. In Section A.2 in the appendix, we consider an alternative model in which the retailers also have the ability to exert effort. Let \( v_i \) denote retailer \( i \)'s effort. We assume that retailer \( i \)'s effort changes the attractiveness of each product in its assortment from \( a \) to \( v_i a \). We further assume that retailer \( i \) incurs a quadratic effort cost, \( \beta_r v_i^2 \), where \( \beta_r \) is the unit cost of effort for the retailers. In the benchmark model, the two retailers simultaneously optimize their assortment sizes and effort levels to maximize their expected profits. In the CC model, the first two stages are identical to those in our original formulation. In the last stage of the CC model, the captain and \( R_2 \) simultaneously make category management decisions, where the captain sets \( n_1 \) and \( v_1 \) subject to the target sales constraint imposed by \( R_1 \), while \( R_2 \) sets \( n_2 \) and \( v_2 \).

Our numerical analysis suggests that the threshold efficiency level above which \( R_1 \) implements CC, \( X_C \), decreases in \( \beta_r \). Intuitively, \( R_1 \) delegates category management decisions to a captain only when the captain has superior category management capabilities. Put differently, a manufacturer’s efficiency may be high enough to help a retailer with a high \( \beta_r \), whereas the same manufacturer may not qualify as a captain for a retailer with a low \( \beta_r \). Thus, \( X_C \) decreases in \( \beta_r \), which implies that the presence of retailer effort can influence the equilibrium outcomes. Nevertheless, retailer effort does not change the competitive dynamics between \( R_1 \) and \( R_2 \). Figure 6(b), shows the retailers’ market shares in a setting with retailer effort. Comparing Figure 6(b) with Figure 5 reveals that the competitive dynamics between the retailers remain qualitatively unchanged. Consequently, our
Figure 6 Robustness of the Competitive Dynamics Between $R_1$ and $R_2$

Notes. In all four figures, we vary $\beta$ to vary $X_C$, which is low when $X_C \leq \bar{X}_C$, moderate when $X_C \in [\bar{X}_C, \hat{X}_C)$, and high when $X_C \geq \hat{X}_C$. In Figure 6(a), we set $p = 3$, $w = 1$, $u_0 = 1$, $u = 1$, $\alpha = 0.02$, and $\mu_1 = 1.5$. In Figure 6(a), $\bar{X}_C = 93$ and $\hat{X}_C = 186$. See Section A.1 in the appendix for details. In Figure 6(b), we set $p = 3$, $w = 1$, $u_0 = 1$, $u = 1$, $\alpha = 0.02$, and $\beta_r = 0.15$. In Figure 6(b), $X_C = 98$ and $\bar{X}_C = 392$. See Section A.2 in the appendix for details. In Figure 6(c), we set $m = 2$, $w_1 = 1$, $u_0 = 1$, $u = 1$, $\alpha = 0.02$, and $r = 0.85$. In Figure 6(c), $\bar{X}_C = 101$ and $\hat{X}_C = 119$. See Section A.3 in the appendix for details. In Figure 6(d), we set $u_0 = 1$, $u = 1$, $c_1 = 0.5$, $r = 0.95$, and $\alpha = 0.02$. In Figure 6(d), $X_C = 90$ and $\bar{X}_C = 136$. See Section A.4 in the appendix for details.

Managerial insights continue to hold in the presence of retailer effort. See Section A.2 in the appendix for details.

5.2.3. Differentiated Products

In our main model described in Section 2, we assume identical parameters across products. In Section A.3 in the appendix, we consider an alternative model in which the manufacturers offer differentiated products. Let $m_{ij} = p_{ij} - w_{ij}$ denote the gross margin for product $j$ offered by retailer $i$. We assume that the gross margins, $m_{ij}$, are identical across products and retailers. That is, $m_{ij} = m$ for $j \in \mathcal{N}_i$ and $i = 1, 2$. We also assume that for product $j$, the deterministic component of its utility, $u_{ij}$, and its wholesale price, $w_{ij}$, are identical across retailers. That is, $u_{1j} = u_{2j} = u_j$.
and \( w_{1j} = w_{2j} = w_j \). These two assumptions enable us to rewrite the attractiveness of product \( j \) as \( a_j = \exp(u_j - (m + w_j)) \).

Without loss of generality, we index products in a descending order based on their attractiveness levels (i.e., \( a_1 > a_2 > ... \)). Furthermore, we assume that \( a_{j+1} = r a_j \), where \( r \in (0, 1) \). Imposing this structure enables us to capture product differentiation with a single parameter, \( r \), where products become more differentiated as \( r \) decreases. Because the assortment cost \( \alpha \) is identical across products and because carrying a more attractive product has a higher marginal benefit, both retailers carry the most attractive products in their assortments. That is, setting retailer \( i \)'s assortment size equal to \( n_i \) implies that retailer \( i \)'s assortment is \( N_i = \{1, 2, \cdots, n_i\} \). Consequently, as we show in Section A.3 in the appendix, we can continue to write the retailers’ and the captain’s expected profits as a function of the retailers’ assortment sizes \( n_1 \) and \( n_2 \). In the benchmark model, \( R_1 \) and \( R_2 \) simultaneously optimize their assortment sizes to maximize their expected profits. In the CC model, we assume that the captain manufacturer is the one with the highest product attractiveness, \( a_1 \), and that implementing CC changes the attractiveness of product \( j \) from \( a_j \) to \( v a_j \) in the focal retailer’s assortment. All three stages of the CC model are identical to those in our original model.

Our numerical analysis suggests that the captain’s efficiency thresholds \( X_C \) and \( \hat{X}_C \) increase in the degree of product similarity, \( r \). Intuitively, a smaller \( r \) decreases the benefit of carrying a large assortment because the overall attractiveness of a retailer’s assortment decreases in \( r \). As such, a manufacturer has more room to improve category performance when \( r \) is small. Hence, the threshold efficiency value above which \( R_1 \) implements CC, \( X_C \), increases in \( r \). Similarly, \( R_2 \) can better cope with \( R_1 \)'s CC implementation when \( r \) is large. Put differently, a small \( r \) makes it more difficult for \( R_2 \) to benefit from \( R_1 \)'s CC implementation. Consequently, the threshold value above which \( R_2 \) suffers from \( R_1 \)'s CC implementation, \( \hat{X}_C \), also decreases in \( r \). Despite affecting the equilibrium outcomes, product differentiation does not change the competitive dynamics between \( R_1 \) and \( R_2 \). Figure 6(c) shows the retailers’ market shares in a setting with differentiated products. Comparing Figure 6(c) with Figure 5 reveals that the competitive dynamics between the retailers remain qualitatively unchanged. Consequently, our managerial insights continue to hold in the presence of differentiated products. See Section A.3 in the appendix for details.

### 5.2.4. Strategic Retail and Wholesale Pricing

In our main model, we assume exogenous retail and wholesale prices. In Section A.4 in the appendix, we consider an alternative model in which the retailers and manufacturers strategically optimize their prices. In our analysis, we closely follow the game-theoretic setup proposed by Heese and Martínez-de Albéniz (2018) in which a single retailer interacts with multiple manufacturers.
We extend the setting proposed by Heese and Martínez-de Albéniz (2018) to two retailers. We consider the following sequence of events in our benchmark model. In the first stage, the retailers simultaneously announce their assortment sizes without announcing their actual assortments. In the second stage, the manufacturers simultaneously determine the wholesale prices they will offer to each retailer. In the third stage, the retailers simultaneously determine their assortments. In the last stage, the retailers simultaneously determine their retail prices.

We consider the following sequence of events in the CC model. In the first stage, \( R_1 \) decides whether it should implement CC. In the second stage, \( R_1 \) sets a sales target for the captain. In the third stage, the retailers simultaneously announce their assortment sizes. In this stage, the captain makes the assortment size decision on behalf of \( R_1 \). In the fourth stage, the manufacturers simultaneously determine the wholesale prices they will offer to each retailer. In the fifth stage, the captain and \( R_2 \) simultaneously make category management decisions. That is, the captain determines its effort level, \( v \), and \( R_1 \)'s assortment, while \( R_2 \) determines its assortment. Similar to our original model, the captain’s effort changes the attractiveness of a product from \( a_{1j} \) to \( va_{1j} \) in \( R_1 \)'s assortment. In the last stage, the retailers simultaneously set their retail prices. Note that we do not allow \( R_1 \) to delegate the retail pricing decision to the captain to be consistent with practice in which the captain manufacturers do not typically make retail pricing decisions due to anti-trust concerns (Federal Trade Commission 2003).

We make the following assumptions to simplify our analysis. First, we assume that the deterministic component of product \( j \)'s utility is identical across retailers (i.e., \( u_{1j} = u_{2j} = u_j \)). We refer to \( \bar{a}_j = \exp(u_j - c_j) \) as the base attractiveness of product \( j \). Second, we assume that the captain’s product has the highest base attractiveness. Third, we assume that \( \bar{a}_{j+1} = r\bar{a}_j \) for all \( j \geq 1 \), where \( r \in (0, 1) \). Without loss of generality, we rank the products such that a lower-ranked product has a higher base attractiveness (i.e., \( \bar{a}_j > \bar{a}_k \) for \( j < k \)). Furthermore, we impose the equilibrium structure developed by Heese and Martínez-de Albéniz (2018) to our problem. Specifically, each retailer carries the most attractive products in its assortment. That is, for a given \( (n_1, n_2) \) pair, we have \( \mathcal{N}_1 = \{1, 2, \ldots, n_1\} \) and \( \mathcal{N}_2 = \{1, 2, \ldots, n_2\} \). In addition, retailer \( i \) has the same margin \( m_i \) for all \( j \in \mathcal{N}_i \). Hence, in the retail price optimization stages of the benchmark and CC models, the retailers simultaneously determine their margins, \( m_1 \) and \( m_2 \). Last, the products are sufficiently similar (i.e., \( r \) is relatively large) so that manufacturer \( j \in \mathcal{N}_i \) sets its wholesale price so as to offer exactly the attractiveness of the first excluded product (i.e., product \( n_i + 1 \)).

