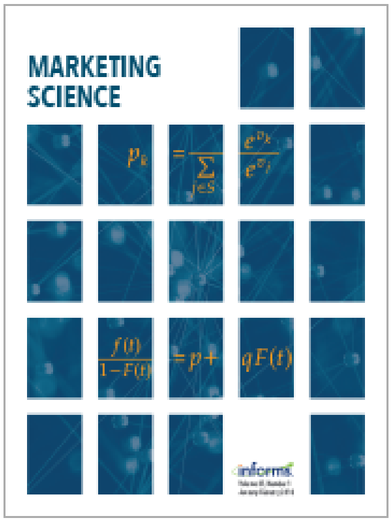


Marketing Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

National Brand's Response to Store Brands: Throw In the Towel or Fight Back?

Sherif Nasser, Danko Turcic, Chakravarthi Narasimhan,

MARKETING SCIENCE
Vol. 32, No. 4, July–August 2013, pp. 591–608
ISSN 0732-2399 (print) | ISSN 1526-548X (online)

http://dx.doi.org/10.1287/mksc.2013.0788

National Brand's Response to Store Brands: Throw In the Towel or Fight Back?

Sherif Nasser, Danko Turcic, Chakravarthi Narasimhan
Olin Business School, Washington University in St. Louis, St. Louis, Missouri 63130
{nasser@wustl.edu, turcic@wustl.edu, narasimhan@wustl.edu}

Nearly a quarter of all products purchased in U.S. supermarkets and drug stores are store brands (SBs). Although the presence of SBs benefits both consumers and retailers, it is a threat to the dominance of the incumbent national brand manufacturers (NBMs). When considering the potential threat of an SB, an NBM generally pursues one of three strategies: accommodate, displace, or buffer. Under the *accommodation* strategy, the NBM repositions the products in his existing product line. Under the *displacement* strategy, the NBM elects to supply the SB to preempt the entry of the SB supplier. Under the *buffering* strategy, the NBM adds a *defender* product, which competes with his own product offering and the new SB. Using a game-theoretic model, we consider a market where consumers are heterogeneous in their valuation of product quality and analyze an NBM's response to an SB threat. We focus on two important drivers: the NBM's ability to differentiate on the quality dimensions and his cost advantage over the outside supplier of SB. To completely characterize the NBM's response, we consider two regimes. In the first regime, the NBM is a monopolist producer. In the second regime, the retailer has the added option of procuring an SB product from an independent, nonstrategic SB manufacturer. By comparing the results from both regimes, we develop a descriptive theory that clarifies the incentives of the NBM to accommodate, displace, or buffer. In doing this, we determine how the NBM's whole product portfolio should be designed, i.e., the positioning (quality levels) and prices of all its offerings.

Key words: product line design; store brands; distribution channels; game theory
History: Received: November 18, 2011; accepted: March 14, 2013; Preyas Desai served as the editor-in-chief and Miguel Villas-Boas served as associate editor for this article. Published online in *Articles in Advance* May 22, 2013.

1. Introduction

Store brands (SBs) continue to grow in sales and volume in the U.S. market, extending a trend that began years ago but was accelerated by the recession: "In supermarkets, store brands advanced to 19.1% in dollar share and unit share was 23.5%. In drug stores, store brands moved up in dollar share to 14.7% and recorded unit share of 16.2%. For total outlets, store brands dollar share rose to 17.4%, while unit share came in at 21.8%" (Private Label Manufacturers Association 2011, p. 1). Their success, however, is often to the detriment of national brands (NBs). When faced with a potential or realized threat of an SB, an NB can compete against this threat by revisiting the four P's of marketing: product, price, promotion (advertising), and place (supply chain). We focus primarily on the first two P's with the goal of answering the following questions:

(1) How should an NB compete with the threat of an SB entry? Should it compete only on price, or should it use a product line strategy? If only on price, should the NB reposition its product?

(2) Can the entry of an SB lead to a product line expansion of the incumbent national brand manufacturer (NBM)? If yes, what would be the positioning of the new products the NBM offers relative to its existing brand and the position of the SB?

(3) Under what conditions would an incumbent NBM eliminate a competing SB supplier by providing either (a) a better-quality SB product or (b) an SB product of the same quality at a lower wholesale price?

We theorize that when competing with SBs, an NBM can generally pursue one of three broad strategies in the positioning space: accommodate, displace, or buffer.

We say that the NBM *accommodates* if he repositions its existing products (i.e., adjusts qualities and/or wholesale prices) *only*, without changing the total number of products in his product line.[1] Examples of accommodation include Coke and Pepsi, which in the 1980s refused to supply Canadian grocers with an SB soft drink. The grocers found another source, Cott Corporation, which became a considerable threat to the two big cola makers (Dunne and Narasimhan 1999).

[1] We use "he" to refer to the national brand manufacturer and "she" to refer to the retailer for clarity.

We say that the NBM *displaces* if he repositions his existing product and elects to supply the SB himself, thereby preempting the entry of the outsider. Examples of the displacement strategy include Alcoa's generic aluminum foil and McCormick's generic spices and seasonings. Both generics are sold next to the leading NBs, also supplied by Alcoa and McCormick's, at various retailers nationwide (*Private Label Buyer* 2011).

Finally, we say that the NBM *buffers* if, in addition to repositioning its existing products, he adds a *defender* (or flanker) product to his product line to fight the SB. The equilibrium demand for the defender, the SB, and the leading NB, however, remains strongly positive. Examples of buffering observed in practice include 3M's Highland version of Post-it notes (Ritson 2009) and L&M, Basic, and Chesterfield brands, which Phillip Morris has effectively used around the world to flank Marlboro (Quelch and Harding 1996).

To explore when an NBM would adopt which strategy, we construct a game-theoretic model of a market where consumers are heterogeneous in their valuation of product quality and analyze the product line design of an NBM that sells his product(s) through a retailer. We analyze two regimes. In the first regime (see §4), our baseline case, the NBM is a monopolist. Assuming that product line expansion is costly, we use this regime to derive a set of conditions on the model parameters under which the NBM chooses to supply only one NB product. We then assume that the same conditions are in force in our second regime, in which the retailer has the added option of procuring an SB product from independent, dedicated SB manufacturers that supply it at marginal cost (see §§5.1 and 5.2). Anticipating this threat, we explore how the NBM's strategic choices of products and prices would be affected (see §5.3). Throughout our analyses, we endogenize the number of products the NBM produces, their qualities, and their wholesale prices, with the goal of answering the above research questions. The answers we propose are driven by two explanatory factors, operationalized in our model as exogenous parameters. The first factor, NBM's *cost advantage*, measures the NBM's ability to supply the SB vis-à-vis the retailer's cost of acquiring it.[2] The second factor, NBM's *differentiation ability*, measures the NBM's ability to raise the quality of his product(s) to differentiate them from the SB. The results we find are summarized in Table 1.

Table 1 **NBM's Optimal Strategies of Competing with an SB**

		NBM's cost advantage (δ)	
		Weak	Strong
Differentiation ability (α)	Low	Accommodate	Displace
	High	Accommodate	Buffer

We find that whenever the NBM's cost advantage is weak (i.e., the SB is very cheap), he simply accommodates the SB by increasing quality and reducing the wholesale price of the incumbent NB. The optimality of expanding the product line in response to SB competition is perhaps our *most important and least intuitive result*, as it demonstrates that the net marginal profit the NBM can gain from introducing an additional product can be higher under competition than under monopoly. In other words, our results suggest that product line expansion can be more effective at improving a bad (competitive) situation than it is at improving a good (monopolistic) one. Thus, our main contribution to the SB literature is in clearly characterizing the conditions under which the NBM would elect to be the supplier of an SB himself and when he would compete by expanding his product line. Several authors identify this as an important direction for future research (see Pauwels and Srinivasan 2009, §§3.4.1 and 4.3; Sethuraman 2009, §5).

[2] One can think of this factor as how cheap or expensive the SB supplied by competing manufacturers is.

2. Literature Review

Although the marketing of SBs is controlled by retailers, the presence of SBs impacts all three market participants: consumers, retailers, and manufacturers.

Retailers introduce SBs primarily for three reasons: (1) to expand the category, (2) to use SBs as a strategic threat to elicit concessions from NBMs, and (3) to create and build store equity/loyalty among their consumers to gain competitive edge against other retailers. The existing literature has largely focused on these incentives as well as on empirical analysis of the effects of SBs on competition. We summarize this below.

Pauwels and Srinivasan (2009) argue that "one of the most important activities for supermarket retailers is the creation and marketing of store brands" (p. 258). The incentive to introduce an SB increases with category sales, margins, and cross-price elasticity of demand (Raju et al. 1995, Dhar and Hoch 1997, Horowitz 2000). An SB introduction ordinarily allows retailers to expand a category and serve consumers that have not been served well by the existing NBs (for empirical results, see Gruca et al. 2001, Pauwels and Srinivasan 2004). To see how changes in product line design are affected by channel dynamics, see Villas-Boas (1998), Dukes et al. (2009), and Liu and Cui (2010).

Narasimhan and Wilcox (1998) show that even when there is no market expansion, retailers have an incentive to introduce an SB to elicit better wholesale price terms from competing manufacturers. They identify perceived risk and retailers' ability to procure a quality SB comparable to an NB as important determinants for the penetration of SBs and of category-level drivers (see also Mills 1995, Ailawadi and Harlam 2004, Bonfrer and Chintagunta 2004, Meza and Sudhir 2010). Given that the retailer can procure them by negotiation and through competitive bidding, SBs also frequently yield higher margins for the retailer than do NBs (e.g., Sayman et al. 2002, Pauwels and Srinivasan 2004). Finally, SBs can help the retailer build loyalty in a crowded retail market. Because SBs are exclusive to the store that distributes them, they give a unique identity and association with the store and can create consumer loyalty (Dick et al. 1996, Corstjens and Lal 2000, Ailawadi et al. 2008). Sudhir and Talukdar (2004) show that SBs contribute more to store differentiation than to greater price sensitivity in the retail market.

There has also been significant research on how retailers should position an SB relative to the incumbent NBs and how to price both product types for retail category profit maximization. Many studies conclude that it is optimal for a retailer to position her SB against the leading NB (Sayman et al. 2002, Scott-Morton and Zettelmeyer 2004). Du et al. (2005) sharpen this finding by identifying situations where it is best to position the SB close to the weaker NB or to position it in the "middle" so that it appeals to both NBs' target segments, and the authors suggest easy-to-implement ways for a retailer to determine which strategy is best to use. In addition, they confirm that introducing an SB not only allows the retailer to gain a higher share of the channel profits through higher retail margins but also often benefits the retailer through increases in NB unit sales. Sayman and Raju (2004) and Choi and Coughlin (2006) generalize the idea of positioning an SB against the leading NB by concluding that the introduction of multiple SBs in the same category is optimal when there are multiple differentiated NBs. For a more comprehensive set of results about the impact on retailers, see excellent reviews by Sethuraman (2009, §4) and Pauwels and Srinivasan (2009).

