Market Entry of A Socially Responsible Retailer

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As consumers become more conscious about social issues, they gain an additional "social benefit" when purchasing from a socially responsible retailer (or brand). This trend has motivated more socially responsible retailers (or brands) to enter the market with a "pre-commitment" to donate a certain proportion of their (A) *profits* or (B) *revenues* for social causes. In this paper, we present a game-theoretic model where a *socially responsible retailer* enters the market with an *incumbent for-profit retailer* and *heterogeneous consumers*. We examine the socially responsible retailer's pricing strategy and entry conditions, the impact of the socially responsible retailer's entry on the incumbent retailer's profit, and the conditions under which the incumbent retailer should deter (or tolerate) the socially responsible retailer's entry.

Our equilibrium analysis generates the following insights. First, even if the incumbent retailer can profitably deter the socially responsible retailer's entry, the incumbent retailer can be better off tolerating it under certain conditions. Second, somewhat interestingly, the incumbent retailer is more likely to deter the type (B) retailer's entry even though such entry is less detrimental to the incumbent retailer.

Key words: Competition, Incumbent, Socially Responsible Operations.

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1 Introduction

Since its debut in a United Nations report in 2006, ESG—the acronym for environmental, social, and governance issues—has captivated the attention of businesses and governments (Dai and Tang 2022). Consistently, new generations (Millennials and Generation Z) are more conscious about social issues. As they enter the labor market and possess higher purchasing power in recent years, they also shift consumer expectations towards social responsibility (Costa 2019). For instance, according to a leading market intelligence agency Mintel, 73% of Americans consider companies' charitable work when they make their purchasing decisions (Mintel 2018). Such consumer expectations towards charitable initiatives create business opportunities for socially responsible retailers

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that are "pre-committed" to making charitable donations to support social causes. These charitable donations differentiate a socially responsible retailer (hereafter, social retailer) from a traditional for-profit retailer (hereafter, for-profit retailer).

Social retailers can pre-commit to donating a certain proportion of their **(A) *profits* or (B) *revenues*** to charities (see Chen 2021 for a list of 35 such retailers).[1] Two examples of type (A) social retailers are Toms and Ivory Ella.[2] Toms donates 1/3 of its profits for grassroots good, including cash grants and partnerships with community organizations, to drive sustainable change, whereas Ivory Ella donates 10% of its profits towards saving elephants. Two examples of type (B) social retailers are Cotopaxi and Judy.[3] Cotopaxi donates 1% of its yearly revenue to nonprofits making sustainable changes in poverty alleviation, while Judy donates 1% of its annual revenue to the Los Angeles Fire Department Foundation, which provides essential equipment and training to supplement city resources. These charitable donations generate **social benefits** for socially conscious consumers who shop at social retailers. These social benefits represent the "warm glow" derived from contributing to the social mission that the social retailer donates to (cf. Andreoni 1990 and Harbaugh 1998).

While consumer expectations can create opportunities for social retailers to enter the market and thrive, this movement can also induce incumbent for-profit retailers to proactively reduce their prices to deter the entry of social retailers. Therefore, in this paper, we study the entry and pricing strategy of a social retailer and the deterrence strategy of an incumbent for-profit retailer. We also compare the impact of a type (A) and type (B) social retailer's entry. In particular, we aim to answer the following research questions:

1. *What is the entry and pricing strategy of a social retailer in the presence of an incumbent for-profit retailer? Should the incumbent retailer deter or tolerate the social retailer's entry?*
2. *How does the entry of a type (A) social retailer differ from the entry of a type (B) social retailer?*

To answer our research questions, we build a two-stage Stackelberg model where a social retailer enters a market to compete with an incumbent for-profit retailer. The social retailer incurs a cost of entry and commits to donating a certain proportion of its profit (if type (A)) or revenue (if type

[1] There are other types of stores that create social values but are beyond the scope of our study. First, there are other retailers that make charitable donations "without pre-commitments," but we do not classify them as "socially responsible" retailers in our context. This is because, without pre-commitments, a consumer cannot take a firm's "future potential charitable donations" into consideration when she makes purchasing decisions. Second, there are for-profit neighborhood stores that create access of fresh produce as well as non-profit cooperative stores that support local economy. However, consumers would react to these stores differently than those with pre-committed charitable donations. We shall discuss this issue in §6.

[2] Founded in 2006, Toms.com is a for-profit company that designs and sells shoes, eyewear, coffee, apparel, and handbags. Founded in 2015, ivoryella.com is an online for-profit retailer that sells clothing and accessories.

[3] Founded in 2014, Cotopaxi is a Utah-based B-corp that sells outdoor gear and apparel with a social-focused mission of eradicating extreme poverty. Founded in 2020, Judy.co sells emergency preparedness kits.

(B)). Consumers in the market are *heterogeneous* in their utility from shopping at both retailers and they obtain social benefits from shopping at the social retailer.

To answer our first research question, we first analyze the strategic interactions among utility-maximizing consumers, a profit-maximizing retailer, and a type (A) social retailer. We find that a type (A) social retailer's optimal price depends on the incumbent retailer's price, and its profit along with its entry condition also depend on its cost of entry. Furthermore, the incumbent retailer's deterrence strategy depends on its unit-cost advantage over the social retailer and the social retailer's entry cost. Interestingly, even if the incumbent retailer can profitably deter the social retailer's entry, the incumbent retailer can be better off tolerating this entry unless it has a substantial competitive advantage over the social retailer (due to the incumbent's significantly lower unit cost or the social retailer's high entry cost).

To answer our second research question, we next examine a type (B) social retailer's entry. While the above results also hold when the social retailer is of type (B), we obtain the following additional insights. First, the donation proportion plays a more important role in pricing decisions of a type (B) retailer. Specifically, to cover for the donations, a type (B) social retailer needs to charge a higher price, and hence obtains a smaller market share. Due to this challenge, *ceteris paribus*, a type (B) social retailer's entry poses a smaller threat for the incumbent retailer. For this reason, one may expect that the incumbent retailer is more tolerant towards a type (B) social retailer, but we show the opposite result. The incumbent is in fact more likely to deter the entry of a type (B) social retailer that commits to donating a certain proportion of its revenue. Our results are informative for policy makers and entrepreneurs aiming to establish social retailers as they show how an incumbent retailer reacts to entry threats made by different types of social retailers.

This paper is organized as follows. We review the relevant literature in §2. After we define our model preliminaries in §3, we analyze the potential entry of a type (A) store and its impact in §4. We analyze the implications of the potential entry of a type (B) store in §5, and we conclude in §6.

2 Literature Review

Our study is related to studies on market entry, mixed oligopoly, and socially responsible retailers.

The market-entry literature, pioneered by Bain (1949), establishes the notion of an incumbent's decision to lower its price below the profit-maximizing price to "deter" the entry of a for-profit competitor. This literature mainly focuses on how a for-profit firm can deter the entry of a for-profit competitor of the same type, and suggests deterrence tools such as pricing (Bain 1949), strategic commitment (Spence 1977, 1979), long-term contracts (Aghion and Bolton 1987), cost signalling (Srinivasan 1991), bundle pricing (Nalebuff 2004), or discount contracts (Ide et al. 2016). Overall these papers focus on the deterrence tools or the market structure rather than focusing on the entrant characteristics. (We refer the reader to Hall (2008) for a review of the market-entry literature.) More recently, Gao et al. (2017) examine the entry of copycats, and show that the incumbent firm can deter the copycat from entering by selling a higher-quality product. There are also some papers in the supply-chain-competition literature (e.g., Corbett and Karmarkar 2001, Korpeoglu et al. 2020) that analyze the market entry and competition of identical for-profit firms. Our work contributes to the market-entry literature on several fronts. First, unlike the literature that studies the entry of for-profit retailers, we examine the entry of a social retailer that pre-commits to donating a certain proportion of its profit (type A) or revenue (type B). This social commitment adds a new dimension to price competition because it also creates social benefits for the social retailer's customers. Our work also compares the entry of the two types of social retailers.

Our work is also related to the literature on mixed oligopoly, which studies competition among firms with different objectives. As reviewed by De Fraja and Delbono (1990), early work on mixed oligopolies focuses on competition between private firms that maximize their profits and public firms that maximize social welfare. These firms usually engage in Cournot competition. Later work considers different extensions such as dynamic settings (Casadesus-Masanell and Ghemawat 2006) or service settings (Zhou et al. 2022) (we refer the reader to Zhou et al. 2022 for a review of recent literature). Our model differs from this literature on several fronts. First, our work considers the market entry of a social retailer that maximizes its profit but subject to donating a certain proportion of its profit or revenue. Indeed, a major contribution of our paper is to compare the entry of these two types of social retailers. Second, we consider the social benefit that consumers receive from shopping at the social retailer because of the "warm glow" of supporting social causes. Because consumers have different valuations and they receive different social benefits in the end, the market is segmented between the incumbent for-profit retailer and the entrant social retailer.

Our work also contributes to the scant literature on socially responsible retailers.[4] There is a body of work that recognizes the "warm glow" that consumers receive from shopping at socially responsible retailers (e.g., Strahilevitz 1999, Bloom et al. 2006). Some more recent papers study the impact of this warm glow on operational decisions. Arya and Mittendorf (2015) investigate the impact of a government subsidy in an environment with one supplier and one socially responsible retailer that commits to donating a certain number of goods. Gao (2020) studies the pricing decisions of a firm that commits to donating a proportion of its revenue to charity without considering any competition. Our work contributes to this literature by considering the market entry of a socially responsible retailer and by comparing the two types of donation strategies this retailer can adopt.

[4] The literature on socially responsible enterprises is quite broad. We refer the reader to Lee and Tang (2018) for a discussion. There is also literature on producer cooperatives (e.g., An et al. 2015, Ayvaz-Cavdaroğlu et al. 2020) and consumer cooperatives (e.g., Sexton and Sexton 1987). As cooperatives significantly differ from social retailers (e.g., are owned by members, have different objectives, charge membership fees), they are beyond the scope of this paper.

3 Model Preliminaries

We consider a Stackelberg competition model that involves an incumbent for-profit retailer (store R) and an entrant social retailer (store S). Different from store R, store S has a pre-announced commitment to make charitable donations. We consider two types of store S: type (A) donates a proportion $\gamma \in (0, 1)$ of its *profit* to charities (e.g., Toms); while type (B) donates a proportion $\gamma \in (0, 1)$ of its *revenue* to charities (e.g., Cotopaxi), where γ is an exogenous parameter based on store S's pre-announced commitment. (As an initial attempt to obtain tractable results, we leave the case when γ is endogenously determined as future research.)

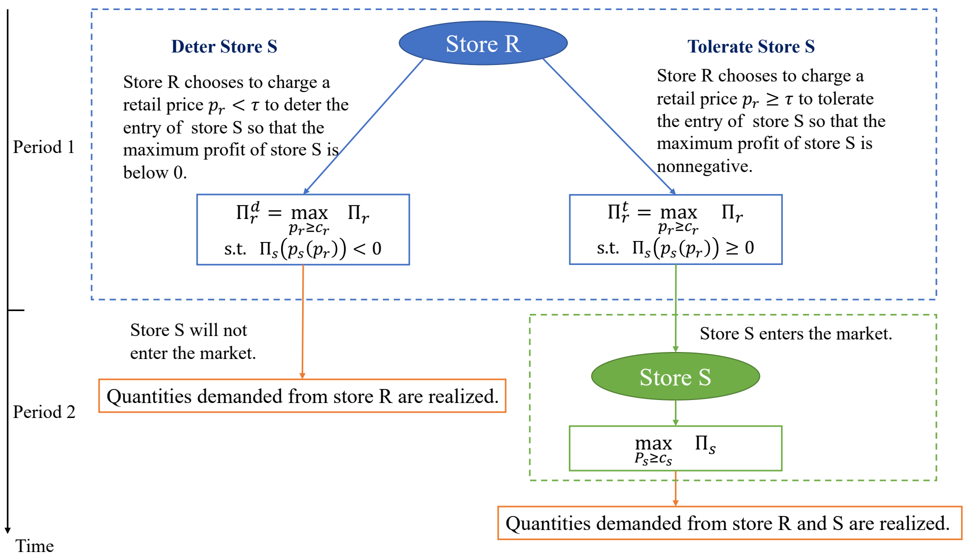


Figure 1 Sequence of events of a market-entry game.

3.1 Sequence of Events

In the sequential game as depicted in Figure 1, the incumbent store R acts as a "leader" who first sets its price p_r considering its unit cost c_r and anticipating the potential entry of store S. Then, upon observing p_r, store S acts as a "follower" who sets its price p_s as a response. (Throughout this paper, subscripts r and s are used to denote stores R and S, respectively.) In period 1 of our market-entry game, store S has not yet entered and incumbent store R can choose its price p_r to deter store S's entry or tolerate it (highlighted in the blue box in Figure 1). If store R chooses to deter by setting a sufficiently low price, then store R operates as a monopoly with the set price p_r in period 2 and the game ends. If store R chooses p_r to tolerate store S's entry, then store S enters in period 2 by incurring an entry cost k. This entry cost k can represent the present value of loan repayments store S has to make using its future earnings to cover its initial investment.

Upon entry, store S observes p_r and competes with store R in a duopoly by choosing its own price p_s that takes its unit cost c_s into consideration (highlighted in the green box in Figure 1).

Note that we adopt two standard assumptions in the market-entry literature reviewed in §2. First, store R's retail price p_r is irreversible in the sense that store R does not change p_r after store S's entry. Spence (1977) articulates that irreversibility is a way for a firm to commit itself to issue a credible threat to potential entry. This is also consistent with the notion of price stickiness (e.g. Chen et al. 2017). Second, store S's cost parameters c_s and k are known by the incumbent store R. This may be a reasonable assumption given that the incumbent retailer has been in business for a while and can roughly gauge costs of a newcomer.

3.2 Backward Induction Steps for Determining Equilibrium Strategies

We now describe how we solve the sequential game that involves store S's potential entry via backward induction. In preparation, let us first describe the consumer demand. Then, we formulate store S's problem in period 2 (the green box in Figure 1), followed by a discussion of store R's problem in period 1 (the blue box in Figure 1).