Our numerical analysis suggests that the manufacturers lower their wholesale prices as a response to a decrease in a retailer’s assortment size. Intuitively, when a retailer reduces its assortment size, the manufacturers have to compete for a smaller number of available slots in the assortment,
leading to lower wholesale prices, as discussed by Heese and Martínez-de Albéniz (2018). For example, when the captain’s efficiency is low, $R_2$ responds to $R_1$’s CC implementation by increasing its assortment size, which in turn leads to an increase in the wholesale prices it receives from the manufacturers. By contrast, $R_2$ decreases its assortment size when $R_1$ works with a highly efficient captain. This assortment size reduction leads to a decline in the wholesale prices it receives from the manufacturers. Our analysis also reveals that a larger assortment and/or higher effort enables a retailer to increase its retail margins. Furthermore, retail margins and market shares move in the same direction. That is, when CC leads to an increase in a retailer’s margin, it also leads to an increase in the same retailer’s market share. Figure 6(d) shows the retailers’ market shares in a setting with strategic pricing. Comparing Figure 6(d) with Figure 5 reveals that the competitive dynamics between the retailers remain qualitatively unchanged. Consequently, our managerial insight continue to hold in the presence of strategic retail and wholesale pricing. See Section A.4 in the appendix for details.

6. Conclusion

We examine the role of retail competition in CC implementations using a game-theoretic setting with two competing retailers. Our analysis leads to four main insights. First, despite preventing the emergence of CC in some cases, retail competition increases the upside potential of CC for the focal retailer. Second, the competing retailer can benefit from the focal retailer’s CC implementation. Third, a manufacturer may agree to serve as a captain even though CC leads to a decline in the profit it generates through the focal retailer channel because retail competition enables the captain to recoup its losses through the competing retailer channel. Fourth, retail competition alleviates the concerns about the potential negative impact of CC on consumers. We derive these insights from a stylized model with several simplifying assumptions. Our robustness checks demonstrate that our insights continue to hold when we relax some of those assumptions.

Our findings have important implications for researchers, managers, and policymakers. The main implication of our study for researchers is that conclusions drawn from previous analytical CC studies, which overlook retail competition, should be treated with caution. This is because studying CC in a monopolistic retailer setting may lead to biased predictions about the emergence of CC and its impact on the category stakeholders. From a managerial standpoint, our study implies that the focal retailer should pay close attention to the direction and magnitude of the share shifting effect. This is because the emergence of CC and its benefits for the focal retailer depend heavily on whether CC enables the focal retailer to steal market share from its competitor. The competing retailer should also pay close attention to the share shifting effect because stealing market share
from the focal retailer may enable the competing retailer to benefit from the focal retailer’s CC implementation. CC also affects the profit the captain generates through the competing retailer channel. Thus, another implication of these market share dynamics is that a manufacturer should go beyond the focal retailer to fully assess the costs and benefits of serving as a captain. Last, our findings imply that policymakers should take the alleviating impact of retail competition into consideration in their antitrust analysis.

In summary, by studying CC in the presence of retail competition, we not only sharpen the existing literature’s predictions about the emergence of CC and its impact on the focal retailer, captain, and consumers, but also generate new insights into the impact of CC on the competing retailer. We hope that this article generates more interest in examining CC and other supply chain collaboration practices in the presence of retail competition.

References


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Appendix

A. Robustness Tests

In this section, we relax some of our modeling assumptions to demonstrate the robustness of our managerial insights.

A.1. Nested Logit Structure

In our main model described in Section 2, we normalize the retailer and product heterogeneity parameters (μ₁ and μ₂, respectively) to one. In this section, we follow Kök and Xu (2011) to explore a more general formulation in which μ₁/μ₂ ≥ 1. Specifically, we continue to set μ₂ = 1, but allow μ₁ > 1 so that the retailer-specific random utility term εᵢ, which appears in the first stage of the consumer choice process, becomes relatively more important than the product-specific random utility term, εᵢⱼ, which appears in the second stage of the consumer choice process. We retain our remaining assumptions (e.g., identical model parameters across products and retailers, exogenous retail and wholesale prices). Consequently, we can isolate the impact of μ₁ by comparing the equilibrium outcomes of a model with μ₁ > 1 with those of our original model in which μ₁ = 1.

In the benchmark model, the expected utility of choosing retailer i is

\[ A_i = E[\max_{k \in \mathcal{N}_i} U_{ik}] = \mu_2 \ln (\sum_{k \in \mathcal{N}_i} \exp ((u_{ik} - p_{ik})/\mu_2)) = \ln(n_i a), \]

where \( a = \exp(u - p) \). Consequently, using Equation (2), we can write retailer i’s market share as

\[ M_i = \frac{\exp(A_i/\mu_1)}{\exp(u_0/\mu_1) + \sum_{l=1}^{2} \exp(A_l/\mu_1)} \]

\[ = \frac{\exp(\ln(n_i a)/\mu_1)}{n^{1/\mu_1} + \sum_{l=1}^{2} \exp(\ln(n_l a)/\mu_1)} \]

\[ = \frac{A_0^{1/\mu_1} + n^{1/\mu_1} + n_2^{1/\mu_2}}{A_0^{1/\mu_1} + n^{1/\mu_1} + n_2^{1/\mu_2}}. \]

In the benchmark model, \( R_1 \) and \( R_2 \) simultaneously optimize their assortment sizes to maximize their expected profits. That is, \( R_i \) solves the following problem:

\[ \max_{n_i \geq 0} (p - w) \left( \frac{n_i^{1/\mu_1}}{A_0^{1/\mu_1} + n_1^{1/\mu_1} + n_2^{1/\mu_2}} - \alpha n_i. \right) \]

In the CC model, we continue to assume that the captain’s effort changes the attractiveness of each product from \( a \) to \( va \) in \( R_1 \)’s assortment. In the last stage of the CC model, the captain and
$R_2$ simultaneously make category management decisions. That is, given $(n_1, v)$, $R_2$ solves

$$\max_{n_2 \geq 0} \quad (p - w) \frac{n_2^{1/\mu_1}}{A_0^{1/\mu_1} + (n_1v)^{1/\mu_1} + n_2^{1/\mu_1} - \alpha n_2}.$$  \hfill (27)

In the same stage, given $n_2$ and the sales target, $T$, imposed by $R_1$, the captain solves

$$\max_{n_1 \geq 0, v \geq 0} \quad w \left( \frac{1}{n_1} \left( \frac{(n_1v)^{1/\mu_1}}{A_0^{1/\mu_1} + (n_1v)^{1/\mu_1} + n_2^{1/\mu_1}} \right) + \frac{1}{n_2} \left( \frac{n_2^{1/\mu_1}}{A_0^{1/\mu_1} + (n_1v)^{1/\mu_1} + n_2^{1/\mu_1}} \right) \right) - \beta v^2$$  \hfill (28)

$$\text{s.t.} \quad \frac{(n_1v)^{1/\mu_1}}{A_0^{1/\mu_1} + (n_1v)^{1/\mu_1} + n_2^{1/\mu_1}} \geq T.$$  \hfill (29)

In the second stage, $R_1$ sets its sales target $T$ subject to the captain’s participation constraint. Finally, in the first stage, $R_1$ decides whether it should implement CC by comparing the expected profit it can obtain under CC with the one it can obtain in the benchmark model.

The retailer heterogeneity parameter, $\mu_1$, prevents us from deriving the equilibrium outcomes of the benchmark and CC models in closed form. Thus, we numerically calculate the equilibrium outcomes for various values of $\mu_1$ and thereby test the robustness of our managerial insights. We consider a setting in which $p = 3$, $w = 1$, $u = 1$, $u_0 = 1$, and $\alpha = 0.02$. We vary $\mu_1$ between 1 and 2 to analyze the impact on $\mu_1$. Recall from our main model that CC does not emerge when $X_C < X_{\hat{C}}$ and that $R_2$ benefits from $R_1$’s CC implementation when $X_C \in [X_{\hat{C}}, \hat{X}_C)$. Figure 7 shows that the captain’s efficiency thresholds $X_C$ and $\hat{X}_C$ decrease in $\mu_1$. Thus, we conclude that $\mu_1$ can influence the emergence of CC and its impact on the category stakeholders. For example, when $\mu_1 = 1$, CC does not emerge if $X_C = 150$. By contrast, a manufacturer with $X_C = 150$ would be considered moderately efficient when $\mu_1 = 1.5$ and highly efficient when $\mu_1 = 2$.

**Figure 7 Captain’s Efficiency as a Function of Retailer Heterogeneity, $\mu_1$**

![Figure 7](image)

Notes. We generate this figure by setting $p = 3$, $w = 1$, $u = 1$, $u_0 = 1$, and $\alpha = 0.02$.

Despite changing the equilibrium outcomes, $\mu_1$ does not affect our managerial insights. Specifically, Figure 8 shows the change in $R_1$’s expected profit as a function of $X_C$ for three different $\mu_1$ values. Figure 8 reveals that when the captain has a relatively low efficiency, retail competition may
prevent the emergence of CC. That is, there exists a range of \( X_C \) values in which CC emerges in the absence but not in the presence of retail competition. (For example, when \( \mu_1 = 1.5 \), this range is \([67,92]\), as Figure 8(b) shows.) Figure 8 further illustrates that when the captain has a relatively high efficiency, the benefit of CC for \( R_1 \) is higher in the presence of retail competition. In other words, retail competition increases the upside potential of CC for \( R_1 \). Collectively, these findings verify the robustness of our first managerial insight that despite preventing the emergence of CC in some cases, retail competition increases the upside potential of CC for the focal retailer.

Figure 8 Impact of CC on the Focal Retailer’s Profit

![Figure 8 Impact of CC on the Focal Retailer’s Profit](image)

Notes. We generate these figures by setting \( p = 3, \ w = 1, \ u = 1, \ u_0 = 1, \) and \( \alpha = 0.02 \). We vary \( \beta \) to vary the captain’s efficiency.

We find that when \( X_C \in [X_C, \hat{X}_C) \), \( R_1 \)'s CC implementation leads to an increase in \( R_2 \)'s expected profit. For example, revisiting Figure 7, this range is \([93,185]\) when \( \mu_1 = 1.5 \). This finding verifies the robustness of our second insight that \( R_2 \) can benefit from \( R_1 \)'s CC implementation. When \( X_C \in [X_C, \hat{X}_C) \), the profit the captain generates through the focal retailer channel declines, but the captain recoups its losses through the competing retailer channel. This finding illustrates the robustness of our third insight that a manufacturer may agree to serve as a captain even though CC leads to a decline in the profit it generates through the focal retailer channel because retail competition enables it recoup its losses through the competing retailer channel.