In contrast to the literature on optimal retail strategies, the literature on how manufacturers can use product lines and prices to respond to new competition is less comprehensive. In a setting where a manufacturer sells directly to consumers, Gabszewicz et al. (1986) show that the optimal number of products depends on the distribution of consumer valuations. In a related paper, Gabszewicz and Thisse (1980) establish that as the number of product varieties in an industry reaches a certain bound, any entry of a new product variety will result in the exit of an incumbent. Brander and Eaton (1984) and Gilbert and Matutes (1993) clarify how manufacturers choose the number and characteristics of the products they produce to compete and preempt certain positions in the product space.

The extant literature on how manufacturers that sell through a retailer should react to anticipated or actual SB product entry is even more sparse. Empirically, we understand (Pauwels and Srinivasan 2004) how SB product introduction affects the incumbent NBs: generic SBs tend to compete with second-tier NBs, whereas the first-tier brands are frequently able to maintain both wholesale price and market share. Intuitively, the incumbent NBs' positioning should also affect their optimal defensive strategy—previous literature suggests that NBs closest to (furthest from) the SB entrant should cut (raise) wholesale price (Hauser and Shugan 1983, Lal 1990, Gruca et al. 2001). However, price reaction is a short-term strategy.

More recent literature explores whether NBMs may be better off by supplying the SB to the retailer. Using an empirical methodology, Chen et al. (2010) investigate conditions under which the NBM would choose to supply the SB. They study a very specific category: liquid milk. This category is characterized by a relatively small difference in the quality between the SBs and NBs, often greater consumer valuation for the SB than for the NB, and the absence of dedicated SB manufacturers. Their results reveal that when two NB milk producers compete, the lower-cost producer finds it optimal to also supply the SB. An important difference between Chen et al. (2010) and our model is that they *exogenously* impose a product line design. Therefore, in their model, it is difficult to tease out whether the additional profit from supplying the SB can be uniquely attributed to the SB or if a similar result could be achieved by expanding the product line with other NBs.

The paper that is the closest to ours is Kumar et al. (2010), who investigate the question of whom a profit-maximizing retailer should optimally choose as her SB supplier—an incumbent NBM or an independent dedicated SB manufacturer. They study a two-consumer (high/low) segment model with one NBM, one retailer, and one independent, dedicated SB supplier. Their analysis shows that the retailer optimally chooses the NBM to supply the SB if (a) the size of the high-type customer segment is large relative to the low-type customer segment, (b) the valuations of the high-type customer segment are large relative to the low-type customer segment, and (c) the retailer's margin requirement on the SB is not very high. Unlike Kumar et al. (2010), however, we assume a continuous distribution of consumer valuations, and we endogenize the choices of the manufacturer and retailer and derive the wholesale and retail margins.

To summarize, relative to the existing literature, we completely characterize the optimal response of a strategic manufacturer facing a strategic retailer and an SB threat. In the product strategy and pricing space, we show that the diverse strategies we observe in the real world can be explained by our model's equilibrium predictions. We illustrate when a manufacturer would compete with just price, when he would become an SB supplier, and when he would compete by expanding his product line in the presence of an SB.

3. The Model

We consider a supply chain with a monopolist retailer, an NBM, and a competitive market of manufacturers supplying an unbranded product at marginal cost. The products in this market are described uniquely by a simple index of quality. We begin by describing consumers, retailer, and manufacturers. Then we describe the decision sequence.

3.1. Consumers

Consumers are heterogeneous in their valuation of product quality and buy at most one unit of a product offered at different quality levels. Let v_j and p_j denote the quality and the retail price, respectively, of product j, and let θ be the consumer's marginal willingness to pay for quality. Then a consumer derives the following utility from buying product j:

$$U_j = \theta v_j - p_j, \quad \text{where } \theta \sim \mathcal{U}(0, 1). \tag{1}$$

Consumers pick product k such that $U_k > 0$ and $U_k \geq U_j$ for all $j \neq k$. If $U_k < 0$, then consumers do not buy in this category.

3.2. Retailer

The profit-maximizing retailer sets the retail prices for all the products she decides to carry. We consider two cases: (i) the baseline case and (ii) the competitive case.

In the baseline case, the retailer can decide to carry up to N products offered by the NBM (see §3.3), and she sets retail prices $p_1, p_2, \ldots,$ so as to achieve

$$\max_{p_1, p_2, \ldots} \sum_{n=1,2,\ldots} (p_n - w_n) d_n, \tag{2}$$

where w_n and d_n denote product n's wholesale price and demand, respectively.

In the competitive case, the retailer has access to the products offered by the NBM as well as to a perfectly competitive market of fringe SB manufacturers offering an unbranded product, which the retailer can sell as an SB. Let v_s and ω denote the quality and wholesale price (marginal cost), respectively, of the SB. Without loss of generality, we normalize v_s to 1. As such, ω represents the price that the retailer pays for an SB product of quality 1. Analogously, we use d_s to denote demand for the SB product, and the retailer sets retail prices so as to achieve

$$\max_{p_s, p_1, p_2, \ldots} \left\{ (p_s - \omega) d_s + \sum_{n=1,2,\ldots} (p_n - w_n) d_n \right\}. \tag{3}$$

3.3. National Brand Manufacturer

The profit-maximizing NBM offers the retailer up to N products with qualities indexed in descending order: $v_N \leq v_{N-1} \leq \cdots \leq v_1$. The NBM is strategic in the sense that his product line design takes into account the retailer behavior see (Villas-Boas 1998, §3.3). We assume that the NBM's marginal production cost function is convex in product quality and operationalize it as $c_n = \alpha v_n^2$, $\alpha \geq 0$. The cost parameter, α, is directly related to the NBM's ability to differentiate his products from those of his competitors. For example, a low (high) level of α indicates that the NBM has a high (low) ability to differentiate his products. The notation $\delta = (\omega - \alpha)$ is used to denote the difference between the retailer's cost of acquiring one unit of the SB and the NBM's cost of producing it—we refer to α as the NBM's *differentiation ability* and δ as the NBM's *cost advantage*. The analysis is carried out on the entire feasible range of α and δ, which is given by

$$S = \left\{ (\delta, \alpha) \colon -\alpha \leq \delta \leq \tfrac{3}{5} - \alpha,\ 0 \leq \alpha \leq \tfrac{1}{6} \right\}. \tag{4}$$

As will be seen, for all $\alpha > 1/6$, the NBM may choose to offer an NB product with quality below the SB's, which is not interesting. However, for all $\delta > 3/5 - \alpha$, the SB is uncompetitive and becomes irrelevant; $\omega \geq 0$ implies $-\alpha \leq \delta$. Considering the entire feasible range, S, is appealing because as empirical findings in Barsky et al. (2002) reveal, the marginal production costs required to produce national brand products often diverge from those required to produce SBs.

The NBM sets product qualities and wholesale prices to attain[3]

$$\max_{\substack{w_1, w_2, \ldots \\ v_1, v_2, \ldots}} \sum_{n=1,2,\ldots,N} (w_n - c_n) d_n - N \times F, \tag{5}$$

where F is a fixed setup cost the NBM incurs for each product version he decides to produce. One can think of F as the cost of setting up production of a particular product version, or the cost of branding. (Where useful, the notation π_N is used to indicate the NBM's *gross profit*; $\Pi_N = \pi_N - N \times F$ is used to indicate the NBM's *profit net of fixed cost*.)

The fixed cost of the SB manufacturers is normalized to 0, implying that they do not have to incur

[3] We restrict our attention to uniform pricing at the wholesale and retail levels.

Table 2 Glossary of Notation

				NBM profits[a]		NBM product attributes[b]	
Subcase	No. of products	SB competition	SB demand	Gross profit[c]	Net profit[d]	Top product	Bottom product
Baseline 1	1	No	n/a	π^{bsln1}	Π^{bsln1}	$x_{1/1}^{\text{bsln1}}$	n/a
Baseline 2	2	No	n/a	π^{bsln2}	Π^{bsln2}	$x_{1/2}^{\text{bsln2}}$	$x_{2/2}^{\text{bsln2}}$
Accommodate	1	Yes	>0	π^{acmd}	Π^{acmd}	$x_{1/1}^{\text{acmd}}$	n/a
Buffer	2	Yes	>0	π^{bffr}	Π^{bffr}	$x_{1/2}^{\text{bffr}}$	$x_{2/2}^{\text{bffr}}$
Displace	2	Yes	$=0$	π^{dspl}	Π^{dspl}	$x_{1/2}^{\text{dspl}}$	$x_{2/2}^{\text{dspl}}$

[a]Where useful, product-specific profits have superscripts (bsln1, one-product baseline case; bsln2, two-product baseline case; acmd, accommodation case; bffr, buffer case; dspl, displacement case).
[b]The variable x is a placeholder for variables ($v=$ quality, $w=$ wholesale price, $p=$ retail price, $d=$ demand). The superscript denotes the subcase, and the subscript denotes the product to which a variable is related.
[c]NBM's gross profit (ignores fixed costs).
[d]NBM's profit net of fixed cost.

branding costs and that their production processes require lower setup costs for a new product version. Because unbranded products tend to be manufactured for specific retailers, they are ordinarily produced in smaller volumes than NB products, which are sold at multiple retailers. Their production processes are therefore often structured differently (see Hayes and Wheelwright 1979; Krajewski and Ritzman 2004, §3; Chryssolouris 2006, §1). By far the most common manufacturing process for products that are produced in small- to medium-sized shipments is a *batch process*. In contrast, products that do not require customization for individual retailers and are put out in large volumes are produced by *line* or *continuous flow processes*. Relevant to us are the cost differences between these processes: compared to the much less flexible line process, the batch process is characterized by *lower fixed costs* (here, normalized to 0) and *higher marginal costs*.

3.4. Game Sequence and Notation

What follows is a sequence of stages in the game between the NBM, the retailer, and the consumers (vectors are in bold):

Stage 1. The NBM chooses how many product versions, N, to produce.

Stage 2. The NBM sets the qualities, $\mathbf{v}$, and wholesale prices, $\mathbf{w}$.

Stage 3. The retailer chooses which and how many product versions, $N' \leq N$, to carry and whether to carry the SB product (if available).

Stage 4. The retailer sets retail prices, $\mathbf{p}$.

Stage 5. Each consumer chooses whether to buy and which product version to buy.

Note that we could have combined Stages 1 and 2 and Stages 3 and 4; we separated them for expositional clarity. In Lemma 1 (see Appendix A), we establish conditions on qualities $\mathbf{v}$ and wholesale prices $\mathbf{w}$ under which $N' = N$. In other words, the condition says that the profit-maximizing retailer does not drop an arbitrary product n if its quality is sufficiently different from the qualities of products $(n-1)$ and $(n+1)$ and if its wholesale price is not too high.[4] For reference, Table 2 lists additional notation used in the remainder of the paper. The proofs of all propositions are presented in Appendix A.