3.2.1 Consumer Utility and Demand

We assume that the consumer utility for shopping at store R is: $U_r = v - p_r$, where v is the consumer valuation for a certain product and $p_r (< 1)$ is the price set by store R. To capture the *heterogeneity* across consumers, we assume that the consumer valuation v follows a uniform distribution such that $v \sim U[0,1]$.

The consumer utility for shopping at store S is assumed to take the following form: $U_s = \beta \cdot v - p_s$, where $\beta \cdot v$ is the consumer valuation for the same/similar product sold by store S and p_s is the price set by store S. We assume $\beta > 1$ so that consumers have a higher valuation when shopping at store S due to its inherent social benefit as explained in §1. This is because store S pre-announces its social commitment to make charitable donations so that each consumer gains a social benefit from patronizing store S. For ease of exposition, we shall assume that all consumers have the same parameter β for both types of store S.

While we assume all consumers obtain the same social benefit β in our main model, our approach can easily be extended to examine the case when there are two classes of consumers so that a certain proportion of consumers are socially conscious with $\beta = B (> 1)$, and the others are not, with $\beta = 1$. Also, β can depend on the type of store S. We observe that our structural results are fairly robust to this extension. To avoid repetition, we provide the detailed analysis of this extension in §EC.1 of the Online Appendix.

We next discuss each retailer's consumer demand, which depends on store R's deterrence strategy. If store R chooses to deter store S's entry by setting a low price p_r, it operates as a monopoly. In this case, only consumers with utility $U_r = v - p_r \geq 0$ will buy the product from store R. Thus, the consumer demand q_r for store R is:

$$q_r = 1 - p_r. \tag{1}$$

If store R chooses to tolerate store 's entry by setting a price p_r, and store S reacts with a price p_s in period 2, then a consumer will shop from store R only when $U_r \geq 0$ and $U_r \geq U_s$; and instead shop from store S only when $U_s \geq 0$ and $U_s \geq U_r$. By considering U_r and U_s as defined above, the consumer demand q_r for store R and q_s for store S satisfy:

$$q_r = \begin{cases} 0 & \text{if } p_s \leq \beta \cdot p_r \\ \frac{p_s - p_r}{\beta - 1} - p_r & \text{if } \beta \cdot p_r < p_s < \beta - 1 + p_r \\ 1 - p_r & \text{if } p_s \geq \beta - 1 + p_r \end{cases}, \tag{2}$$

$$q_s = \begin{cases} 1 - \frac{p_s}{\beta} & \text{if } p_s \leq \beta \cdot p_r \\ 1 - \frac{p_s - p_r}{\beta - 1} & \text{if } \beta \cdot p_r < p_s < \beta - 1 + p_r \\ 0 & \text{if } p_s \geq \beta - 1 + p_r \end{cases}. \tag{3}$$

Armed with the consumer demand functions as stated above, we now proceed to formulate store S's problem in period 2, followed by Store R's problem in period 1. This sequence is intended to facilitate the backward induction steps for solving the Stackelberg game as depicted in Figure 1.

3.2.2 Store S's Problem in Period 2

If store R sets a sufficiently low price p_r in period 1 to deter store S's entry, then store S's best response in period 2 is to not enter the market. In this case, store S does not have a pricing decision.

If store R chooses its p_r in period 1 in such a way that it will tolerate store S's entry, then store S's best response is to enter the market. In this case, store S can set a price p_s to compete with store R in a duopoly taking p_r as given. By considering its unit cost c_s ($\leq \beta$ to eliminate trivial cases where store S can never make profit) and the entry cost k, store S can determine its best-response price p_s that maximizes its profit after donation. For any given p_r, store S can factor in the consumer demand q_s given by (3) and formulate its problem as follows. First, a type (A) store S, which commits to donating a proportion γ of its *profit* (i.e., revenue net of the costs of goods and other expenses such as loan repayments) to charity, chooses its price $p_s^A(p_r)$ by solving:

$$\Pi_s^A(p_r) = \max_{p_s \geq c_s} \ \Pi_s = (1-\gamma) \cdot [(p_s - c_s) \cdot q_s - k],$$
$$\text{s.t.} \quad q_s = \begin{cases} 1 - \frac{p_s}{\beta} & \text{if } p_s \leq \beta \cdot p_r \\ 1 - \frac{p_s - p_r}{\beta - 1} & \text{if } \beta \cdot p_r < p_s < \beta - 1 + p_r \\ 0 & \text{if } p_s \geq \beta - 1 + p_r \end{cases}. \tag{4}$$

A type (A) store S decides to enter the market if and only if $\Pi_s^A(p_r) \geq 0$.

A type (B) store S, which commits to donating a proportion γ of its *revenue* to charities, chooses its price $p_s^B(p_r)$ as a best response by solving:

$$\Pi_s^B(p_r) = \max_{p_s \geq c_s} \ \Pi_s = (1-\gamma)\cdot p_s \cdot q_s - (c_s \cdot q_s + k) = (1-\gamma)\cdot \left[\left(p_s - \frac{c_s}{1-\gamma}\right)\cdot q_s - \frac{k}{1-\gamma}\right],$$
$$\text{s.t.} \quad q_s = \begin{cases} 1 - \frac{p_s}{\beta} & \text{if } p_s \leq \beta \cdot p_r \\ 1 - \frac{p_s - p_r}{\beta - 1} & \text{if } \beta\cdot p_r < p_s < \beta - 1 + p_r \\ 0 & \text{if } p_s \geq \beta - 1 + p_r \end{cases}. \tag{5}$$

A type (B) store S decides to enter the market if and only if $\Pi_s^B(p_r) \geq 0$. Note that store S needs to charge $p_s \geq \frac{c_s}{1-\gamma}$ to be able to enter the market. Therefore, we assume the pre-committed proportion $\gamma < 1 - \frac{c_s}{\beta}$ to eliminate trivial cases where store S never enters the market.

If we compare (4) and (5), we see that the objective function of a type (B) store S boils down to the objective function of a type (A) store S by replacing c_s with $\frac{c_s}{1-\gamma}$ and replacing k with $\frac{k}{1-\gamma}$.

3.2.3 Store R's Problem in Period 1

In period 1, store R can anticipate store S's best-response entry decision and price $p_s(p_r)$ (with superscripts A and B suppressed). Then, we can formulate store R's problem (highlighted in blue box of Figure 1) depending on store R's decision to deter or tolerate store S's entry.

If store R chooses to deter store S's entry, then store R's monopoly demand q_r is as given by (1), and store R can determine its optimal price p_r^d by solving:

$$\Pi_r^d = \sup_{p_r \geq c_r} \ \Pi_r = (p_r - c_r)\cdot(1-p_r),$$
$$\text{s.t.} \quad \Pi_s\left(p_s(p_r)\right) < 0. \tag{6}$$

(Superscripts d and t denote store R's deterrence and tolerance strategies, respectively.) Note that the constraint $\Pi_s\left(p_s(p_r)\right) < 0$ ensures deterrence.

If store R tolerates store S's entry so that store R's duopoly demand q_r is as given by (2), then store R can determine its optimal price p_r^t that solves:

$$\Pi_r^t = \max_{p_r \geq c_r} \ \Pi_r = (p_r - c_r)\cdot q_r,$$
$$\text{s.t.} \quad \Pi_s\left(p_s(p_r)\right) \geq 0,$$
$$q_r = \begin{cases} 0 & \text{if } p_s(p_r) \leq \beta\cdot p_r \\ \frac{p_s(p_r) - p_r}{\beta - 1} - p_r & \text{if } \beta \cdot p_r < p_s(p_r) < \beta - 1 + p_r \\ 1 - p_r & \text{if } p_s(p_r) \geq \beta - 1 + p_r. \end{cases} \tag{7}$$

Note that the constraint $\Pi_s\left(p_s(p_r)\right) \geq 0$ ensures store S's entry.

3.2.4 Equilibrium Prices and Strategies

We determine equilibrium decisions of store R and S as follows. First, by comparing store R's optimal profit Π_r^d when deterring store S as given in (6) and Π_r^t when tolerating store S as given in (7), we determine store R's equilibrium deterrence strategy and price in period 1. Specifically, store R chooses to deter the entry of store S if $\Pi_r^d > \Pi_r^t$, and tolerate store S's entry otherwise. Meanwhile, store R chooses its equilibrium price p_r^* that maximizes its profit (i.e., $\Pi_r^* = \max\{\Pi_r^d, \Pi_r^t\}$). Second, we characterize store S's equilibrium entry and pricing decisions in period 2. Specifically, if store R chooses to tolerate store S's entry, we can retrieve store S's corresponding equilibrium price $p_s(p_r^*)$ through substitution (otherwise, store S cannot enter). This way, we can determine equilibrium prices to be chosen by both stores. This completes the description of our backward induction steps for solving our market-entry game that involves an incumbent for-profit retailer R and an entrant social retailer S.

Our analysis proceeds in the following order. First, in §4, we analyze the case of a type (A) social retailer. Then, in §5, we analyze the case of a type (B) social retailer, followed by a comparison of these two types of social retailers.

4 Analysis of Type (A) Store S against Store R

We present our analysis in line with the backward induction steps described in §3.2. In §4.1, we characterize period 2 of our market-entry game where store S chooses its best-response price by solving (4) given store R's price p_r. Then, in §4.2, we characterize period 1 of our market-entry game where store R determines its equilibrium deterrence strategy and price by anticipating store S's best-response entry and pricing decisions.

4.1 Type (A) Store S's Best-Response Pricing Strategy

We first characterize the best-response pricing strategy for type (A) store S. For any given store R's retail price p_r, store S determines its best-response price by solving (4), and store S can enter the market only when its *effective* maximum profit $\Pi_s^A \geq 0$. For ease of exposition, we let $\tilde{\Pi}_s^A = (p_s^A - c_s) \cdot q_s^A$ be the maximum gross profit that store S can earn without considering the donation proportion γ or the entry cost k. Hence, the effective maximum profit $\Pi_s^A = (1-\gamma) \cdot (\tilde{\Pi}_s^A - k)$. By solving (4), we obtain the following proposition.

PROPOSITION 1. *(a) Given store R's price p_r, a type (A) store S can afford to enter the market only when its entry cost k is below $\tilde{\Pi}_s^A(p_r)$ (i.e., $k \leq \tilde{\Pi}_s^A(p_r)$), where*

$$\tilde{\Pi}_s^A(p_r) = \begin{cases} 0 & p_r \leq c_s + 1 - \beta \\ \frac{(\beta-1+p_r-c_s)^2}{4(\beta-1)} & p_r \in (c_s + 1 - \beta, \frac{\beta-1+c_s}{2\beta-1}) \\ (\beta \cdot p_r - c_s)(1-p_r) & p_r \in [\frac{\beta-1+c_s}{2\beta-1}, \frac{\beta+c_s}{2\beta}] \\ \frac{(\beta-c_s)^2}{4\beta} & p_r > \frac{\beta+c_s}{2\beta} \end{cases}. \tag{8}$$

Furthermore, $\tilde{\Pi}_s^A(p_r)$ is non-decreasing in p_r.

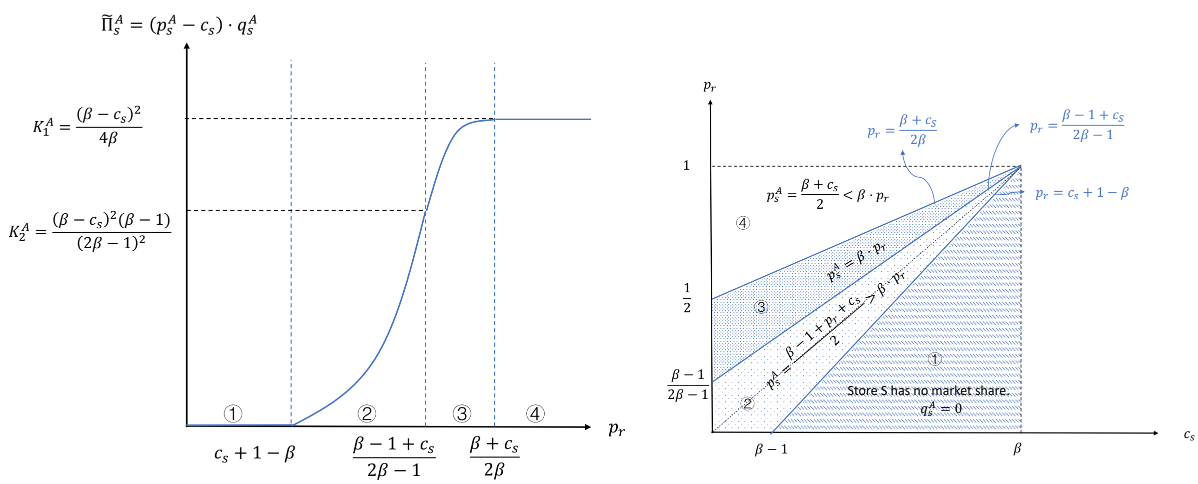
(b) Suppose store S enters the market (which from above requires $p_r > c_s + 1 - \beta$). Then, store S's best-response price p_s^A, consumer demand q_s^A, and retained profit $\Pi_s^A = (1-\gamma)\cdot(\tilde{\Pi}_s^A - k)$ satisfy:

(i) If $p_r \in (c_s + 1 - \beta, \frac{\beta-1+c_s}{2\beta-1})$, then the best-response $p_s^A = \frac{\beta-1+p_r+c_s}{2} > \beta\cdot p_r$, so the corresponding $q_s^A = \frac{\beta-1+p_r-c_s}{2(\beta-1)}$ and $\Pi_s^A = (1-\gamma)\cdot\left[\frac{(\beta-1+p_r-c_s)^2}{4(\beta-1)} - k\right]$.

(ii) If $p_r \in [\frac{\beta-1+c_s}{2\beta-1}, \frac{\beta+c_s}{2\beta}]$, then the best-response $p_s^A = \beta\cdot p_r$, so the corresponding $q_s^A = 1 - p_r$ and $\Pi_s^A = (1-\gamma)\cdot[(\beta\cdot p_r - c_s)(1-p_r) - k]$.

(iii) If $p_r > \frac{\beta+c_s}{2\beta}$, then the best-response $p_s^A = \frac{\beta+c_s}{2} < \beta\cdot p_r$, so the corresponding $q_s^A = \frac{\beta-c_s}{2\beta}$, and $\Pi_s^A = (1-\gamma)\cdot\left[\frac{(\beta-c_s)^2}{4\beta} - k\right]$.