Our fourth insight is that retail competition alleviates the potential negative impact of CC on consumers by preventing large drops in the market penetration of the category. Figure 9 verifies the robustness of this insight. Specifically, in the monopolistic retailer setting, the drop in the market penetration of the category can be as high as 29% when \( \mu_1 = 1 \), 21% when \( \mu_1 = 1.5 \), and 16% when \( \mu_1 = 2 \). Such large drops in the market penetration of the category do not occur in the presence retail competition.

Based on these numerical results, we conclude that our managerial insights continue to hold when \( \mu_1 > 1 \).
Figure 9 Impact of CC on the Market Penetration of the Category

(a) $\mu_1 = 1$

(b) $\mu_1 = 1.5$

(c) $\mu_1 = 2$

Notes. We generate these figures by setting $p = 3$, $w = 1$, $u = 1$, $u_0 = 1$, and $\alpha = 0.02$. We vary $\beta$ to vary the captain’s efficiency.

A.2. Retailer Effort

In our main model described in Section 2, the captain has the ability to exert effort and thereby change the attractiveness of each product in $R_1$’s assortment from $a$ to $va$, whereas the retailers are unable to exert such effort. In this section, we consider an alternative model in which the retailers also have the ability exert effort. We retain our remaining assumptions (e.g., identical model parameters) to isolate the impact of retailer effort.

Let $v_i$ denote retailer $i$’s effort level. In the benchmark model, we define retailer $i$’s objective function as

$$
\Pi_i(n_i, v_i|n_{3-i}, v_{3-i}) = (p - w) \frac{n_i v_i}{A_0 + n_1 v_1 + n_2 v_2} - \alpha n_i - \beta_r v_i^2,
$$

where $\beta_r$ is the cost of effort for the retailers. In the benchmark model, retailer $i$ solves

$$
\max_{n_i \geq 0, v_i \geq 0} \Pi_i(n_i, v_i|n_{3-i}, v_{3-i}).
$$

In the CC model, we continue to assume that the captain incurs the effort cost. In the last stage of the CC model, the captain and $R_2$ simultaneously make category management decisions. That is, given $(n_1, v_1)$, $R_2$ solves

$$
\max_{n_2 \geq 0, v_2 \geq 0} (p - w) \frac{n_2 v_2}{A_0 + n_1 v_1 + n_2 v_2} - \alpha n_2 - \beta_r v_2^2.
$$

In the same stage, given $(n_2, v_2)$ and the sales target, $T$, the captain solves

$$
\max_{n_1 \geq 0, v_1 \geq 0} w \frac{v_1 + v_2}{A_0 + n_1 v_1 + n_2 v_2} - \beta v_1^2
$$

s.t. \hspace{1cm} \frac{n_1 v_1}{A_0 + n_1 v_1 + n_2 v_2} \geq T.

In the second stage of the CC model, $R_1$ sets its sales target $T$ subject to the captain’s participation
constraint. In the first stage, $R_1$ decides whether it should implement CC.

The analytical complexity of the retailers’ and the captain’s objective functions in the presence of retailer effort prevents us from deriving the equilibrium outcomes in closed form. As such, we numerically demonstrate the robustness of our managerial insights. We consider a setting in which $p = 3$, $w = 1$, $u = 1$, $u_0 = 1$, and $\alpha = 0.02$. We vary $\beta_r$ between 0.1 and 0.2 to analyze the impact on $\beta_r$. Figure 10 shows that the captain’s efficiency thresholds $X_C$ and $\hat{X}_C$ decrease $\beta_r$. Intuitively, $R_1$ delegates its category management decisions to a captain manufacturer only when the captain has superior category management capabilities. That is, working with a highly capable retailer (i.e., a retailer with a low effort cost) requires the captain manufacturer to have a relatively high efficiency. Consequently, the threshold efficiency value above which $R_1$ implements CC, $X_C$, decreases in $\beta_r$. Similarly, $R_2$ can better cope with $R_1$’s CC implementation when it has a relatively low effort cost. Consequently, the threshold value above which $R_2$ suffers from $R_1$’s CC implementation, $\hat{X}_C$, also decreases in $\beta_r$.

**Figure 10 Captain’s Efficiency as a Function of the Retailers’ Effort Cost, $\beta_r$.**

Although retailer effort changes the equilibrium outcomes, it does not affect our managerial insights. Figure 11 shows the change in $R_1$’s expected profit as a function of $X_C$ for three different $\beta_r$ values. Figure 11 reveals that when the captain’s efficiency is relatively low, retail competition may prevent the emergence of CC. That is, there exists a range of $X_C$ values in which CC emerges in the absence but not in the presence of retail competition. (For example, when $\beta_r = 0.15$, this range is $[84, 97]$, as Figure 11(b) shows.) Figure 11 further illustrates that when the captain has a relatively high efficiency, the benefit of CC for $R_1$ is higher in the presence of retail competition. In other words, retail competition increases the upside potential of CC for $R_1$ for all three $\beta_r$ values. Collectively, these findings verify the robustness of our first managerial insight that despite preventing the emergence of CC in some cases, retail competition increases the upside potential of CC for the focal retailer.

Notes. We generate this figure by setting $p = 3$, $w = 1$, $u = 1$, $u_0 = 1$, and $\alpha = 0.02$. 
Figure 11 Impact of CC on the Focal Retailer’s Profit

(a) $\beta_r = 0.1$
(b) $\beta_r = 0.15$
(c) $\beta_r = 0.2$

Notes. We generate these figures by setting $p = 3$, $w = 1$, $u = 1$, $u_0 = 1$, and $\alpha = 0.02$. We vary $\beta$ values to vary the captain’s efficiency.

We find that when $X_C \in [X_C, \hat{X}_C)$, $R_1$’s CC implementation leads to an increase in $R_2$’s expected profit. For example, revisiting Figure 10, this range is [98,391] when $\beta_r = 0.15$. This finding verifies the robustness of our second insight that $R_2$ can benefit from $R_1$’s CC implementation. When $X_C \in [\underline{X}_C, \hat{X}_C)$, the profit the captain generates through the focal retailer channel declines, but the captain recoups its losses through the competing retailer channel. This finding illustrates the robustness of our third insight that a manufacturer may agree to serve as a captain even though CC leads to a decline in the profit it generates through the focal retailer channel because retail competition enables it recoup its losses through the competing retailer channel.

Our fourth insight is that retail competition alleviates the potential negative impact of CC on consumers by preventing large drops in the market penetration of the category. Figure 12 verifies the robustness of this insight. Specifically, in the monopolistic retailer setting, the drop in the market penetration of the category can be as high as 44% when $\beta_r = 0.1$, 49% when $\beta_r = 0.15$, and 54% when $\beta_r = 0.2$. Such large drops in the market penetration of the category do not occur in the presence retail competition.

Based on these numerical results, we conclude that our managerial insights continue to hold in the presence of retailer effort.

A.3. Differentiated Products

In our main model described in Section 2, we assume that all products in the category are identical. In this section, we consider a model in which the manufacturers offer differentiated products. Specifically, let $a_{ij} = \exp(u_{ij} - (m_{ij} + w_{ij}))$ denote the attractiveness of product $j$ offered by retailer $i$, where $m_{ij} = p_{ij} - w_{ij}$ denotes its gross margin. We make the following assumptions for ease of exposition. First, we assume that the gross margins, $m_{ij}$, are identical across products and
Figure 12 Impact of CC on the Market Penetration of the Category

(a) $\beta_r = 0.1$

(b) $\beta_r = 0.15$

(c) $\beta_r = 0.2$

Notes. We generate these figures by setting $p = 3$, $w = 1$, $u = 1$, $u_0 = 1$, and $\alpha = 0.02$. We vary $\beta$ values to vary the captain’s efficiency.

retailers. That is, $m_{ij} = m$ for $j \in \mathcal{N}_i$ and $i = 1, 2$. Second, we assume that for product $j$, the utility intercepts, $u_{ij}$, and the wholesale prices, $w_{ij}$, are identical across retailers. That is, $u_{1j} = u_{2j} = u_j$ and $w_{1j} = w_{2j} = w_j$. These two assumptions enable us to rewrite the attractiveness of product $j$ as $a_j = \exp(u_j - (m + w_j))$.

Without loss of generality, we index products in a descending order based on their attractiveness levels (i.e., $a_1 > a_2 > ...$). Furthermore, we assume that $a_{j+1} = ra_j$, where $r \in (0, 1)$. Imposing this structure enables us to capture product differentiation with a single parameter $r$. Namely, products become more differentiated as $r$ decreases. Because the assortment cost $\alpha$ is identical across products and because carrying a more attractive product has a higher marginal benefit, both retailers carry the most popular products in their assortments. That is, setting retailer $i$’s assortment size to $n_i$ implies that retailer $i$’s assortment is $\mathcal{N}_i = \{1, 2, \ldots, n_i\}$. As such, the expected utility of choosing retailer $i$ is $A_i = E[\max_{k \in \mathcal{N}_i} U_{ik}] = \ln \left(\sum_{k=1}^{n_i} a_k\right) = \ln \left(\sum_{k=1}^{n_i} r^{k-1} a_1\right) = \ln \left(\frac{1-r^{n_i}}{1-r}a_1\right)$.

Consequently, we can write the proportion of consumers that purchase product $j$ from retailer $i$ as

$$M_{ij} = Pr(j|i) \times Pr(i)$$

$$= \frac{a_j I_{ij}}{\sum_{k=1}^{n_i} a_k} \times \frac{\sum_{k=1}^{n_i} a_k}{a_0 + \sum_{k=1}^{n_1} a_k + \sum_{k=1}^{n_2} a_k}$$

$$= \frac{(1-r)^{j-1} a_1 I_{ij}}{(1-r)a_0 + (1-r^{n_1})a_1 + (1-r^{n_2})a_1}.$$
Accordingly, retailer $i$’s expected profit in the benchmark model is

$$
\Pi_i(n_i|n_{3-i}) = \sum_{j \in N_i} (p_{ij} - w_{ij}) M_{ij} - \alpha n_i
$$

(38)

$$
= m \sum_{j=1}^{n_i} (1-r)a_0 + (1-r^n_1)a_1 + (1-r^n_2)a_1 - \alpha n_i
$$

(39)

$$
= m \frac{(1-r^n_1)a_1}{(1-r)a_0 + (1-r^n_1)a_1 + (1-r^n_2)a_1 - \alpha n_i}
$$

(40)

In the benchmark model, the retailers simultaneously optimize their assortment sizes, $n_1$ and $n_2$, to maximize their expected profits. Note that Equation (40) captures the same tradeoff as its counterpart in our original model, Equation (7). That is, increasing the assortment size increases a retailer’s market share, but doing so also increases the assortment cost.

