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**Research Note**

# Price-Matching Guarantees, Retail Competition, and Product-Line Assortment

Anne T. Coughlan
Kellogg School of Management, Northwestern University, Evanston, Illinois 60208,
a-coughlan@kellogg.northwestern.edu

Greg Shaffer
William E. Simon Graduate School of Business, University of Rochester, Rochester, New York 14627,
shaffer@simon.rochester.edu

Price-matching guarantees (PMGs) are offers to match a competitor's price on a specific item. Such guarantees are extremely common in U.S. retail practice, and their impact has been studied in several published papers. The existing analytic literature models each retailer as a single-product seller; most work assumes that each retailer's product is identical with (or completely substitutable for) the competitor's product. In reality, competing retailers often sell multiple products, and these products do not always overlap, or may overlap partially but not totally. Furthermore, retailers that offer PMGs routinely exclude certain offerings from PMG coverage. This raises the interesting question of how product variety and product-stocking factors affect retailer decisions about offering PMGs.

In this paper, we simultaneously consider three factors of retailing importance that imply results consistent with PMG use and nonuse: the ability to choose to stock the same product as, or a product differentiated from, a competitor's offering; the possibility of shelf-space limitations on the ability to stock complete variety; and the category-demand-enhancing effect of variety. These are sensible and realistic descriptive factors shaping retailers' product and pricing decisions, and because they have not been considered jointly in the prior literature on PMGs, their joint consideration helps to expand our understanding of the drivers of PMG implementation and impact. In the presence of these three factors, we examine retailers' decisions about whether to offer a PMG, what product(s) to stock, and how to price the product(s) stocked.

Our results show that shelf-space limitations have an important influence on PMG provision: in particular, when retailers are shelf-space constrained, and product substitutability in the category is sufficiently large, choosing to use PMGs (which by definition also requires stocking identical products) is strictly less profitable than enduring Bertrand (price) competition but enjoying retail product differentiation. The result that PMGs can be profit-reducing relative to head-to-head retail competition is a novel one, driven in our model by the opportunity costs of stocking identical products, i.e., the inability to benefit from the demand-enhancing effects of variety and the differential (small or large) between Bertrand pricing and PMG pricing levels. We further show that under asymmetric shelf-space availability, either product variety will be severely limited or retailers will offer a different array of products. Weak substitution between products leads to the latter, with pricing between the differentiated products Bertrand and monopoly levels; strong substitution leads to the former, with pricing at the monopoly level. Our results also show that with unlimited shelf space, both competing retailers offer PMGs, stock the entire available product line, and enjoy monopoly pricing. Given our focus on product variety issues, we also relate our results to the literature on branded variants.

Our results demonstrate that the nature of product variety, the availability of retail shelf space, and the category-demand-enhancing effect of variety are key market characteristics that jointly and strongly affect the optimality of PMGs and the resulting pricing and profitability characteristics of the market.

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## 1. Introduction

PMGs are retail offers to match a competitor's lower price if the lower price occurs on an item (brand and stockkeeping unit) that is also carried by the offering retailer. PMGs are offered on many types of goods, including electronics, appliances, tires, and office supplies. One department store, Carson Pirie Scott in Chicago, has signs posted throughout the store proclaiming "We will not be intentionally undersold!" The signs invite consumers who find a lower price on the same item elsewhere to bring it to Carson's attention and the difference in price will be refunded.

Retailers who offer PMGs usually sell multiple categories of products (e.g., Carson Pirie Scott sells women's clothing, men's clothing, children's clothing, accessories, housewares, shoes, leather goods, and fine jewelry) and offer multiple products within a given category. In some of these categories, many or most of the products offered are the same as those available at other retailers (e.g., branded women's, men's, and children's clothing). In other categories, however, there may be little or no overlap with the products of other retailers (e.g., fine jewelry, which is typically unbranded), making the offering of a PMG a moot point in these categories. The PMG offer can also be accompanied by explicit exclusions of certain categories in a retailer's line (for example, Office Depot's offer excludes purchases of computer services, delivery, installation, extended warranties, and custom printing).[1]

These observations are puzzling and suggest that the offering of PMGs may depend on product-category characteristics and, we posit, shelf-space constraints. Every retailer faces some constraint on the degree of product variety it can offer within any category (for example, it is impossible for Carson's to stock every style and supplier of clothing or fine jewelry; it is impossible for an office supplies retailer to offer every possible kind and level of office supplies and custom printing services; and it is impossible for a window treatments retailer to stock all styles, sizes, and makers of blinds). These constraints affect pricing because any decrease in the provision of variety is likely to reduce overall category demands.[2]

This paper examines the joint effect of these three factors (the existence of multiple possible products in any category, the possibility of shelf-space constraints that prevent complete coverage in the category, and the category demand benefits of an increase in product variety) on the optimal PMG policy, product line choice, and retail pricing decisions.

