The price-matching dilemma

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Abstract

We characterize when strategic considerations of stores to match prices set by rivals on branded goods devolve into a prisoner's dilemma. We consider a setting where stores also offer generic products, creating incentives to raise prices for branded goods that compete with generics—to shift consumer purchases toward more profitable generics. Price-matching guarantees commit stores not to set high prices for branded goods, thereby attracting more shoppers. When shopping price-elasticities are sufficiently high, a prisoner's dilemma results.

1 Introduction

Simple economic reasoning suggests that automatic price-matching guarantees should help cartels set collusively high prices. The logic is that because any price cuts are matched automatically, price-matching guarantees should eliminate all incentives to reduce prices. Papers making this point in a single product setting date back to Hay (1982); Salop (1986) and Logan and Lutter (1989).[1] Indeed, the popular press, as encapsulated by the Economist magazine, has argued that price-matching will guarantee profits and sustain collusion.[2]

Our paper develops the strategic foundations for how price-matching guarantees can instead result in price wars and reductions in profits. In our spatial duopoly, each store carries branded versions of two goods, and a generic (store-brand) alternative to one branded good. Generics are less costly to produce, providing firms incentives to set higher prices for a branded good that competes with a generic—to shift consumer purchases toward the more profitable generic—than for branded goods for which they lack good generic alternatives.[3] When stores do not carry generic substitutes for the same branded good, the stores price their branded goods differently. The same incentives arise when we allow each store to carry both branded and generic (store-brand) versions of the two goods. The quality of the generic alternatives varies across stores—each store has a high quality generic version of one good, and a low quality version of the other, and the quality of the generic substitute for a branded good differs between the two stores. This heterogeneity in the quality of generics across stores causes stores to price their branded goods differently.

Our paper shows how this creates a possible role for price-matching guarantees. In practice, stores carry an array of products and while consumers see price matching guarantees prior to visiting a store, few consumers see prices of individual goods until they shop. Price-

[1]Hviid and Shaffer (2010) argue that price-matching should raise prices by even more when combined with most-favored consumer clauses (MFC) that allow consumers to request refunds if a store lowers its price within a certain period of time. However, Chen and Liu (2011) find that the introduction of price-matching and MFC by Best Buy resulted in *lower* prices in the industry.

[2]*http://www.economist.com/news/finance-and-economics/21643239-price-match-guarantees-prevent-rather-provoke-price-wars-guaranteed-profits.*

[3]Salinger (1991) argues that similar pricing incentives could arise when firms vertically integrate, and the downstream firm carries rival products. The downstream firm might increase the prices of rival products to divert consumption toward the product of its upstream firm. Luco and Marshall (2017) find that the vertical integrations of "The Coca Cola Company" and "PepsiCo" with their bottlers resulted to lower prices for Coca Cola and PepsiCo products, and higher prices for rival products, such as Dr Pepper.

matching guarantees allow stores to reassure consumers that they will not be 'ripped off' by higher-priced branded products if they visit a store. Price-matching commits stores not to charge higher prices than a rival for its branded goods when the incentives to price branded good higher differ across stores due to the cross-store heterogeneity in the qualities of their generics. In turn, reductions in branded good prices encourage stores to further reduce prices of generics to shift consumer purchases toward generics.

In this way, price-matching commits a store to lower prices, which attracts more shoppers. We show that when travel to a store is sufficiently cheap so that consumer choice of where to shop is sensitive to prices, stores become trapped in a *Prisoner's Dilemma*: Store profits would be higher if neither store matched, but price-matching is a strictly dominant strategy, as the attraction of drawing more shoppers by price-matching more than compensates for lower prices. For intermediate travel costs, a *Stag-Hunt* game arises: neither store wants to initiate price-matching unless it thinks that a rival will. Only when travel is expensive do stores lack incentives to price-match.

Motivation for our analysis comes from the experiences of major supermarket chains in the UK—Tesco, Sainsbury's and Waitrose. In the past decade, these chains adopted the strategy of offering price-matching guarantees on *branded* products, promising to match lower prices of competitors on branded products, but *not generic* alternatives.[4] For example, under Tesco's policy, daily prices are collected from competitors, and differences between its prices of branded products and those of its competitors are automatically refunded to consumers at checkout.[5] A long-running price war ensued.[6] Profits and share prices fell sharply, as highlighted by newspaper articles with titles like, 'the new grocery price war could destroy

[4]ASDA and Morrison's offer superficially similar, but distinct, price pledges (Arbatskaya et al. (2004)). ASDA employs a price-beating pledge (*https://www.asdapriceguarantee.co.uk/terms.html*), and Morrison's used to award points to consumers based on how much cheaper a shopping basket was at a rival *(https://www.theguardian.com/money/2015/oct/09/changes-to-morrisons-match-more-loyalty-scheme)*. We thank an anonymous referee for pointing this out.

[5]Tesco offers the price-matching guarantee only if at least ten products are purchased and limits reimbursement to £20 (*https://secure.tesco.com/brandguarantee*). Waitrose guarantees to price-match Tesco for 1,000 branded products that its consumers use most frequently (*http://www.telegraph.co.uk/finance/newsbysector/retailandconsumer/9242654/Waitrose-extends-price-match-guarantee-with-Tesco.html*). Sainsbury's used to automatically issue a voucher for the difference in the prices of its branded goods, and the lowest of prices at ASDA and Tesco, redeemable at the next visit. (*https://www.theguardian.com/money/2013/mar/11/supermarket-deals-price-promises-match-up*).

[6]*http://marketing-sciences.com/price-matching-history-whats-supermarket-wars/*.

the supermarkets' (*http://www.fool.co.uk/investing/2016/08/03/the-new-grocery-price-war-could-destroy-the-supermarkets/*). While this period of time was marked by other changes to the UK supermarket industry, including increased competition from low cost entrants, our model reconciles the price matching, which, in turn, can explain some of the profit decline.

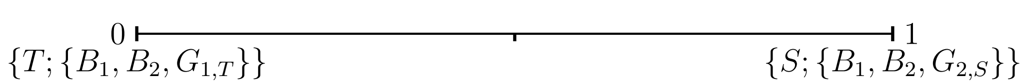
Other explanations for why price-match guarantees are offered or can be ineffective do not hold in the UK setting. With automatic price discounts, consumers do not bear hassle costs (Hviid and Shaffer (1999)); price-matching does not discriminate between informed and uninformed consumers (Png and Hirshleifer (1987), Corts (1996)); and in costly search or information acquisition settings, price-matching reduces optimal consumer search and information acquisition, leading to *higher* prices and profits (Moorthy and Winter (2006), Yankelevich and Vaughan (2016)). Coughlan and Shaffer (2009) is the sole paper to consider multiple products; and it focuses on how shelf space and product differentiability affect the profitability of price-matching guarantees, and not the strategic effects of generic alternatives.