Proposition 1 shows that given store R's price p_r, store S can enter the market only when its entry cost k is below its gross profit $\tilde{\Pi}_s^A$ as given in (8). Figure 2(a) illustrates the maximum gross profit $\tilde{\Pi}_s^A$ of store S for any given store R's price p_r. Observe from Figure 2(a) that $\tilde{\Pi}_s^A$ is increasing in p_r, which implies that store S can more easily enter the market given a higher p_r.



(a) Store S's gross profit $\tilde{\Pi}_s^A$. (b) Store S's best-response price p_s^A.

Figure 2 Type (A) store S's best-response pricing strategy.

Next, before we explain the best-response pricing decision of store S as stated in Proposition 1, let us first examine the corresponding consumer demand for store R and store S as given by (2) and (3). By substituting the best-response price $p_s^A(p_r)$ in Proposition 1 into (2) and (3), we get:

Corollary 1. *When $p_r \le c_s + 1 - \beta$, store S's demand $q_s^A = 0$ and store R's demand $q_r^A = 1 - p_r$, which is decreasing in p_r. Otherwise, when store S's entry cost $k \le \tilde{\Pi}_s^A$ and store S enters the market, the best-response price p_s^A set by store S is non-decreasing in both store R's retail price p_r and store S's per unit cost c_s. Moreover, the corresponding demand for each store is as follows.*

(i) When $p_r \in (c_s + 1 - \beta, \frac{\beta-1+c_s}{2\beta-1})$*, store S's best-response price* $p_s^A > \beta \cdot p_r$*. Hence, upon store S entry, store R's demand* $q_r^A = \frac{\beta-1+c_s-(2\beta-1)p_r}{2(\beta-1)}$*, which is increasing in* c_s *and decreasing in* p_r*. Also, the corresponding store S's demand* $q_s^A = \frac{\beta-1+p_r-c_s}{2(\beta-1)}$*, which is increasing in* p_r *and decreasing in* c_s*.*

(ii) When $p_r \geq \frac{\beta-1+c_s}{2\beta-1}$*, store S's best-response price* $p_s^A \leq \beta \cdot p_r$*. As a result, after store S enters, store R's demand* $q_r^A = 0$ *and store S's demand* q_s^A *is non-increasing in* p_r *and* c_s*, where*

$$q_s^A = 1 - \frac{p_s^A}{\beta} = \begin{cases} \frac{\beta-c_s}{2\beta} & \text{if } p_r > \frac{\beta+c_s}{2\beta} \\ 1 - p_r & \text{if } p_r \in [\frac{\beta-1+c_s}{2\beta-1}, \frac{\beta+c_s}{2\beta}] \end{cases}.$$

We now explain the implications of the best-response pricing decision of store S as described in Proposition 1 and Corollary 1 and illustrated in Figure 2. As Proposition 1 shows, when store R's retail price p_r is low (i.e., $p_r \leq (c_s + 1 - \beta)$), store S cannot make profit, so is unable to enter the market (see Figure 2 zone (1)). When p_r is moderate (i.e., $p_r \in (c_s + 1 - \beta, \frac{\beta-1+c_s}{2\beta-1})$), store S will charge $p_s^A = \frac{\beta-1+p_r+c_s}{2} > \beta \cdot p_r$. As such, store S and R can co-exist in the market (see Figure 2 zone (2)), and the corresponding consumer demand q_s^A for store S is increasing in p_r and decreasing in c_s, while the consumer demand q_r^A for store R is increasing in c_s and decreasing in p_r.

When store R's retail price p_r is high (i.e., $p_r \geq \frac{\beta-1+c_s}{2\beta-1}$), compared with p_r, store S can afford to charge a competitive price p_s^A that is no larger than $\beta \cdot p_r$. Then as shown in Corollary 1(ii), upon store S's entry, store R's market share will be squeezed out. Specifically, Proposition 1(b)(ii) implies that when p_r is high but still lower than $\frac{\beta+c_s}{2\beta}$ (i.e., $p_r \in [\frac{\beta-1+c_s}{2\beta-1}, \frac{\beta+c_s}{2\beta}]$), it is optimal for store S to charge $p_s^A = \beta p_r$, which is increasing in p_r and independent of c_s (see Figure 2 zone (3)). As such, the corresponding consumer demand q_s^A is decreasing in p_r and independent of c_s. Proposition 1(b)(iii) suggests that if p_r is very high (i.e., $p_r > \frac{\beta+c_s}{2\beta}$), it is optimal for store S to charge $p_s^A = \frac{\beta+c_s}{2\beta} < \beta p_r$, which is independent of p_r and is increasing in c_s (see Figure 2 zone (4)). As a result, the corresponding consumer demand q_s^A is independent of p_r and is decreasing in c_s.

4.2 Store R's Equilibrium Deterrence Strategy

To characterize store R's equilibrium deterrence strategy, we proceed in the following order. First, we characterize the conditions under which store R can deter store S's entry. Then, we derive store R's profits when it chooses to deter and when it chooses to tolerate store S's entry. Finally, we compare these profits to find store R's equilibrium deterrence strategy and equilibrium price.

According to Proposition 1, store S will enter the market only when $k \leq \tilde{\Pi}_s^A(p_r)$, where $\tilde{\Pi}_s^A(p_r)$ is as in (8). Let us first determine the conditions for p_r under which $k > \tilde{\Pi}_s^A(p_r)$.

To begin, recall from Proposition 1 that $\tilde{\Pi}_s^A(p_r)$ as given by (8) is increasing in p_r. Observe from (8) that when $p_r > \frac{\beta+c_s}{2\beta}$, $\tilde{\Pi}_s^A = \frac{(\beta-c_s)^2}{4\beta}$. Hence, when $k \leq \frac{(\beta-c_s)^2}{4\beta}$, there exists a finite deterrence threshold τ^A that solves $\tilde{\Pi}_s^A(\tau^A) = k$, such that store R can deter store S's entry by choosing sufficiently low retail price $p_r < \tau^A$ or tolerate store S's entry by setting $p_r \geq \tau^A$. Note that when store S's entry cost $k > \frac{(\beta - c_s)^2}{4\beta}$, store S can never enter the market regardless of the value of p_r (i.e., $\tau^A = \infty$). We formally characterize τ^A in the following lemma. For ease of exposition, we define $K_1^A \equiv \frac{(\beta-c_s)^2}{4\beta}$ and $K_2^A \equiv \tilde{\Pi}_s^A(\frac{\beta-1+c_s}{2\beta-1}) = \frac{(\beta-c_s)^2(\beta-1)}{(2\beta-1)^2}$.

LEMMA 1. *The deterrence threshold τ^A for store R's retail price p_r, such that store R can deter store S's entry by setting $p_r < \tau^A$ or tolerate store S's entry by setting $p_r \geq \tau^A$, satisfies:*

$$\tau^A = \begin{cases} \sqrt{4k(\beta-1)} + c_s + 1 - \beta & k \leq K_2^A \\ \frac{c_s + \beta - \sqrt{(c_s-\beta)^2 - 4k\beta}}{2\beta} & k \in (K_2^A, K_1^A] \\ \infty & k > K_1^A \end{cases}. \tag{9}$$

By factoring in store S's best-response entry and pricing decisions, we now consider store R's problems depending on its choice to deter or tolerate store S's entry. Lemma 1 shows that to deter store S's entry, store R should set a price $p_r < \tau^A$. Hence, store R's problem (6) when choosing to deter store S's entry (which is only possible when $\tau^A > c_r$) can be reformulated as:

$$\Pi_r^{d,A} = \sup_{p_r \in [c_r, \tau^A)} \Pi_r = \sup_{p_r \in [c_r, \tau^A)} (p_r - c_r) \cdot (1 - p_r). \tag{10}$$

If store R chooses to tolerate store S's potential entry, it sets a price $p_r \geq \tau^A$. Recall that the consumer demand q_r^A for store R after store S's entry is as given by Corollary 1. Thus, store R's problem (7) when choosing to tolerate store S's entry can be reformulated as:

$$\begin{aligned} \Pi_r^{t,A} = &\max_{p_r \geq \max\{c_r, \tau^A\}} \Pi_r = (p_r - c_r) \cdot q_r, \\ &\text{s.t.} \quad q_r = \begin{cases} 0 & \text{if } p_r \geq \frac{\beta-1+c_s}{2\beta-1} \\ \frac{\beta-1+c_s-(2\beta-1)p_r}{2(\beta-1)} & \text{if } p_r \in (c_s+1-\beta, \frac{\beta-1+c_s}{2\beta-1}) \\ 1 - p_r & \text{if } p_r \leq c_s + 1 - \beta \end{cases}. \end{aligned} \tag{11}$$

Store R should deter store S's entry by setting a price p_r below τ^A if $\Pi_r^{d,A} > \Pi_r^{t,A}$, and tolerate it otherwise. Hence, by comparing $\Pi_r^{d,A}$ and $\Pi_r^{t,A}$, we can determine store R's equilibrium deterrence strategy (i.e., deter or tolerate) and store R's equilibrium retail price p_r^A that yields:

$$\Pi_r^A(p_r^A) = \max_{p_r \geq c_r} \{\Pi_r^{d,A}, \ \Pi_r^{t,A}\} \tag{12}$$

We now solve store R's problem (12). To examine the impact of store R's unit cost on its deterrence strategy, we let store R's unit cost $c_r = \alpha \cdot c_s$, where the parameter α captures store R's cost competitiveness relative to store S. Besides store R's cost competitiveness, we also consider store S's entry barrier via its entry cost k. We present store R's equilibrium deterrence strategy in Proposition 2. In preparation, we define $\Theta_1^A(k)$ and $\Theta_2^A(k)$ as two thresholds for α such that:

$$\Theta_1^A(k) = \begin{cases} \frac{c_s+\beta-\sqrt{(c_s-\beta)^2-4k\beta}}{2\beta c_s} & k \in (K_2^A, K_1^A] \\ \frac{c_s(4\beta-3)+(\beta-1)(1-4\beta+8\sqrt{k(\beta-1)}+4\sqrt{k(\frac{\beta-c_s}{\sqrt{k(\beta-1)}}-2)})}{c_s(2\beta-1)} & k \le K_2^A \end{cases}, \tag{13}$$

$$\Theta_2^A(k) = \begin{cases} \frac{c_s+\beta-\sqrt{(c_s-\beta)^2-4k\beta}}{2\beta c_s} & k \in (K_2^A, K_1^A] \\ \frac{\beta-1+c_s}{(2\beta-1)c_s} & k \le K_2^A \end{cases}. \tag{14}$$

It is easy to verify that when $k \in (K_2^A, K_1^A]$, $\Theta_1^A(k) = \Theta_2^A(k)$, which are increasing in k. However, when $k \le K_2^A$, $\Theta_1^A(k)$ is increasing in k, while $\Theta_2^A(k)$ is independent of k.

PROPOSITION 2. *Suppose store S's entry cost k satisfies $k \le K_1^A$ so that store S has a chance to enter the market. Then, store R's equilibrium deterrence strategy and equilibrium price p_r^A satisfy:*

(I) If $k \in (K_2^A, K_1^A]$, and

(a) if $\alpha < \Theta_1^A(k)$, it is optimal for store R to deter store S's entry. Specifically, (i) when $\alpha \in \big[\frac{c_s-\sqrt{(c_s-\beta)^2-4k\beta}}{\beta c_s}, \Theta_1^A(k)\big)$, store R's equilibrium deterrence price $p_r^A = \tau^A - \epsilon = \frac{c_s+\beta-\sqrt{(c_s-\beta)^2-4k\beta}}{2\beta} - \epsilon$, where $\epsilon \to 0^+$; (ii) when $\alpha < \frac{c_s-\sqrt{(c_s-\beta)^2-4k\beta}}{\beta c_s}$, store R's equilibrium deterrence price $p_r^A = p_r^0 = \frac{1+c_r}{2}$. Furthermore, store R's demand $q_r^A = 1 - p_r^A$.

(b) if $\alpha \ge \Theta_2^A(k) = \Theta_1^A(k)$, store R's equilibrium price $p_r^A = c_r$. However, store R cannot deter the inevitable entry of store S, and after store S enters, $q_r^A = 0$.

(II) If $k \in (0, K_2^A]$, and

(a) if $\alpha < \Theta_1^A(k)$, it is optimal for store R to deter store S's entry. Specifically, (i) when $\alpha \in \big[\frac{2c_s+1-2\beta+4\sqrt{k(\beta-1)}}{c_s}, \Theta_1^A(k)\big)$, store R's equilibrium deterrence price $p_r^A = \tau^A - \epsilon = \sqrt{4k(\beta-1)} + c_s + 1 - \beta - \epsilon$, where $\epsilon \to 0^+$; (ii) when $\alpha < \frac{2c_s+1-2\beta+4\sqrt{k(\beta-1)}}{c_s}$, then store R's equilibrium deterrence price $p_r^A = p_r^0 = \frac{1+c_r}{2}$. Furthermore, store R's demand $q_r^A = 1 - p_r^A$.

(b) if $\alpha \in [\Theta_1^A(k), \Theta_2^A(k))$, it is optimal for store R to tolerate store S's entry by setting the equilibrium tolerating price $p_r^A = \frac{\beta-1+c_s+(2\beta-1)c_r}{2(2\beta-1)}$. In this case, store R's demand $q_r^A = \frac{\beta-1+c_s+c_r-2\beta c_r}{4(\beta-1)}$.

(c) if $\alpha \ge \Theta_2^A(k)$, then it is optimal for store R to set $p_r^A = c_r$. However, store R cannot deter the inevitable entry of store S, and after store S enters, $q_r^A = 0$.

Before we interpret Proposition 2, let us summarize our results graphically as depicted in Figure 3. In this figure, we map out store R's equilibrium deterrence strategy based on the competitiveness of each store. Specifically, store R is less competitive when the parameter α is high due to relatively higher unit cost than store S. Similarly, store S is less competitive when its entry cost k is high.