In our model, we find that when product substitutability in a category is high and shelf space is limited, it is optimal for retailers to offer PMGs and stock the same products. However, when product substitutability is low and shelf space is limited, a retail strategy of offering PMGs and stocking identical products actually reduces profit relative to a strategy of offering nonoverlapping products. This accords with the patterns we have observed where retailers exclude PMG coverage in categories with high differentiation potential (e.g., fine jewelry, custom printing, and build-to-order computers), while offering PMGs in lower differentiation categories (e.g., branded sportswear and office supplies).

Although our finding that PMGs can reduce profit under some circumstances is surprising, it is based on a heretofore unrecognized trade-off between price and product differentiation. On the one hand, PMGs may facilitate higher prices. On the other hand, PMGs are only applicable, and thus may only dampen competition, when retailers' products are identical. This imposes opportunity costs on the firms when product variety is a choice variable rather than an exogenous factor: category demand may be reduced, and the firms forego the ability to earn contribution margin on the foregone sales. Thus, a strategy of not offering a PMG can be optimal when the benefits of market expansion resulting from product differentiation outweigh any competition-dampening benefits of using PMGs.

Our findings answer the question of why a retailer might offer a PMG but then choose to stock overlapping products in only some, but not all, of its product categories. We also answer the related question of why a retailer might choose *not* to offer a storewide PMG even when such an offer may facilitate higher prices and thus dampen overall competition.

The contribution of our work can be seen by comparison with PMG research to date. Two streams of analytic research have investigated the implications of PMGs for pricing and profitability.[3] The first stream argues that PMGs can dampen competition between retailers, thus leading to higher prices (see, e.g., Salop 1986, Logan and Lutter 1989, Chen 1995, Zhang 1995). The second stream considers alternative motivations and/or mitigating factors. Png and Hirshleifer (1987) and Corts (1997) allow for informed and uninformed consumers and show that PMGs can be used as price discrimination devices. Moorthy and Winter (2006) show that with informed and uninformed consumers, and asymmetric retail costs, competitive prices can

[1] Staples excludes purchases of their EasyTechSM services and custom printing. OfficeMax excludes purchases of build-to-order computers and custom products. Circuit City excludes purchases of services of all types, "Due to the differences in services being performed." In product categories like blinds and window treatments, custom products and special orders are routinely excluded from PMG coverage. These offers and exclusions can all be viewed on the companies' websites. In the blinds and window treatments category, for example, see BestBlinds.com or National Blind Store.com.

[2] Any standard quadratic utility function, for example, produces a demand system in which variety has a positive effect on category demand. Our model structure is general enough to encompass any such utility function specification.

[3] There is also a stream of empirical and experimental research. Jain and Srivastava (2000) and Mañez (2006) find that, under some circumstances, PMGs can lead to greater price competition, while Srivastava and Lurie (2001) find that PMGs can reduce consumer search and thus decrease price competition. Hess and Gerstner (1991), Arbatskaya et al. (1999, 2004, 2006), and Fatas and Mañez (2007) find evidence that PMGs support higher overall prices.

result. Hviid and Shaffer (1994) and Corts (1995) allow for price beating offers in addition to PMGs and show that competitive prices may be restored if such offers are used. Hviid and Shaffer (1999) show that when consumers face hassle costs (i.e., when it is not costless to take advantage of a PMG), retailers' ability to facilitate higher prices will be limited, but not impossible. Chen et al. (2001) show that competitive pricing can hold if PMGs cause an increase in consumer search behavior.

In all of these papers it is assumed that each retailer offers just one product, and, with the exception of Zhang (1995), that competing retailers sell the same product. These papers shed no light on the product line issues raised here. In Zhang (1995) two single-product retailers choose where to locate along a Hotelling line where market demand is fixed. Zhang finds that PMGs are always used if allowed, with both products located in the middle of the product space. Only if PMGs are prohibited do competitors offer variety by maximally differentiating their products. Thus, while Zhang's paper offers the possibility of product variety in the context of a PMG model, in equilibrium, product variety is never chosen over PMGs with homogeneous products, nor is it possible to address why firms might not offer PMGs as they are always chosen when available.

In Zhang's model, PMGs are always beneficial for retailers because they dampen price competition with no loss of demand. Because our model takes into account the potential demand-enhancing effect of product variety as well as shelf-space limitations, we show that when retailers cannot sell every possible product, the competition-dampening effect of PMGs may be more than offset by the opportunity cost of the foregone aggregate sales from the loss in product variety.

## 2. Model Structure

Consider a market with two retailers, 1 and 2, and two products, A and B. Each retailer can sell one or both products depending on the availability of shelf space. To simplify the exposition, we assume that while the two products are imperfect substitutes, the retailers are homogeneous.[4] That is, we assume that product $i$ sold through retailer 1 is identical to product $i$ sold through retailer 2, where $i = \mathrm{A}, \mathrm{B}$. We also assume that the marginal cost of selling each product is $c$ and that demands are symmetric.