In the CC model, we assume that the captain manufacturer is the one with the highest product attractiveness, $a_1$, and that implementing CC changes the attractiveness of product $j$ from $a_j$ to $va_j$ in $R_1$’s assortment. In the last stage of the CC model, the captain and $R_2$ simultaneously make category management decisions. That is, given $(n_1, v_1)$, $R_2$ solves

$$
\max_{n_2 \geq 0} m \frac{(1-r^n_2)a_1}{(1-r)a_0 + (1-r^n_1)va_1 + (1-r^n_2)a_1} - \alpha n_i.
$$

(41)

In the same stage, given $n_2$ and the sales target, $T$, the captain solves

$$
\max_{n_1 \geq 0, v_1 \geq 0} \frac{w_1}{(1-r)a_0 + (1-r^n_1)va_1 + (1-r^n_2)a_1} - \beta v^2
$$

(42)

subject to

$$
\frac{(1-r^n_1)va_1}{(1-r)a_0 + (1-r^n_1)va_1 + (1-r^n_2)a_1} \geq T.
$$

(43)

In the second stage of the CC model, $R_1$ sets its sales target $T$ subject to the captain’s participation constraint. In the first stage, $R_1$ decides whether it should implement CC.

The analytical complexity of the retailers’ and the captain’s profit functions prevents us from characterizing the equilibrium outcomes in closed form. Hence, we numerically examine the robustness of our managerial insights. We consider a setting in which $m = 2$, $w_1 = 1$, $u_0 = 1$, $u_1 = 1$, and $\alpha = 0.02$. Figure 13 shows that the captain’s efficiency thresholds $\hat{X}_C$ and $\hat{X}_C'$ increase in the degree of product similarity, $r$. Intuitively, a smaller $r$ value decreases the benefit of carrying a large assortment as the overall attractiveness of a retailer’s assortment, $\sum_{k=1}^{n_i} a_k = \sum_{k=1}^{n_i} r^{k-1} a_1 = \frac{1-r^n_j}{1-r} a_1$, decreases in $r$. As such, a manufacturer has more room to improve category performance when $r$ is small. Put differently, a manufacturer that is considered to have low efficiency in a category with identical products can serve as a captain when $r$ is small. Hence, the threshold efficiency value above which $R_1$ implements CC, $\hat{X}_C$, increases in $r$. Similarly, $R_2$ can better cope with $R_1$’s CC implementation when $r$ is large. In other words, a small $r$ makes it more difficult for $R_2$ to benefit from $R_1$’s CC implementation. Consequently, the threshold value above which $R_2$ suffers from $R_1$’s...
CC implementation, $\tilde{X}_C$, also increases in $r$.

**Figure 13 Captain’s Efficiency as a Function of the Degree of Product Similarity, $r$**

![Figure 13](image)

Notes. We generate this figure by setting $m = 2$, $w_1 = 1$, $u_0 = 1$, $u_1 = 1$, and $\alpha = 0.02$.

Although product differentiation changes the equilibrium outcomes, it does not affect our managerial insights. Figure 14 shows the change in $R_1$’s expected profit as a function of $X_C$ for three different $r$ values. Figure 14 reveals that when the captain’s efficiency is relatively low, retail competition may prevent the emergence of CC. That is, there exists a range of $X_C$ values in which CC emerges in the absence but not in the presence of retail competition. (For example, when $r = 0.9$, this range is [88,105], as Figure 14(b) shows.) Figure 14 further illustrates that when the captain has a relatively high efficiency, the benefit of CC for $R_1$ is higher in the presence of retail competition. In other words, retail competition increases the upside potential of CC for $R_1$ for all three $r$ values. Collectively, these findings verify the robustness of our first managerial insight that despite preventing the emergence of CC in some cases, retail competition increases the upside potential of CC for the focal retailer.

**Figure 14 Impact of CC on the Focal Retailer’s Profit**

![Figure 14](image)

Notes. We generate these figures by setting $m = 2$, $w_1 = 1$, $u_0 = 1$, $u_1 = 1$, and $\alpha = 0.02$. We vary $\beta$ values to vary the captain’s efficiency.
We find that when $X_C \in [\hat{X}_C, \bar{X}_C)$, $R_1$’s CC implementation leads to an increase in $R_2$’s expected profit. For example, revisiting Figure 13, this range is $[106,134]$ when $r = 0.9$. This finding verifies the robustness of our second insight that $R_2$ can benefit from $R_1$’s CC implementation. When $X_C \in [\hat{X}_C, \bar{X}_C)$, the profit the captain generates through the focal retailer channel declines, but the captain recoups its losses through the competing retailer channel. This finding illustrates the robustness of our third insight that a manufacturer may agree to serve as a captain even though CC leads to a decline in the profit it generates through the focal retailer channel because retail competition enables it to recoup its losses through the competing retailer channel.

Our fourth insight is that retail competition alleviates the potential negative impact of CC on consumers by preventing large drops in the market penetration of the category. Figure 15 verifies the robustness of this insight. Specifically, in the monopolistic retailer setting, the drop in the market penetration of the category can be as high as 27% when $r = 0.85$, 31% when $r = 0.9$, and 32% when $r = 0.95$. Such large drops in the market penetration of the category do not occur in the presence retail competition.

**Figure 15 Impact of CC on the Market Penetration of the Category**

Notes. We generate these figures by setting $m = 2$, $w_1 = 1$, $u_0 = 1$, $u_1 = 1$, and $\alpha = 0.02$. We vary $\beta$ values to vary the captain’s efficiency.

Based on these numerical results, we conclude that our managerial insights continue to hold in the presence of differentiated products.

A.4. **Strategic Retail and Wholesale Pricing**

In our main model described in Section 2, we assume exogenous retail and wholesale prices. In this section, we consider an alternative model in which the retailers and manufacturers strategically optimize their prices. We retain our remaining assumptions to isolate the impact of strategic pricing.

In our analysis, we closely follow the game-theoretic setup proposed by Heese and Martínez-de Albéniz (2018). Their model has a single retailer and the following sequence of events. In the first
stage, the retailer announces its assortment size without announcing the actual assortment. In the second stage, the manufacturers simultaneously determine the wholesale prices they will offer to the retailer. In the third stage, the retailer determines its assortment. In the last stage, the retailer sets its retail prices. They derive following key results: First, it is optimal for the retailer to charge the same margin for each product in its assortment. Second, the retailer’s optimal assortment is composed of the most attractive products. Third, when the manufacturers’ products are sufficiently similar, the manufacturers set their wholesale prices so as to offer exactly the attractiveness of the first excluded manufacturer. Last, committing to an assortment size without announcing the actual assortment intensifies manufacturer competition and thereby enables the retailer to earn a higher profit.

We extend the setting proposed by Heese and Martínez-de Albéniz (2018) to two retailers. We have the following sequence of events in our benchmark model. In the first stage, the retailers simultaneously announce their assortment sizes, \( n_1 \) and \( n_2 \), without announcing their actual assortments, \( N_1 \) and \( N_2 \). In the second stage, the manufacturers simultaneously determine the wholesale prices they will offer to each retailer. In the third stage, the retailers simultaneously determine their assortments. In the last stage, the retailers simultaneously determine their retail prices. We have the following sequence of events in the CC model. In the first stage, \( R_1 \) decides whether it should implement CC by comparing the expected profit it can obtain under CC with the expected profit it can obtain in the benchmark model. In the second stage, \( R_1 \) sets a sales target for the captain. In the third stage, the retailers simultaneously announce the assortment sizes \( n_1 \) and \( n_2 \). In this stage, the captain makes the assortment size decision on behalf of \( R_1 \). In the fourth stage, the manufacturers simultaneously determine the wholesale prices they will offer to each retailer. In the fifth stage, the captain and \( R_2 \) simultaneously make category management decisions. That is, the captain determines its effort level, \( v \), and \( R_1 \)'s assortment, \( N_1 \), while \( R_2 \) determines its assortment, \( N_2 \). Similar to our original model, the captain’s effort changes the attractiveness of a product from \( a_{ij} \) to \( va_{ij} \) in \( R_1 \)'s assortment. In the last stage, the retailers simultaneously set their retail prices. Note that we do not allow \( R_1 \) to delegate the retail pricing decision to the captain to be consistent with practice in which the captain manufacturers do not typically make retail pricing decisions due to anti-trust concerns (Federal Trade Commission 2003).

We use the following structure to simplify our numerical analysis. First, we assume that the deterministic component of product \( j \)'s utility is identical across retailers (i.e., \( u_{1j} = u_{2j} = u_j \)). We refer to \( \tilde{a}_j = \exp(u_j - c_j) \) as the base attractiveness of product \( j \). Second, we assume that the captain’s product has the highest base attractiveness. Third, we assume that \( \tilde{a}_{j+1} = r\tilde{a}_j \) for all \( j \geq 1 \), where \( r \in (0, 1) \). Imposing this structure enables us to capture the degree of product
differentiation with a single parameter, \( r \). Without loss of generality, we rank the products such that a lower-ranked product has a higher base attractiveness (i.e., \( \bar{a}_j > \bar{a}_k \) for \( j < k \)). Last, we impose the equilibrium structure developed by Heese and Martínez-de Albéniz (2018) to our problem.