The objective of our paper is to illustrate the impact SB competition has on the NBM's product line, positioning, and pricing strategies. Our analysis can be seen as an analytical experiment that isolates the impact of the SB and determines the NBM's optimal response to SB competition. For this analysis, we compare a baseline case without the threat of an SB to the competitive case. This approach describes either an incumbent NBM that had operated in a market without SB competition for a substantial length of time before the SB entered the market or an incumbent NBM that has foresight and correctly anticipates the retailer's choice of the SB when designing the qualities of the NB product line.

4. Baseline Case: Equilibrium Without SB Competition

We begin with the analysis of our baseline case, which is a game where the NBM is the sole producer of goods. Our central result in this section is Proposition 1, which establishes that if the fixed cost F is in the range $[1/(675\alpha), 1/(54\alpha)]$, then the NBM designs only one product and the retailer decides to carry this product. This result becomes an important reference point later in the paper when we analyze the competitive effect of the SB.

Proposition 1. *Let* $\underline{F} = 1/(675\alpha)$ *and* $\bar{F} = 1/(54\alpha)$, *and suppose the NBM faces no SB competition. Whenever* $F \in [\underline{F}, \bar{F}]$, *the NBM produces only one NB product and the retailer decides to carry it.*

[4] For similar conditions, see expressions (3) and (4) in Villas-Boas (1998).

Table 3 Baseline Case: Equilibrium Product Attributes and Profits

Subcase	No. of products	Qualities	Wholesale prices	Profits	Demands
Baseline 1	1	$v_{1/1}^{\text{bsln1}} = \frac{1}{3\alpha}$	$w_{1/1}^{\text{bsln1}} = \frac{2}{9\alpha}$	$\pi^{\text{bsln1}} = \frac{1}{54\alpha}$	$d_{1/1}^{\text{bsln1}} = \frac{1}{6}$
Baseline 2	2	$v_{1/2}^{\text{bsln2}} = \frac{2}{5\alpha}$	$w_{1/2}^{\text{bsln2}} = \frac{7}{25\alpha}$	$\pi_{1/2}^{\text{bsln2}} = \frac{3}{250\alpha}$	$d_{1/2}^{\text{bsln2}} = \frac{1}{10}$
		$v_{2/2}^{\text{bsln1}} = \frac{1}{5\alpha}$	$w_{2/2}^{\text{bsln2}} = \frac{3}{25\alpha}$	$\pi_{2/2}^{\text{bsln2}} = \frac{1}{125\alpha}$	$d_{2/2}^{\text{bsln2}} = \frac{1}{10}$
				$\pi^{\text{bsln2}} = \frac{1}{50\alpha}$	

The intuition behind the above result is as follows. Suppose that by expanding his product line from one to two products, the NBM were to deviate from the equilibrium identified in Proposition 1. We use the mnemonics "bsln1" and "bsln2" to denote the one-product and two-product cases, respectively. We summarize the NBM's equilibrium product attributes and payoffs in Table 3.

The increase of the product line size has two effects on the NBM's profits: a market expansion effect (EXP, $+$) and a cannibalization effect (SC, $-$). The expansion effect of switching from one to two products is defined as the profit the NBM earns from the second, low-quality product. That is, $\text{EXP}_{\text{bsln}} \equiv \pi_{2/2}^{\text{bsln2}}$. The cannibalization effect is defined as the difference between the profit the NBM earns from selling the high-quality product from the two-product portfolio and the profit he earns from selling only one product. That is, $\text{SC}_{\text{bsln}} \equiv \pi_{1/2}^{\text{bsln2}} - \pi_{1/1}^{\text{bsln1}}$. From Table 3, it follows that

$$\text{EXP}_{\text{bsln}} = \frac{1}{125\alpha}, \quad \text{SC}_{\text{bsln}} = -\frac{22}{3{,}375\,\alpha}, \quad \text{and}$$
$$\text{EXP}_{\text{bsln}} + \text{SC}_{\text{bsln}} = \frac{1}{675\alpha}.$$

The net effect, $\text{EXP}_{\text{bsln}} + \text{SC}_{\text{bsln}}$, although positive, is clearly less than $\underline{F}$, leading the NBM to abandon the second product in the absence of competition.[5] For this result to hold in general, however, it must also be established that for any $1 \le m < n$, the *net* expansion and cannibalization effects of the mth product is always larger than the net expansion and cannibalization effects of the nth product. We present this step in the formal of proof of Proposition 1, which is included in Appendix A.

5. Competitive Case: Equilibria with SB Competition

Recall from Proposition 1 that, as long as F is bound within the prescribed range, in the absence of SB competition, a monopolist NBM will introduce *only one* product. Now, suppose the retailer has an alternative supplier capable of producing a product at the quality level of 1. An interesting question arises: *Should the NBM expand his product line, and if so, what qualities should he choose?* In the presence of SB competition, the NBM has many strategic options in the product line, positioning (quality), and pricing space. We summarize the strategic choices of the NBM in Stages 1 and 2 of the game described in §3.4 in Figure 1, where we provide a descriptive label for the NBM's strategy in each subgame or option.

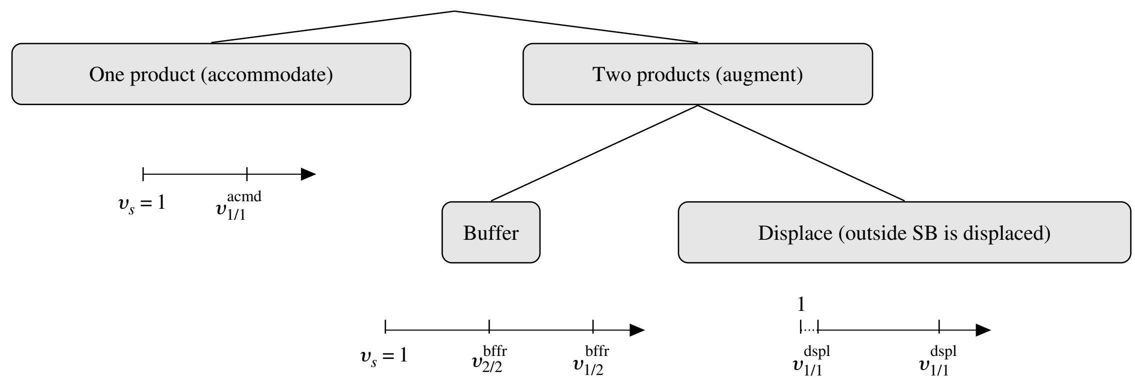
In Figure 1, "accommodate" refers to not responding through product line, but only through adjusting the quality and price of his single offering. "Augment" means to expand the product line with a defender product. Here, there are two potential choices: (i) "buffer," where the NBM inserts a second product between his premium-quality product and the SB such that both NB products and the SB have positive sales; or (ii) "displace," where through his choices of product qualities, the NBM preempts the SB entry by effectively supplying an SB product to the retailer that eliminates her incentive to procure the SB from an outside supplier. Note that this second product the NBM supplies may be of higher quality than what the retailer would have obtained from the competitive fringe. Further, regardless of the strategy pursued, the NBM may adjust the quality of his premium product to be above or below the choice he would have made in the absence of the competitive threat.

As evident from Figure 1, an NBM may alter his product line in terms of both the number of products and their qualities. Per our earlier discussion, a second product has two effects on the NBM's profits: a market expansion effect (EXP, $+$) and a cannibalization effect ($SC, -$). The net effect, although positive, was less than $\underline{F}$, leading the NBM to abandon the second product in the absence of competition. However, in the presence of the competitive SB threat, the calculus changes. The comparison now is whether ($\text{EXP} + SC - \underline{F}$) is greater than the loss that would result if the NBM were to maintain the status quo by keeping one product (even allowing for endogenously adjusting its quality). Given the NBM's choices, the retailer strategically decides which product(s) to stock and at what prices. Based on the NBM's choices of qualities for his products, it is possible that, under some conditions, the retailer might abandon the pursuit of the outside supplier and instead choose a product supplied by the NBM, leading to the "displacement" of the outside supplier.

For expositional clarity, we discuss the subgames of Stages 2–5 conditional on the product line decision of Stage 1. Then we explore whether to accommodate or "fight back" with a broader product line in §5.3.

[5] Wernerfelt (1986) obtains a similar result within a Hotelling framework.

Figure 1 NBM's Strategic Choices



We proceed to solve for the full equilibrium through backward induction by examining the subgames corresponding to the three nodes in Figure 1: accommodate, buffer, and displace. In each subgame, we solve for retail prices as a function of (δ, α) and substitute the retailer's choices in the NBM's profit function to obtain the NBM's profit in each subgame. In all the equilibria we derive, the NBM designs the product line while taking retailer behavior into account, such that that the profit-maximizing retailer chooses not to exclude any NB products offered.

5.1. Equilibrium Choices When Competing with One Product (Accommodation)

When the NBM competes against the SB with a single offering, we say that the NBM *accommodates* the SB. Compared with the monopoly case, here, the NBM chooses to supply a higher-quality product at a lower price; i.e., $w_{1/1}^{\text{acmd}} \le w_{1/1}^{\text{bsln1}}$ and $v_{1/1}^{\text{bsln1}} \le v_{1/1}^{\text{acmd}}$. With the existence of an SB, the aggregate demand expands and the retailer is clearly better off. As shown in Figure 2(a), for low values of δ, the NBM's one product lets the SB enjoy positive demand. There is a small region that exists for high values of α, where the NBM sets the quality and wholesale price of its product such that the retailer drops the SB. The mechanics of how the NBM sets qualities and wholesale prices to drive the SB demand to zero will be discussed in further detail in the next section under the displacement strategy. Because the accommodation case is straightforward, we relegate the analysis details to Appendix B; however, note that we use the results from the appendix to illustrate when accommodation versus augmentation would prevail.