Consumers are fully informed of product availability and prices at each store. Their demands are denoted by $D_\mathrm{A} = f_\mathrm{A}(P_\mathrm{A}, P_\mathrm{B})$ and $D_\mathrm{B} = f_\mathrm{B}(P_\mathrm{A}, P_\mathrm{B})$, where $P_\mathrm{A} = \min(P_{\mathrm{A}1}, P_{\mathrm{A}2})$ and $P_\mathrm{B} = \min(P_{\mathrm{B}1}, P_{\mathrm{B}2})$ are the minimum prices offered to consumers by retailers 1 and 2 on products A and B, respectively.

We will make the usual assumption that demand is decreasing in the product's own price and increasing in the other product's price. We will also make the standard assumption that own price effects dominate cross-price effects, so that an equal increase in $P_\mathrm{A}$ and $P_\mathrm{B}$ causes the demand for each product to decrease. The assumption of demand symmetry implies that, for any two scalars $a$ and $b$, $f_\mathrm{A}(a, b) = f_\mathrm{B}(b, a)$.

We model the effects of PMGs as follows. If a retailer does not offer a PMG, then any consumer buying from that retailer pays the list price for the product. By contrast, if a retailer offers a PMG, then any consumer buying from that retailer pays the *minimum* of the available list prices in the market for the product. Thus, we assume that if retailer 1 offers a PMG, then any consumer buying product $i$ from retailer 1 effectively pays only $\min\{P_{i1}, P_{i2}\}$.[5]

Retailers make product-line decisions taking as given the availability of shelf space. We consider two possible values—unlimited shelf space (which permits the retailer to stock product A, product B, or both), and limited shelf space (which permits the retailer to stock at most one product).

Each retailer has three choices: whether to offer a PMG, what product or products to carry in its store, and what price(s) to charge for the product(s). We assume the retailers make these choices sequentially, and thus we posit the following three-stage game:

*Stage* 1. Each retailer chooses either to offer a PMG or not (denoted by *no PMG*).

*Stage* 2. Each retailer chooses which product(s) to stock (subject to shelf-space availability).

*Stage* 3. Each retailer chooses what price(s) to charge for the product(s).

We solve the game recursively using subgame perfection as our solution concept. In the event of

[4] This assumption, while not without loss of generality, is nevertheless useful for three reasons. First, it corresponds to Zhang's (1995) model in which if the retailers choose products at the same location, marginal cost pricing ensues. Second, it biases the results in favor of observing PMGs. If, for example, retailers were weak substitutes, there would be no need to adopt PMGs to dampen competition. Third, in a more general framework, we would expect the retailers' equilibrium prices and profits in the case in which neither retailer has a PMG to be continuous and decreasing in the strength of their substitution. This suggests that our results will not be knife-edge, and hence, we would expect our qualitative results to be robust to local changes in substitution, provided that retailers are sufficiently close substitutes.

[5] There are other assumptions one could make. For example, if there are nonzero hassle costs in invoking PMGs, then, as Hviid and Shaffer (1999) have shown, a consumer may be willing to purchase product $i$ at price $P_{i1} > P_{i2}$ if $P_{i1} - P_{i2}$ is less than the hassle cost of asking store 1 to meet store 2's lower price. Although this assumption reduces the effectiveness of PMGs, the trade-off we identify would still exist as long as PMGs have some ability to dampen competition.

multiple Nash equilibria in a stage game, we rule out equilibria that are Pareto-dominated. Thus, if the retailers can earn a higher payoff by playing one equilibrium over another, we assume they will do so.

In Stage 1, the possible strategy combinations are {no PMG, no PMG}, {PMG, no PMG}, {no PMG, PMG}, or {PMG, PMG}, for retailers 1 and 2, respectively. In Stage 2, the possible strategy combinations are denoted by $S_1 \times S_2$, where $S_i = \{\text{A}, \text{B}, \text{A\&B}\}$ is the set of product choices for retailer $i$. With unlimited shelf space, all three product choices are possible for a retailer. However, when a retailer has limited shelf space, we assume it cannot choose the A&B option. Thus, for example, if both retailers have limited shelf space, we assume that neither retailer can choose the A&B option. In Stage 3, the two retailers simultaneously set price(s) to maximize their individual profits, given the offering (or lack thereof) of PMGs in the marketplace and the set of product(s) sold at the two stores.