We next lay out the model in which each store offers a single generic that differs across stores. We characterize pricing with and without price-matching. We then analyze consumer choice of where to shop, and derive store profits with and without price-matching. A characterization of equilibrium outcomes follows. We conclude with a discussion of robustness. In particular, as we establish in the appendix that the same mechanisms and results apply when stores offer multiple generics, of heterogeneous qualities. Proofs are in an Appendix.

2 Model

Our spatial model features two stores located at opposite ends of the unit interval. Store T is located at 0, and store S is located 1. Each store carries branded versions of goods 1 and 2, denoted B_1 and B_2. Store T carries a generic substitute to B_1, denoted $G_{1,T}$, and store S carries a generic substitute to B_2, denoted $G_{2,S}$. The marginal cost of producing branded goods is $c > 0$, while generics are costless to produce.

Figure 1: Spatial Economy



A measure one of consumers is uniformly distributed on $[0,1]$. To travel distance d, consumers incur cost $\alpha m(d)$, where $m'(d) > 0$, $m''(d) \geq 0$, and $\alpha > 0$. Consumers value at most one unit of each good, and utility is separable across the two goods. Valuations of branded goods are independently and identically uniformly distributed across consumers with $V_{Bi} \sim U[0,1]$ for good $i = 1, 2$. With probability $1-\gamma$, a consumer values a generic as much as its branded counterpart, i.e., $V_{Gi} = V_{Bi}$, but with probability $\gamma \in (0,1)$, she only values a generic at $V_{Gi} = \beta V_{Bi}$, where $\beta < 1$.

Stores only sell the generic to consumers who discount it if the branded good is sufficiently costly to produce relative to how much consumers discount the generic $(1-\beta)$, and the likelihood $1-\gamma$ that they do not discount the generic. Assumption 1 details a sufficient condition for firms sell to some consumers who discount the generic:

Assumption 1. $c > \sqrt{(1-\beta)^3 (1-\gamma) / \big(\beta (\gamma + \beta (1-\beta)(1-\gamma))\big)}$.

Consumers only see a store's prices and learn their valuations for goods when they visit the store. This creates a potential role for price-matching guarantees that commit stores to setting prices on branded goods that do not exceed those set by rivals. The assumption that consumers do not learn their valuations until they visit a store simplifies analysis; our qualitative findings do not hinge on this assumption.

Timing. At stage 1, each store announces whether it will price-match its rival's branded goods prices, and sets prices. Consumers see price-match announcements, but not prices. At stage 2, consumers form beliefs about prices and valuations, and decide which store to visit. At stage 3, consumers visit stores, see prices, learn valuations and make purchase decisions.

We use the function δ_j to indicate whether store $j \in \{T, S\}$ price-matches: $\delta_j = 1$ if it price-matches and $\delta_j = 0$ if it does not. Store T's strategy is given by the vector $\{\delta_T, p_T(\delta_T)\}$, where $p_T(\delta_T) = \{p^B_{1T}(\delta_T), p^B_{2T}(\delta_T), p^G_{1T}(\delta_T)\}$, and store S's strategy is given by $\{\delta_S, p_S(\delta_S)\}$, where $p_S(\delta_S) = \{p^B_{1S}(\delta_S), p^B_{2S}(\delta_S), p^G_{2S}(\delta_S)\}$.

Consumers form expectations $p^e(\delta_T, \delta_S) = \{p^e_T(\delta_T), p^e_S(\delta_S)\}$ about prices. Consumers make two decisions. First, based on price-matching announcements, expected prices, and location d, a consumer chooses a store to visit, $\sigma_1(d, p^e(\delta_T, \delta_S)) \in \{T, S\}$. Then, once at store $j \in \{T, S\}$, a consumer sees in-store prices, learns her valuations of branded goods, $V_B = \{V_{B1}, V_{B2}\}$ and whether she discounts generics, $b \in \{0, 1\}$. Given this information, the consumer makes her purchase choices, $\sigma_2\left(V_B, b, p_j\left(\delta_j\right)\right)$. We solve the model recursively.

In-store consumer behavior. Consider a consumer who visits store T, sees prices $p_T\left(\delta_T\right) = \{p_{1T}^B\left(\delta_T\right), p_{2T}^B\left(\delta_T\right), p_{1T}^G\left(\delta_T\right)\}$, and learns that her branded good valuations are $V_B = \{V_{B1}, V_{B2}\}$. We verify below that, in equilibrium, stores set lower prices for generics, i.e., $p_{1T}^B\left(\delta_T\right) \geq p_{1T}^G\left(\delta_T\right)$. Thus, a consumer who does not discount the generic never buys the branded version, and she buys the generic version if and only if $V_{Gi} (= V_{Bi}) \geq p_{iT}^G$. A consumer who values the branded good B_1 at V_{B1} and discounts the generic obtains utility $V_{B1} - p_{1T}^B\left(\delta_T\right)$ from purchasing B_1 and $\beta V_{B1} - p_{1T}^G\left(\delta_T\right)$ from purchasing $G_{1,T}$. Thus, the consumer opts for the branded version if and only if

$$V_{B1} - p_{1T}^B\left(\delta_T\right) > \max\left\{0, \beta V_{B1} - p_{1T}^G\left(\delta_T\right)\right\}. \tag{1}$$

Switching from the branded good to the generic results in a consumption utility loss of $\left(1-\beta\right) V_{B1}$, but saves the consumer $p_{1T}^B\left(\delta_T\right) - p_{1T}^G\left(\delta_T\right) \geq 0$. The loss in utility from downgrading to the generic is proportional to a consumer's valuation—higher valuation consumers lose more—but the savings from the price difference do not vary with a consumer's valuation. Hence, we can express condition (1) in terms of the valuations of consumers who opt for the branded good. Consumer types with high valuations

$$V_{B1} \geq \tilde{V}_{B1}\left(\delta_T\right) = \max\Big\{p_{1T}^B(\delta_T), \frac{p_{1T}^B\left(\delta_T\right) - p_{1T}^G\left(\delta_T\right)}{1-\beta}\Big\}, \tag{2}$$

opt for the branded good, while those with intermediate valuations

$$V_{B1} \in [p_{1T}^G\left(\delta_T\right)/\beta, \tilde{V}_{B1}\left(\delta_T\right)], \tag{3}$$

select the generic (when β is large enough that $p_{1T}^B\left(\delta_T\right) > p_{1T}^G\left(\delta_T\right)/\beta$). When $p_{1T}^B\left(\delta_T\right) > p_{1T}^G\left(\delta_T\right)/\beta$ some consumers who discount generics buy it, and the consumer who is indifferent between B_1 and $G_{1,T}$ has valuation $\tilde{V}_{B1}\left(\delta_T\right) = \left(p_{1T}^B\left(\delta_T\right) - p_{1T}^G\left(\delta_T\right)\right)/\left(1-\beta\right)$. Absent of a generic substitute, a consumer buys B_2 at store T if and only if $V_{B2} \geq p_{2T}^B\left(\delta_T\right)$.