By using this notion, we can interpret Proposition 2 via Figure 3 as follows. First, when α is sufficiently large (i.e., $\alpha > \Theta_2^A(k)$, where $\Theta_2^A(k)$ is given by (14)), store R's unit cost $c_r = \alpha c_s$ is

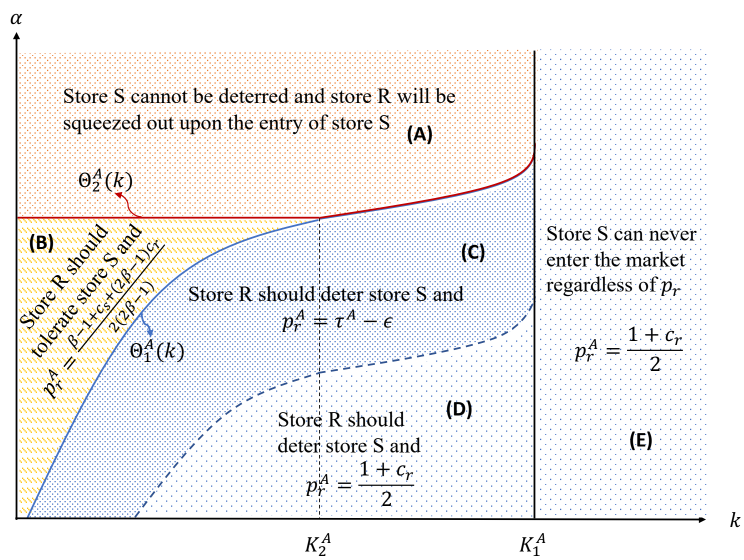


Figure 3 Store R's equilibrium deterrence strategy and its equilibrium price p_r^A.

much higher than store S's unit cost so that store R is not competitive. Hence, Proposition 2(I)(b) and 2(II)(c) reveal that store R cannot deter store S's entry and will earn nothing upon store S's entry as depicted in region (A) of Figure 3.

Second, we focus on region (B) of Figure 3 where store S has a slight competitive advantage over store R because $\alpha \in [\Theta_1^A(k), \Theta_2^A(k))$ as given in Proposition 2(II)(b). In this case, although store R can potentially deter store S's entry by setting its price $p_r < \tau^A$ as stated in Lemma 1, it is too costly for store R to do so. Instead, store R is better off tolerating store S's entry to compete in a duopoly market so that both stores can co-exist.

Third, we focus on region (C) of Figure 3 where store R has a slight competitive advantage over store S because $\alpha < \Theta_1^A(k)$, where $\Theta_1^A(k)$ is given by (13). Based on Proposition 2(I)(a) and 2(II)(a), store R can and should deter store S's entry by setting its price $p_r < \tau^A$ as stated in Lemma 1 as depicted in two areas shaded in blue in Figure 3.

Finally, in regions (D) and (E) of Figure 3, store S's competitive disadvantage against store R is so high that it cannot even enter the market to compete with the monopoly price of store R. As such, it is optimal for store R to behave like a monopoly by setting it price $p_r^A = p_r^0 = \frac{1+c_r}{2}$.

By substituting the equilibrium price p_r^A given by Proposition 2 for different regions of (k, α) into Proposition 1 and Corollary 1, we can derive store S's equilibrium price p_s^A, equilibrium profit $\tilde{\Pi}_s^A$, and demand q_s^A (and store R's demand q_r^A). Because our focus is on the deterrence strategy, we shall omit these tedious expressions under different conditions. Instead, we shall extend our analysis to the case when store R faces a potential entry of a type (B) store S in the next section.

5 Analysis of Type (B) Store S against Store R

We now extend our analysis for a type (B) store S with pre-announced commitment to donate a proportion γ of its *revenue* to charities. By using the approach in §4, we characterize type (B) store S's best-response pricing strategy and store R's deterrence strategy against store S's entry.

5.1 Type (B) Store S's Best-Response Pricing Strategy

For any given store R's retail price p_r, a type (B) store S would determine its best-response price by solving (5) so that it can afford to enter the market only when its *effective* maximum profit $\Pi_s^B(p_r) \geq 0$. By solving (5), we can characterize the best-response pricing strategy of type (B) store S as stated in Proposition 3. Using the same approach as before, let $\tilde{\Pi}_s^B \equiv ((1-\gamma)p_s^B - c_s) \cdot q_s^B$ be store S's gross profit where its charitable donation $\gamma p_s^B q_s^B$ is deducted but the entry cost k is not. We can derive the effective profit of a type (B) store S as $\Pi_s^B = \tilde{\Pi}_s^B - k$.

PROPOSITION 3. *(a) Given store R's price p_r, type (B) store S can afford to enter the market only when its gross profit is higher than its entry cost (i.e., $\tilde{\Pi}_s^B(p_r) \geq k$), where*

$$\tilde{\Pi}_s^B(p_r) = \begin{cases} 0 & p_r \leq \frac{c_s}{1-\gamma} + 1 - \beta \\ \frac{[(1-\gamma)(\beta-1+p_r)-c_s]^2}{4(\beta-1)(1-\gamma)} & p_r \in (\frac{c_s}{1-\gamma} + 1 - \beta, \frac{c_s}{(1-\gamma)(2\beta-1)} + \frac{\beta-1}{2\beta-1}) \\ [(1-\gamma)\cdot\beta\cdot p_r - c_s](1-p_r) & p_r \in [\frac{c_s}{(1-\gamma)(2\beta-1)} + \frac{\beta-1}{2\beta-1}, \frac{c_s}{2\beta(1-\gamma)} + \frac{1}{2}] \\ \frac{(\beta(1-\gamma)-c_s)^2}{4\beta(1-\gamma)} & p_r > \frac{c_s}{2\beta(1-\gamma)} + \frac{1}{2} \end{cases}. \tag{15}$$

Furthermore, $\tilde{\Pi}_s^B(p_r)$ is non-decreasing in p_r and is non-increasing in γ.

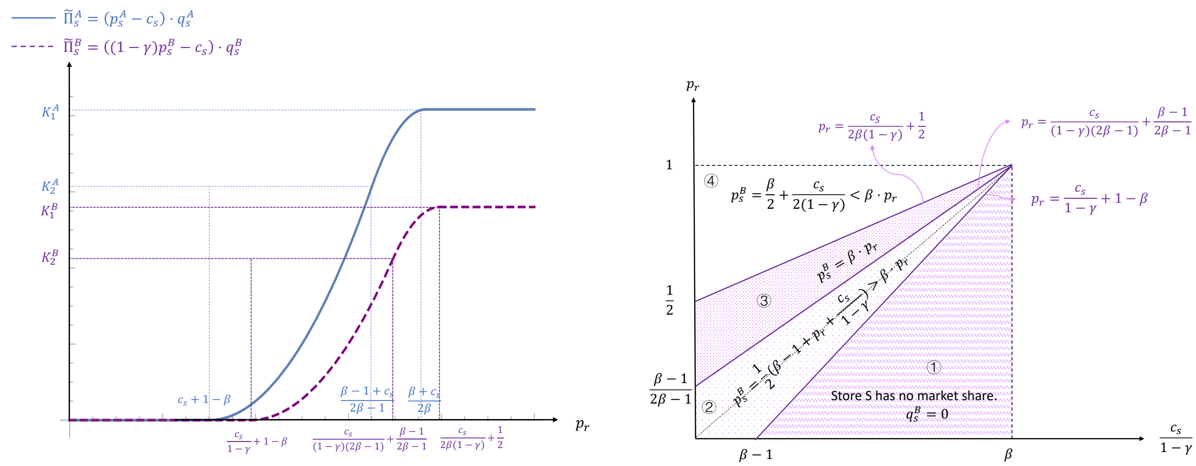
(b) Suppose store S enters the market (which from above requires $p_r > \frac{c_s}{1-\gamma} + 1 - \beta$). Then, store S's best-response price p_s^B, consumer demand q_s^B, and retained profit $\Pi_s^B = \tilde{\Pi}_s^B - k$ satisfy:

(i) If $p_r \in (\frac{c_s}{1-\gamma} + 1 - \beta, \frac{c_s}{(1-\gamma)(2\beta-1)} + \frac{\beta-1}{2\beta-1})$, then the best-response $p_s^B = \frac{1}{2}(\beta - 1 + p_r + \frac{c_s}{1-\gamma}) > \beta \cdot p_r$, so the corresponding $q_s^B = \frac{\beta-1+p_r}{2(\beta-1)} - \frac{c_s}{2(1-\gamma)(\beta-1)}$ and $\Pi_s^B = \frac{[(1-\gamma)(\beta-1+p_r)-c_s]^2}{4(\beta-1)(1-\gamma)} - k$.

(ii) If $p_r \in [\frac{c_s}{(1-\gamma)(2\beta-1)} + \frac{\beta-1}{2\beta-1}, \frac{c_s}{2\beta(1-\gamma)} + \frac{1}{2}]$, then the best-response $p_s^B = \beta \cdot p_r$, so the corresponding $q_s^B = 1 - p_r$ and $\Pi_s^A = [(1-\gamma)\cdot\beta\cdot p_r - c_s](1-p_r) - k$.

(iii) If $p_r > \frac{c_s}{2\beta(1-\gamma)} + \frac{1}{2}$, then the best-response $p_s^B = \frac{\beta}{2} + \frac{c_s}{2(1-\gamma)} < \beta \cdot p_r$, so the corresponding $q_s^B = \frac{1}{2} - \frac{c_s}{2\beta(1-\gamma)}$, and $\Pi_s^B = \frac{(\beta(1-\gamma)-c_s)^2}{4\beta(1-\gamma)} - k$.

Observe that Proposition 3 possesses a similar structure as Proposition 1. Analogous to a type (A) store S, a type (B) store S can enter the market only when its gross profit $\tilde{\Pi}_s^B \geq k$, where $\tilde{\Pi}_s^B$ is given in (15). We depict the gross profit $\tilde{\Pi}_s^B(p_r)$ and the best-response pricing strategy of type (B) store S in Figure 4, which resembles Figure 2. Notice that $\tilde{\Pi}_s^B(p_r)$ is non-decreasing in p_r and decreasing in γ. Therefore, it is easier for a type (B) store S to enter the market when store R charges a higher retail price p_r or store S donates a lower proportion γ of its revenue to charity.



(a) Thresholds for k: $\tilde{\Pi}_s^A$ and $\tilde{\Pi}_s^B$. (b) Type (B) Store S's best-response price p_s^B.

Figure 4 Type (B) store S's best-response pricing strategy.

This is different from a type (A) store S where the proportion γ has no impact on the ease of entry for store S.

Next, by substituting $p_s^B(p_r)$ as stated in Proposition 3 into (1) and (2), we can derive the consumer demand for both stores in Corollary 2.

COROLLARY 2. *When $p_r \le \frac{c_s}{1-\gamma} + 1 - \beta$, store S's demand $q_s^B = 0$ and store R's demand $q_r^B = 1 - p_r$, which is decreasing in p_r. Otherwise, when $\tilde{\Pi}_s^B \ge k$ and a type (B) store S enters the market, the best-response price p_s^B set by store S is non-decreasing in store R's retail price p_r, store S's per unit cost c_s, and the donating proportion γ. The corresponding demand for each store satisfies:*

(i) When $p_r \in (\frac{c_s}{1-\gamma} + 1 - \beta, \frac{c_s}{(1-\gamma)(2\beta-1)} + \frac{\beta-1}{2\beta-1})$, store S's best-response price $p_s^B > \beta \cdot p_r$. Upon store S's entry, store R's demand $q_r^B = \frac{\beta-1-(2\beta-1)p_r}{2(\beta-1)} + \frac{c_s}{2(1-\gamma)(\beta-1)}$, which is increasing in c_s and γ, while decreasing in p_r. Also, store S's corresponding demand $q_s^B = \frac{\beta-1+p_r}{2(\beta-1)} - \frac{c_s}{2(1-\gamma)(\beta-1)}$, which is increasing in p_r and decreasing in c_s and γ.

(ii) When $p_r \ge \frac{c_s}{(1-\gamma)(2\beta-1)} + \frac{\beta-1}{2\beta-1}$, store S's best-response price $p_s^B \le \beta \cdot p_r$. After store S enters, store R's demand $q_r^B = 0$ and store S's demand q_s^B is non-increasing in p_r, c_s, and γ, where:

$$q_s^B = 1 - \frac{p_s^B}{\beta} = \begin{cases} \frac{1}{2} - \frac{c_s}{2\beta(1-\gamma)} & \text{if } p_r > \frac{c_s}{2\beta(1-\gamma)} + \frac{1}{2} \\ 1 - p_r & \text{if } p_r \in [\frac{c_s}{(1-\gamma)(2\beta-1)} + \frac{\beta-1}{2\beta-1}, \frac{c_s}{2\beta(1-\gamma)} + \frac{1}{2}] \end{cases}.$$

Corollary 2 is similar in spirit to Corollary 1, yet differs from it with respect to the effect of γ. Specifically, a type (B) store S's best-response price p_s^B increases with the proportion γ because by donating a larger proportion of its revenue to charity, a type (B) store S has to charge a higher price to retain profitability. Also, as store S charges a higher price, its consumer demand q_s^B also decreases. Furthermore, in the case when store R's price p_r is low, the consumer demand for store R q_r^B increases as γ increases. This implies that given a fixed β, the threat that a type (B) store S imposes on store R decreases with the proportion γ.

5.2 Store R's Equilibrium Deterrence Strategy and Price

To characterize store R's deterrence strategy, we proceed in the same order as in §4.2. First, we characterize the conditions under which store R can deter store S. Then, we derive store R's profits when choosing to deter or tolerate store S's entry. Finally, we compare these profits to find store R's equilibrium deterrence strategy and equilibrium price.

We first characterize the deterrence threshold for p_r (denoted as τ^B) in Lemma 2 so that store R can deter a type (B) store S's entry by choosing a retail price $p_r < \tau^B$ or tolerate its entry by setting $p_r \geq \tau^B$. Akin to thresholds K_1^A and K_2^A associated with type (A) store S's entry in §4.2, we define $K_1^B = \frac{[\beta(1-\gamma)-c_s]^2}{4\beta(1-\gamma)}$ and $K_2^B = \tilde{\Pi}_s^B \left(\frac{c_s}{(1-\gamma)(2\beta-1)} + \frac{\beta-1}{2\beta-1} \right) = \frac{[\beta(1-\gamma)-c_s]^2(\beta-1)}{(2\beta-1)^2(1-\gamma)}$. Notice that both K_1^B and K_2^B are decreasing in γ although K_1^A and K_2^A does not depend on γ. Also, observe from Proposition 3 and Figure 4(a) that a type (B) store S can never enter the market when its entry cost $k > K_1^B$ regardless of the value of p_r (i.e., $\tau^B = \infty$). We characterize the case when $k \leq K_1^B$ by focusing on the deterrence threshold τ^B as follows.