## 3. Solving for the Stage 3 Equilibria

We begin by solving for the Stage 3 pricing equilibria for all possible subgames, contingent on the availability of shelf space, which we take as exogenous, the PMG policies having been chosen in Stage 1, and the products to be offered chosen in Stage 2. To do this concisely, we must introduce some additional notation.[6]

For $j \neq i$, let the maximized profit on product $i$ for a given price $P_j$ be defined as

$$\Pi_i(P_j) \equiv \max_{P_i}(P_i - c) f_i(P_i, P_j),$$

and note that $\Pi_i(P_j)$ is increasing in $P_j$ and obtains its maximum at $\Pi_i(\infty)$. Furthermore, let

$$\Pi_{\text{A, B}} \equiv \max_{P_\text{A}, P_\text{B}}(P_\text{A} - c) f_\text{A}(P_\text{A}, P_\text{B}) + (P_\text{B} - c) f_\text{B}(P_\text{A}, P_\text{B}),$$

and note that $\Pi_{\text{A, B}}$, the monopoly profit when both products are sold, weakly exceeds the maximum of $\Pi_\text{A}(\infty)$ and $\Pi_\text{B}(\infty)$, the monopoly profits when only product A or product B, respectively, are sold.

Last, we let $P_\text{A}^*$, $P_\text{B}^*$ denote the differentiated products Bertrand equilibrium prices for products A and B, respectively. We assume that $P_\text{A}^*$ and $P_\text{B}^*$ exist and are unique. Thus,

$$P_\text{A}^* \equiv \arg\max_{P_\text{A}}(P_\text{A} - c) f_\text{A}(P_\text{A}, P_\text{B}^*),$$

and

$$P_\text{B}^* \equiv \arg\max_{P_\text{B}}(P_\text{B} - c) f_\text{B}(P_\text{A}^*, P_\text{B}).$$

[6] See Technical Appendix A.1, which can be found at http://mktsci.pubs.informs.org, for derivations of the payoffs in this section.

**Table 1** **Retailer Product-Choice Combinations: At Most One Retailer Offers a PMG**

| | Retailer 2 | | |
|---|---|---|---|
| Retailer 1 | A only | B only | A & B |
| A only | 0, 0 | $\Pi_\text{A}(P_\text{B}^*)$, $\Pi_\text{B}(P_\text{A}^*)$ | 0, $\Pi_\text{B}(c)$ |
| B only | $\Pi_\text{B}(P_\text{A}^*)$, $\Pi_\text{A}(P_\text{B}^*)$ | 0, 0 | 0, $\Pi_\text{A}(c)$ |
| A & B | $\Pi_\text{B}(c)$, 0 | $\Pi_\text{A}(c)$, 0 | 0, 0 |

Using the notation above, this implies that the Bertrand equilibrium profits are $\Pi_\text{A}(P_\text{B}^*)$ on product A, and $\Pi_\text{B}(P_\text{A}^*)$ on product B. Note that our assumption of symmetry implies that $\Pi_\text{A}(P_\text{B}^*) = \Pi_\text{B}(P_\text{A}^*)$.

### 3.1. At Most One Retailer Offers a PMG

Consider first what happens when at most one retailer offers a PMG in Stage 1. If the two retailers then offer the same product assortment in Stage 2, marginal cost pricing will ensue, leaving both retailers with zero profit. If one retailer offers one product and the other offers both products, the price of the product offered at both outlets will be driven down to marginal cost, leaving the retailer that sells only one product with zero profit. In these situations, the retailer that sells both products will make zero profit on the commonly carried product and positive (but less than the differentiated products Bertrand) profit on the other product. Finally, if one retailer chooses product A and the other chooses product B, Bertrand prices will ensue and the retailers will earn $\Pi_\text{A}(P_\text{B}^*)$ and $\Pi_\text{B}(P_\text{A}^*)$, respectively.

Table 1 summarizes each retailer's equilibrium profit in Stage 3 for the various combinations. As per convention, the first (second) payoff in each cell corresponds to the row (column) player's payoff.

### 3.2. Both Retailers Offer PMGs

Consider now the case where both retailers offer PMGs in Stage 1. Monopoly pricing will prevail whenever both retailers offer the same product assortment in Stage 2 (i.e., either {A, A}, {B, B}, or {A&B, A&B}). At monopoly prices, neither retailer has an incentive to cut its price because its rival is committed to matching it.[7] Thus, each retailer earns $\Pi_i(\infty)/2$ if only product $i$ is sold and $\Pi_{\text{A, B}}/2$ if both products are sold. On the other hand, if there is no overlap in the retailers' product lines (i.e., either {A, B} or {B, A}), then each retailer earns its differentiated Bertrand payoff as discussed.

When product lines are partially overlapping (i.e., either {A, A&B}, {B, A&B}, {A&B, A}, or {A&B, B}), equilibrium retail prices will be asymmetric, with

[7] It can be shown that other equilibria also exist, but these equilibria are dominated by the one with monopoly pricing.