Store Pricing. Ex ante, consumers only differ in their spatial locations. Given price-matching announcements (δ_T, δ_S), there is a unique consumer location $d(\delta_T, \delta_S; \alpha)$ such that store T attracts consumers located at $d < d(\delta_T, \delta_S; \alpha)$, and store S attracts consumers located at $d > d(\delta_T, \delta_S; \alpha)$. Consider store T. In-store prices affect purchase decisions of consumers at the store, but not which consumers visit. This is because consumer choices of where to shop are based on their locations, and expected valuations and prices; while purchasing decisions are determined by realized valuations and in-store prices. Because the distribution of valuations does not vary with a consumer's location, the position of the marginal consumer simply scales profits and does not affect a store's price choices. Similarly, store S's price-matching policy does not affect store T's pricing since it does not alter the distribution of consumer valuations at store T or impose constraints on store T's pricing. As a result, store T's profit takes a simple form—it is given by the measure $d(\delta_T, \delta_S; \alpha)$ of consumers that visit it times the (expected) profit per consumer, $\pi_T(\delta_T)$:

$$\Pi_T(\delta_T, \delta_S) = d(\delta_T, \delta_S; \alpha)\, \pi_T(\delta_T)\,. \tag{4}$$

When store T prices so that some consumers who discount its generic buy it, i.e., when $p^B_{1T}(\delta_T) > p^G_{1T}(\delta_T)/\beta$, then $\tilde{V}_{B1} = \left(p^B_{1T}(\delta_T) - p^G_{iT}(\delta_T)\right)/(1-\beta)$. Substituting for $\tilde{V}_{B1}$ reveals that store T's expected profit per customer is:

$$\begin{aligned}\pi_T(\delta_T) = \gamma &\left[\left(p^B_{1T}(\delta_T) - c\right)\left(1 - \frac{p^B_{1T}(\delta_T) - p^G_{1T}(\delta_T)}{1-\beta}\right) + p^G_{1T}(\delta_T)\left(\frac{p^B_{1T}(\delta_T) - p^G_{1T}(\delta_T)}{1-\beta} - \frac{p^G_{1T}(\delta_T)}{\beta}\right)\right] \\ &+ (1-\gamma)\left[p^G_{1T}(\delta_T)\left(1 - p^G_{1T}(\delta_T)\right)\right] + p^B_{2T}(\delta_T)\left(1 - p^B_{2T}(\delta_T)\right).\end{aligned} \tag{5}$$

Expected profit per consumer for store S, $\pi_S(\delta_S)$, is defined analogously.

Proposition 1. (no price-matching) *Under Assumption 1, if store $j \in \{T, S\}$ does not price-match, it sets the price of its generic at its stand-alone monopoly price, the price of the competing branded above its stand-alone monopoly price, and the price of the branded without a competing generic at its stand-alone monopoly price. Store T sets prices:*

$$p^G_{1T}(0) = \frac{\beta}{2(\beta + \gamma(1-\beta))}, \quad p^B_{1T}(0) = \frac{1+c}{2} + p^G_{1T}(0) - \frac{\beta}{2}, \quad p^B_{2T}(0) = \frac{1+c}{2}. \tag{6}$$

The stark monopoly pricing result reflects that no consumer sees prices before shopping. If a few consumers see prices before shopping, then price competition rises, causing stores to reduce prices, but they still raise prices of branded goods to induce consumers to switch to purchasing generic versions by amounts that hinge on the heterogeneous qualities of the generics.

A monopolist charges the stand-alone monopoly price of $(1+c)/2$ when she only offers the branded version of a good. When a generic substitute is also offered, the store charges more than this monopoly price in order to induce some consumers who discount generics, and who would otherwise buy the branded good, to instead purchase the generic, which is cheaper to produce.[7] A sufficient condition for a store to sell the branded good is $1-\beta > c$, which says that it is efficient to sell the branded good to high valuation consumers rather than the discounted generic.

In contrast, the generic is priced at its stand-alone monopoly price. The marginal consumer of the branded version is indifferent between the branded and the generic alternative. Increasing the price of the branded version diverts consumers to the generic, but it does not cause consumers to drop out. Consequently, marginal increases in p_{1T}^G are completely passed on to the price of the branded good, so that $p_{1T}^B(0) = p_{1T}^G(0) + (1-\beta+c)/2$. Thus, the marginal effects of p_{1T}^G are the same as if it were a stand-alone monopoly good.[8]

When some discounters buy a generic, its price rises with β, i.e., when consumers discount it by less. Competing branded good pricing is more nuanced: the price of a branded good is a non-monotonic function of β. Higher values of β raise a generic's price, which is a force for raising the price of its branded analogue. However, when β is higher, the quality upgrade $(1-\beta)$ from the generic to the branded good is lower, which reduces the premium that a store can charge for the branded good. This latter effect dominates unless consumers discount the generic so sharply that $\beta < \sqrt{\gamma}/\left(1+\sqrt{\gamma}\right)$. In particular, $\beta \geq 1/2$ ensures that $p_{1T}^B(0)$ always decreases in β.

Proposition 1 extends readily to allow for asymmetric generic quality across stores, for example if $\beta_S > \beta_T$ so that store S's generic is better. Regardless of generic quality, stores

[7] To see that $p_{1T}^B(0) > (1+c)/2$, notice that $p_{1T}^G(0) > \beta/2$ for $\gamma < 1$.

[8] This extends more generally as long as no consumer of the branded good is on the cusp of not buying.

set higher prices for the branded good that competes with its generic, creating a potential role for price-matching guarantees.