Imposing the equilibrium structure developed by Heese and Martínez-de Albéniz (2018) to our problem has the following implications. First, each retailer carries the most attractive products in its assortment. That is, for a given \((n_1, n_2)\) pair, we have \( \mathcal{N}_1 = \{1, 2, \cdots, n_1\} \) and \( \mathcal{N}_2 = \{1, 2, \cdots, n_2\} \). Second, retailer \( i \) has the same margin \( m_i \) for all \( j \in \mathcal{N}_i \). As such, the retailers simultaneously determine their margins, \( m_1 \) and \( m_2 \), in the retail price optimization stages of the benchmark and CC models. Last, the products are sufficiently similar (i.e., \( r \) is relatively large) so that manufacturer \( j \in \mathcal{N}_i \) sets its wholesale price so as to offer exactly the attractiveness of the first excluded product (i.e., product \( n_i + 1 \)). More formally, \( w_{ij} \) is set such that \( \exp(u_j - (m_i + w_{ij})) = \exp(u_{n_i + 1} - (m_i + c_{n_i + 1})) \). Let \( s_{ij} = w_{ij} - c_j \) denote the unit margin manufacturer \( j \) generates by selling its product to retailer \( i \). Then we can rewrite the same equality as \( \exp(u_j - (m_i + s_{ij} + c_j)) = \exp(u_{n_i + 1} - (m_i + c_{n_i + 1})) \). Rearranging terms gives \( s_{ij} = (u_j - c_j) - (u_{n_i + 1} - c_{n_i + 1}) \). Because we assume that \( \bar{a}_{k+1} = r\bar{a}_k \), we have \( u_k - c_k = (k - 1) \ln(r) + (u_1 - c_1) \). Consequently, \( s_{ij} = (u_j - c_j) - (u_{n_i + 1} - c_{n_i + 1}) = \frac{j - 1 - n_i}{n_i} \ln(r) \). Note that \( \partial w_{ij}/\partial n_i = \partial s_{ij}/\partial n_i = -\ln(r) \geq 0 \). This structure implies that when a retailer reduces its assortment size, the manufacturers respond by reducing their wholesale prices. This is because they now have to compete for a smaller number of available slots in the assortment, as discussed by Heese and Martínez-de Albéniz (2018).

The structure we impose enables us to write the attractiveness of product \( j \) offered by retailer \( i \) as follows

\[
a_{ij} = \exp(u_j - p_{ij}) = \exp(u_j - c_j) \exp(-m_i) \exp(-s_{ij}) = r^{j-1} \exp(u_1 - c_1) \exp(-m_i) r^{n_i+1-j} = r^{n_i} \exp(u_1 - (m_i + c_1)).
\]

That is, once we determine the wholesale prices, \( w_{ij} = s_{ij} + c_j \), we can concisely write \( a_{ij} \) as a function of three model parameters \((u_1, c_1, \text{ and } r)\) and two decision variables \((n_i \text{ and } m_i)\). As a result, we can analyze a model with strategic wholesale and retail pricing with five model parameters, \( c_1, u_0, u_1, r, \text{ and } \alpha \).

The complexity of the benchmark and CC models prevents us from characterizing the equilibrium outcomes in closed form. As such, we numerically demonstrate the robustness of our managerial insights. We consider a setting in which \( c_1 = 0.5, \ u_0 = 1, \ u_1 = 1, \ r = 0.95, \text{ and } \alpha = 0.02 \). Recall that we defined the captain’s efficiency as \( w/\beta \) in our original model. In this section, we
define the captain’s efficiency as $X_C = 1/\beta$ for ease of exposition since $w/\beta$ would be harder to interpret due to the manufacturers’ wholesale responses to $\beta$. Figure 16 provides a snapshot of the equilibrium outcomes as a function of the captain’s efficiency. Because the manufacturer margins, $s_{ij}$, vary across products, we use the average manufacturer margin $\bar{s}_i = \frac{1}{n_i} \sum_{j \in N_i} s_{ij}$ as a proxy for the manufacturers’ strategic response to the retailers’ assortment changes. Figure 16(a) shows the average manufacturer margins in the benchmark and CC models. In the benchmark model, the two retailers have symmetric equilibrium outcomes (e.g., same assortments, same retail margins). As such, they also have the same average manufacturer margins. Similar to our original model, CC leads to a decline in $R_1$’s assortment size. As a response to $R_1$’s assortment size reduction, the manufacturers lower their wholesale prices to stay in the assortment. Consequently, CC leads to a decline in the average manufacturer margin in the focal retailer channel.

The focal retailer’s CC implementation may increase or decrease the average manufacturer margin in the competing retailer channel. Namely, when the captain’s efficiency is low, $R_2$ responds to $R_1$’s CC implementation by increasing its assortment size, which in turn leads to an increase in the average manufacturer margin. By contrast, $R_2$ decreases its assortment size when $R_1$ works with a highly efficient captain. This assortment size reduction leads to a decline in the average manufacturer margin for the products $R_2$ carries in its assortment. Figure 16(b) and 16(c) show the retail margins and market shares, respectively. We find that a larger assortment and/or higher effort enables a retailer to increase its retail margins. Furthermore, retail margins and market shares move in the same direction. That is, when CC leads to an increase in a retailer’s margin, it also leads to an increase in the same retailer’s market share.

Figure 16 Impact of CC on the Equilibrium Outcomes

Notes. We generate these figures by setting $c_1 = 0.5$, $u_1 = 1$, $u_0 = 1$, $\alpha = 0.02$, and $r = 0.95$. We vary $\beta$ values to vary the captain’s efficiency, which we define as $1/\beta$ in this section.

Figure 16(c) also reveals that strategic retail and wholesale pricing does not change the market share dynamics between the retailers. Consequently, our managerial insights continue to hold.
Specifically, Figure 17(a) illustrates that there exists a range of $X_C$ values in which CC emerges in the absence but not in the presence of retail competition. In other words, we find that when the captain has a relatively low efficiency, retail competition may prevent the emergence of CC. Figure 17(a) also shows that when the captain has a relatively high efficiency, the benefit of CC for $R_1$ is higher in the presence of retail competition. In other words, retail competition increases the upside potential of CC for $R_1$. Collectively, these findings verify the robustness of our first managerial insight that despite preventing the emergence of CC in some cases, retail competition increases the upside potential of CC for the focal retailer.

**Figure 17 Impact of CC on the Focal Retailer’s Profit and Market Penetration of the Category**

(a) Focal retailer’s profit

(b) Market penetration of the category

Notes. We generate these figures by setting $c_1 = 0.5$, $u_1 = 1$, $u_0 = 1$, $\alpha = 0.02$, and $r = 0.95$. We vary $\beta$ values to vary the captain’s efficiency, which we define as $1/\beta$ in this section.

Our second and third insights also continue to hold in the presence of retailer effort. Specifically, $R_2$ benefits from $R_1$’s CC implementation if $X_C \in [90, 130]$. In the same parameter set (i.e., when $X_C \in [90, 130]$), the captain loses money through the focal retailer channel, but recoups its losses through the competing retailer channel. Our fourth insight is that retail competition alleviates the potential negative impact of CC on consumers by preventing large drops in the market penetration of the category. Figure 17(b) illustrates the robustness of this insight. Specifically, when the captain’s efficiency, $X_C$, is relatively low, the drop in the market penetration of the category can exceed 10%. Such a large drop in the market penetration of the category does not occur in the presence retail competition because retail competition prevents the emergence of CC for relatively low $X_C$ values.

Based on these numerical results, we conclude that our managerial insights continue to hold in the presence of strategic retail and wholesale pricing.
B. Proofs

Proof of Proposition 1. For a given \( n_j \), the first order condition for \( n_i \) reduces to

\[
n_i(n_j) = \sqrt{X_R(A_0 + n_j)} - (A_0 + n_j)
\]

where \( A_0 = \frac{a_0}{a} \) and \( X_R = \frac{p - w}{a} \). First, suppose \( n_j \leq X_R - A_0 \) so that \( n_i(n_j) = \sqrt{X_R(A_0 + n_j)} - (A_0 + n_j) \geq 0 \). Then, the equilibrium assortment sizes are determined by solving the retailers’ first order conditions simultaneously as

\[
n_i = \sqrt{X_R(A_0 + n_j(i))} - (A_0 + n_j(i))
\]

\[
0 = n_i^2 - \left( \frac{X_R}{4} - A_0 \right) n_i - A_0 \left( \frac{X_R}{4} - \frac{A_0}{4} \right)
\]

\[
n_i^B = n_j^B = \frac{1}{2} \left( \frac{X_R}{4} \Phi - A_0 \right)^+
\]

where \( \Phi = 1 + \sqrt{1 + \frac{8A_0}{X_R}} \). Equation (51) satisfies non-negativity condition only when \( A_0 \in [0, X_R] \).

Notice also that for any \( A_0 \in [0, X_R] \), we have \( \Phi \in [2, 4] \), which in return ensures that \( n_i^B \in [0, \frac{X_R}{4}] \). Then, it is a matter of simple algebra to show that \( A^B = A_0 + n_i^B + n_2^B = \frac{X_R}{4} \Phi, M^B = \frac{4A_0}{X_R} \Phi \), and \( M_i^B = \frac{n_i^B}{A^B} = \frac{1}{2} \left( 1 - \frac{4A_0}{X_R} \Phi \right) \). Thus, the equilibrium profits for the focal and competing retailers are \( \Pi_i^B = (p - w)M_i^B - c n_i^B = \alpha \frac{X_R}{2} \left( 1 - \frac{4A_0}{X_R} \Phi \right) \left( 1 - \frac{\Phi}{4} \right) \). A manufacturer who sells its product in both retailers’ gets the profit of \( \pi^B = w \frac{8}{X_R} \Phi \).

Proof of Lemma 1. Let \( z^*(n_2|T) \equiv v^*(n_2|T) n_i^*(n_2|T) = \frac{T}{1 - T} (A_0 + n_2) \). Then, we can rewrite \( R_2 \)’s best response function as \( n_i^*(z) = \left( \sqrt{X_R(A_0 + z)} - (A_0 + z) \right)^+ \). Thus, we can find the equilibrium by solving the following set of equations for \( z \) and \( n_2 \):

\[
z = \frac{T}{1 - T} (A_0 + n_2)
\]

\[
n_2 = \left( \sqrt{X_R(A_0 + z)} - (A_0 + z) \right)^+.
\]

Suppose that the solution is such that \( \sqrt{X_R(A_0 + z)} - (A_0 + z) \geq 0 \). Then, jointly solving \( z = \frac{T}{1 - T} (A_0 + n_2) \) and \( n_2 = \sqrt{X_R(A_0 + z)} - (A_0 + z) \) leads to \( z = \frac{A(T)^2}{X_R} - A_0 \) and \( n_2 = A(T) - \frac{A(T)^2}{X_R} \), where \( A(T) = \frac{X_R}{2} \left( T + \sqrt{T^2 + 4 \frac{A_0}{X_R}} \right) \). Since \( T \geq 0 \), \( A(T) \geq \frac{X_R}{2} \sqrt{4 \frac{A_0}{X_R}} \), which implies that \( z = \frac{A(T)^2}{X_R} - A_0 \geq 0 \), which in turn implies that \( R_1 \) offers the category. In this solution, \( n_2 = \sqrt{X_R(A_0 + z)} - (A_0 + z) = A(T) - \frac{A(T)^2}{X_R} \geq 0 \) must hold due to our assumption that \( \sqrt{X_R(A_0 + z)} - (A_0 + z) \geq 0 \).