**Table 2** Retailer Product-Choice Combinations: Both Retailers Offer PMGs

| | Retailer 2 | | |
|---|---|---|---|
| Retailer 1 | A only | B only | A & B |
| A only | $\frac{\Pi_A(\infty)}{2}, \frac{\Pi_A(\infty)}{2}$ | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ | $\frac{\Pi_A(\tilde{P}_B)}{2}, \tilde{\Pi}_{A,B}$ |
| B only | $\Pi_B(P_A^*), \Pi_A(P_B^*)$ | $\frac{\Pi_B(\infty)}{2}, \frac{\Pi_B(\infty)}{2}$ | $\frac{\Pi_A(\tilde{P}_B)}{2}, \tilde{\Pi}_{A,B}$ |
| A & B | $\tilde{\Pi}_{A,B}, \frac{\Pi_A(\tilde{P}_B)}{2}$ | $\tilde{\Pi}_{A,B}, \frac{\Pi_A(\tilde{P}_B)}{2}$ | $\frac{\Pi_{A,B}}{2}, \frac{\Pi_{A,B}}{2}$ |

both prices between the differentiated Bertrand prices and the monopoly prices. For example, if {A, A&B} is chosen in Stage 2, then in Stage 3 the equilibrium prices on products A and B, $\tilde{P}_A$ and $\tilde{P}_B$, are given by

$$\tilde{P}_A \equiv \arg\max_{P_A}(P_A - c)\frac{f_A(P_A, \tilde{P}_B)}{2},$$

$$\tilde{P}_B \equiv \arg\max_{P_B}(P_B - c)f_B(\tilde{P}_A, P_B) + (\tilde{P}_A - c)\frac{f_A(\tilde{P}_A, P_B)}{2}.$$

Let $\tilde{\Pi}_{A,B} \equiv (\tilde{P}_B - c)f_B(\tilde{P}_A, \tilde{P}_B) + \frac{1}{2}(\tilde{P}_A - c)f_A(\tilde{P}_A, \tilde{P}_B)$ be retailer 2's equilibrium profit in this case and let $\Pi_A(\tilde{P}_B)/2 \equiv \frac{1}{2}(\tilde{P}_A - c)f_A(\tilde{P}_A, \tilde{P}_B)$ be retailer 1's equilibrium profit (define $\Pi_B(\tilde{P}_A)/2$ analogously, and note that, by symmetry, $\Pi_A(\tilde{P}_B)/2 = \Pi_B(\tilde{P}_A)/2$). Because both prices are higher than the differentiated Bertrand prices,[8] it follows that overall profit will be higher than when each retailer carries a single, nonoverlapping product. However, because prices are below monopoly levels, overall profit will be lower than when both retailers carry both products. These outcomes are summarized in Table 2.

## 4. Solving for the Stage 2 Equilibria

We now solve for the Stage 2 equilibria for all possibles subgames, contingent on the availability of shelf space, the PMG policies that were chosen in Stage 1 and subject to equilibrium behavior by both players in Stage 3. Tables 1 and 2 summarize the relevant payoffs at the start of Stage 2.

### 4.1. At Most One Retailer Offers a PMG

Consider first the subgames that arise when at most one retailer offers a PMG. It is straightforward from Table 1 that whether both retailers are constrained to offer one product, only one retailer is constrained to offer one product, or neither retailer is constrained to offer one product, {B, A} and {A, B} are the only undominated Nash equilibria. It follows that when at most one retailer offers a PMG, the unique outcome of the continuation game is for the two retailers to choose different products. In these cases, the lone retailer's PMG (if a PMG is offered) is ineffective by itself. Thus the retailers' incentives are to avoid the direct price competition that would otherwise occur if product lines overlap.

### 4.2. Both Retailers Offer PMGs

Now consider the subgames that arise when both retailers offer PMGs. Here, PMGs effectively work together to dampen competition (see Table 2) and there is no need for the firms to avoid overlapping their products, at least for pricing purposes. However, as discussed in the introduction, when shelf space is limited, a retailer's opportunity cost of offering the same product as its competitor is the contribution it could have earned on foregone sales from an expansion of the product category. Whether this trade-off exists, and how severe it is, depends on the shelf space limits facing each retailer.

If both retailers are constrained, then the decision each retailer faces is whether to sell the same product as its rival or a different product. If it offers a different product, then differentiated Bertrand pricing prevails. If it offers the same product, monopoly pricing prevails. Thus, the trade-off each retailer must consider is whether it is more profitable to garner *all* the sales on one product, albeit at a lower (differentiated products Bertrand) price, or *half* the total sales on one product, albeit at a higher (monopoly) price. If the former option is more profitable, the unique equilibrium outcome is for each retailer to offer a different product, rendering their PMGs inapplicable. If the latter option is more profitable, the unique equilibrium outcome is for both retailers to sell the same product.