5.2. Equilibrium Choices When Competing with Two Products (Augmentation)

Suppose the NBM competes against the SB with two products with qualities $v_{1/2}$ and $v_{2/2}$, where $1 \le v_{2/2} < v_{1/2}$. We will refer to the high-quality NB product as the *premium NB* and to the lower-quality NB product as the *defender*. As we state in Stage 3 of the game, the retailer chooses which products to carry. She will carry the premium NB if $w_{1/2} < (v_{1/2} - v_{2/2} + w_{2/2})$, the defender if $w_{2/2} < (((v_{1/2} - v_{2/2})w_s) + ((v_{2/2} - 1)w_{1/2}))/(v_{1/2} - 1)$, and the SB if $w_s < w_{2/2}/v_{2/2}$.[6] Since the NBM internalizes the retailer's optimal response, the first two conditions are always satisfied by the NBM's interior solution based on his first-order conditions (FOCs). The NBM has two basic options: use the defender to *buffer* the SB by setting the quality and wholesale price of the defender such that $w_s < w_{2/2}/v_{2/2}$ or *displace* the SB by setting $w_{2/2}/v_{2/2} \le w_s$. To analytically characterize the range of (δ, α) where buffering dominates displacement, we begin with retail demands for the two NBs and the SB:

$$d_{1/2} = 1 - \frac{p_{1/2} - p_{2/2}}{v_{1/2} - v_{2/2}}, \quad d_{2/2} = \frac{p_{1/2} - p_{2/2}}{v_{1/2} - v_{2/2}} - \frac{p_{2/2} - p_s}{v_{2/2} - 1}, \quad \text{and} \quad d_s = \frac{p_{2/2} - p_s}{v_{2/2} - 1} - p_s. \tag{6}$$

Using (6), the retailer solves (3), where the maximum is achieved by taking

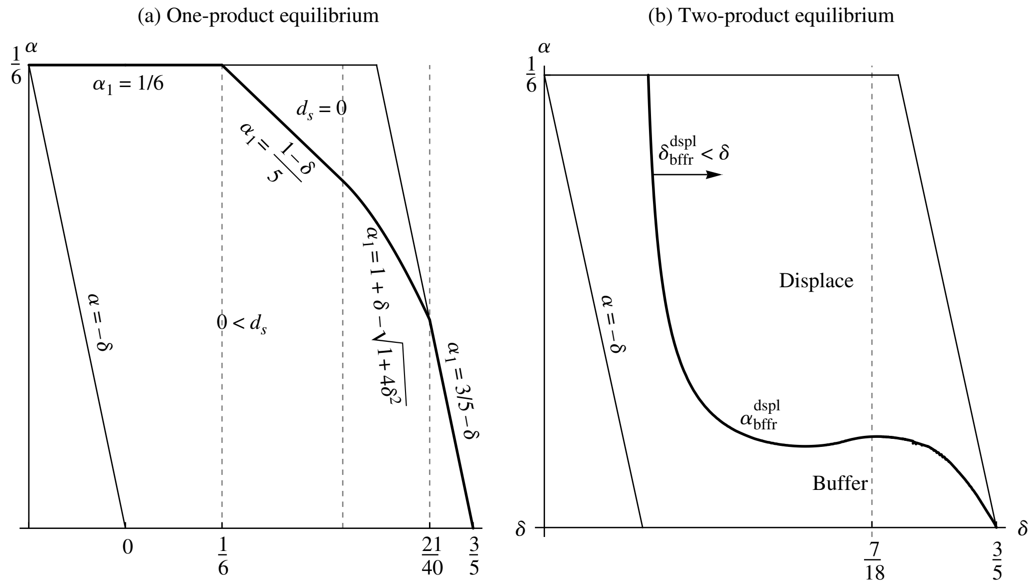
$$p_{1/2} = \frac{v_{1/2} + w_{1/2}}{2}, \quad p_{2/2} = \frac{v_{2/2} + w_{2/2}}{2}, \quad \text{and} \quad p_s = \frac{1 + \alpha + \delta}{2}.$$

By substituting the retail prices, we obtain demands as functions of wholesale prices (we use the notation $(\ldots)^+$ to denote the positive part):

$$d_s = \left(\frac{w_{2/2} - (\alpha + \delta) v_{2/2}}{2(v_{2/2} - 1)} \right)^+,$$
$$d_{1/2} = \frac{v_{1/2} - v_{2/2} - (w_{1/2} - w_{2/2})}{v_{1/2} - v_{2/2}}, \quad \text{and}$$
$$d_{2/2} = \begin{cases} \dfrac{w_{1/2} v_{2/2} - w_{2/2} v_{1/2}}{2 v_{2/2} (v_{1/2} - v_{2/2})} & \text{if } w_{2/2} \le (\alpha + \delta) v_{2/2}, \\[2ex] \dfrac{w_{1/2}(v_{2/2} - 1) - w_{2/2}(v_{1/2} - 1) + (\alpha + \delta)(v_{1/2} - v_{2/2})}{2(v_{1/2} - v_{2/2})(v_{2/2} - 1)} & \\ \text{otherwise.} & \end{cases} \tag{7}$$

[6] These conditions are directly derived from Equation (A4) in Appendix A.

Figure 2 Accommodation and Augmentation Subgame Equilibria



Given the demand functions (7), the NBM will set wholesale prices and qualities so as to maximize his profits as specified in Equation (5) with $N = 2$. (Analytical expressions for qualities and wholesale prices are given in Appendix B.1.)

In Equation (7), we can observe that the demand for the SB, d_s, and the demand for the defender, $d_{2/2}$, are both kinked because by setting $w_{2/2}/v_{2/2} \le \alpha + \delta$, the NBM will cause the profit-maximizing retailer to drop the SB. Therefore, everything else being equal, an attractively priced defender will displace the SB. On the other hand, if $w_{2/2}/v_{2/2} > \alpha + \delta$, the retailer will decide to carry the SB, implying that a less attractively priced defender will merely buffer the SB.

Proposition 2 below characterizes the parameter ranges where buffering and displacement survive in the subgame equilibrium. For expositional clarity, we describe the equilibria for two important cases: high α ($\alpha \in A_H$) and low α ($\alpha \in A_L$), descriptive of an NBM with low and high differentiation ability.[7] The sets A_H and A_L can be seen graphically in Figure 6 and are formally defined in Appendix C.

Proposition 2. *Suppose the NBM competes against the SB with two NB products.*

(i) *If the NBM's differentiation ability is high (i.e., $\alpha \in A_L$), then he buffers his premium NB with a second product. The retailer chooses to carry both NB products and the SB.*

(ii) *If the NBM's differentiation ability is low (i.e., $\alpha \in A_H$) and $\delta_{\text{bffr}}^{\text{dspl}} \le \delta$, then he displaces the SB. The retailer chooses to carry both NB products and drops the outside SB supplier.*

(iii) *If the NBM's differentiation ability is low (i.e., $\alpha \in A_H$) and $\delta < \delta_{\text{bffr}}^{\text{dspl}}$, then he buffers his premium NB with a second product. The retailer chooses to carry both NB products and the SB.*

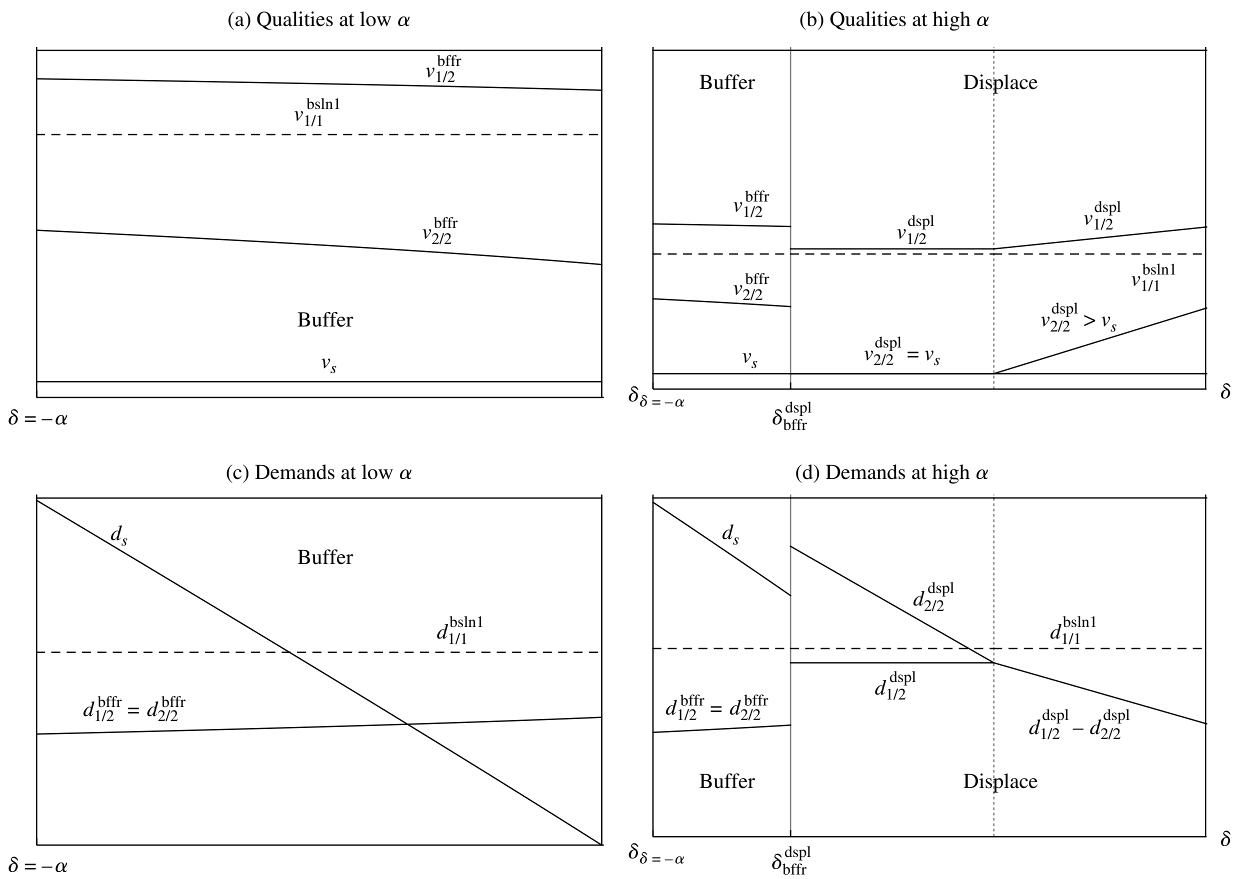
The best NBM strategy in this positioning subgame is guided by both his differentiation ability α and his cost advantage δ; the NBM is in the strongest (weakest) position against the SB when α is low (high) and δ is high (low).

As part (i) of Proposition 2 illustrates, an NBM with a high differentiation ability (low α) maximizes his profit by designing a product line with a high-quality premium NB, offering a defender that is sufficiently differentiated from the SB, and setting relatively high wholesale prices for both products. Although the defender product takes sales away from the SB, all three products receive positive demand (see Figure 3(c)), and the retailer does not drop the SB. Figure 3(a) shows how the qualities of the premium NB and of the defender, $v_{1/2}^{\text{bffr}}$ and $v_{2/2}^{\text{bffr}}$, compare with the quality of the NB product in the baseline case, $v_{1/1}^{\text{bsln1}}$. From these, we can clearly see that effective *buffering requires that the defender product be positioned so as to take more sales away from the SB than from the premium NB*, which the NBM achieves by distorting the quality of the premium NB upwards (relative to the baseline case).

In contrast as part (ii) of Proposition 2 shows, it is costly for a low-differentiation ability (high α) NBM to raise the quality of his premium NB and produce a high-quality defender. As a result, the NBM finds it optimal to set the quality of the premium NB close to

[7] For completeness, in Appendix B.1, we characterize the equilibrium on the entire feasible range of α. This is shown graphically in Figure 2(b).

Figure 3 Qualities and Demands with Two Branded Products



the baseline case (see Figure 3(b)). To minimize cannibalization, however, the NBM must now distort the quality of the defender downwards (relative to the buffering case). This means that for high-range values of δ, the equilibrium quality of the defender product, $v_{2/2}^{\text{dspl}}$, is much lower than the buffering quality, $v_{2/2}^{\text{bffr}}$, but continues to exceed the quality of the SB, v_s. For midrange values of δ, the quality of the defender *matches* the SB's quality. In both cases, the defender is optimally priced to match the SB's retail margin by setting $w_{2/2}^{\text{dspl}} = v_{2/2}^{\text{dspl}}(\alpha+\delta)$, which causes the retailer to abandon the outside SB supply (see Figure 3(d)).