Now suppose that store j commits to matching its rival's branded good prices, so that consumers pay the lower of the two stores' prices. Then, branded good prices are given by

$$
\begin{aligned}
p_{1j}^{B}(1) &= \min\left\{p_{1T}^{B}(0), p_{1S}^{B}(0)\right\} = \frac{1+c}{2} \\
p_{2j}^{B}(1) &= \min\left\{p_{2T}^{B}(0), p_{2S}^{B}(0)\right\} = \frac{1+c}{2}.
\end{aligned}
\tag{7}
$$

Because firms price branded goods with competing generics more highly, and stores sell different generics (or more generally, the qualities of their generics differ), the stores price their branded goods differently, creating a potential role for price-matching guarantees.

Proposition 2. (price-matching) *Under Assumption 1, when store $j \in \{T, S\}$ commits to price-match, the price of the branded good for which price-matching bind falls to the stand-alone monopoly price, inducing the store to reduce the price of its generic analogue. The price of a branded good for which price-matching does not bind is unchanged by price-matching.*

Price-matching puts downward pressure on prices: absent price-matching, stores induce consumers to buy the generic by charging higher prices for branded goods that compete with a generic. Price-matching effectively delegates some of a store's pricing to its rival, committing the store to charging the rival's lower price on a branded good. In turn, to induce consumers to switch to the generic, the store reduces the price of the competing generic. Price-matching lowers prices which reduces expected profit per consumer, but increases expected consumer surplus, and thus, consumer base. The store will price-match only when the latter increase is large enough to swamp the reduced profit per consumer.

Consumer Choice of Store and Store Profits. When deciding which store to visit, a consumer does not know her valuations, and her forecasts of prices only hinge on whether a store price matches or not. The expected consumer surplus from visiting store T is

$$\mathcal{U}\left(p_T^e\left(\delta_T\right)\right)=\gamma\left[\int_{\frac{p_{1T}^{Be}(\delta_T)-p_{1T}^{Ge}(\delta_T)}{1-\beta}}^{1}\left(V_{B1}-p_{1T}^{Be}\left(\delta_T\right)\right)dV_{B1}+\int_{\frac{p_{1T}^{Ge}(\delta_T)}{\beta}}^{\frac{p_{1T}^{Be}(\delta_T)-p_{1T}^{Ge}(\delta_T)}{1-\beta}}\left(V_{B1}-p_{1T}^{Ge}\left(\delta_T\right)\right)dV_{B1}\right]$$
$$+\left(1-\gamma\right)\left[\int_{p_{1T}^{Ge}(\delta_T)}^{1}\left(V_{G1}-p_{1T}^{Ge}\left(\delta_T\right)\right)dV_{G1}\right]+\left[\int_{p_{2T}^{Be}(\delta_T)}^{1}\left(V_{B2}-p_{2T}^{Be}\left(\delta_T\right)\right)dV_{B2}\right]$$

A consumer located at d derives expected utility from visiting store T of $\mathcal{U}\left(p_T^e\left(\delta_T\right)\right)-\alpha m\left(d\right)$. The expected utility from visiting store S, $\mathcal{U}\left(p_S^e\left(\delta_S\right)\right)-\alpha m\left(1-d\right)$, is defined analogously. We assume that travel is sufficiently cheap that $\alpha m\left(1/2\right)\leq\mathcal{U}\left(p_T^e\left(0\right)\right)$, i.e., all consumers are willing to visit a store in equilibrium, even if the stores do not price match. Given price-matching announcements $\left(\delta_T,\delta_S\right)$, a consumer located at d visits store T if

$$\mathbb{U}\left(\delta_T,\delta_S\right)\equiv\mathcal{U}\left(p_T^e\left(\delta_T\right)\right)-\mathcal{U}\left(p_S^e\left(\delta_S\right)\right)\geq\alpha\left(m\left(d\right)-m\left(1-d\right)\right)\equiv\alpha\mathbb{M}\left(d\right). \tag{8}$$

Conversely, she visits store S if $\mathbb{U}\left(\delta_T,\delta_S\right)<\alpha\mathbb{M}\left(d\right)$, where $\mathbb{M}\left(d\right)$ is strictly increasing in d, with $\mathbb{M}\left(1/2\right)=0$. In equilibrium, expected prices equal in-store prices. When either both stores price-match or no store price-matches, expected consumer surplus is the same in each store, i.e. $\mathbb{U}\left(0,0\right)=\mathbb{U}\left(1,1\right)=0$. If only store T price-matches ($\delta_T=1$, $\delta_S=0$), then prices in store T are expected to be lower than in store S, so $\mathbb{U}\left(1,0\right)>0>\mathbb{U}\left(0,1\right)$.

Given price-matching announcements $\left(\delta_T,\delta_S\right)$, the indifferent consumer is located at $d\left(\delta_T,\delta_S;\alpha\right)$. When both stores announce the same price-matching policy, they offer the same expected consumer surplus (i.e., $\mathbb{U}\left(\delta_T,\delta_S\right)=0$ for $\delta_T=\delta_S\in\{0,1\}$), and consumers visit the closest store, so $d\left(0,0;\alpha\right)=d\left(1,1;\alpha\right)=1/2$. When neither store price-matches, profits are

$$\Pi_T\left(0,0\right)=\Pi_S\left(0,0\right)=\frac{1}{2}\pi\left(0\right), \tag{9}$$

and when both price-match,

$$\Pi_T\left(1,1\right)=\Pi_S\left(1,1\right)=\frac{1}{2}\pi\left(1\right). \tag{10}$$

When only store T price-matches, $\mathbb{U}\left(\delta_T,\delta_S\right)=\mathbb{U}\left(1,0\right)>0$. Condition (8) then implies that there exists an $\underline{\alpha} > 0$, such that for $\alpha < \underline{\alpha}$, travel is so cheap that all consumers visit store T; and when $\alpha > \underline{\alpha}$, there exists a location $d(1,0;\alpha) \in (1/2, 1]$ of a consumer who is indifferent between the two stores.

Travel costs rise with α causing more consumers to choose store based on distance rather than price, shifting $d(1,0;\alpha)$ toward $1/2$. Store profits are

$$\Pi_T(1,0) = d(1,0;\alpha)\,\pi(1)\,,\ \Pi_S(1,0) = (1 - d(1,0;\alpha))\,\pi(0)\,. \tag{11}$$

By symmetry, when only store S price-matches ($\delta_T = 0$, $\delta_S = 1$), the indifferent consumer is located at $d(0,1;\alpha) = 1 - d(1,0;\alpha)$, and store profits are

$$\Pi_T(0,1) = d(0,1;\alpha)\,\pi(0) \text{ and } \Pi_S(0,1) = (1 - d(0,1;\alpha))\,\pi(1)\,.$$

Equilibrium. We now show how the number and nature of equilibria hinge on the travel cost parameter α that determines the price-elasticities of consumer shopping choices.