If neither retailer is constrained, then it is straightforward from Table 2 that {A&B, A&B} is a Nash equilibrium. Moreover, because monopoly pricing prevails in this equilibrium, any other Nash equilibrium must yield strictly lower profit for each retailer. Thus, in this case, when both retailers offer PMGs, the unique undominated equilibrium of the game is for both retailers to offer both products.

Now suppose that retailer 1 is constrained but retailer 2 is not. This situation could arise, for example, in a market defined by a big-box retailer and a local mom-and-pop retailer, selling in the same product area. More generally, it can arise whenever retailers differ in the relative amount of shelf space they devote to a particular product category, irrespective of whether they are similar in size and capacity.

[8] The price on B is higher, $\tilde{P}_B \geq P_B^*$, because of the extra term in retailer 2's maximization problem. The price on A is higher, $\tilde{P}_A \geq P_A^*$, because retailer 1's profit-maximizing price on product A is increasing in the price of product B.

In these subgames, given that it cannot sell both products, retailer 1 is indifferent between choosing product A or product B (by symmetry). Suppose it chooses product A. Given this, retailer 2 could also choose to sell only product A. If so, then prices will be at the monopoly level and each firm will earn half the monopoly profit on product A. By contrast, retailer 2 could sell only product B, in which case each retailer will earn differentiated Bertrand profits. Last, retailer 2 could sell both products, in which case it will share positive profit with retailer 1 on product A and earn full (albeit less than monopoly) profit on product B. Clearly, retailer 2's best choice will depend on the relationship among these three profits.

From our previous discussion, we know that if retailer 2 sells both products, its shared profit with retailer 1 on product A will exceed half the Bertrand profit on product A, and its full (albeit less than monopoly) profit on product B will exceed the full Bertrand profit on product B. Thus, $\widetilde{\Pi}_{A,B} > \Pi_A(P_B^*)/2 + \Pi_B(P_A^*) > \Pi_B(P_A^*)$, and we know that for retailer 2 selling both products dominates selling only product B when retailer 1 sells product A. Comparing $\widetilde{\Pi}_{A,B}$ and $\Pi_A(\infty)/2$, however, is more difficult. Note that as the products become closer substitutes, $\widetilde{\Pi}_{A,B} - \Pi_A(\infty)/2$ decreases. When products are independent, retailer 2 earns half the monopoly profit on the commonly carried product and all the monopoly profit on the product that only it carries. In this case, $\widetilde{\Pi}_{A,B} = \Pi_A(\infty)/2 + \Pi_B(\infty) > \Pi_A(\infty)/2$. However, when products are perfect substitutes, competition leads to marginal cost pricing on both products, and $\widetilde{\Pi}_{A,B} = 0$. In this case, $\widetilde{\Pi}_{A,B} < \Pi_A(\infty)/2$. It follows that, depending on the degree of substitution between products A and B, either profit may be higher.

In summary, we have shown that when products are sufficiently weak substitutes, retailer 2 will want to sell both products regardless of which product is sold by retailer 1. Because retailer 1 is indifferent between selling product A and product B when retailer 2 sells both products, it follows that, when only one retailer is constrained, both retailers have PMGs, and products are sufficiently weak substitutes; {A, A&B} and {B, A&B} are Nash equilibria of the continuation game. By contrast, when products are sufficiently close substitutes, each retailer will want to sell the same product as its rival and retailer 2 will not want to sell both products (given the fact that $\Pi_A(\infty)/2 > \widetilde{\Pi}_{A,B} > \Pi_B(P_A^*)$ in this case). It also follows that, when one retailer is constrained, both retailers have PMGs, and products are sufficiently close substitutes; {A, A} and {B, B} are the only Nash equilibria of the continuation game.

**Table 3** **PMG, No PMG Combinations: Neither Retailer Is Constrained**

| | Retailer 2 | |
|---|---|---|
| Retailer 1 | No PMG | PMG |
| No PMG | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ |
| PMG | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ | $\frac{\Pi_{A,B}}{2}, \frac{\Pi_{A,B}}{2}$ |

## 5. Results

We are now ready to solve for the Stage 1 equilibria, contingent on the availability of shelf space and subject to equilibrium behavior by both players in Stages 2 and 3. There are three cases to consider, the case in which both retailers are constrained to sell only one product, the case in which only retailer is so constrained, and the case in which both retailers can sell any combination of products.

### 5.1. Neither Retailer Is Constrained

Table 3 summarizes the equilibrium outcomes derived in the previous subsection for the case in which neither retailer is constrained. Because monopoly profits are higher than differentiated Bertrand profits, the unique undominated equilibrium of this game is for both retailers to offer PMGs.