In part (iii) of Proposition 2, the NBM is in the worst possible position because both his differentiation ability and his cost advantage are low. Under such conditions, the NBM is unable to price the defender low enough to displace the SB (to displace the SB, the NBM must set $w_{2/2}^{\text{dspl}} \le v_{2/2}^{\text{dspl}}(\alpha+\delta)$). His optimal defender product therefore ends up buffering the SB—the resulting qualities and demands are illustrated in Figures 3(b) and 3(d).

5.3. Throw in the Towel (Accommodate) or Fight Back (Augment)?

In §§5.1 and 5.2 we examined the equilibrium product positioning and prices when the NBM chooses to either accommodate or augment when fully anticipating the retailer's strategic behavior. Now we turn to Stage 1 of the game, where the NBM decides *whether* to accommodate or augment, and if latter, how.

Given the range of the fixed cost, F, we have ruled out the possibility that the NBM would design more than two products in the absence of an SB competitive threat. Based on our assumption about (δ, α), we have also ruled out the case where the NBM would supply a second product whose quality is lower than the SB's. Therefore the NBM is left with two basic options (see Figure 1): "throw in the towel" by offering one NB product that accommodates the SB or "fight back" by offering a second NB product that either buffers or displaces the SB. It follows that the profit-maximizing NBM will introduce a defender if and only if

$$F < \pi^k(\delta,\alpha) - \pi^{\text{acmd}}(\delta,\alpha),$$
$$\text{where } k \in \{\text{bffr}, \text{dspl}\} \text{ and } \underline{F} \le F \le \bar{F}. \quad (8)$$

In the baseline case, we have already shown that the costly product line expansion dictates product "pooling," meaning that the combined expansion effect (EXP, $+$) and cannibalization effect (SC, $-$) of the second NB product never exceeds the fixed cost hurdle $\underline{F}$. Hence, it is *not* obvious that inequality (8) can hold in the presence of the SB. The intriguing question is, if it is never optimal for the monopolist NBM to launch a second product, why would it be optimal when the NBM is in a worse competitive situation?[8] The next proposition answers the question as to when the NBM would decide to fight with additional products and why.

Proposition 3. *Suppose the NBM competes with the SB and* $\underline{F} \le F \le \bar{F}$ (*cf. Proposition* 1).

1. *If the NBM's cost advantage is low* (δ *is below some* $\bar{\bar{\delta}}$), *then the NBM accommodates the SB. The value of the critical* $\bar{\bar{\delta}}$ *depends on the NBM's differentiation ability, i.e., whether* $\alpha \in A_L$ *or* $\alpha \in A_H$. *We denote these critical values as* $\delta_{\text{acmd}}^{\text{bffr}}$ *and* $\delta_{\text{acmd}}^{\text{dspl}}$.
2. *If the NBM's cost advantage is high, two outcomes are possible. The NBM buffers by introducing a second product when his differentiation ability is high and* $\delta > \delta_{\text{acmd}}^{\text{bffr}}$. *The retailer introduces the outside supplier's product as an SB, and there are three products in the market. When the NBM's differentiation ability is low and* $\delta > \delta_{\text{acmd}}^{\text{dspl}}$, *the NBM produces a second product that displaces the outside supplier's product. The retailer rationally decides to abandon the outside supplier.*

Proposition 3 identifies the two important strategic insights: (1) when the NBM will shun product strategy and rely only on price (accommodate) and (2) when, conditional on augmentation, the NBM will decide to buffer or displace. Interestingly, Proposition 3 points out the interaction effect of α and δ on the NBM's strategic decision when δ is high. In Figure 6, we show the final equilibrium graphically.

5.3.1. Accommodate vs. Augment. For low values of δ, the NBM accommodates the SB entry and forgoes the expansion of the product line through a second product. To see the intuition for why this equilibrium would survive, consider what would happen if the NBM were to offer a second product when δ is low. Remember that the strategic trade-off between accommodation and augmentation for NBM is the net effect of increased profits (demand expansion *minus* cannibalization *minus* F). Now, a low value of δ $(= w - \alpha)$ implies that the outside SB marginal cost is reasonably close to α. When the NBM's ability to differentiate is high (α is low), then w is correspondingly low, and two forces are at work: (i) the NBM can create enough spacing in the quality space between its products (low α) to create market expansion for himself, and (ii) a low value of w leads the retailer to price the SB aggressively close to the defender product, leading not only to erosion in the margin for the defender but threatening cannibalization with the premium NB, which would lead to erosion in the margin of the premium NB. The combined effect is that the net incremental profit for the NBM is not sufficient to overcome $\underline{F}$.

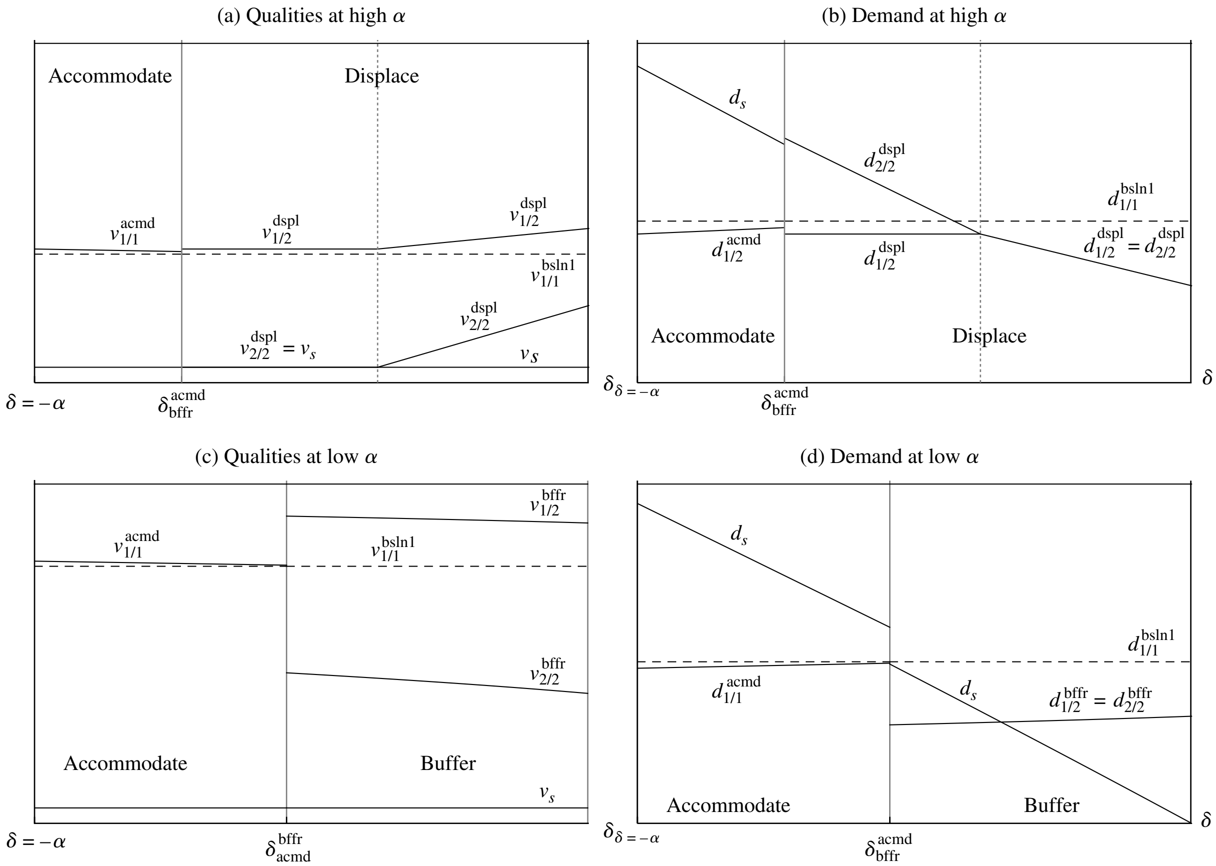
When the NBM's ability to differentiate is low (high α) and w is correspondingly high, the calculus changes. High α implies that ramping up quality is very costly, which further implies that ramping up high quality to entice the high θ consumers is difficult because the marginal cost of quality is increasing more rapidly compared with the consumers' marginal willingness to pay for quality. This means it is more difficult for the NBM to create enough spacing between his products in the quality space. This would lead to a lesser expansion effect for the NBM, with severe cannibalization not because of aggressive pricing at the lower end but because of the closeness of the NB products in the quality space. Once again, the incremental profit does not compensate for $\underline{F}$, and the NBM forsakes the introduction of the second product.

5.3.2. Buffer vs. Displace. We now turn to the case when the NBM enjoys a significant cost advantage (high δ). This means the SB cost is high relative to the marginal cost of the NBM. When the NBM's ability to differentiate is also high (low α), it is the best of both worlds for the NBM. Because of his differentiation ability, he can create two products and create enough spacing between them to enhance the market expansion effect. Because of the cost advantage, he does not have to worry about severe margin erosion at the low end that could exacerbate the threat of cannibalization.

To create enough separation between his products, the NBM chooses a high-quality defender and prices it so that $w_{2/2} > v_{2/2}(\alpha+\delta)$, which causes the retailer to retain the outside SB (see §5.2). However, to take more sales away from the SB than from the premium NB, the NBM must differentiate his premium NB and his second (defender) product *more* than in the monopoly case. This is seen graphically in Figure 4(c). The corresponding demands are shown in Figure 4(d). (In Figure 5(b), note that $0 < v_{1/2}^{\text{bffr}} - v_{1/2}^{\text{bffr}} < v_{1/2}^{\text{bsln2}} - v_{1/2}^{\text{bsln2}}$.) In particular, compared with the monopoly case, the NBM distorts the quality of the premium NB upwards and the quality of the defender downwards. This positioning strategy leads the NBM to experience much *less cannibalization* ($SC, -$) *in the competitive case than in the monopoly case* (see the ΔSC curve in Figure 5(a))—so much less that, for high values of δ, the marginal profit of the defender product becomes large enough to offset the fixed cost hurdle $\underline{F}$. This is why the NBM can sustain the buffering strategy in the final equilibrium. Of course, in the absence of the SB threat, the NBM would optimally revert to the single-product strategy, which demonstrates that *the*

[8] Ritson (2009, p. 94) observes that "a manager will probably never encounter a strategy as tempting or potentially ruinous as a fighter brand."