Rearranging the terms of \( A(T) - \frac{A(T)^2}{X_R} \geq 0 \) reveals that \( \sqrt{X_R(A_0 + z)} - (A_0 + z) \geq 0 \) when \( T \leq 1 - \frac{A_0}{X_R} \). Hence, when \( T \in [0, 1 - A_0/X_R] \), both retailers offer the category, where \( \tilde{n}_2(T) = A(T) - \frac{A(T)^2}{X_R}, \tilde{v}(T) = X_C \frac{1 - T}{2(\tilde{n}_2(T)^2)} = \frac{X_C}{2A(T)} \) and \( \tilde{n}_1(T) = \frac{2T}{X_C} \left( \frac{A_0 + n_2}{1 - T} \right)^2 = \frac{2A(T)}{X_C} \left( \frac{A(T)^2}{X_R} - A_0 \right) \). \( \square \)
**Proposition 2.** Anticipating the category captain’s and the rival retailer’s assortment setting equilibrium strategies from Lemma 1, the focal retailer solves

\[
\max_{T \geq 0} \quad (p - w) \frac{v(T)n_1(T)}{A(T)} - \alpha n_1(T),
\]

\[
\text{s.t.} \quad \frac{X_R}{A(T)} \left(1 + \frac{X_C}{4A(T)}\right) \geq \frac{8}{\Phi},
\]

The second derivative of the objective function with respect to \(A(T)\) is \(-\alpha \left(\frac{2X_R A_0}{A(T)^2} + \frac{12A(T)}{X_C X_R}\right) < 0\). So, the objective function is concave in \(A(T)\). Furthermore, the left-hand side of the constraint is decreasing in \(A\). Let \((A(T))^*\) denote the solution that corresponds to a binding constraint. Accordingly, the set of feasible \(A(T)\) is \([0, (A(T))^*]\). Furthermore, let \((A(T))^*\) denote the solution that solves the first-order condition (with respect to \(A(T)\)) of the objective function. Thus, the optimal \(A(T)\) is \(\min \{A(T)^*, (A(T))^*\}\). We find that

\[
A(T)^* = \frac{X_R}{2} \left(\frac{X_C + 2A_0}{3X_R} + \sqrt{\left(\frac{X_C + 2A_0}{3X_R}\right)^2 + \frac{8X_C A_0}{3X_R^2}}\right)^{1/2}.
\]

Furthermore, by solving the binding constraint, we get

\[
A(T)^* = \frac{X_R}{2} \left(\frac{1}{8} \left(\Phi + \sqrt{\Phi \left(\frac{8X_C}{X_R}\right)}\right)\right).
\]

So, the optimal \(A(T)\) for \(R_1\) equals \(\frac{X_R}{2} \Theta\), where

\[
\Theta = \min \left\{ \left(\frac{X_C + 2A_0}{3X_R} + \sqrt{\left(\frac{X_C + 2A_0}{3X_R}\right)^2 + \frac{8X_C A_0}{3X_R^2}}\right)^{1/2}, \frac{1}{8} \left(\Phi + \sqrt{\Phi \left(\frac{8X_C}{X_R}\right)}\right) \right\}.
\]

Setting \(A(T) = \frac{X_R}{2} \left(T + \sqrt{T^2 + \frac{4A_0}{X_R}}\right)\) equal to \(\frac{X_R}{2} \Theta\) and solving for \(T\) leads to \(T^C = \frac{1}{2} \left(\Theta - \frac{4A_0}{X_R \Theta}\right)\).

Accordingly, \(v^C = v^*(T^C) = \frac{X_R \Theta}{X_R \Theta}\), \(n_1^C = n_1(T^C) = \frac{X_R \Theta}{X_R \Theta} \left(\frac{X_R \Theta}{4} \Theta^2 - A_0\right)\), \(n_2^C = n_2^C(v^C n_2^C) = \frac{X_R}{2} \left(1 - \frac{\Theta}{2}\right)\), and \(A^C = A_0 + v^C n_1^C + n_2^C = \frac{X_R}{2} \Theta\). Thus, the equilibrium market shares are \(M_0^C = \frac{2A_0}{X_R \Theta}\), \(M_1^C = \frac{v^C n_1^C}{A^C} = \frac{1}{2} \left(\Theta - \frac{4A_0}{X_R \Theta}\right)\), and \(M_2^C = \frac{C}{X_R} = 1 - \Theta^2\). Furthermore, the equilibrium expected profits for \(R_1\) and \(R_2\) are

\[
\Pi_1^C = (p - w)M_1^C + \alpha n_1^C = \alpha \frac{X_R}{4} \left(2 - \frac{X_R \Theta^2}{\Phi X_R}\right)\left(\Theta - \frac{4A_0}{X_R \Theta}\right)\]

and

\[
\Pi_2^C = (p - w)M_2^C - \alpha n_2^C = \alpha \frac{X_R}{4} (2 - \Theta)^2\text{, respectively.}
\]

Finally, consider the non-negativity constraints on the assortment sizes. Notice that \(n_1^C \geq 0\) when \(\Theta \geq 2\sqrt{\frac{A_0}{X_R}}\) and \(n_2^C \geq 0\) when \(\Theta \leq 2\). Also, \(2\sqrt{\frac{A_0}{X_R}} \leq 2\) simplifies to \(A_0 \leq X_R\), which is true by assumption. Let \(X_R^L\) and \(X_C\) be such that \(\Theta (X_R^L) = 2\sqrt{A_0/X_R}\) and \(\Theta (X_C) = 2\), respectively. Then, \(X_C \in [X_R^L, X_C]\) ensures that both \(n_1^C\) and \(n_2^C\) are non-negative. Since \(\Theta\) is increasing in \(X_C\), by solving \(\Theta = 2\sqrt{A_0/X_R}\), we get the lower threshold as

\[
X_C^L = \max \left\{2A_0, 4X_R \left(\frac{8A_0}{\Phi X_R} - \sqrt{\frac{A_0}{X_R}}\right)\right\}.
\]

Similarly, by solving \(\Theta = 2\), we get the upper threshold as

\[
X_C = \max \left\{4X_R \frac{8 - \Phi}{\Phi X_R}, 2X_R \left(\frac{4X_R}{A_0 + X_R} - 1\right)\right\}.
\]

Notice
that, as $A_0$ approaches to zero, we have $X_C^L = \max\{0,0\} = 0$ and $\bar{X}_C = \max\{12X_R, 6X_R\} = 12X_R$ and, when $A_0$ approaches to $X_R$, we have $X_C^L = \max\{2X_R, 4X_R\} = 4X_R$ and $\bar{X}_C = \min\{4X_R, 2X_R\} = 4X_R$. Thus, the lower and upper bounds simplify to

$$X_C^L = \max\left\{2A_0, 4X_R\left(\frac{8A_0}{\Phi X_R} - \sqrt{\frac{A_0}{X_R}}\right)\right\} = 4X_R \left(\frac{8A_0}{\Phi X_R} - \sqrt{\frac{A_0}{X_R}}\right),$$

$$\bar{X}_C = \max\left\{4X_R \frac{8 - \Phi}{\Phi}, 2X_R \left(\frac{4X_R}{A_0 + X_R} - 1\right)\right\} = 4X_R \frac{8 - \Phi}{\Phi},$$

respectively.

**Proof of Proposition 3.** Recall that $\Pi_1^C = \alpha \frac{X_R}{4} \left(2 - \frac{X_R}{X_C} \Theta^2\right) \left(\Theta - \frac{4A_0}{\Phi X_R}\right)$. Notice that $\Theta$ is increasing in $X_C$, and $\frac{X_R}{X_C} \Theta^2$ is decreasing in $X_C$. Thus, $\Pi_1^C$ is increasing in $X_C$, while $\Pi_1^B$ does not depend on $X_C$. When $X_C = X_C^L$, we have $\Theta = 2\sqrt{\frac{A_0}{X_R}}$ and $\Pi_1^C = 0$. Thus, $\Pi_1^C \leq \Pi_1^B$ when $X_C = X_C^L$. Recall from Equation (58) that $\Theta(X_C) = \min\{\Theta_1(X_C), \Theta_2(X_C)\}$ where $\Theta_1(X_C) = \left(\frac{X_C + 2A_0}{3X_R} + \sqrt{\left(\frac{X_C + 2A_0}{3X_R}\right)^2 + \frac{8X_C A_0}{3X_R}}\right)^{1/2}$ and $\Theta_2(X_C) = \frac{1}{8} \left(\Phi + \sqrt{\Phi^2 + \frac{8X_C}{X_R}}\right)$. Let $\hat{X}_C \equiv X_R \Phi$.

When $X_C = \hat{X}_C$, $\hat{\Theta}_1 = \Theta_1(\hat{X}_C) = \left(\frac{X_R \Phi + 2A_0}{3X_R} + \sqrt{\left(\frac{X_R \Phi + 2A_0}{3X_R}\right)^2 + \frac{8A_0 \Phi}{3X_R}}\right)^{1/2}$ and $\hat{\Theta}_2 = \Theta_2(\hat{X}_C) = \frac{\Phi}{2}$. Note that $\hat{\Theta}_1$ is increasing in $A_0$ because $\Phi$ is increasing in $A_0$. Also, when $A_0 = 0$, we have $\hat{\Theta}_1 = \sqrt{\frac{2}{3}} > \hat{\Theta}_2 = 1$ and when $A_0 = X_R$, we have $\hat{\Theta}_1 \simeq 2.41 > \hat{\Theta}_2 = 2$. Thus, we can conclude that when $X_C = \hat{X}_C$, $\Theta(\hat{X}_C) = \min\{\Theta_1(\hat{X}_C), \Theta_2(\hat{X}_C)\} = \Theta_2(\hat{X}_C) = \frac{\Phi}{2}$.