Proposition 3. *There exist α^M and α^N, with $\alpha^N > \alpha^M$, such that for $\alpha < \alpha^M$, price-matching is a strictly dominant strategy, and in the unique equilibrium both stores price-match. If $\alpha > \alpha^N$, then in the unique equilibrium neither store price-matches. Finally, if $\alpha \in \left[\alpha^M, \alpha^N\right]$, then two equilibria exist, one where both stores price-match, and one where neither store price-matches. Firm profits are strictly lower in the price-matching equilibrium.*

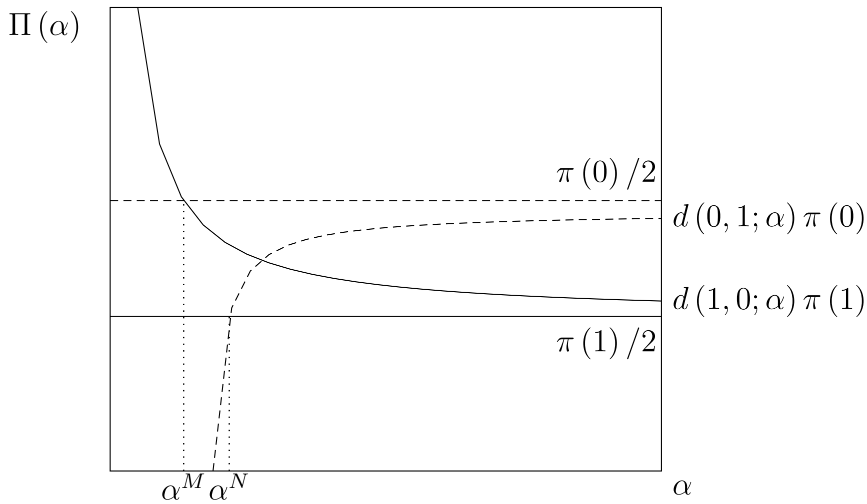
When store S does not price-match, store T price-matches if the profit $d(1,0;\alpha)\,\pi(1)$ exceeds that from not matching $\pi(0)/2$. Similarly, when store S price-matches, store T price-matches if $\pi(1)/2 \geq d(0,1;\alpha)\,\pi(0)$, where $d(0,1;\alpha) = 1 - d(1,0;\alpha)$. Since profit per consumer without price-matching $\pi(0)$ exceeds that with price-matching $\pi(1)$, we have

$$\left(1 - d\left(1,0;\alpha^N\right)\right)\pi(0) = \frac{1}{2}\pi(1) < \frac{1}{2}\pi(0) = d\left(1,0;\alpha^M\right)\pi(1)\,.$$

Rearranging yields

$$d\left(1,0;\alpha^N\right) = 1 - \frac{1}{2}\frac{\pi(1)}{\pi(0)} < \frac{1}{2}\frac{\pi(0)}{\pi(1)} = d\left(1,0;\alpha^M\right),$$

Figure 2: Linear and Quadratic Travel Costs



For a store to want to initiate price-matching rather than just want to retaliate to price-matching by a rival, shopping choices must be more price elastic, i.e., α must be smaller, $\alpha^N > \alpha^M$. This reflects that if a rival price-matches, then a store loses $\pi(0)$ from each consumer who switches to its rival, but it only gains $\pi(1)$ from each consumer who switches to it when it matches.

Figure 2 depicts store T's profit when travel costs are linear or quadratic. Shopping elasticity decreases in α: $d(1,0;\alpha)$ and $d(0,1;\alpha)$ decrease and increase in α, respectively. When $\alpha < \alpha^M$, travel is sufficiently cheap that price matching generates enough business-stealing effects that a Prisoner's Dilemma emerges: stores would rather not price-match to get profit $\pi(0)/2$, but a commitment to lower prices increases the consumer base by enough to make a unilateral deviation to price matching profitable (i.e., $d(1,0;\alpha)\,\pi(1) > \pi(0)/2$). Retaliating to price-matching is even more attractive, so stores end up price-matching and only earning $\pi(1)/2$ (i.e., $d(0,1;\alpha)\,\pi(0) < \pi(1)/2$).

When $\alpha \in [\alpha^M, \alpha^N]$, shopping elasticities are not high enough for a store to unilaterally give up on unconstrained monopoly profits $\pi(0)/2$ (i.e., $d(1,0;\alpha)\,\pi(1) < \pi(0)/2$). However, enough consumers respond to price-matching that when a rival is expected to price-match, retaliation is optimal (i.e. $d(0,1;\alpha)\,\pi(0) < \pi(1)/2$). Hence, which equilibrium prevails hinges on beliefs about a rival's actions.

Finally, when $\alpha > \alpha^N$, travel is costly enough that even if a rival is expected to price-match, retaliation would not be optimal because it would not attract enough customers.

3 Concluding Discussion

Simple reasoning suggests that firms should be able to support collusively high prices by offering price guarantees that commit them to matching lower prices set by rivals. Nonetheless, in recent years, when most major UK supermarkets offered to match the prices set by rivals for branded goods, price wars and large profit losses ensued. We reconcile such outcomes in a setting where consumers see whether stores offer price-matching guarantees, but only see prices when they go to a store, and stores offer generic products that are less costly to produce. Price-matching guarantees commit stores not to set high prices for branded goods that compete with their generics, thereby attracting more shoppers. We show that when travel is inexpensive, so that consumer choice of where to shop is price elastic, then in the unique equilibrium, a prisoner's dilemma results in which supermarkets have a dominant strategy to price-match. For intermediate shopping elasticities, two equilibria exist—a low profit equilibrium in which all stores price match, and a high profit equilibrium in which no store does. Only when travel is sufficiently costly is the high profit, no-price matching equilibrium unique.

The keys for our results are that (1) consumers only see price-matching guarantees (not prices) prior to choosing a store, and (2) absent price-matching, stores set different prices, creating a price-lowering effect when stores commit to matching lower branded prices set by a rival. Thus, our qualitative findings extend when consumers know their valuations before visiting a store, as in Rhodes (2015). In the appendix, we establish that our results also extend when stores carry generic substitutes for both branded goods, but, for example, store T has a high quality generic substitute for good 1, and a lower quality substitute for good 2, while store S has the opposite generic product composition. The key is that stores will differ according to which branded good they price more highly, creating a role for price-match guarantees.