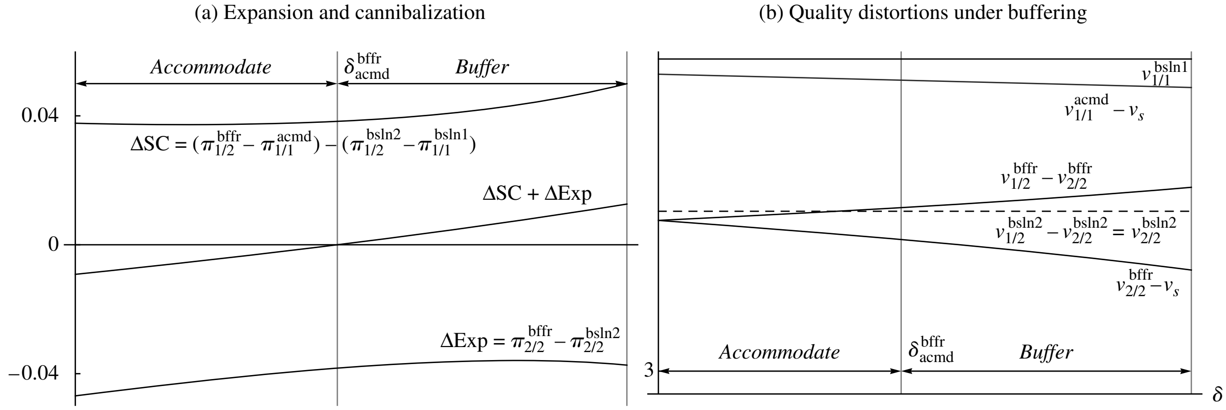
Figure 4 Subgame-Perfect Nash Equilibrium Qualities and Demands



net marginal profit the NBM can gain from introducing an additional product can be higher under competition than under monopoly.

When α is high, the NBM's ability to ramp up quality is lower. Thus the NBM finds it difficult to create enough spacing to generate adequate market expansion. This is seen graphically in Figure 4(a). The corresponding demands are shown in Figure 4(b). However, because of his cost advantage, the NBM is able to be price competitively with the outside supplier for the same quality product and hence displaces the outside supplier by offering a wholesale price of $w_{2/2}^{\text{dspl}} \le v_{2/2}^{\text{dspl}}(\alpha+\delta)$. (As in the buffering case, for high values of δ, the NBM experiences sufficiently less cannibalization so that the marginal profit of the defender product becomes large enough to offset the fixed cost $\underline{F}$ required for its introduction.) The retailer is incentivized to take this as his SB and abandons the outside supplier.

Figure 5 Accommodation vs. Buffering, $\alpha \in A_L$

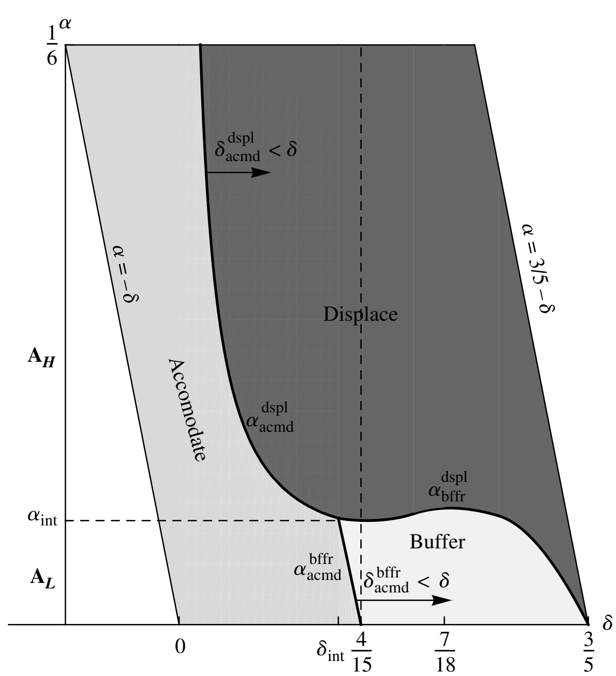


5.4. Empirical and Managerial Implications

In this section, using our equilibrium results and the associated conditions, we circle back to the motivating examples presented in §1. Figure 6 shows the regions within the $(\delta - \alpha)$ space where each of the NBM's product line strategies dominates. As an example of successful buffering, we use 3M's Highland version of Post-it notes (Ritson 2009). Post-it notes, the premium NB, were invented by 3M and are somewhat unique because of the adhesive used, which was under patent protection until late 1990s. We can conjecture that 3M's adhesives would be difficult to imitate by fringe producers, which would be consistent with high δ. The premium NB also continues to evolve, which would be consistent with low α. For example, in 2003, the company came out with an updated version of Post-it notes that could adhere to vertical and nonsmooth surfaces. Compatible with our results, 3M buffers its premium NB with a lower-priced version called Highland, which uses a lower-grade paper and lower-grade adhesive.

The second example is from a large consumer packaged goods manufacturer in the adult incontinence category. The firm has been a virtual monopolist with very little competition except from a few small manufacturers offering regional brands. Recently, it faced strong competition from SBs with such aggressive entry strategies that its market share began a steady decline. To combat this, the firm innovated and introduced a higher-quality product with a higher value point and price. The firm labeled this a "trade-up strategy." This high-quality product was launched; meanwhile, the firm kept its old NB as a buffer between its new high-quality product and the SBs. Within three quarters of the new product launch, the combined market share for the firm was higher than it was with the single NB because the market, in turn, expanded. When asked why the firm does not offer an SB itself, a manager, who presented the case, replied, "Our plant and equipment costs are high due to the better technology that affords manufacturing bigger lots and higher quality." Although the model in this paper is a static game, this example clearly illustrates that the equilibrium that we advance seems to mirror the facts of this case as they unfolded in this category. It would be useful to collect more systematic data and interview more managers to offer stronger empirical support than what we are able to offer through these anecdotal examples.

Figure 6 NBM's Subgame-Perfect Nash Equilibrium Strategy by Region



In §1, we chose Alcoa as an example of an NBM that uses the displacement strategy. Alcoa is the world's leading producer of aluminum foil, a commodity-like product whose production requires a substantial investment in heavy infrastructure. (Aluminum foil is produced in large mills by rolling sheet ingots cast from molten aluminum.) We can conjecture that aluminum foil is consistent with high α (i.e., it is an NB product that is difficult to improve through product innovation) and high δ (i.e., it is a product that is difficult for a smaller fringe producer to make more efficiently). Consistent with our prediction in Proposition 3, in many stores nationwide, Alcoa displaces outside SB producers by becoming the SB supplier.

Finally, examples of accommodation from practice include Coke and Pepsi, which in the 1980s refused to supply Canadian grocers with an SB soft drink (Dunne and Narasimhan 1999). The grocers found another source, Cott Corporation, which became a considerable threat to the two big cola makers. We can conjecture that SB soft drinks are easy to produce (after all, even at home, it is possible to very inexpensively produce a wide variety of soft drinks using supplies sold by companies such as SodaStream). Therefore SB soft drinks would be consistent with low δ in our model and, consistent with Proposition 3, both Coke and Pepsi would optimally accommodate them. For more definitive links to industry practices, however, it would be interesting to validate our model empirically.

6. Extension to Multiple Retailers

One important issue to consider is that in many markets NBMs sell through multiple retailers.[9] Modeling multiple retailers would undoubtedly introduce

[9] We thank an anonymous reviewer whose comments encouraged this extension to multiple retailers.

some additional trade-offs. Suppose the NBM sells through two independent retailers—say, R1 and R2—who serve two distinct nonoverlapping markets. If the retailers are symmetric, then it is straightforward to show that the NBM can achieve the outcome presented in §5.3.

Now, suppose the retailers are asymmetric. Suppose R1 can acquire the SB at the same cost that the NBM incurs to make it; i.e., $\delta_1 = 0$. R2 can only acquire the SB at a higher price than the NBM's cost of producing it, implying $0 < \delta_2$. In this case, an NBM with low α is still able to achieve the outcome presented in §5.3. In particular, if an NBM with low α finds it optimal to buffer (offer a defender that does not displace the SB with high δ), both R1 and R2 optimally carry the SB, the defender, and the premium NB. More interestingly, if an NBM with high α sells through asymmetric retailers, then the next proposition shows that the two retailers will differ in their choice of which products to carry.

Proposition 4. *Suppose the NBM sells his products through two independent retailers as outlined above. There exists two adjacent intervals, Δ_L and Δ_H, such that*

(i) *if $\delta_2 \in \Delta_L$, he offers one product, and each retailer carries the NB product as well as her outside SB; and*

(ii) *if $\delta_2 \in \Delta_H$, he offers two products, and R1 carries only the top quality product as well as her outside SB, and R2 carries both NB products and drops her outside SB.*

Proposition 4 shows that when serving multiple retailers who are sufficiently heterogeneous in their cost of acquiring the SB (i.e., δ_2 is sufficiently high), the NBM will expand his product line with a defender product that appeals to some retailers but not to others. This is in line with the common marketing practice under which some retailers carry the NBM's entire product line while others do not.[10]

7. Conclusion

The introduction and presence of SBs in the United States and in other developed countries is an important strategic concern to NBMs. Over the past decade, annual sales of SB products have increased by 40% in supermarkets and by 96% in drug stores (Private Label Manufacturers Association 2011). It is therefore important to study how an NBM should respond to a potential threat of an SB entry. Specifically, we look at the following questions.

1. Should an NBM compete against the threat of an SB just with price and price promotions? For example, the 2010 PLMA data show extreme efforts made by NBMs (e.g., elevated promotional spending, short-term price cuts) to recapture market share lost to SBs in previous years (see Private Label Manufacturers Association 2011).

2. Should the NBM defend his position by innovative product line expansion? If so, how exactly should he position his offerings when faced with the threat of an SB?

To answer these questions, we construct a game-theoretic model of an NBM, a retailer, and a competitive fringe market and examine the equilibrium product qualities and prices that would prevail in this market. To make relevant comparisons, we considered a range of parameter space where the NBM introduces only one product in the absence of the SB. Past research has shown that incumbent NBMs could accommodate SBs by lowering their wholesale prices (Narasimhan and Wilcox 1998) and includes conditions under which NBMs would optimally become SB suppliers (Chen et al. 2010, Kumar et al. 2010). Building on this literature, we fully explore the conditions under which the NBM will accommodate the SB by changing the price of his existing product only, how and when he might fight back with his own products, and when he will become the supplier of the SB. By examining two key drivers—cost advantage and the ability to differentiate relative to the competitive fringe—we show that product positioning strategies are an important component of the NBM's competitive response.[11]

Our main results, illustrated in Figure 6, are as follows.

1. Whether and how to fight back hinges on the above-mentioned key drivers and the interplay between them. Cost advantage is key to product line expansion, and the choice of positioning strategy is dictated by the relative ability to differentiate.

2. When the cost advantage relative to outside SB suppliers is low, the NBM typically accommodates the entry of the SB but changes his wholesale price and improves the quality of his existing product. The market expands, and while the SB gains, the NB loses profits relative to the case when there is no SB.

3. When the NBM enjoys a significant cost advantage over the competitive fringe, he competes with

[10] Of course, there are other factors outside the scope of this study that can influence the retailer's product assortment decision. These include shelf space constraints, stocking and assortment costs, etc.