Proposition 1. *When shelf space is unlimited, the unique undominated equilibrium involves each retailer offering a PMG and selling both products. Moreover, both products are priced at monopoly levels.*

PMGs dampen competition with no adverse effects in this case. Both retailers offer PMGs and both sell the full complement of products at monopoly prices. The fact that retailers must sell identical products for PMGs to be effective does not entail a trade-off when shelf space is unlimited.

### 5.2. Only One Retailer Is Constrained: Hybrid Case

Possible Stage 1 outcomes for the case in which only one retailer is constrained are summarized in Tables 4 and 5. After evaluation of the possible strategies, we have the following proposition.

Proposition 2. *When only one retailer is constrained, the unique undominated equilibrium involves both retailers offering PMGs. When products are weak substitutes,*

**Table 4** **PMG, No PMG Combinations, Hybrid Case: $\Pi_A(\infty)/2 > \widetilde{\Pi}_{A,B}$ (High Product Substitutability)**

| | Retailer 2 | |
|---|---|---|
| Retailer 1 | No PMG | PMG |
| No PMG | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ |
| PMG | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ | $\frac{\Pi_A(\infty)}{2}, \frac{\Pi_A(\infty)}{2}$ |

**Table 5** **PMG, No PMG Combinations, Hybrid Case: $\Pi_A(\infty)/2 < \tilde{\Pi}_{A,B}$ (Low Product Substitutability)**

| | Retailer 2 | |
|---|---|---|
| Retailer 1 | No PMG | PMG |
| No PMG | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ |
| PMG | $\Pi_A(P_B^*), \Pi_B(P_A^*)$ | $\frac{\Pi_A(\tilde{P}_B)}{2}, \tilde{\Pi}_{A,B}$ |

*the unconstrained retailer will sell both products and prices will be greater than the Bertrand prices* (*but less than the monopoly prices*). *When products are close substitutes, both retailers will sell the same product at the monopoly price.*

Proof. See Technical Appendix A.2, which can be found at http://mktsci.pubs.informs.org.

As in the previous case, the equilibrium involves both retailers offering PMGs. However, unlike in that case, monopoly pricing need not result. When the equilibrium entails {A, A&B} (or analogously {B, A&B}), a higher price for product A confers a positive externality on the profitability of product B. However, retailer 1 does not enjoy any of this positive externality and thus has no incentive to price as high as retailer 2. Because both retailers offer PMGs, the lowest price for product A prevails in the market. As a result, the equilibrium price for product B is also less than the monopoly level. This suggests that a retailer with a broad-based product line may not wield the retailing power that one might intuitively believe when competing against a more narrow-line rival. Rather, the very asymmetry that defines the competition creates pricing pressure on the entire product line of the broader line rival.

### 5.3. Both Retailers Are Constrained

When both retailers are constrained to sell only one product, PMGs are now no longer strictly profitable.

Proposition 3. *When shelf space is limited for both retailers, the unique undominated equilibrium depends on the degree of substitution between products. When products are weak substitutes, each retailer will sell a different product, PMGs will not be offered, and Bertrand prices will prevail. When products are close substitutes, both retailers will offer PMGs, sell the same product, and charge monopoly prices.*

Proof. See Technical Appendix A.3, which can be found at http://mktsci.pubs.informs.org. □

When shelf space is limited, either both firms will specialize in a different product or both firms will offer the same product, depending on the relationship between $\Pi_A(\infty)/2$ and $\Pi_B(P_A^*)$. Which outcome is more profitable depends on the substitutability between products. If products are highly substitutable, the differentiated Bertrand prices lie well below the monopoly levels. This makes an {A, B} or {B, A} solution unattractive, even though it would give each retailer all the sales of the product it chooses to sell. On the other hand, if products are weakly substitutable, little margin is lost by choosing product differentiation (and no PMGs) over product duplication (with PMGs). The result is a differentiated products retail market with lower prices and expanded category demand.

**Table 6** **Equilibrium Strategies as a Function of Shelf-Space Availability at Retail**

| | Unlimited shelf space | Hybrid case | Limited shelf space |
|---|---|---|---|
| PMG policy | {PMG, PMG} | {PMG, PMG} | Close substitutes: {PMG, PMG}<br>Weak substitutes: {no PMG, no PMG} |
| Product variety | {A&B, A&B} | Close substitutes: {A, A} or {B, B}<br>Weak substitutes: {A, A&B} or {B, A&B} | Close substitutes: {A, A} or {B, B}<br>Weak substitutes: {A, B} or {B, A} |
| Retail prices | Monopoly for A and B | Close substitutes: Monopoly for A or B<br>Weak substitutes: >Bertrand for A and B | Close substitutes: Monopoly for A or B<br>Weak substitutes: Bertrand for A and B |

## 6. Discussion and Conclusion

The incorporation of multiple products and the possibility of retail shelf-space constraints into the consideration of firms' decisions whether to offer PMGs yields testable implications for market outcomes. We summarize the results for the three cases in Table 6.