Our findings extend in expected ways if stores are asymmetrically situated. For example, if one store has a larger market (e.g., if stores are located at 0 and 1, and consumers are distributed on $[0, 1+\epsilon]$), then it is more reluctant than the smaller store to price match. As a result, when market sizes are similar, then in any equilibrium, stores behave symmetrically, and the strategic considerations of the smaller store determine the cutoffs for possible equilibrium outcomes. When markets differ by more, an equilibrium may exist for intermediate shopping elasticities in which only the small store matches prices.

Similar characterizations obtain when stores only carry one generic, but the quality of their generics differ. When $\beta_S > \beta_T \geq \frac{1}{2}$, store S will set a lower price for the branded good that competes with its generic than will store T. When there are enough discounters, store S offers greater consumer surplus (in the absence of price matching guarantees), as its branded good prices are lower and its generic quality higher. This raises the relative attraction to store T of price matching. As a result, when generic qualities are sufficiently similar, then in any equilibrium, stores behave symmetrically, and the strategic considerations of store T with the inferior generic determine the cutoffs for possible equilibrium outcomes. When generic qualities differ by more, an equilibrium may exist for intermediate shopping elasticities in which only store T matches prices.

Appendix A: Multiple/Overlapping Generics Substitutes

We extend our analysis to consider overlapping generic substitutes. Both stores carry branded goods B_1 and B_2. Store T carries a high-quality generic substitute to B_1, denoted $G_{1,T}$, and a low-quality generic substitute to B_2, denoted $G_{2,T}$. Store S carries a low-quality generic substitute to B_1, denoted $G_{1,S}$, and a high-quality substitute to B_2, denoted $G_{2,S}$. Consumers who discount generics value a high-quality generic at $V_{Gi} = \beta_H V_{Bi}$, and a low-quality generic at $V_{Gi} = \beta_L V_{Bi}$, where $\beta_L < \beta_H < 1$. We also assume that $1-\beta_H > c$, so that it is efficient for the highest valuation consumers to purchase the branded version even when the substitute is a high quality generic. This ensures that stores want to sell both branded goods. Assumption 2 is the analogue of Assumption 1, ensuring that stores sell both types of generics to some consumers who discount them.

Assumption 2. $c > \sqrt{\left(1-\beta_L\right)^3\left(1-\gamma\right)/\big(\beta_L\left(\gamma+\beta_L\left(1-\beta_L\right)\left(1-\gamma\right)\right)\big)}$.

Information and timing is as before: when deciding which store to visit, a consumer does not know her valuations, and her forecasts of prices only hinge on whether a store price matches or not. Thus, in-store consumer behavior is given by conditions 2 and 3, substituting for the relevant β. For example, in store T, consumers who discount generics with valuations

$$V_{B1} \geq \tilde{V}_{B1}\left(\delta_T\right) = \max\Big\{p^B_{1T}(\delta_T), \frac{p^B_{1T}\left(\delta_T\right) - p^G_{1T}\left(\delta_T\right)}{1-\beta_H}\Big\}, \tag{12}$$

opt for the branded version of good 1, while those with intermediate valuations

$$V_{B1} \in [p^G_{1T}\left(\delta_T\right)/\beta_H, \tilde{V}_{B1}\left(\delta_T\right)], \tag{13}$$

select the generic version (when β_H is large enough that $p^B_{1T}\left(\delta_T\right) > p^G_{1T}\left(\delta_T\right)/\beta_H$), while consumers who do not discount generics always buy the generic version. Consumer choices of branded and generic versions of good 2 follow similarly, replacing β_H by β_L.

Store T's profit again equals the measure $d\left(\delta_T, \delta_S; \alpha\right)$ of consumers that visit it times the (expected) profit per consumer, $\pi_T\left(\delta_T\right)$: $\Pi_T\left(\delta_T, \delta_S\right) = d\left(\delta_T, \delta_S; \alpha\right) \cdot \pi_T\left(\delta_T\right)$. Assuming $p^B_{iT}\left(\delta_T\right) > p^G_{iT}\left(\delta_T\right)/\beta_i$ for $i = \{1, 2\}$ holds so that some discounters buy the generic, store

T's expected profit per customer is:

$$\pi_T(\delta_T) = \gamma \left[\left(p_{1T}^B(\delta_T) - c\right)\left(1 - \frac{p_{1T}^B(\delta_T) - p_{1T}^G(\delta_T)}{1-\beta_H}\right) + p_{1T}^G(\delta_T)\left(\frac{p_{1T}^B(\delta_T) - p_{1T}^G(\delta_T)}{1-\beta_H} - \frac{p_{1T}^G(\delta_T)}{\beta_H}\right) \right.$$
$$\left. + \left(p_{2T}^B(\delta_T) - c\right)\left(1 - \frac{p_{2T}^B(\delta_T) - p_{2T}^G(\delta_T)}{1-\beta_L}\right) + p_{2T}^G(\delta_T)\left(\frac{p_{2T}^B(\delta_T) - p_{2T}^G(\delta_T)}{1-\beta_L} - \frac{p_{2T}^G(\delta_T)}{\beta_L}\right)\right]$$
$$+ (1-\gamma)\left[p_{1T}^G(\delta_T)\left(1 - p_{1T}^G(\delta_T)\right) + p_{2T}^G(\delta_T)\left(1 - p_{2T}^G(\delta_T)\right)\right]. \tag{14}$$

Expected profit per consumer for store S, $\pi_S(\delta_S)$, is defined analogously.

Demand independence in the two goods means that, absent of price-matching, optimal pricing in the multiple-generic case is a simple extension of Proposition 1.

Proposition 4. (no price-matching-multiple-generics) *Under Assumption 2, if store $j \in \{T, S\}$ does not price-match, it prices its generics at their stand-alone monopoly prices, and it prices branded goods above their stand-alone monopoly prices. Store T sets prices:*

$$p_{1T}^G(0) = \frac{\beta_H}{2(\beta_H + \gamma(1-\beta_H))},\ p_{1T}^B(0) = p_{1T}^G(0) + \frac{1+c-\beta_H}{2},$$
$$p_{2T}^G(0) = \frac{\beta_L}{2(\beta_L + \gamma(1-\beta_L))},\ \ p_{2T}^B(0) = p_{2T}^G(0) + \frac{1+c-\beta_L}{2}. \tag{15}$$

Both branded goods are priced above their stand-alone monopoly price to induce product switching towards the generic substitute.