Lemma 2. *Store R can either deter a type (B) store's entry by setting $p_r < \tau^B$, or tolerate its entry by setting $p_r \geq \tau^B$, where:*

$$\tau^B = \begin{cases} \frac{\sqrt{4k(\beta-1)(1-\gamma)}+c_s}{1-\gamma} + 1 - \beta & k \leq K_2^B \\ \frac{c_s+\beta(1-\gamma)-\sqrt{(c_s-\beta(1-\gamma))^2-4k\beta(1-\gamma)}}{2\beta(1-\gamma)} & k \in (K_2^B, K_1^B] \\ \infty & k > K_1^B \end{cases}. \tag{16}$$

Furthermore, when $k \leq K_1^B$, the threshold τ^B is increasing in γ.

Lemma 2 implies that the deterrence threshold τ^B for a type (B) store S is higher than τ^A for a type (A) store S, so it is easier for store R to deter the entry of a type (B) store S (i.e., store R can deter type (B) store S when charging a higher price).

Next, by comparing $\Pi_r^{d,B}$ and $\Pi_r^{t,B}$, we can characterize store R's equilibrium deterrence strategy in Proposition 4. In preparation, let us recall from §4.2 that store R's deterrence strategy is based on its cost competitiveness measured by α (because $c_r = \alpha \cdot c_s$) and store S's entry cost k. Also, akin to the thresholds $\Theta_1^A(k)$ and $\Theta_2^A(k)$ associated with a type (A) store as defined in §4.2, we define $\Theta_1^B(k)$ and $\Theta_2^B(k)$ that correspond to a type (B) store as

$$\Theta_1^B(k) = \begin{cases} \frac{c_s+\beta(1-\gamma)-\sqrt{(c_s-\beta(1-\gamma))^2-4k\beta(1-\gamma)}}{2\beta(1-\gamma)c_s} & k \in (K_2^B, K_1^B] \\ \frac{c_s(4\beta-3)+(\beta-1)(1-\gamma-4\beta(1-\gamma)+8\sqrt{k(\beta-1)(1-\gamma)}+4\sqrt{k(1-\gamma)(\frac{\beta(1-\gamma)-c_s}{\sqrt{k(\beta-1)(1-\gamma)}}-2))}}{c_s(2\beta-1)(1-\gamma)} & k \leq K_2^B \end{cases}, \tag{17}$$

$$\Theta_2^B(k) = \begin{cases} \frac{c_s+\beta(1-\gamma)-\sqrt{(c_s-\beta(1-\gamma))^2-4k\beta(1-\gamma)}}{2\beta(1-\gamma)c_s} & k \in (K_2^B, K_1^B] \\ \frac{\beta-1}{(2\beta-1)c_s} + \frac{1}{(2\beta-1)(1-\gamma)} & k \leq K_2^B \end{cases}. \tag{18}$$

It is worth noting that $\Theta_1^B(k)$ and $\Theta_2^B(k)$ are both increasing in proportion γ. Using these thresholds, we can specify store R's deterrence strategy against a type (B) store's entry as follows.

Proposition 4. *Suppose a type (B) store S's entry cost $k \in (0, K_1^B]$ so that store S has a chance to enter the market. Then, store R's equilibrium deterrence strategy and equilibrium price p_r^B satisfy:*

(I) If $k \in (K_2^B, K_1^B]$, and

(a) if $\alpha < \Theta_1^B(k)$, it is optimal for store R to deter store S's entry with an equilibrium deterrence price p_r^B as follows. (i) When $\alpha \in [\frac{c_s-\sqrt{(c_s-\beta(1-\gamma))^2-4k\beta(1-\gamma)}}{\beta(1-\gamma)c_s}, \Theta_1^B(k))$, $p_r^B = \tau^B - \epsilon = \frac{c_s+\beta(1-\gamma)-\sqrt{(c_s-\beta(1-\gamma))^2-4k\beta(1-\gamma)}}{2\beta(1-\gamma)} - \epsilon$, where $\epsilon \to 0^+$; (ii) when $\alpha < \frac{c_s-\sqrt{(c_s-\beta(1-\gamma))^2-4k\beta(1-\gamma)}}{\beta(1-\gamma)c_s}$, $p_r^B = p_r^0 = \frac{1+c_r}{2}$. After deterring store S's entry, store R's demand $q_r^B = 1 - p_r^B$.

(b) if $\alpha \geq \Theta_2^B(k) = \Theta_1^B(k)$, store R's equilibrium price $p_r^B = c_r$; however, store R cannot deter the inevitable entry of store S, and after store S enters, $q_r^B = 0$.

(II) If $k \in (0, K_2^B]$, and

(a) if $\alpha < \Theta_1^B(k)$, it is optimal for store R to deter store S's entry with an equilibrium deterrence price p_r^B as follows. (i) When $\alpha \in [\frac{2[c_s+\sqrt{4k(\beta-1)(1-\gamma)}]+(1-2\beta)(1-\gamma)}{c_s(1-\gamma)}, \Theta_1^B(k))$, $p_r^B = \tau^B - \epsilon = \frac{\sqrt{4k(\beta-1)(1-\gamma)}+c_s}{1-\gamma} + 1 - \beta - \epsilon$, where $\epsilon \to 0^+$; (ii) when $\alpha < \frac{2[c_s+\sqrt{4k(\beta-1)(1-\gamma)}]+(1-2\beta)(1-\gamma)}{c_s(1-\gamma)}$, $p_r^B = p_r^0 = \frac{1+c_r}{2}$. After deterring store S's entry, store R's demand $q_r^B = 1 - p_r^B$.

(b) if $\alpha \in [\Theta_1^B(k), \Theta_2^B(k))$, it is optimal for store R to tolerate store S's entry by setting the equilibrium tolerating price $p_r^B = \frac{1}{2} \cdot (c_r + \frac{(\beta-1)(1-\gamma)+c_s}{(2\beta-1)(1-\gamma)})$. After tolerating store S's entry, store R's demand $q_r^B = \frac{c_s+(\beta-1+c_r-2\beta c_r)(1-\gamma)}{4(\beta-1)(1-\gamma)}$.

(c) if $\alpha \geq \Theta_2^B(k)$, then it is optimal for store R to set $p_r^B = c_r$; however, store R cannot deter the inevitable entry of store S, and after store S enters, $q_r^B = 0$.

Proposition 4 shows that the equilibrium deterrence strategy for store R against a type (B) store S possesses the same structure as that against a type (A) store S (see Proposition 2) with the exceptional effect of the donation proportion γ. Specifically, while γ has no effect on the entry of a type (A) store S, it has three major effects on the entry of a type (B) store S. First, K_2^B decreases with γ, so a type (B) store S that commits a larger proportion γ has a lower chance of entering the market. Second, $\Theta_2^B(k)$ in (18) is increasing in γ. As such, it is less likely that store R will be squeezed out when a type (B) store S commits to a larger γ. Finally, thresholds $\Theta_1^B(k)$ and $\Theta_2^B(k)$ given in (17) and (18) are increasing in γ, which implies that store R will take a more aggressive deterrence strategy against a type (B) store S when the proportion γ is higher.

5.3 Comparison of Type (A) and Type (B) Store S

Best-response pricing strategies for type (A) and type (B) store S. First, by comparing the results given in Propositions 1 and 3 together with Corollaries 1 and 2, we obtain Corollary 3 that compares entry conditions, best-response pricing strategies, and consumer demand for type (A) and type (B) store S.

COROLLARY 3. *Given store R's price p_r, entry conditions and best-response prices for type (A) and type (B) store S, along with the corresponding consumer demand satisfy the following properties:*

(a) **Entry condition.** *The entry condition for a type (A) store (i.e., $\tilde{\Pi}_s^A \geq k$) is less stringent than that of type (B) because $\tilde{\Pi}_s^A \geq \tilde{\Pi}_s^B$.*

(b) **Best-response pricing strategy.** *A type (B) store would charge a higher price than a type (A) store upon entering the market; i.e., $p_s^B \geq p_s^A$.*

(c) **Consumer demand.** *The consumer demand for a type (A) store is higher than that of a type (B) store; i.e., $q_s^A \geq q_s^B$. Accordingly, the consumer demand for store R is lower upon a type (A) store S's entry than a type (B) store S's entry; i.e., $q_r^A \leq q_r^B$.*

Corollary 3 has the following implications. First, Corollary 3(a) states that the gross profit $\tilde{\Pi}_s^B$ is smaller than $\tilde{\Pi}_s^A$, which implies that it is easier for a type (A) store S to enter the market than a type (B) store S even with a higher entry cost. This is also depicted in Figure 4(a) earlier, where the purple dashed curve ($\tilde{\Pi}_s^B$) is below the blue solid curve ($\tilde{\Pi}_s^A$). Second, Corollary 3(b) implies that the price set by a type (B) store S is higher than a type (A) store S because type (B) store has to cover some of its donations via higher price. Finally, Corollary 3(c) implies that, from store R's perspective, a type (A) store S poses a higher threat than a type (B) store S because the former can siphon off more demand from store R after entering the market than the latter. This is because a type (A) store S can afford to charge a lower price than a type (B) store S.

Store R's equilibrium deterrence strategies against a type (A) and type (B) store S. Recall from Lemmas 1 and 2 that store R can deter a type A (type B) store S by setting a price $p_r < \tau^A$ ($p_r < \tau^B$). As such, by directly comparing τ^A and τ^B, we can derive the relative difficulty of deterring different types of store S. Furthermore, as parameter α captures store R's cost competitiveness relative to store S and store S's entry cost k represents store S's entry barrier, we now compare the thresholds for α and k as presented in Propositions 2 and 4 so as to compare the relative competitiveness of store R over type (A) and type (B) store S. More formally, the following corollary compares store R's deterrence strategy against different types of store S.

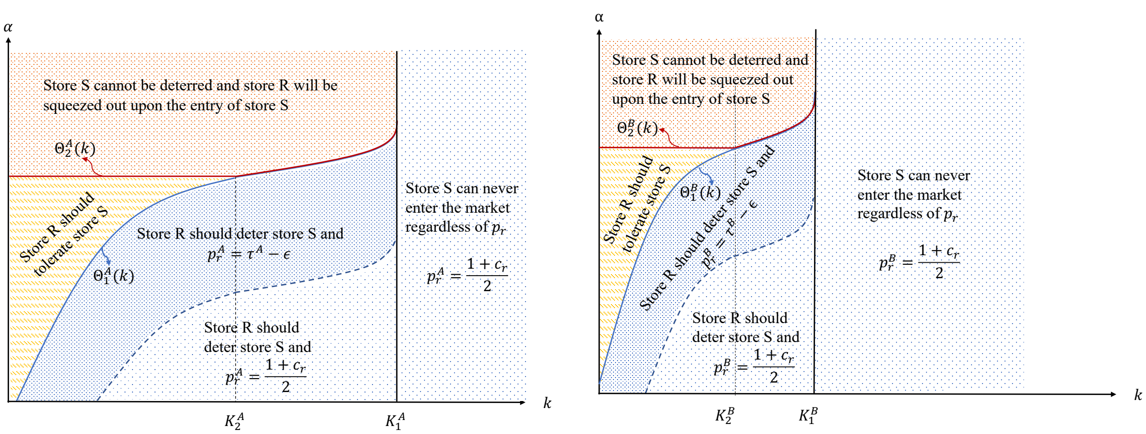
COROLLARY 4. *Store R's deterrence strategies against a type (A) and a type (B) store S satisfy the following properties:*

(a) **The price deterrence thresholds.** *The price deterrence thresholds for store R's retail price against two types of store S satisfy $\tau^A < \tau^B$.*

(b) **The cost deterrence thresholds.** *Store R's deterrence strategies as stated in Propositions 2 and 4 hinge on whether k lies within a certain region and whether α is above or below certain thresholds: K_i^j and $\Theta_i^j(k)$, $i \in \{1, 2\}$ and $j \in \{A, B\}$. Specifically, these thresholds satisfy: $K_1^A > K_1^B$, $K_2^A > K_2^B$, $\Theta_1^A(k) < \Theta_1^B(k)$, and $\Theta_2^A(k) < \Theta_2^B(k)$.*

Corollary 4(a) implies that a type (B) store poses a lower entry threat than a type (A) store. Specifically, because $\tau_A < \tau_B$, the condition for deterring a type (A) store (i.e., $p_r < \tau^A$) is more stringent than that of type (B). Consequently, store R can deter a type (B) store by charging a higher price p_r than that it needs to deter a type (A) store.

Corollary 4(b) is more intricate, and it has the following implications as depicted in Figure 5. First, observe that $K_1^B < K_1^A$. Hence, if the entry cost $k \in [K_1^B, K_1^A)$ for both types of store S, then a type (B) store cannot afford to enter the market even though a type (A) may be able to do so. Hence, a type (B) store S has less power of entry than a type (A) store S. Second, Corollary 4(b) states that $\Theta_2^B > \Theta_2^A$. Hence, if $\alpha \in (\Theta_2^A(k), \Theta_2^B(k)]$ for both types of store S, then store R cannot deter the type (A) store S's entry, while it can deter the type (B) store S's entry. Hence, type (A) store S is more resilient against deterrence strategies than a type (B) store. Third, Corollary 4(b) shows that $K_2^B < K_2^A$ and $\Theta_1^A(k) < \Theta_1^B(k)$. Thus, if $k < K_2^B < K_2^A$, $\alpha \in (\Theta_1^A(k), \Theta_2^A(k)]$ and $\alpha < \Theta_1^B(k)$, it is optimal for store R to deter the entry of a type (B) store, but tolerate the entry of a type (A) store. This implies that store R tends to take a more aggressive deterrence strategy against the entry of a type (B) store S than a type (A) store S.