[11] As pointed out by an anonymous reviewer, "An additional angle to the cross-regime comparison conducted in this paper is from a regulatory perspective. Some markets might be faced with regulatory constraints such that incumbent firms might enjoy monopoly supplier status within such markets. Structural changes in the market due to changing regulations—such as the economic deregulations in Asia, or easing of tariffs on outsourced suppliers—can open up markets to SB like competitors, making it necessary for incumbents to adjust product line design and prices. In such a case, comparison across the monopolistic regime and the competitive regime can yield useful insights."

new products. At high levels of the ability to differentiate, the NBM introduces a defender positioned between his premium brand and the SB. We refer to this as buffering. At low levels of differentiation ability, the NBM takes over the supply of the SB, and we call this displacing. In this case the retailer rationally abandons the pursuit of the competitive fringe. Interestingly, under some conditions, the NBM supplies a premium private label as the SB, consistent with what has been said about retailer demands.

4. Introduction of an SB of lower quality than that of the incumbent NB leads to an expansion of the market and lower average retail price. The retailer always benefits from the potential to introduce an SB.

In our model development, we assumed that the NBM has foresight and correctly anticipates the retailer's choice for the SB in designing the qualities of the NB product line. If an NBM has attained a strong position for some time prior to the anticipated introduction of the SB, the cost of repositioning or improving the quality of the NB may be too high for the NBM. However, if we restrict the NB quality to be the same, even after entry of an SB, all our results still hold; of course, the price levels and profits would be different in the different regimes. The quality of the defender product would be lower than the equilibrium quality with foresight.

The analysis presented in this paper can be generalized in several ways. First, we assumed that the taste parameter, θ, in our utility function is uniformly distributed across the population. Suppose a firm conducts marketing research and estimates the heterogeneity distribution. One can then use that distribution to model heterogeneity and solve the game. Second, future research may include retail competition in the model and examine the role of SBs as a means of store differentiation rather than as a way to serve low-valuation customers. Finally, future research may also examine the role of retailer-specific factors such as assortment cost and shelf space constraints.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/mksc.2013.0788.

Acknowledgments

The authors gratefully acknowledge comments by Nanda Kumar, participants at the 2011 Customer Insights Conference held at the Yale School of Management, participants at the 2011 Summer Institute in Competitive Strategy conference, and the editorial team, which improved the paper.

Appendix A. Baseline Case

Proof of Proposition 1. First we analyze the retailer's product and pricing decisions when she is offered $N > 0$ products. The product qualities are $v_1, v_2, \ldots, v_N$: $v_{n+1} < v_n$ $\forall n \in \{1, \ldots, N\}$, and the wholesale prices are $w_1, w_2, \ldots, w_N$. Let $\theta^n_{n+1} = (p_{n-1} - p_n)/(v_{n-1} - v_n)$ denote the consumer type who is indifferent between products n and $n+1$. Hence, demand for an arbitrary product n expressed as a function of retail price and quality is given by

$$d_n(p_n) = \begin{cases} \theta^{n-1}_n - \theta^n_{n+1} = \dfrac{p_{n-1} - p_n}{v_{n-1} - v_n} - \dfrac{p_n - p_{n+1}}{v_n - v_{n+1}} \\ \quad \text{if } p_n < \dfrac{p_{n+1}(v_{n-1} - v_n) + p_{n-1}(v_n - v_{n+1})}{v_{n-1} - v_{n+1}}, \\ 0 \ \ \text{otherwise.} \end{cases} \quad \text{(A1)}$$

The demand function of any arbitrary product n is kinked since the retailer can drop it by setting its retail price sufficiently high to drive its demand to 0. This is easy to see as

$$\frac{p_{n+1}(v_{n-1} - v_n) + p_{n-1}(v_n - v_{n+1})}{v_{n-1} - v_{n+1}} < p_n \implies \theta^{n-1}_n < \theta^n_{n+1};$$

i.e., the interval of θ types that prefer product n over $n+1$ and $n-1$ is empty. The θ types are bounded by 1 from the top; this is equivalent to the existence of a product, $n = 0$, such that $U_1(\theta) < U_0(\theta)$ $\forall \theta \geq 1 \Leftarrow v_0 - p_0 = v_1 - p_1$. The option of not buying is equivalent to the existence of a product, $n = N+1$, such that $p_{N+1} = 0$ and $v_{N+1} = 0$.

To examine whether the retailer decides to carry an arbitrary product, we start by assuming that she carries all N products, and we derive conditions under which she prefers not to drop an arbitrary product n. From (A1) and (2), the product n equilibrium retail price is[12]

$$p_n = \frac{v_n + w_n}{2}, \quad 0 \leq n \leq N+1. \quad \text{(A2)}$$

Substituting for p_n in (A1) yields demand for product n as a function of w_n and v_n:

$$d_n(w_n) = \frac{v_n(w_{n-1} - w_{n+1}) - v_{n+1}(w_{n-1} - w_n) - v_{n-1}(w_n - w_{n+1})}{2(v_{n-1} - v_n)(v_n - v_{n+1})}, \quad 1 \leq n \leq N. \quad \text{(A3)}$$

To account for the upper bound on θ and the outside option, we define $w_0 \equiv p_0 + p_1 - v_1$ and $v_0 \equiv w_0 + 2v_1 - 2p_1$.

Lemma 1. *Suppose there are N products available to the retailer with qualities $v_1, v_2, \ldots, v_N$: $v_{n+1} < v_n \, \forall n \in \{1, \ldots, N\}$ and wholesale prices $w_1, w_2, \ldots, w_N$. A profit-maximizing retailer decides to carry product n whenever*

$$\frac{v_n - v_{n+1}}{v_{n-1} - v_{n+1}} w_{n-1} + \frac{v_{n-1} - v_n}{v_{n-1} - v_{n+1}} w_{n+1} > w_n, \quad 1 \leq n \leq N. \quad \text{(A4)}$$

Proof of Lemma 1. Using (A4), $d_n(w_n) > 0$. Moreover, (A2) implies $p_n > w_n$. If the retailer carries all N products,

[12] See the technical appendix, available as supplemental material at http://dx.doi.org/10.1287/mksc.2013.0788, for a detailed derivation of Equation (A2).

her profit is given by (EC.4) in the technical appendix. If she drops an arbitrary product $i \in [1, N]$, her profit *decreases* by

$$\frac{(v_1 - v_2 - w_1 + w_2)^2}{4(v_1 - v_2)} > 0 \quad \text{if } i = 1, \quad \text{and}$$
$$\frac{(v_i(w_{i-1} - w_{i+1}) - v_{i+1}(w_{i-1} - w_i) - v_{i-1}(w_i - w_{i+1}))^2}{4(v_{i-1} - v_i)(v_i - v_{i+1})(v_{i-1} - v_{i+1})} > 0 \quad \text{if } i = 2, 3, \ldots, N. \quad \square$$

Note that Lemma 1 focuses on the retailer's product and pricing decisions strictly based on qualities and wholesale process regardless of who is offering the products. The next lemma establishes the equilibrium product qualities and wholesale prices when a profit-maximizing NBM offers N products and confirms that these satisfy the conditions in Lemma 1.

Lemma 2. (i) *A monopolist NBM achieves the maximal profit of* $\Pi_N = (N(N+1))/(12\alpha(2N+1)^2) - N \times F$ *by setting qualities and wholesale prices respectively to*

$$v_n = \frac{N - n + 1}{\alpha(2N+1)} \quad \text{and} \quad w_n = \frac{(2 - n + 3N)(1 - n + N)}{2(1 + 2N)^2\alpha}.$$

(ii) $v_1, v_2, \ldots, v_N$ *and* $w_1, w_2, \ldots, w_N$ *as given in part* (i) *satisfy the constraints in Lemma* 1.

Proof of Lemma 2. To prove part (i), use (A3) and (5) to obtain the product n equilibrium wholesale price:[13]

$$w_n = \frac{v_n(1 + \alpha v_n)}{2}. \tag{A5}$$

After direct substitution, the maximization problem for the NBM's quality decision becomes

$$\max_{v_n} \frac{\alpha}{8} \sum_{n=1}^{N} v_n(1 - \alpha v_n)(v_{n-1} - v_{n+1}).$$

The FOCs produce $v_0 = w_0 + 2v_1 - 2p_1 = (1 - \alpha v_1)/\alpha$ (see Lemma 1) and $v_n = (N - n + 1)/(\alpha(2N+1))$, where $1 \le n \le N$.

Direct substitution returns an optimal profit of

$$\Pi = \sum_{n=1}^{N} \frac{(N + 1 - n)(n + N)}{4(2N+1)^3\alpha} - N \times F.$$

This series can be further simplified using Faulhaber's formula to yield the profit expression given in Lemma 2. Finally, the expression for w_n is obtained by substituting for $v_n = (N - n + 1)/(\alpha(2N+1))$ in Equation (A5).

To prove part (ii), note that $v_n = (N - n + 1)/(\alpha(2N+1))$ implies $v_1 \ge v_2 \ge \cdots \ge v_N > 0$. Next, substitute $w_n = (v_n(1 + \alpha v_n))/2$ into (A4) to obtain

$$\frac{\alpha}{2}(v_{n-1} - v_n)(v_{n-1} - v_{n+1})(v_n - v_{n+1}) \ge 0.$$

Note that the above condition and condition (A4) are *equivalent*. The proof is now complete because $v_1 \ge v_2 \ge \cdots \ge v_N > 0$. $\square$

[13] See the technical appendix for a detailed derivation of Equation (A5).

Now, to complete the proof of Proposition 1, let $\Delta_N \equiv \Pi_N - \Pi_{N-1}$ denote the marginal profit contribution of the Nth product. Substitution yields

$$\Delta_N = \frac{N}{6\alpha(4N^2 - 1)^2} - F, \quad \text{and} \qquad \frac{\partial \Delta_N}{\partial N} = -\frac{1 + 12N^2}{6(4N^2 - 1)^3\alpha} < 0. \tag{A6}$$

Using (A6), we establish that $\partial\Delta_N/\partial N < 0 \Rightarrow \Delta_{N+x} < \Delta_N$ $\forall x \in \mathbb{N}^+$ and that $\Delta_{N+1} \le 0 \Leftrightarrow \Pi_N \ge \Pi_{N+1}$. Therefore N is the optimal number of products if and only if $\Delta_{N+1} \le 0 < \Delta_N$.