When store j price-matches its rival's branded good prices, the branded good prices are

$$p_{1j}^B(1) = \min\left\{p_{1T}^B(0), p_{1S}^B(0)\right\},\ \ p_{2j}^B(1) = \min\left\{p_{2T}^B(0), p_{2S}^B(0)\right\}. \tag{16}$$

As Proposition 4 details, the heterogeneity across stores in the qualities of their generics ensures that the stores will price their branded goods differently, giving rise to a potential role for price-matching guarantees.

Proposition 5. (price-matching-multiple-generics) *Under Assumption 2, when a store commits to price-match, the price falls for the branded good for which price-matching binds. The price of its generic analogue also falls. Prices of the branded and generic versions of the good for which price-matching does not bind equal their levels absent price-matching.*

The intuition is identical to the single generic case: price-matching puts downward pressure on prices forcing the store to reduce the price of its competing generic in order to induce consumers to switch from the branded version to the generic.

Price-matching increases expected consumer surplus, which at store T is given by

$$\begin{aligned}\mathcal{U}\left(p_T^e\left(\delta_T\right)\right) = \gamma & \left[\int_{\frac{p_{1T}^{Be}(\delta_T)-p_{1T}^{Ge}(\delta_T)}{1-\beta_H}}^{1} \left(V_{B1} - p_{1T}^{Be}\left(\delta_T\right)\right) dV_{B1} + \int_{\frac{p_{1T}^{Ge}(\delta_T)}{\beta_H}}^{\frac{p_{1T}^{Be}(\delta_T)-p_{1T}^{Ge}(\delta_T)}{1-\beta_H}} \left(V_{B1} - p_{1T}^{Ge}\left(\delta_T\right)\right) dV_{B1}\right.\\ & \left. + \int_{\frac{p_{2T}^{Be}(\delta_T)-p_{2T}^{Ge}(\delta_T)}{1-\beta_L}}^{1} \left(V_{B2} - p_{2T}^{Be}\left(\delta_T\right)\right) dV_{B2} + \int_{\frac{p_{2T}^{Ge}(\delta_T)}{\beta_L}}^{\frac{p_{2T}^{Be}(\delta_T)-p_{2T}^{Ge}(\delta_T)}{1-\beta_L}} \left(V_{B2} - p_{2T}^{Ge}\left(\delta_T\right)\right) dV_{B2}\right]\\ & + (1-\gamma)\left[\int_{p_{1T}^{Ge}(\delta_T)}^{1} \left(V_{G1} - p_{1T}^{Ge}\left(\delta_T\right)\right) dV_{G1} + \int_{p_{2T}^{Ge}(\delta_T)}^{1} \left(V_{G2} - p_{2T}^{Ge}\left(\delta_T\right)\right) dV_{G2}\right].\end{aligned}$$

That is, given price-matching reduces profit per consumer, a store will price-match only if it increases expected consumer surplus, and thus its consumer base.

As with a single generic, a consumer located at d visits store T when given the price-matching announcements (δ_T, δ_S), inequality (8) holds; i.e., expected consumer surplus difference between the store exceeds the difference in travel costs. Similarly, store profits for the different price-match announcements are given by equations (9)-(11). Hence, the qualitative findings and intuition of our main result in Proposition 3 extends to this multi-generic setting.

Appendix B: Proofs

Lemma 1. *If $c > \frac{(1-\beta)^2(1-\gamma)}{\gamma+\beta(1-\beta)(1-\gamma)}$ inequality $p_{ij}^B\left(\delta_j\right) > p_{ij}^G\left(\delta_j\right)/\beta$ holds so that store $j = \{T, S\}$ sells generic good $i = \{1, 2\}$ to some consumers who discount it at price*

$$p_{ij}^G\left(\delta_j\right) = \frac{\beta\left(1 + 2p_{ij}^B\left(\delta_j\right)\gamma + \beta\left(1-\gamma\right) - \gamma\left(1+c\right)\right)}{2\left(\gamma + \beta\left(1-\beta\right)\left(1-\gamma\right)\right)}. \tag{17}$$

Proof of Lemma 1: Consider store T. Assuming $p_{iT}^B\left(\delta_T\right) > p_{iT}^G\left(\delta_T\right)/\beta$, then given $p_{it}^B\left(\delta_T\right)$, the first-order condition of profit (5) with respect to $p_{iT}^G\left(\delta_T\right)$ is

$$\begin{aligned}\frac{\partial \pi_T\left(\delta_T\right)}{\partial p_{iT}^G\left(\delta_T\right)} = \gamma & \left[\left(p_{iT}^B\left(\delta_T\right) - c - p_{iT}^G\left(\delta_T\right)\right)\frac{1}{1-\beta} + \left(\frac{p_{iT}^B\left(\delta_T\right) - p_{iT}^G\left(\delta_T\right)}{1-\beta} - \frac{p_{iT}^G\left(\delta_T\right)}{\beta}\right) - \frac{p_{iT}^G\left(\delta_T\right)}{\beta}\right]\\ & + (1-\gamma)\left[1 - 2p_{iT}^G\left(\delta_T\right)\right] = 0.\end{aligned} \tag{18}$$

As the generic's price is raised, among discounters (first square brackets), some switch to the branded good (first term), some still buy the generic (second term), and the marginal consumer ceases buying (third term). The term for non-discounters (second square brackets) reflects typical monopoly considerations. Simplifying, yields equation (17).

It is easily shown that if $c > \frac{(1-\beta)^2(1-\gamma)}{\gamma+\beta(1-\beta)+(1-\gamma)}$, then, for $p_{1T}^{B}(\delta_T)$ less than $p_{1T}^{B}(0)$ in Proposition 1, inequality $p_{ij}^{B}(\delta_j) > p_{ij}^{G}(\delta_j)/\beta$ holds. In such case, the utility loss for the marginal discounter from switching from branded to generic $(1-\beta)\tilde{V}_G = (1-\beta)\, p_{iT}^{G}(\delta_T)/\beta$ is less than the price discount $p_{iT}^{B}(\delta_T) - p_{iT}^{G}(\delta_T)$, ensuring that some discounters buy the generic. □

Proof of Proposition 1: Store T chooses $\{p_{iT}^{B}(0),\ p_{iT}^{G}(0)\}_{i=1,2}$ to maximize profit per consumer $\pi_T(0)$. Assuming $p_{iT}^{B}(0) > p_{1T}^{G}(0)/\beta$ holds, then the first-order condition with respect to $p_{iT}^{B}(0)$ is

$$\frac{\partial \pi_T(0)}{\partial p_{iT}^{B}(0)} = \left(1 - \frac{p_{iT}^{B}(0) - p_{iT}^{G}(0)}{1-\beta}\right) - \left(p_{iT}^{B}(0) - c - p_{iT}^{G}(0)\right)\frac{1}{1-\beta} = 0.$$