(a) Deterrence strategy against type (A) store S (b) Deterrence strategy against type (B) store S

Figure 5 Store R's equilibrium deterrence strategy against both types of store S

6 Conclusion

In recent years, there is a strong shift in consumer preferences towards social responsibility, and this shift creates a suitable environment for new socially responsible retailers to enter the market. Yet, incumbent for-profit retailers can anticipate and try to deter such entry. Motivated by this problem, we study entry conditions of a commonly observed class of socially responsible retailers that pre-commit to donating a certain proportion of their profits (type (A)) or revenues (type (B)). We have built a stylized model of an incumbent for-profit retailer and an entrant social retailer of either type (A) or type (B). The incumbent retailer may choose to deter the social retailer's entry by setting a sufficiently low price or to tolerate its entry. In the latter case, the incumbent retailer has to compete against the social retailer in a duopoly setting.

Our results reveal that the incumbent retailer's deterrence strategy depends on its cost competitiveness (captured by α) and the social retailer's entry cost (captured by k). An interesting finding is that even when the incumbent retailer has the power to deter the entry of the social retailer, it may still choose to tolerate its entry. We also compare the two types of social retailers. We find that a type (A) social retailer poses a higher entry threat for the incumbent than type (B) social retailer, yet interestingly, the incumbent is more aggressive to deter the entry of type (B) social retailer. Thus, it is easier for a type (A) social retailer to enter the market. This managerial insight may guide entrepreneurs who aim to establish social retailers to pre-commit to donating a certain proportion of their profits rather than revenues.

Our paper is the first attempt to understand the market dynamics between an incumbent for-profit retailer and a common class of socially responsible retailers. There are several avenues for further research. First, for tractability, we have assumed that the donation proportion of profit or revenue is exogenous. However, it would be interesting to factor in how this proportion affects the social benefit, entry conditions of the social retailer, and the deterrence strategy of the incumbent retailer. We shall relegate this pursuit to future research. Second, we have examined a common class of social retailers, but there are other classes of social retailers. For example, food cooperatives have specific operational intricacies, and studying the entry of such cooperatives would be an interesting research avenue to pursue.

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Appendix: Proofs

Proof of Proposition 1. We first analyze the best-response pricing strategy p_s for any given p_r in the event that store S can enter the market. Based on the consumer demand for store S as given by (3), store S can either set (1) $p_s \leq \beta \cdot p_r$ or (2) $p_s > \beta \cdot p_r$.

Case 1: $p_s \leq \beta \cdot p_r$**.** In this case, after store S enters the market, store S's demand $q_s = 1 - \frac{p_s}{\beta}$. As such, store S's problem given by (4) can be written as:

$$\max_{c_s \leq p_s \leq \beta \cdot p_r} (1-\gamma) \cdot [(p_s - c_s) \cdot (1 - \frac{p_s}{\beta}) - k]. \tag{19}$$

When $p_r < \frac{c_s}{\beta}$, (19) is infeasible and it is impossible for store S to set $p_s \leq \beta \cdot p_r$. When $p_r \geq \frac{c_s}{\beta}$, according to Store S's first-order condition, we can obtain the extreme point $p_s^* = \frac{\beta + c_s}{2}$. By considering the boundary cases, we obtain: (1) when $p_r \in [\frac{c_s}{\beta}, \frac{\beta + c_s}{2\beta})$, the optimal solution to (19) is $p_{s1}^A = \beta \cdot p_r$; however, (2) when $p_r \geq \frac{\beta + c_s}{2\beta}$, the optimal solution to (19) is $p_{s1}^A = \frac{\beta + c_s}{2}$.

Case 2: $p_s \in [\beta \cdot p_r, \beta - 1 + p_r)$**.** In this case, after store S enters the market, the demand for store S $q_s = 1 - \frac{p_s - p_r}{\beta - 1}$. As such, store S's problem given by (4) can be written as:

$$\max_{p_s \geq \max\{\beta \cdot p_r,\ c_s\}} (1-\gamma) \cdot [(p_s - c_s) \cdot (1 - \frac{p_s - p_r}{\beta - 1}) - k]. \tag{20}$$

By checking the first-order condition, we obtain the extreme point $p_s^* = \frac{\beta - 1 + p_r + c_s}{2}$. By considering the boundary cases, we obtain: (1) when $p_r \leq c_s + 1 - \beta$, (20) is infeasible because $p_s \geq c_s \geq p_r + \beta - 1$; (2) when $p_r \in (c_s + 1 - \beta, \frac{\beta - 1 + c_s}{2\beta - 1})$, then the optimal solution to (20) is $p_{s2}^A = \frac{\beta - 1 + p_r + c_s}{2}$; (3) when $p_r \geq \frac{\beta - 1 + c_s}{2\beta - 1}$, the optimal solution to (20) is $p_{s2}^A = \beta \cdot p_r$.

Case 3: $p_s \geq \beta - 1 + p_r$**.** In this case, as $q_s = 0$, store S's profit $\Pi_s^A = -(1-\gamma)k \leq 0$.

We obtain store S's best-response pricing strategy p_s^A as stated in Proposition 1 based on the optimal solution of p_s under case 1 and 2 and by comparing the optimal profit of store S by either setting $p_s \leq \beta p_r$ or $p_s \geq \beta p_r$. As such, we can also obtain store S's corresponding demand q_s^A and profit Π_s^A via substitution. Next, by considering $\Pi_s^A \geq 0$, we can obtain the entry condition as stated in Proposition 1. ■

Proof of Corollary 1. By substituting the best-response price p_s^A as given in Proposition 1 into the consumer demand for store R and store S as given by (2) and (3), we can obtain the corresponding q_r^A and q_s^A together with the comparative statistics as given in Corollary 1. ■

Proof of Lemma 1. Recall from Proposition 1 that store S's entry condition is $k \leq \tilde{\Pi}_s^A(p_r)$, where $\tilde{\Pi}_s^A$ is as given by (8) and is increasing in p_r. As such, by solving $k = \tilde{\Pi}_s^A(p_r)$, we can obtain the solution $p_r = \tau^A$, where τ^A as given by (9). ■

Proof of Proposition 2. From Proposition 1, we know that $\tilde{\Pi}_s^A \leq \frac{(\beta-c_s)^2}{4\beta} = K_1^A$ so that when $k > K_1^A$, store S can never enter the market. As such, we focus on the deterrence strategy of store R for the case when $k \leq K_1^A$ so that store S can have a chance to enter the market. In particular, we will consider the case when (1) $k \in (K_2^A, K_1^A]$ and (2) $k \leq K_2^A$.

Case 1: $k \in (K_2^A, K_1^A]$**.** According to Lemma 1, we can obtain $\tau^A = \frac{c_s+\beta-\sqrt{(c_s-\beta)^2-4k\beta}}{2\beta} > \frac{\beta-1+c_s}{2\beta-1}$ so that store R can deter store S's entry by setting $p_r < \tau^A$, while tolerate store S's entry by setting $p_r \geq \tau^A$. First, as store R needs to charge $p_r \geq c_r$, then if $\tau^A = \frac{c_s+\beta-\sqrt{(c_s-\beta)^2-4k\beta}}{2\beta} \leq c_r$, store R cannot deter the entry of store S. If $c_r > \tau^A$, then store R can either choose to deter or tolerate store S's entry. Recall from corollary 1 that if $p_r \geq \frac{\beta-1+c_s}{2\beta-1}$, then after store S enters, the consumer demand for store R in equilibrium $q_r^A = 0$. Hence, if store R chooses to tolerate store S's entry by setting $p_r \geq \tau^A > \frac{\beta-1+c_s}{2\beta-1}$, store R's profit will be zero. Hence, it is optimal for store R to deter store S's entry when $c_r < \tau^A = \frac{c_s+\beta-\sqrt{(c_s-\beta)^2-4k\beta}}{2\beta}$. Hence, store R's deterrence problem given by (10) can be rewritten as $\Pi_r^{d,A} = \max_{p_r \in [c_r, \tau^A)} \Pi_r = (p_r - c_r)(1-p_r)$. By considering the first-order condition together with the boundary cases, we obtain that store R's equilibrium deterrence strategy together with the equilibrium price as given by the first statement of Proposition 2.

Case 2: $k \in (0, K_2^A]$**.** Based on Lemma 1, $\tau^A = \sqrt{4k(\beta-1)} + c_s + 1 - \beta$ when $k \leq K_2^A$. To analyze store R's optimal price $p_r^{d,A}$ when it chooses to deter store S's entry, we rewrite (10) as:

$$\Pi_r^{d,A} = \sup_{c_r \leq p_r < \tau^A} \Pi_r = (p_r - c_r) \cdot (1 - p_r). \tag{21}$$

By considering the first-order condition together with the boundary cases, we obtain store R's optimal price $p_r^{d,A}$ that deters store S's entry as follows:

- If $c_r < 2c_s + 1 - 2\beta + 4\sqrt{k(\beta-1)}$, then it is optimal for store R to set $p_r^d = \frac{1+c_r}{2}$;

- If $c_r \in [2c_s + 1 - 2\beta + 4\sqrt{k(\beta-1)}, \tau^A)$, then it is optimal for store R to set $p_r^{d,A} = \tau^A - \epsilon$, where $\epsilon \to 0$;
- If $c_r \geq \tau^A$, then (21) is infeasible and store R cannot deter store S's entry.

Next, to analyze store R's optimal price p_r^t when it chooses to tolerate store S's entry, we rewrite (11) as:

$$\Pi_r^{t,A} = \max_{p_r \geq \max\{c_r, \tau^A\}} (p_r - c_r) \cdot q_r^A, \tag{22}$$

where q_r^A is as given in (11). By considering the first-order condition together with the boundary cases, we obtain store R's optimal price $p_r^{t,A}$ that tolerates store S's entry as follows:

- if $c_r \geq \frac{\beta-1+c_s}{2\beta-1}$, then $p_r^{t,A} = c_r$ and according to Corollary 1, after store S enters, the consumer demand for store R $q_r^A = 0$;
- if $c_r \in (\frac{1}{2}[3 + 4c_s + 8\sqrt{k(\beta-1)} - 4\beta + \frac{1-2c_s}{2\beta-1}], \frac{\beta-1+c_s}{2\beta-1})$, then it is optimal for store R to set $p_r^{t,A} = \frac{\beta-1+c_s+(2\beta-1)c_r}{2(2\beta-1)}$;
- if $c_r \leq \frac{1}{2}[3 + 4c_s + 8\sqrt{k(\beta-1)} - 4\beta + \frac{1-2c_s}{2\beta-1}]$, then it is optimal for store R to set $p_r^{t,A} = \tau^A$.

Hence, we can obtain the corresponding $\Pi_r^{d,A}$ and $\Pi_r^{t,A}$ via substitution. By comparing $\Pi_r^{d,A}$ and $\Pi_r^{t,A}$, we can solve (12) as follows. First, if $c_r \geq \tau^A$ (and $\tau^A < \frac{\beta-1+c_s}{2\beta-1}$), store R cannot deter store S's entry, so $p_r^A = p_r^{t,A}$. Second, if $c_r \leq \frac{1}{2}[3 + 4c_s + 8\sqrt{k(\beta-1)} - 4\beta + \frac{1-2c_s}{2\beta-1}]$ (and $\frac{1}{2}[3 + 4c_s + 8\sqrt{k(\beta-1)} - 4\beta + \frac{1-2c_s}{2\beta-1} > 2c_s + 1 - 2\beta + 4\sqrt{k(\beta-1)})$, store R has to set $p_r^{t,A} = \tau^A$ to tolerate store S's entry; however, by setting a slightly lower price $\tau^A - \epsilon$, store R can deter store S and get a higher consumer demand. Hence, in this case $p_r^A = p_r^{d,A}$. Finally, when $c_r \in (\frac{1}{2}[3 + 4c_s + 8\sqrt{k(\beta-1)} - 4\beta + \frac{1-2c_s}{2\beta-1}], \tau^A)$, we compare store R's two strategies: tolerating store S by setting $p_r^{t,A} = \frac{\beta-1+c_s+(2\beta-1)c_r}{2(2\beta-1)}$ or deterring store S by setting $p_r^{d,A} = \tau^A - \epsilon$, and we obtain the threshold for c_r as $\theta^A \equiv \frac{c_s(4\beta-3)+(\beta-1)(1-4\beta+8\sqrt{k(\beta-1)}+4\sqrt{k(\frac{\beta-c_s}{\sqrt{k(\beta-1)}}-2)})}{2\beta-1}$. As such, in this case when $c_r \geq \theta^A$, $\Pi_r^{t,A} \geq \Pi_r^{d,A}$ so that it is optimal for store R to tolerate store S's entry by setting $p_r^{t,A} = \frac{\beta-1+c_s+(2\beta-1)c_r}{2(2\beta-1)}$, while when $c_r < \theta^A$, $\Pi_r^{t,A} < \Pi_r^{d,A}$ so that it is optimal for store R to deter store S's entry by setting $p_r^{d,A} = \tau^A - \epsilon$. By also considering $c_r = \alpha c_s$ and rearranging the results, we obtain store R's equilibrium deterrence strategy when $k \in (0, K_2^A]$ as given in Proposition 2(II). ■

Proof of Proposition 3. Recall from (4) and (5) that the objective function of a type (B) store S resembles that of a type (A) store S by replacing c_s with $\frac{c_s}{1-\gamma}$ and replacing k with $\frac{k}{1-\gamma}$. As such, by using the same approach as we used to prove Proposition 1, we can prove that the best-response pricing strategy of a type (B) store S together with its entry condition is as given by Proposition 3. Different from the type (A) store S, the gross profit $\tilde{\Pi}_s^B$ together with the best-response price p_s^B set by a type (B) store S is a function of γ. And by checking the first-order derivatives, we can easily obtain that $\tilde{\Pi}_s^B$ as given in (15) is non-decreasing in p_r and is non-increasing in γ. ■

Proof of Corollary 2. By substituting the best-response price p_s^B as given in Proposition 3 into the consumer demand for store R and store S as given by (2) and (3), we can obtain the corresponding q_r^B and q_s^B together with the comparative statistics as given in Corollary 2. ■

Proof of Corollary 3. Recall from Proposition 3 and Corollary 2 that $\tilde{\Pi}_s^B$ and q_s^B are non-increasing in γ, while p_s^B and q_r^B are non-decreasing in γ. Hence, we can obtain the results as given by Corollary 3. ■