By substituting $X_C = X_R \Phi$ into $\Pi_1^C - \Pi_1^B$, we get

$$\Pi_1^C - \Pi_1^B = \alpha \frac{X_R}{4} \left[2 \left(1 - \frac{\Phi}{12}\right) \left(\Phi - \frac{4A_0}{X_R \Phi}\right) - 2 \left(1 - \frac{4A_0}{X_R \Phi}\right) \left(1 - \frac{\Phi}{4}\right)\right] \geq 0$$

since $\Phi \in [2, 4]$. Thus, $\Pi_1^C \geq \Pi_1^B$ when $X_C = \hat{X}_C$. Furthermore, $\Theta(\hat{X}_C) = \frac{\Phi}{2} \leq 2 = \Theta(\hat{X}_C)$, which implies that $\hat{X}_C \leq \hat{X}_C$. Hence, there exists a threshold $X_C \in [X_C^L, \hat{X}_C]$ such that $R_1$ prefers traditional category management when $X_C \in [X_C^L, X_C]$ and CC when $X_C \in [X_C, \hat{X}_C]$.

**Proof of Proposition 4.** In the monopoly benchmark model, $R_1$ sets its assortment size to

$$n_1^{MB} = \arg\max_{n_1 \geq 0}\left\{\left(p - w\right) \frac{n_1}{A_0 + n_1} - \alpha n_1\right\} = \left(\sqrt{X_R A_0} - A_0\right)^+ \quad (59)$$

Notice that $n_1^{MB} \geq 0$ if and only if $X_R \geq A_0$. Since this condition holds in our parameter set, we have $A^{MB} = A_0 + n_1^{MB} = \sqrt{X_R A_0}$, $M_0^{MB} = \frac{A_0}{X_R}$, and $M_1^{MB} = \frac{n_1^{MB}}{A_0^{MB}} = 1 - \sqrt{\frac{A_0}{X_R}}$. Thus, the equilibrium expected profits for $R_1$ and the captain are $\Pi_1^{MB} = (p - w)M_1^{MB} - \alpha A_1^{MB} = \alpha \left(\sqrt{X_R} - \sqrt{A_0}\right)^2$ and $\pi_c^{MB} = \frac{w}{A_0^{MB}} = \frac{w}{\sqrt{X_R A_0}}$.

Next, consider the CC scenario. We solve the model through backward induction. In stage 3, the captain selects $v$ and $n_1$ subject to $R_1$’s constraint that its sales should not fall below $T$. That
is, the captain solves the following problem:

$$\max_{(v,n_1) \geq 0} w \frac{v}{\alpha_0 + \nu n_1} - \beta v^2;$$

subject to

$$\frac{\nu n_1}{\alpha_0 + \nu n_1} \geq T.$$  \hfill (60)

Notice that the objective function is decreasing in $n_1$. Thus, the optimal $n_1$ is determined by the constraint. Solving the constraint for $n_1$, we get

$$n_1(v, T) = \frac{A_0}{\nu} \left( \frac{T}{1 - T} \right).$$  \hfill (62)

Replacing $n_1$ with $n_1(v, T)$ in the objective function and solving for $v$ lead to

$$A(T) = A_0 + v(T)n_1(T) = \frac{A_0}{1 - T}, v(T) = \frac{w(1 - T)}{2 \beta A_0} = \frac{X_C}{\alpha_0(T)}, n_1(T) = n_1(v(T), T) = \frac{2A(T)}{w A_0 (1 - T)^2} = \frac{2A(T)}{X_C} (A(T) - A_0),$$

and

$$\Pi_1(T) = (p - w) \frac{v(T)n_1(T)}{A(T)} - \alpha n_1(T) = \alpha X_R \left( 1 - \frac{A_0}{X(T)} \right) \left( 1 - \frac{2A(T)^2}{X_R X_C} \right).$$

Anticipating $v(T)$ and $n_1(T)$, $R_1$ solves

$$\max_{T \geq 0} \alpha X_R \left( 1 - \frac{A_0}{A(T)} \right) \left( 1 - \frac{2A(T)^2}{X_R X_C} \right);$$

subject to

$$\frac{X_R}{A(T)} \left( \frac{X_C}{4A(T)} \right) \geq \sqrt{\frac{X_R}{A_0}}.$$  \hfill (64)

The objective function is concave in $A(T)$. Furthermore, the left-hand side of the constraint is decreasing in $A(T)$. Let $A(T)^\ast$ denote the solution that corresponds to a binding constraint. Accordingly, the set of feasible $A(T)$ is $[0, A(T)^\ast]$. Furthermore, let $A(T)^\ast$ denote the solution that solves the first order condition (with respect to $A(T)$) of the objective function. Thus, the optimal $A(T)$ for $R_1$ is $\min \{ A(T)^\ast, A(T)^{**} \}$. We find that

$$A(T)^\ast = \frac{X_R}{2} \Theta^\ast = \frac{X_R}{2} \left( 1 + \frac{27}{3} \frac{X_R X_C}{A_0} + \sqrt{\left( 1 + \frac{27}{3} \frac{X_R X_C}{A_0} \right)^2 - 1} \right)^{\frac{1}{3}}.$$  \hfill (65)

Furthermore, the unique non-negative $A(T)$ value that leads to a binding constraint is

$$A(T)^{**} = \frac{X_R}{2} \Theta^{**} = \frac{X_R}{2} \left( \frac{X_C}{X_R} \sqrt{\frac{A_0}{X_R}} \right).$$  \hfill (66)

Thus, the optimal $A(T)$ for $R_1$ equals $\frac{X_R}{2} \Theta^M$, where

$$\Theta^M = \min \{ \Theta^\ast, \Theta^{**} \} = \min \left\{ \frac{2}{3} \sum_{i=0}^{2} \left( 1 + \frac{27}{3} \frac{X_R X_C}{A_0} + \sqrt{\left( 1 + \frac{27}{3} \frac{X_R X_C}{A_0} \right)^2 - 1} \right)^{\frac{1}{3}}, \frac{X_C}{X_R} \sqrt{\frac{A_0}{X_R}} \right\}.$$  \hfill (67)

First, notice $\Theta^{**}$ is increasing in $A_0$. Also, it is straightforward to calculate that $\frac{\partial \Theta^{**}}{\partial A_0} \leq 0$ when

$$\left( 1 + \frac{27}{3} \frac{X_R X_C}{A_0^2} + \sqrt{\left( 1 + \frac{27}{3} \frac{X_R X_C}{A_0^2} \right)^2 - 1} \right)^{\frac{2}{3}} - 1 \geq 0.$$  \hfill (68)
Since the last inequality always holds, $\Theta^*$ is decreasing in $A_0$. Also, as $A_0$ approaches to 0, $\Theta^*$ approaches to positive infinity and $\Theta^{**}$ approaches to 0. Thus, for small values of $A_0$, we have $\Theta^* > \Theta^{**}$. On the other extreme, when $A_0 = X_R$, we have

$$\Theta^* = \frac{1}{3} \sum_{i=0}^{2} \left( 1 + 27 \frac{X_C}{X_R} + \sqrt{\left( 1 + 27 \frac{X_C}{X_R} \right)^2 - 1} \right)^{i-1}$$

and $\Theta^{**} = \sqrt{\frac{X_C}{X_R}}$. (69)

Notice also that, when $A_0 = X_R$, we have $X_C = 4X_R$. Thus, the only feasible $X_C$ is $X_C = 4X_R$. In this case, we have $\Theta^* \simeq 2.39 > 2 = \Theta^{**}$. Thus, the optimal $A(T)$ for $R_1$ equals $\frac{X_B}{2} \Theta^M$ where $\Theta^M = \{\Theta^*, \Theta^{**}\} = \Theta^{**} = \sqrt{\frac{X_C}{X_R}} \sqrt{\frac{A_0}{X_R}}$ for all $X_C \in [X_C^L, X_C]$ and $A_0 \in [0, X_R]$.

Setting $A(T) = \frac{A_0}{X_R}$ equal to $\frac{X_B}{2} \Theta^M$ and solving for $T$ leads to $T^{MC} = 1 - \frac{2A_0}{X_R}$, $M^{MC}$. Accordingly, $v^{MC} = v(T^{MC}) = \frac{X_C}{X_R \Theta^M}$, $n_1^{MC} = n_1(T^{MC}) = \frac{X_C \Theta^M}{X_R}$ $\left( \frac{X_B}{2} \Theta^M - A_0 \right)$. Thus, the equilibrium market shares are $M_0^{MC} = \frac{2A_0}{X_R \Theta^M}$ and $M_1^{MC} = \frac{\frac{A_0}{X_R \Theta^M}}{\frac{A_0}{X_R}} = 1 - \frac{2A_0}{X_R \Theta^M}$. Furthermore, the equilibrium profits are $\Pi_1^{MC} = (p - w)M_1^{MC} - \alpha n_1^{MC} = \alpha X_R \left( 1 - \frac{2A_0}{X_R \Theta^M} \right) \left( 1 - \frac{X_R}{X_C \Theta^M} \right)^2$.