The first term reflects the first-order effect of an increase in price, a higher price is received. The second term reflects the product switch effect as the marginal consumer switches to the generic following an increase in the price of branded good B_i, $p_{iT}^{B}(0)$. Simplifying, yields

$$p_{iT}^{B}(0) = p_{1T}^{G}(0) + \frac{1-\beta+c}{2}. \tag{19}$$

Setting $\delta_T = 0$ in Lemma 1 gives the price of the generic. Combining (19) and (17) yields

$$p_{iT}^{G}(0) = \frac{\beta}{2\left(\beta + \gamma\left(1-\beta\right)\right)}. \tag{20}$$

$$p_{iT}^{B}(0) = p_{iT}^{G}(0) + \frac{1+c-\beta}{2} = \frac{1+c}{2} + (1-\gamma)(1-\beta)\, p_{1T}^{G}(0). \tag{21}$$

Instead, store T can set $p_{iT}^{B}(0) = (1+c)/2$ and $p_{iT}^{G}(0) = 1/2$ with only non-discounters buying the generic. For $c > \sqrt{(1-\beta)^3(1-\gamma)/\left(\beta\left(\gamma+\beta\left(1-\gamma\right)\right)\right)}$, the store wants to sell the generic to discounters, while $c > (1-\beta)^2(1-\gamma)/\left(\gamma+\beta\left(1-\gamma\right)\right)$ implies $p_{1T}^{B}(0) > p_{1T}^{G}(0)/\beta$ (i.e., discounters buy generic). Both inequalities are implied by Assumption 1. □

Proof of Proposition 2: Consider store T. Price-matching binds for good 1, thus condition (7) implies $p_{1T}^{B}(1) = (1+c)/2$. Since $p_{1T}^{B}(1) < p_{1T}^{B}(0)$, Lemma 1 implies that $p_{1T}^{G}(1) <$

$p^G_{1T}(0)$, provided some discounters buy the generic. In fact, routine algebra reveals that

$$p^G_{1T}(1) = \left(\frac{\gamma + \beta(1-\beta)(1-\gamma)}{\gamma + \beta(1-\beta)(1-\gamma)^2}\right) p^G_{1T}(0)$$

As before the store can instead set $p^B_{iT}(1) = (1+c)/2$ and $p^G_{iT}(1) = 1/2$ with only non-discounters buying generic. If (and only if) Assumption 1 holds the store wants to lower the price of the generic to sell the generic to discounters. For $c > (1-\beta)^2(1-\gamma)/\big(\gamma + \beta(1-\beta)(1-\gamma)\big)$, $p^B_{1T}(1) > p^G_{1T}(1)/\beta$ holds (i.e., discounters buy generic). The latter condition on c is implied by Assumption 1. Thus, both prices are lowered to sell the generic to discounters. $\square$

Proof of Proposition 3: Given symmetry, it suffices to characterize either store's best response. If neither store price-matches, then the indifferent consumer is located at $d(0,0;\alpha) = 1/2$ and store T earns profit $\Pi_T(0,0) = \pi(0)/2$. If store T deviates to price-matching, then it earns profit $\Pi_T(1,0) = d(1,0;\alpha)\pi(1)$, where $d(1,0;\alpha) > 1/2$. Store T wants to deviate to price-match, when store S does not price-match, if

$$\left(d(1,0;\alpha) - \frac{1}{2}\right)\pi(1) + \frac{1}{2}\pi(1) \geq \frac{1}{2}\pi(0) \Leftrightarrow d(1,0;\alpha) \geq d\left(1,0;\alpha^M\right) = \frac{1}{2}\left(1 + \frac{\pi(0) - \pi(1)}{\pi(1)}\right).$$

Here $\pi(0) > \pi(1)$ implies $d\left(1,0;\alpha^M\right) > 1/2$, while $d\left(1,0;\alpha^M\right) < 1$ is implied by $\pi(0) < 2\pi(1)$, which holds. Thus, $d\left(1,0;\alpha^M\right) \in (1/2, 1)$. Monotonicity of $d(1,0;a)$ in α implies $d(1,0;\alpha) > d\left(1,0;\alpha^M\right), \forall \alpha < \alpha^M$, i.e., store T strictly prefers to price-match.

Now consider store S, and suppose that store T price-matches. If store S does not price-match, its profit will be $(1 - d(1,0;\alpha))\pi(0)$, where $d(1,0;\alpha) > 1/2$, and its profit from price-matching will be $\pi(1)/2$. Store S' best response is to retaliate if

$$(1 - d(1,0;\alpha))\pi(0) \leq \frac{1}{2}\pi(1) \Leftrightarrow d(1,0;\alpha) \geq d\left(1,0;\alpha^N\right) = \frac{1}{2}\left(1 + \frac{\pi(0) - \pi(1)}{\pi(0)}\right).$$

Here $\pi(0) > \pi(1)$ implies $d\left(1,0;\alpha^N\right) \geq 1/2$, and $d\left(1,0;\alpha^N\right) \leq 1$ follows from $\pi(1) > 0$. Thus, $d\left(1,0;\alpha^N\right) \in (1/2, 1)$. As before, monotonicity of $d(1,0;a)$ in α implies that $\forall \alpha < \alpha^N$ store S strictly prefers to price-match when store T price-matches, and for all $\alpha > \alpha^N$ store S strictly prefers not to price-match. Moreover, $\pi(1) < \pi(0)$ implies $d\left(1,0;a^N\right) < d\left(1,0;\alpha^M\right)$.

Since $d(1,0;a)$ is a strictly decreasing function of α, we have $\alpha^N > \alpha^M$. $\square$

Proof of Proposition 4: By demand independence the proof is identical to Proposition 1, replacing β for the appropriate β_i for $i = \{1,2\}$. Assumption 2 suffices for the store to want to sell both generics to consumers who discount them, and for some discounters to want to buy them. $\square$

Proof of Proposition 5: Assume $\beta_H \neq \gamma(1-\beta_L)/(\gamma(1-\beta_L)+\beta_L)$, so that price-matching binds for one of the two goods leading to a lower price for the branded analogue. Demand independence implies that the price of the generic substitute is again given by Lemma 1, replacing for β_i. Assumption 2 is sufficient for the store to want to sell the generic to consumers who discount it, and for some discounters to want to buy it, regardless for which good the price-matching binds. $\square$

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