Proof of Lemma 2. Recall from Proposition 3 that the entry condition for store S is $k \leq \tilde{\Pi}_s^B(p_r)$, where $\tilde{\Pi}_s^B$ is as given by (15) and is increasing in p_r. As such, by solving $k = \tilde{\Pi}_s^B(p_r)$, we can obtain the solution $p_r = \tau^B$, where τ^B is as given by (16). By taking the first order derivative of τ^B with respect to γ, we obtain that (1) when $k \leq K_2^B$, $\frac{\partial \tau^B}{\partial \gamma} = \frac{c_s + \sqrt{k(\beta-1)(1-\gamma)}}{(1-\gamma)^2} > 0$; and (2) when $k \in (K_2^B, K_1^B]$, $\frac{\partial \tau^B}{\partial \gamma} = \frac{c_s(\beta(1-\gamma)-c_s)+2k\beta(1-\gamma)+c_s\sqrt{(c_s-\beta(1-\gamma))^2-4k\beta(1-\gamma)}}{2\beta\sqrt{(c_s-\beta(1-\gamma))^2-4k\beta(1-\gamma)}(1-\gamma)^2} > 0$. Hence, we can verify that τ^B is increasing in γ. ■

Proof of Proposition 4. Armed with store S's entry condition and best-response pricing strategy as given by Proposition 3 and by using the same approach as shown in the proof of Proposition 2, we can derive store R's equilibrium deterrence strategy against a type (B) store S together with its equilibrium price p_r as given by Proposition 4. ■

Proof of Corollary 4. Recall from Lemma 2 and Proposition 4 that τ^B, Θ_1^B, and Θ_2^B are increasing in γ. Next, by taking the first order derivatives of K_1^B and K_2^B with respect to γ, we obtain $\frac{\partial K_1^B}{\partial \gamma} = \frac{c_s^2-\beta^2(1-\gamma)^2}{4\beta(1-\gamma)^2} < 0$ and $\frac{\partial K_2^B}{\partial \gamma} = \frac{(\beta-1)(c_s^2-\beta^2(1-\gamma)^2)}{(2\beta-1)^2(1-\gamma)^2} < 0$ so that K_1^B and K_2^B are decreasing in γ. It is easy to verify that when $\gamma = 0$, we have $\tau^B = \tau^A$, $\Theta_i^B = \Theta_i^A$, and $K_i^B = K_i^A$ for $i \in \{1, 2\}$. Thus, for any $\gamma > 0$, we have $\tau^B < \tau^A$, $\Theta_i^B < \Theta_i^A$, and $K_i^B > K_i^A$. ■

Online Appendix

EC.1 Discussion: Store-Specific Social Benefit

In this section, we extend our base model to the case when the social benefit β is store-type specific for any given pre-committed proportion γ. Let β_A and β_B be social benefits associated with type (A) and type (B) stores, respectively. We can set $\beta_B = n \cdot \beta_A$ without loss of generality, where $n > 0$. We shall examine two scenarios. Scenario 1 deals with the case when $n \leq 1$, which occurs when consumers experience a stronger "warm glow" when store's charitable donation is based on profit (as committed by a type (A) store). Scenario 2 examines the case when $n > 1$ in which consumers experience a stronger warm glow when store's charitable donation is based on revenue (as committed by a type (B) store).

By considering these two scenarios, we can compare store S's entry conditions and Store R's deterrence strategy between these two types of store S. Clearly, such a comparison involves direct comparison of those deterrence thresholds $\Theta_1^A(k)$ and $\Theta_2^A(k)$ associated with a type (A) store S against the corresponding thresholds $\Theta_1^B(k)$ and $\Theta_2^B(k)$ associated with a type (B) store S. However, observe from (13) and (14) that these thresholds are complex functions of β_A and β_B, so their analytical comparison is not tractable. For this reason, we conduct our comparisons numerically.

Our numerical analysis mainly shows the robustness of our main findings. Even when $n > 1$ (i.e., a type (B) store S generates higher warm glow), unless n is very large, it is always easier for a type (A) store S to enter the the market and poses a larger entry threat for store R. We detail our analysis in the following sections.

EC.1.1 Store S's Entry Condition for any Given Store R'S Price

To examine the deterrence strategy of store R, we need to begin with the entry condition of each type of store (i.e., type (A) or type (B)) for any given store R's price p_r. Recall from Proposition 1 (Proposition 3) that a type (A) (type (B)) store can enter the market when the entry cost $k \leq \tilde{\Pi}_s^A$ (when $k < \tilde{\Pi}_s^B$), where the gross profit $\tilde{\Pi}_s^A$ ($\tilde{\Pi}_s^B$) is given in (8) ((15)). Because $\tilde{\Pi}_s^A$ and $\tilde{\Pi}_s^B$ are also functions of β, we can denote them as $\tilde{\Pi}_s^A(\beta)$ and $\tilde{\Pi}_s^B(\beta)$ so that we can compare $\tilde{\Pi}_s^A(\beta)$ and $\tilde{\Pi}_s^B(\beta)$ for the case when β is store type-specific. Specifically, we fix $\beta_A = \beta_0$ (> 1) and consider $\beta_B = n \cdot \beta_A = n \cdot \beta_0$ (> 1), where n varies from $0 < n \leq 1$ to $n > 1$.

Scenario 1: $n \leq 1$. To establish a benchmark by leveraging our analytical results established in §4 and §5, let us consider the case when $n = 1$ so that $\beta_A = \beta_B = \beta_0$. In this case, we can apply statement (1) of Corollary 3 to show that $\tilde{\Pi}_s^B(\beta_0) \leq \tilde{\Pi}_s^A(\beta_0)$. This observation implies that, for the same entry cost k, it is easier for a type (A) store to enter the market than type (B) store when $n=1$. This is also illustrated in Figure 4(a), where the blue solid curve (gross profit for the type (A) store) is above the purple dashed curve (gross profit for the type (B) store).

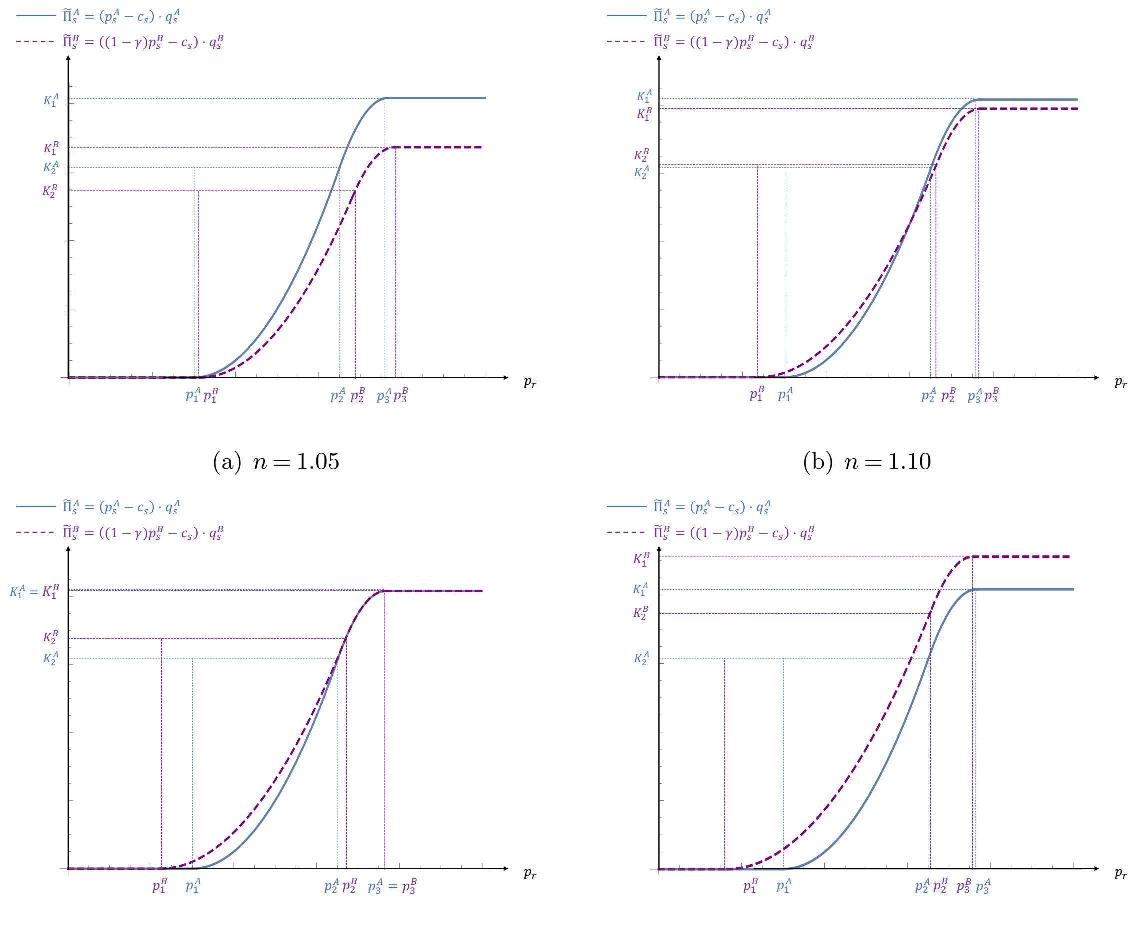
Armed with this benchmark result, we now consider the case when $n<1$ so that $\beta_B = n\cdot\beta_0 < \beta_0 (=\beta_A)$, we can easily check that $\tilde{\Pi}_s^B(\beta_B) = \tilde{\Pi}_s^B(n\beta_0) \le \tilde{\Pi}_s^B(\beta_0) \le \tilde{\Pi}_s^A(\beta_0) = \tilde{\Pi}_s^A(\beta_A)$. Using the same analogy for the case when $n=1$, we can conclude that it is easier for a type (A) store to enter the market than a type (B) store when $n<1$.

We can also compare two thresholds K_1^A and K_1^A as a benchmark that will prove useful later. Recall from §4.2 and §5.2 that $K_1^A \equiv \frac{(\beta_A - c_s)^2}{4\beta_A}$ and $K_1^B \equiv \frac{[\beta_B(1-\gamma)-c_s]^2}{4(\beta_B(1-\gamma))}$ so that, regardless of store R's price p_r, a type (j) store ($j=A,B$) can never enter the market when its entry cost $k > K_1^j$. Also, recall from §4 and §5 that a type (A) store's gross profit $\tilde{\Pi}_s^A = \frac{(\beta_A-c_s)^2}{4\beta_A} \equiv K_1^A$ when $p_r \ge \frac{\beta+c_s}{2\beta}$ and a type (B) store's gross profit $\tilde{\Pi}_s^B = \frac{[\beta_B(1-\gamma)-c_s]^2}{4(\beta_B(1-\gamma))} \equiv K_1^B$ when $p_r > \frac{c_s}{2\beta(1-\gamma)} + \frac{1}{2}$ so that K_1^j represents the upper bound of $\tilde{\Pi}_s^j$ for $j=A,B$ (as shown in Figures 2(a) and 4(a)). By combining the above observation that $\tilde{\Pi}_s^B(\beta_B) \le \tilde{\Pi}_s^A(\beta_A)$ and the fact that $K_1^B < K_1^A$ when $n<1$, we can conclude it is easier for type (A) store to enter the market than a type (B) store when $n<1$.

REMARK EC.1. When $n \le 1$ (i.e., $\beta_B \le \beta_A$), the gross profits satisfy $\tilde{\Pi}_s^B(\beta_B) \le \tilde{\Pi}_s^A(\beta_A)$ and the corresponding upper bounds of the gross profits $K_1^B < K_1^A$. As such, it is easier for a type (A) store S to enter the market than a type (B) store S.

Scenario 2: $n>1$. When $n>1$, the comparison of the gross profits $\tilde{\Pi}_s^A(p_r)$ and $\tilde{\Pi}_s^B(p_r)$ for any given p_r is more nuanced. We conduct our numerical analysis by setting the parameters as follows: $\gamma = 0.1$, $c_s = 0.8$, $\beta_0 = 1.5$, and $n = \{1.05, 1.10, 1.11, 1.15\}$. Analogous to Figure 4(b), we depict the results in Figure EC.1 by considering different values of n. (For ease of exposition, we use p_i^j, $i \in \{1,2,3\}$ and $j \in \{A,B\}$ to denote the thresholds for p_r that used to characterize the piece-wise function of $\tilde{\Pi}_s^A(p_r)$ and $\tilde{\Pi}_s^B(p_r)$ as given in (8) and (15).)

Observe from Figures EC.1(a) to (d) that, as n increases, the purple curve that represents the gross profit $\tilde{\Pi}_s^B$ would move up because as the social benefit $\beta_B = n\beta_0$ increases with n. (However, the blue curve that represents $\tilde{\Pi}_s^A$ remains the same because the social benefit $\beta_A = \beta_0$ is independent of n.) In Figure EC.1(a) when $n = 1.05 > 1$, the purple curve is below the blue curve, which resembles Figure 4(a). This implies that even when $\beta_B = n\beta_0 > \beta_0(=\beta_A)$, it is still possible to have $\tilde{\Pi}_s^B(\beta_B) \le \tilde{\Pi}_s^A(\beta_A)$ so that it is easier for a type (A) store S to enter the market than a type (B) store S. Second, observe from Figure EC.1(b) that in the case when $n = 1.10$, the purple curve is first above the blue curve when p_r is small, while is below the blue curve when p_r is large. Akin to Figure 4(a), we also illustrate the values of K_1^A and K_1^B in the y-axis of Figure EC.1. Observe from Figure EC.1(a) and (b), we have $K_1^B < K_1^A$ for the case when $n = 1.05$ or $n = 1.10$.



(a) $n = 1.05$

(b) $n = 1.10$

(c) $n = 1.11$

(d) $n = 1.15$

Figure EC.1 Both types of store S's entry condition when $n > 1$.