Finally, consider $R_1$’s profit difference

$$\Delta \Pi_1^{MC} (X_C) = \Pi_1^{MC} - \Pi_1^{MB} = \alpha X_R \left( 1 - \frac{2A_0}{X_R \Theta^M} \right) \left( 1 - \frac{X_R}{2X_C} \left( \Theta^M \right)^2 \right) - \Pi_1^{MB}$$

$$= \alpha X_R \left[ \left( 1 - \sqrt{\frac{A_0}{4X_R}} \right) \left( 1 - \sqrt{\frac{A_0}{X_C} \sqrt{\frac{A_0}{X_R}}} \right) - \left( 1 - \frac{A_0}{X_R} \right)^2 \right].$$

Clearly, $\Delta \Pi_1^{MC} (X_C)$ is increasing in $X_C$. Also, when $X_C = \bar{X}_C = 4X_R \frac{8 - \Phi}{8 - \Phi}$, we have

$$\Delta \Pi_1^{MC} (\bar{X}_C) = \alpha X_R \left[ \left( 1 - \sqrt{\frac{A_0}{4X_R}} \right) \left( 1 - \sqrt{\frac{A_0}{X_C} \sqrt{\frac{A_0}{8 - \Phi} \sqrt{\frac{A_0}{X_R}}} \right) - \left( 1 - \frac{A_0}{X_R} \right)^2 \right].$$

Notice that $\frac{A_0}{X_R} \in [0,1]$ for all $A_0 \in [0, X_R]$. Then, we have $1 - \sqrt{\frac{A_0}{4X_R}} > 1 - \sqrt{\frac{A_0}{X_R}}$ and $1 - \sqrt{\frac{A_0}{X_R} \sqrt{\frac{A_0}{8 - \Phi} \sqrt{\frac{A_0}{X_R}}} \geq 1 - \frac{A_0}{X_R}$. Therefore, $\Delta \Pi_1^{MC} (\bar{X}_C) \geq 0$ always holds. In Proposition 5, we show that $\Delta \Pi_1^{MC} (X_C) \geq 0$ when $X_C = \bar{X}_C$, which implies that $\Delta \Pi_1^{MC} (X_C^L) \leq 0$ since $X_C^L \leq \bar{X}_C$. Because $\Delta \Pi_1^{MC} (X_C)$ is increasing in $X_C$ with $\Delta \Pi_1^{MC} (X_C^L) \leq \Delta \Pi_1^{MC} (\bar{X}_C)$, there exist a threshold $X_C^M_1 \in [X_C^L, \bar{X}_C]$ such that $\Pi_1^{MC} < \Pi_1^{MB}$ when $X_C \in [X_C^L, X_C^M_1]$ and $\Pi_1^{MC} \geq \Pi_1^{MB}$ when $X_C \in [X_C^M_1, \bar{X}_C]$.

Proof of Proposition 5. Since we assume $X_C \in [X_C^M_1, \bar{X}_C]$, which ensures that $\Pi_1^C \geq \Pi_1^B$, we only need to consider the profits of the captain under both scenarios. Recall that by solving the
captain’s participation constraints, we get

\[ A(T)^\ast\ast = \frac{X_R}{2} \left( \frac{1}{8} \left( \Phi + \sqrt{\Phi \left( \Phi + \frac{8XC}{X_R} \right)} \right) \right) \]  \hspace{1cm} (70)

for the duopoly case (where both \( R_1 \) and \( R_2 \) offer the category) and

\[ A(T)^\ast\ast = \frac{X_R}{2} \sqrt{\frac{X_C}{X_R} \sqrt{\frac{A_0}{X_R}}} \]  \hspace{1cm} (71)

for the monopoly case (where only \( R_1 \) offers the category). Because the captain’s participation constraint is decreasing in \( A(T) \) in both scenarios, the emergence of CC is harder under duopoly (i.e., \( X_C \geq X_C^M \)) if and only if

\[ \Delta(A_0) = \frac{1}{8} \left( \Phi + \sqrt{\Phi \left( \Phi + \frac{8XC}{X_R} \right)} \right) - \sqrt{\frac{X_C}{X_R} \sqrt{\frac{A_0}{X_R}}} \geq 0 \]  \hspace{1cm} (72)

When \( A_0 = 0 \), \( \Delta(0) = \frac{1}{8} \left( 1 + \sqrt{1 + \frac{8XC}{X_R}} \right) \). Since \( \Delta(0) \geq 0 \) for all \( X_C \in [X_C, \tilde{X}_C] \), the inequality holds. When \( A_0 = X_R \), the condition \( \Delta(A_0) \geq 0 \) reduces to \( \sqrt{\frac{X_R}{X_C}} + \sqrt{2 + \frac{X_R}{X_C}} \geq 2 \). Since the left-hand side of this inequality is decreasing in \( X_C \), we only need to show that the condition holds in the upper bound case of \( X_C = \tilde{X}_C = 4X_R \frac{X_R - \Phi}{\Phi} = 4X_R \). When \( X_C = 4X_R \), we have \( \sqrt{\frac{X_R}{X_C}} + \sqrt{2 + \frac{X_R}{X_C}} = 2 \). Thus, the inequality holds. Consequently, \( \Delta(A_0) \geq 0 \) holds for all \( X_C \in [X_C, \tilde{X}_C] \) and \( A_0 \in [0, X_R] \), and the value of \( A(T) \) that solves the category captain’s participation constraint is higher under duopoly. Also, since \( A(T) \) is increasing in \( X_C \), the value of \( X_C \) that solves the category captain’s participation constraint is higher under duopoly, i.e., \( X_C \geq X_C^M \), where \( \tilde{X}_C \) solves \( \Pi^{MC}(\tilde{X}_C^M) = \Pi^{MB} \). This also implies that \( \Pi^{MC}(X_C) \geq \Pi^{MB} \).

\[ \text{Proof of Proposition 6.} \] Using the equilibrium expressions from Proposition 2, we obtain

\[ \Delta\Pi_{21} = (p - w) (M_2^C - M_2^B) = \alpha \frac{X_R}{2} \left( \frac{\Phi}{2} - \Theta \right) \]  \hspace{1cm} (73)

\[ \Delta\Pi_{22} = \alpha (n_2^B - n_2^C) = \alpha \frac{X_R}{2} \left( 1 - \frac{1}{2} \left( \Theta + \frac{\Phi}{2} \right) \right) \left( \frac{\Phi}{2} - \Theta \right) \]  \hspace{1cm} (74)

Recall from the proof of Proposition 3 that \( \hat{X}_C \in [X_C, \tilde{X}_C] \) and that \( \Theta(\hat{X}_C) = \frac{\Phi}{2} \). Because \( \Theta(X_C) \) is an increasing function of \( X_C \) with \( \Theta(\hat{X}_C) = \frac{\Phi}{2} \), \( \Theta(X_C) \leq \frac{\Phi}{2} \) when \( X_C \in [X_C, \hat{X}_C] \) and \( \Theta(X_C) > \frac{\Phi}{2} \) when \( X_C \in (\hat{X}_C, \tilde{X}_C) \). Then, \( \Delta\Pi_2 = \Pi_2^C - \Pi_2^B = \alpha \frac{X_R}{2} \left( 4 - \left( \Theta + \frac{\Phi}{2} \right) \right) \left( \frac{\Phi}{2} - \Theta \right) \geq 0 \) when \( X_C \in [X_C, \hat{X}_C] \) and \( \Delta\Pi_2 < 0 \) when \( X_C \in (\hat{X}_C, \tilde{X}_C) \). Similarly, when \( X_C \in [\hat{X}_C, \tilde{X}_C] \), we have \( \Delta\Pi_{21} \geq 0 \), when \( X_C \in (\hat{X}_C, \tilde{X}_C) \), we have \( \Delta\Pi_{21} < 0 \). Finally, notice that \( \Delta\Pi_{22} \) is convex in \( \Theta \) and its value is equal to zero when \( \Theta = 2 - \frac{\Phi}{2} \) or \( \Theta = \frac{\Phi}{2} \). Let \( \hat{X}_C \) be such that \( \Theta(\hat{X}_C) = 2 - \frac{\Phi}{2} \). Since \( \Delta\Pi_{22} \) is convex in \( \Theta \), we have \( \Delta\Pi_{22} \leq 0 \) when \( X_C \in [\max\{\hat{X}_C, X_C\}, \hat{X}_C] \) and \( \Delta\Pi_{22} > 0 \) when \( X_C \in [X_C, \max\{\hat{X}_C, \tilde{X}_C\}] \cup (\hat{X}_C, \tilde{X}_C) \).
Proof of Proposition 7. Using the equilibrium expressions from Proposition 2, we obtain

\[
\Delta \pi_{C1} = w \left( \frac{v^C}{A^C} - \frac{1}{A^B} \right) - \beta (v^C)^2 = \beta \left( \frac{X_C}{X_R \Theta} \right)^2 \left( 1 - \frac{4X_R \Theta^2}{X_C \Phi} \right),
\]

\[
\Delta \pi_{C2} = w \left( \frac{1}{A^C} - \frac{1}{A^B} \right) = \frac{4w}{X_R \Theta \Phi} \left( \frac{\Phi}{2} - \Theta \right),
\]

where \( A^C = A_0 + v^C n_1^C + n_2^C \) and \( A^B = A_0 + n_1^B + n_2^B \). Recall from Proposition 6 that \( \hat{X}_C = X_R \Phi \).

When \( X_C \in [\hat{X}_C, \hat{X}_C] \) we have \( \Theta \leq \frac{\Phi}{2} \) and when \( X_C \in (\hat{X}_C, \hat{X}_C] \) we have \( \Theta > \frac{\Phi}{2} \). Notice that \( \frac{X_R \Theta^2}{X_C \Phi} \) is monotone decreasing in \( X_C \) and \( 1 - \frac{4X_R \Theta^2}{X_C \Phi} = 0 \) when \( X_C = \hat{X}_C \). Thus, when \( X_C \in [\hat{X}_C, \hat{X}_C] \) we have \( \Delta \pi_{C1} \leq 0 \) and when \( X_C \in (\hat{X}_C, \hat{X}_C] \) we have \( \Delta \pi_{C1} > 0 \). Similarly, because the sign of \( \Delta \pi_{C2} \) changes at \( X_C = \hat{X}_C \), when \( X_C \in [\hat{X}_C, \hat{X}_C] \) we have \( \Delta \pi_{C2} \geq 0 \), and when \( X_C \in (\hat{X}_C, \hat{X}_C] \) we have \( \Delta \pi_{C2} < 0 \).

Proof of Proposition 8. First, notice that \( \Delta \pi_S \equiv M_1^C + M_2^C - (M_1^B + M_2^B) = 1 - M_0^C - (1 - M_0^B) = M_0^B - M_0^C = \frac{4A_0}{X_R \Phi} - \frac{2A_0}{X_R \Theta} = \frac{4A_0}{X_R \Theta \Phi} (\Theta - \frac{\Phi}{2}) \), where the last equality follows from Propositions 1 and 2. We know from Proposition 6 that \( \Theta \leq \frac{\Phi}{2} \) when \( X_C \in [\hat{X}_C, \hat{X}_C] \) and \( \Theta > \frac{\Phi}{2} \) when \( X_C \in (\hat{X}_C, \hat{X}_C] \). Thus, \( \Delta \pi_S \leq 0 \) when \( X_C \in [\hat{X}_C, \hat{X}_C] \), and \( \Delta \pi_S > 0 \) when \( X_C \in (\hat{X}_C, \hat{X}_C] \).