Our analysis shows that in the benchmark case with unlimited shelf space, competing retailers will offer PMGs and stock the entire available product line, setting monopoly prices. In a market with asymmetric shelf-space availability, PMGs are also the equilibrium pricing policy choice. However, either product variety will be limited or retailers will offer different arrays of products. Weak substitution between products leads to the latter, with pricing between the differentiated Bertrand and monopoly levels. Strong substitution leads to the former, with both firms pricing at the monopoly level. In a market where both retailers are shelf-space-constrained, the equilibrium strategies depend on the degree of substitution between products. If products are sufficiently weak substitutes, the retailers optimally carry nonoverlapping product lines, differentiated Bertrand pricing prevails, and neither retailer offers a PMG. By contrast, if products are sufficiently close substitutes, both retailers carry the same product, both offer PMGs, and both set monopoly prices. The surprising finding that PMGs may result in profit levels that are not only below the monopoly level but also lower than competitive-pricing, no PMG levels, when products are sufficiently weak substitutes and shelf space is limited, arises because our structure explicitly takes into account the opportunity cost of limiting demand through limiting product variety in a PMG marketplace. This result is consistent with observed practice, such as the explicit exclusion of PMG coverage in product lines with significant product differentiation opportunities (e.g., build-to-order possibilities in computer sales) and where it is impossible to stock a full product line.

One way in which the degree of differentiation between products can be increased in the category is through the sale of branded variants, i.e., nonidentical, but substitutable, commonly branded products carried by different retailers (Bergen et al. 1996). Bergen et al. argue that branded variants prevent direct comparability between two retailers' offerings, while giving each retailer a presence in the same part of the market space. Our analysis suggests that branded variants are a substitute marketing strategy for PMGs, when they sufficiently differentiate an otherwise low-differentiation category. Consider a situation where product substitutability is initially high (i.e., the category exhibits little differentiation). Because they increase perceived differentiation, branded variants, like PMGs, can be profitable in this situation, saving retailers from the virtually undifferentiated, price-equals-marginal-cost competition that would otherwise result. However, unlike PMGs, which work directly on pricing incentives, branded variants work indirectly by first increasing perceived differentiation. If this increase is small enough (and/or the cost of implementing a branded-variants strategy is high enough), our model predicts that a PMG, no-differentiation strategy will be superior to the branded-variant strategy. More generally, the testable hypothesis is that the likelihood of seeing PMGs decreases with the degree of differentiation achieved through a branded-variants strategy.

Our results show that even when PMGs are optimal, they do not always lead to monopoly pricing in equilibrium. Although this result has been shown in some existing PMG research, the context here is different. For example, our findings do not rely on differences in consumers' information sets, or on whether consumers incur hassle costs when invoking PMGs. Instead, our results follow from the profit-maximizing behavior of retailers when their endogenously chosen product lines are only partially overlapping. In this case, as we have seen, the ability of PMGs to dampen competition is compromised.

Our results also yield insights about the implications of PMGs for product variety in the market. We find that PMGs may or may not imply broad variety. On the one hand, when differentiation is low, retailers will offer PMGs but fail to offer full product variety. By contrast, retailers with no shelf-space limitations may provide full product variety, as may retailers with shelf-space constraints who have the ability to sell products that are highly differentiated. If PMGs were prohibited, the equilibrium—regardless of shelf-space constraints—would be for each retailer to stock a single product that is different from its competitor. Thus, a PMG prohibition would be predicted to generate product variety under all conditions, while the availability of PMGs sometimes lessens variety.

Relative dominance in a retail market does not necessarily endow the larger retailer with higher profit. When the limitations faced by retailers on their shelf space are asymmetric, prices may decrease in our model. This suggests that the presence of a larger retailer in a market may increase price competition rather than harming it. The presence of a larger retailer may also result in broader product variety. Thus, asymmetry in retailing can be beneficial to consumers—ensuring broader product variety and more competitive pricing.

In short, our results demonstrate that the nature of product variety and the availability of retail shelf space are key market characteristics that jointly affect the optimality of PMGs, the resulting prices and profit, and consumer welfare characteristics of the market.[9] Our results also show that retailers with access to PMGs may nevertheless choose not to offer them. If PMGs are offered, retailers may choose to make them applicable in some product lines but not others. Our results further help to explain the optimal degree of overlap of product lines for competing retailers. Last, we show new conditions under which equilibrium pricing need not rise to monopolistic levels, even when all retailers offer PMGs.

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[9] Other factors examined in the literature also play a role in PMG use and profitability. For instance, Sivakumar and Weigand (1996) comment on the trade-off between using PMGs and allowing product returns. PMGs afford an opportunity for the retailer to avoid the many costs of handing product returns. While it is beyond the scope of the present research to examine the product returns/PMG trade-off, this suggests a fruitful line of inquiry for future research.

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