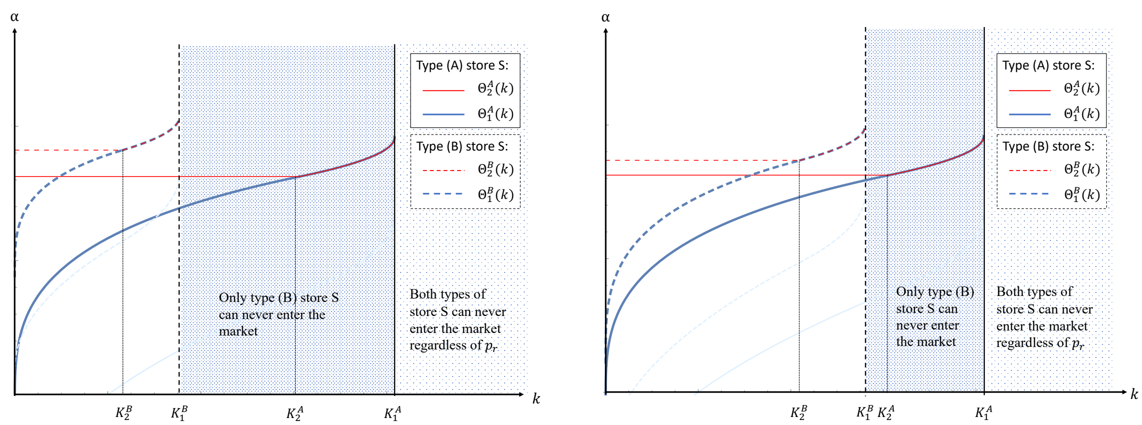
Third, in Figure EC.1(c), the purple curve is first above the blue curve when p_r is small, while is coincide with the blue curve when p_r is large. Also, from Figure EC.1(c), we know $K_1^B = K_1^A$ for the case when $n = 1.11$. Finally, Figure EC.1(d) illustrates that when $n = 1.15$, the purple curve is above the blue curve and $K_1^B > K_1^A$, which implies that in this case it is easier for a type (B) store to enter the market than a type (A) store.

Remark EC.2. When n is below a certain threshold (that is larger than 1) and/or p_r is high, the gross profits satisfy $\tilde{\Pi}_s^B(\beta_B) \leq \tilde{\Pi}_s^A(\beta_A)$ so that it is easier for a type (A) store to enter the market. However, when n is sufficiently larger than 1 and/or p_r is low, $\tilde{\Pi}_s^B(\beta_B) > \tilde{\Pi}_s^A(\beta_A)$ so that a type(B) store finds it easier to enter the market.

Remarks 1 and 2 reveal that when a type (B) store S generates a much larger warm glow than a type (A) store S, the type of store that can enter the market more easily and pose a larger entry threat to store R would depend on the value of p_r set by store R. This observation motivates us to examine store R's equilibrium deterrence strategy when it sets its equilibrium price p_r^A and p_r^B. We examine this issue next.

EC.1.2 Store R's Equilibrium Deterrence Strategy via Its Equilibrium Price

By taking entry conditions of both types of stores for any given store R's price p_r as examined in §EC.1.1 into consideration, we now examine numerically store R's equilibrium deterrence strategy associated with both types of store S. Note that store R's equilibrium price p_r^A and p_r^B also depends on the type of store S. Recall from Propositions 2 and 4 that store R's equilibrium deterrence strategy depends on store S's entry cost k and store R's cost competitiveness, which is captured by the parameter α (because $c_r = \alpha c_s$). Hence, we shall compare those cost deterrence thresholds K_1^j, K_2^j, $\Theta_1^j(k)$, $\Theta_2^j(k)$, $j \in \{A, B\}$ based on the values of k and α as presented in Propositions 2 and 4. Consistent with §EC.1.1, we conduct our numerical analysis by setting: $\gamma = 0.1$, $c_s = 0.8$ and $\beta_0 = 1.5$.



(a) $n = 0.9$ (b) $n = 1$

Figure EC.2 Store R's equilibrium deterrence strategy against both types of store S when $n \leq 1$.

Scenario 1: $n \leq 1$. We first use our results in §4 and §5 to examine the case when $n = 1$. Applying Corollary 4, we get: $K_1^A > K_1^B$, $K_2^A > K_2^B$, and $\Theta_1^A(k) < \Theta_1^B(k)$, $\Theta_2^A(k) < \Theta_2^B(k)$. This is depicted explicitly in Figure EC.2(b) (and implicitly in Figure 5). This ordering of these thresholds has the following implications. First, recall from §6.1 that, when $n = 1$, $K_1^B < K_1^A$ so that it is easier for a type (A) store to enter the market than a type (B) store. Second, recall from Propositions 2 and 4 that when $\alpha > \Theta_2^j(k)$, $j \in \{A, B\}$, store R cannot deter the inevitable entry of a type (j) store S and upon store S's entry, store R will be squeezed out. Hence, as $\Theta_2^B(k) > \Theta_2^A(k)$, store R is more likely to be squeezed out upon the entry of a type (A) store S. Third, recall from Propositions 2 and 4 that when $\alpha < \Theta_1^j$, $j \in \{A, B\}$, it is optimal for store R to deter the entry of a type (j) store. As such, when $n=1$, $\Theta_1^A(k)<\Theta_1^B(k)$ implies that it is more likely for store R to deter a type (B) store from entry. This result is illustrated in Figure EC.2(b) that depicts the thresholds $\Theta_1^j(k)$ (blue curve) and $\Theta_2^j(k)$ (red curve) for both type (A) (solid curve) and type (B) (dashed curve) store S. Observe from Figure EC.2(b) that both of the red and blue dashed curves are above the red and blue solid curves so that the "deterrence area" of a type (j) store (i.e., $\alpha<\Theta_1^j$) is larger when $j=B$.[5] Hence, it is easier for a type (A) store to enter the market when $n=1$.

Next, we consider the case when $n<1$. By noting from Figure EC.2(a) that both of the red and blue dashed curves are above the red and blue solid curves so that the "deterrence area" of a type (j) store (i.e., $\alpha<\Theta_1^j$) is larger when $j=B$. We can use the same argument as before to conclude that it is easier for a type (A) store to enter the market when $n<1$.

Remark EC.3. When $n\le 1$ (i.e., $\beta_B\le\beta_A$), the deterrence thresholds satisfy $K_1^A>K_1^B$, $K_2^A>K_2^B$, and $\Theta_1^A(k)<\Theta_1^B(k)$, $\Theta_2^A(k)<\Theta_2^B(k)$, implying that it is easier for a type (A) store to enter the market. Hence, a type (A) store poses a higher entry threat to store R than a type (B) store.

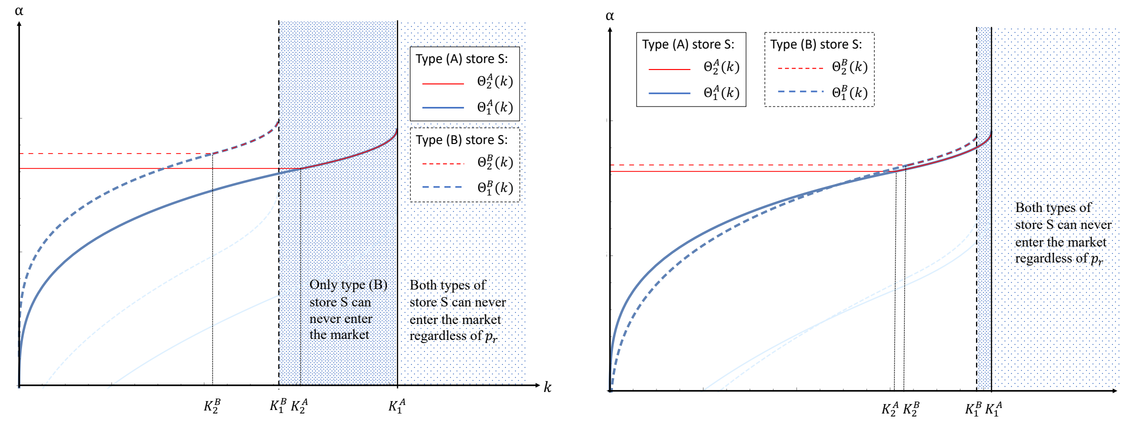
<u>Scenario 2: $n>1$.</u> Recall from Remark EC.1 and EC.2 in §EC.1.1 that, when $n\le 1$, $K_1^B<K_1^A$ always holds. However, As n increases above 1, there is a transition from $K_1^A>K_1^B$ to $K_1^A\le K_1^B$. Hence, the comparison of those deterrence cost thresholds is more nuanced. Specifically, we conduct our numerical analysis by considering two cases: (1) $K_1^A>K_1^B$, and (2) $K_1^A\le K_1^B$.

<u>*Case (1): $K_1^A>K_1^B$, which holds when $n=\{1.05,1.10\}$.*</u> When $n=1.05$, Figure EC.3(a) reveals that (1) both the red and blue dashed curves (i.e., $\Theta_i^B(k)$) are above the corresponding solid curves (i.e., $\Theta_i^A(k)$) and (2) the dashed vertical line (i.e., K_1^B) is on the left of the solid vertical line (i.e., K_1^A), which resembles Figure EC.2. This implies that even when $n>1$, it is easier for a type (A) store to enter the market, creating a higher entry threat for store R.

Next, as we increase n from 1.05 to 1.10 so that Figure EC.3(a) is transitioned to Figure EC.3(b). As shown in Figure EC.3(b), the red dashed curve is above the red solid curve (i.e., $\Theta_2^B(k)>\Theta_2^A(k)$). However, the blue dashed curve (i.e., $\Theta_1^B(k)$) is no longer above the blue solid curve (i.e., $\Theta_1^A(k)$) for any entry cost k. Therefore, we have a mixed result: the entry threat of type (A) store S is higher; while store R's deterrence strategy against each type of store would depend on n and k, and α.

<u>*Case (2): $K_1^A\le K_1^B$, which holds when $n=\{1.15,1.30\}$*</u> . Different from Case (1) as shown in Figure EC.3, Figure EC.4 reveals that the shaded dark blue area no longer exists because $K_1^A\le K_1^B$

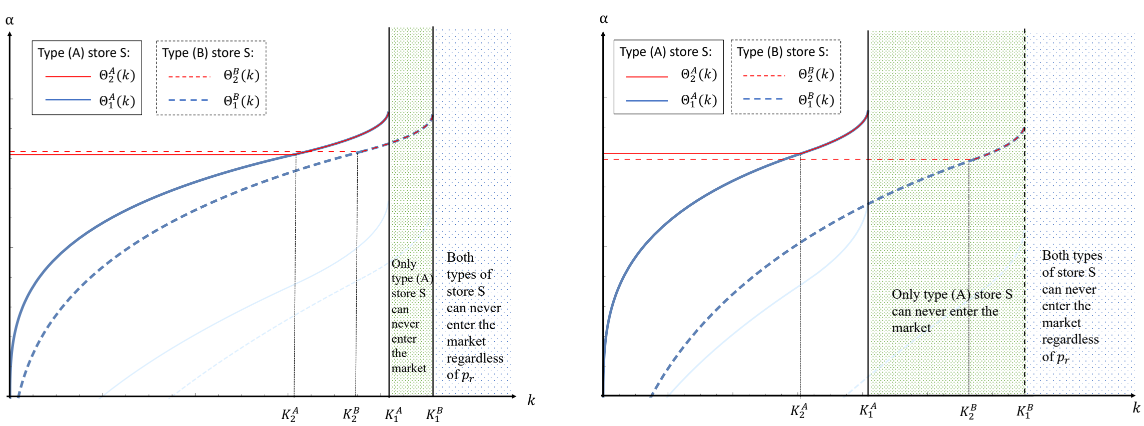
[5] Also, the vertical line that represent the thresholds K_i^j ($i\in\{1,2\}$ and $j\in\{A,B\}$) satisfy $K_1^B<K_1^A$ and $K_2^B<K_2^A$. In Figure EC.2(b), the shaded area on the right hand side of the vertical solid line K_1^A shows the region where both types of store S can never enter the market regardless of p_r. As $K_1^B<K_1^A$, the shaded area between the vertical solid line and dashed line shows the region where type (B) store S can never enter the market, while type (A) store S has a potential to enter the market.



(a) $n = 1.05$ (b) $n = 1.10$

Figure EC.3 Store R's equilibrium deterrence strategy against both types of store S when $n > 1$ and $K_1^A > K_1^B$.

in Case (2). Instead, when the entry cost $k \in (K_1^B, K_1^A)$, the shaded green area emerges, which represents the region in which a type (A) store can never enter the market whereas a type (B) store S can enter the market when $\alpha > \Theta_1^B(k)$ (i.e., when store R's unit cost $c_r = \alpha c_s$ is substantially higher than that of the type (B) store S).



(a) $n = 1.15$ (b) $n = 1.30$

Figure EC.4 Store R's equilibrium deterrence strategy against both types of store S when $n > 1$ and $K_1^A < K_1^B$.

When $n = 1.15$, Figure EC.4(a) reveals that the blue dashed curve (i.e., $\Theta_1^B(k)$) is now below the blue solid curve (i.e., $\Theta_1^A(k)$), while the red dashed curve (i.e., $\Theta_2^B(k)$) is no longer above the corresponding solid curve (i.e., $\Theta_2^A(k)$) for any entry cost k. Again, we have a mixed result: store R's deterrence strategy against a type (A) store S is more stringent; while the entry threat level of each type of store S would depend on k and α.

However, when $n = 1.30$, both the blue and red dashed curve moves down because β_B increases as n increases. In this case, Figure EC.4(b) reveals the opposite to case (1) that the red solid curve (i.e., $\Theta_2^A(k)$) is now above the red dashed curve (i.e., $\Theta_2^B(k)$). When this happens, it is easier for a type (B) store to enter the market, creating a larger entry threat.

Remark EC.4. When $n > 1$ (i.e., $\beta_B > \beta_A$), the deterrence thresholds K_1^B increases in n, while Θ_i^B ($i \in \{1,2\}$) decreases in n. Therefore, it is possible to observe that $K_1^B < K_1^A$ or $K_1^B \geq K_1^A$, depending on n; and $\Theta_i^B > \Theta_i^A$ or $\Theta_i^B \leq \Theta_i^A$ ($i \in \{1,2\}$), depending on n and k.

Remarks 3 and 4 can be summarized as follows. When the social benefit β is type specific so that $\beta_B = n\beta_A$, the relative threat level depends on the value of n. When n is below a certain threshold (that is larger than 1), it is always easier for a type (A) to enter the the market, creating a larger entry threat for store R. However, when n is sufficiently larger than 1, customers derive a larger social benefit from type (B) so that type (B) store S finds it easier to enter the market and poses a larger entry threat for store R.