We can rewrite the necessary and sufficient conditions for N being the NBM's optimal number of products as $F_N \le F < F_{N-1}$, where $F_N \equiv N/(6\alpha(4N^2 - 1)^2)$ represents the fixed cost hurdle for the Nth product.[14] The necessary and sufficient conditions for 1 being the optimal number of products is $F_2 < F < F_1$. From Equation (A6), $F_2 = \underline{F} = 1/(675\alpha)$ and $F_1 = \bar{F} = 1/(54\alpha)$, which completes the proof. $\square$

Appendix B. Competitive Case: Accommodation (One Branded Product)

Suppose the NBM follows an accommodation strategy and offers one product with quality $v_{1/1}^{\text{acmd}} > 1$ at a wholesale price $w_{1/1}^{\text{acmd}}$. Let $p_{1/1}^{\text{acmd}}$ and p_s^{acmd}, respectively, denote the retail prices of the NBM's product and the SB. As such, the demand functions faced by the retailer are

$$d_{1/1}^{\text{acmd}} = 1 - \frac{p_{1/1}^{\text{acmd}} - p_s^{\text{acmd}}}{v_{1/1}^{\text{acmd}} - 1} \quad \text{and} \qquad d_s^{\text{acmd}} = \frac{p_{1/1}^{\text{acmd}} - p_s^{\text{acmd}}}{v_{1/1}^{\text{acmd}} - 1} - p_s^{\text{acmd}}. \tag{B1}$$

Substituting and solving the retailer's maximization problem in (3) yields optimal retail prices of

$$p_{1/1}^{\text{acmd}} = \frac{v_{1/1}^{\text{acmd}} + w_{1/1}^{\text{acmd}}}{2} \quad \text{and} \quad p_s^{\text{acmd}} = \frac{1 + \alpha + \delta}{2}. \tag{B2}$$

Substituting the retail prices from (B2) into (B1) results in the subgame equilibrium demand for the SB of $(w_{1/1}^{\text{acmd}} - (\alpha + \delta)v_{1/1}^{\text{acmd}})/(2(v_{1/1}^{\text{acmd}} - 1))$. Hence, the NBM can drive the demand of the SB product to 0 by setting $w_{1/1}^{\text{acmd}} \le (\alpha + \delta)v_{1/1}^{\text{acmd}}$, and his demand function can be expressed as

$$d_{1/1}^{\text{acmd}} = \begin{cases} \dfrac{v_{1/1}^{\text{acmd}} - w_{1/1}^{\text{acmd}}}{2v} & \text{if } w_{1/1}^{\text{acmd}} \le (\alpha + \delta)v_{1/1}^{\text{acmd}}, \\[2ex] \dfrac{(v_{1/1}^{\text{acmd}} - 1) - (w_{1/1}^{\text{acmd}} - (\alpha + \delta))}{2(v_{1/1}^{\text{acmd}} - 1)} & \text{otherwise.} \end{cases} \tag{B3}$$

[14] Of course, when product line expansion is free, $F = 0$, Δ_N will always be positive, and the NBM will produce a continuum of products $v \in \{0, 1/(2\alpha)\}$ serving consumer types $\theta \in \{\frac{3}{4}, 1\}$.

Next, we define a function, $\alpha_1(\delta)$, which we use in the proof of Proposition 5 below. The function is shown graphically in Figure 2(a). Let

$$\alpha_1(\delta)=\begin{cases}\frac{1}{6} & \text{if } -\alpha\le\delta<\frac{1}{6},\\ \dfrac{1-\delta}{5} & \text{if } \frac{1}{6}\le\delta<\frac{3}{8},\\ 1+\delta-\sqrt{1+4\delta^2} & \text{if } \frac{3}{8}\le\delta<\frac{13}{30},\\ \dfrac{3-5\delta}{5} & \text{if } \frac{13}{30}\le\delta\le\frac{3}{5}.\end{cases}\tag{B4}$$

Proposition 5. *If the NBM competes with the SB with one branded product, he sets the quality and wholesale price of the branded product as follows:*

$$v_{1/1}^{\text{admd}}=\begin{cases}\dfrac{1+4\alpha+\sqrt{1-4(1+3\delta)\alpha+4\alpha^2}}{6\alpha} & \textit{if } \alpha<\alpha_1,\\ \dfrac{\alpha+\delta}{2\alpha} & \textit{if } \alpha_1\le\alpha;\end{cases}$$

$$w_{1/1}^{\text{admd}}=\begin{cases}\dfrac{v_{1/1}^{\text{acmd}}(1+\alpha v_{1/1}^{\text{acmd}})}{2} & \textit{if } \alpha<\alpha_1,\\ (\alpha+\delta)v_{1/1}^{acmd} & \textit{if } \alpha_1\le\alpha.\end{cases}$$

The retailer decides to carry the NB product and the SB if $0\le\alpha<\alpha_1$. *If* $\alpha_1\le\alpha\le\frac{1}{6}$, *the retailer decides to carry the NB product and drops the SB.*

Proof of Proposition 5. Substituting the demands in (B3) into (5) results in the NBM's objective function as follows:

$$\pi_{1/1}^{\text{acmd}}=\max_{w_{1/1}^{\text{acmd}},v_{1/1}^{\text{acmd}}}\begin{cases}(w_{1/1}^{\text{acmd}}-c_{1/1}^{\text{acmd}})\dfrac{v_{1/1}^{\text{acmd}}-w_{1/1}^{\text{acmd}}}{2v}\\ \quad\text{if } w_{1/1}^{\text{acmd}}\le(\alpha+\delta)v_{1/1}^{\text{acmd}},\\ (w_{1/1}^{\text{acmd}}-c_{1/1}^{\text{acmd}})\dfrac{(v_{1/1}^{\text{acmd}}-1)-(w_{1/1}^{\text{acmd}}-(\alpha+\delta))}{2(v_{1/1}^{\text{acmd}}-1)}\\ \quad\text{if } (\alpha+\delta)v_{1/1}^{\text{acmd}}<w_{1/1}^{\text{acmd}}.\end{cases}\tag{B5}$$

First, consider the case where the NBM drives the demand for the SB to 0 by setting $w_{1/1}^{\text{acmd}}=(\alpha+\delta)v_{1/1}^{\text{acmd}}$ (see the upper prong of Equation (B5)). Given the choice of wholesale price, the NBM's optimal quality is $v_{1/1}^{\text{acmd}}=(\alpha+\delta)/(2\alpha)$, and his optimal profit is

$$\pi_{1/1}^{\text{acmd}}=\frac{(\alpha+\delta)^2(1-\alpha-\delta)}{8\alpha}.\tag{B6}$$

Next, consider the case where the NBM lets the SB enjoy positive demand (see the lower prong of Equation (B5)). The FOC yields the optimal quality and wholesale price of

$$v_{1/1}^{\text{acmd}}=\frac{1+4\alpha+\sqrt{1-4(1+3\delta)\alpha+4\alpha^2}}{6\alpha}\quad\text{and}$$

$$w_{1/1}^{\text{acmd}}=\frac{v_{1/1}^{\text{acmd}}(1+\alpha v_{1/1}^{\text{acmd}})}{2},$$

respectively. Whenever $\delta\in[0,\frac{1}{3}]$, the positive SB demand condition $w_{1/1}^{\text{acmd}}>(\alpha+\delta)v_{1/1}^{\text{acmd}}$ is satisfied for all α, and the NBM can achieve an optimal profit of

$$\pi_{1/1}^{\text{acmd}}=\frac{(1+4\alpha^2-4\alpha(1-3\delta)+(1-2\alpha)\sqrt{1+4\alpha^2-4\alpha(1+3\delta)})^2}{108\alpha(1-2\alpha+\sqrt{1-4(1+3\delta)\alpha+4\alpha^2})}.\tag{B7}$$

Straightforward algebraic comparisons reveal that the right side of Equation (B6) is strictly smaller than the right side of Equation (B7) if (i) $-\alpha\le\delta\le\frac{1}{6}$ and $\alpha<\frac{1}{6}$, (ii) $\frac{1}{6}\le\delta\le\frac{1}{3}$ and $\alpha<(1-\delta)/5$, and (iii) $\frac{1}{3}\le\delta\le\frac{3}{5}-\alpha$ and $\alpha<1+\delta-\sqrt{1+4\delta^2}$. The definition of α_1, given by (B4), now implies the values for $v_{1/1}^{\text{acmd}}$ and $w_{1/1}^{\text{acmd}}$. Finally, to analytically check the retailer's incentives to carry the NB and the SB, use Lemma 1 with $N=2$, $(v_1,v_2)=(v_{1/1}^{\text{acmd}},1)$, and $(w_1,w_2)=(v_{1/1}^{\text{acmd}},\alpha+\delta)$. □

B.1. Competitive Case: Augmentation (Two Branded Products)

Proof of Proposition 2. First, define $\alpha_{\text{bffr}}^{\text{dspl}}(\delta)$ as the value of $\alpha(\delta)$ for which $\pi^{\text{bffr}}(\delta,\alpha_{\text{bffr}}^{\text{dspl}}(\delta))=\pi^{\text{dspl}}(\delta,\alpha_{\text{bffr}}^{\text{dspl}}(\delta))$. (That is, given the cost advantage δ, the function $\alpha_{\text{bffr}}^{\text{dspl}}(\delta)$ is the differentiation ability at which the NBM is indifferent between buffering and displacement. It can be shown that for each δ, there exists a unique $\alpha_{\text{bffr}}^{\text{dspl}}(\delta)$.) Also, define the point $(\hat{\alpha}_{\text{int}},\hat{\delta}_{\text{int}})=((1/34)(-23+2\sqrt{145}),\frac{1}{3}(1+(1/34)(-23+2\sqrt{145})))\approx(0.032,0.344)$, which is shown graphically in Figure 2(b). The result in Proposition 2 is a consequence of the following lemma.

Lemma 3. *Suppose the NBM competes with the SB with two branded products.*

(i) *If* $0\le\alpha<\alpha_{\text{bffr}}^{\text{dspl}}(\delta)$, *then he* buffers *his premium product with a second product. The retailer decides to carry both NB products and the SB.*

(ii) *If* $\alpha_{\text{bffr}}^{\text{dspl}}(\delta)\le\alpha$, *then he* displaces *the SB. The retailer decides to carry both NB products and drops the SB.*

Proof of Lemma 3. Solving the NBM's FOCs reveals the following qualities, wholesale prices, and profits. If $\delta\le\frac{3}{5}-\alpha$ and $\alpha<\alpha_{\text{bffr}}^{\text{dspl}}$, then

$$v_{1/2}^{\text{bffr}}=\frac{1+8\alpha+\sqrt{1-4\alpha(1-\alpha+15\delta)}}{30\alpha},$$

$$v_{2/2}^{\text{bffr}}=\frac{11+8\alpha+\sqrt{1-4\alpha(1-\alpha+15\delta)}}{10\alpha},$$

$$w_{1/2}^{\text{bffr}}=\big(-2\alpha(-2\sqrt{1-4\alpha(-\alpha+15\delta+1)}-121\alpha-105\delta+61)+13\sqrt{1-4\alpha(-\alpha+15\delta+1)}+113\big)(450\alpha),$$

$$w_{2/2}^{\text{bffr}}=\big(3(\sqrt{1-4\alpha(-\alpha+15\delta+1)}+1)-2\alpha(-2\sqrt{1-4\alpha(-\alpha+15\delta+1)}-21\alpha-5\delta+1)\big)(50\alpha),$$

$$\pi^{\text{bffr}}=\frac{26(1-2\alpha)^3+360\delta\alpha(1-2\alpha)+(1-4\alpha(1-\alpha+15\delta))^{3/2}}{1{,}350\alpha}.$$

If ($\delta\le\hat{\delta}_{\text{int}}$ and $\alpha_{\text{bffr}}^{\text{dspl}}\le\alpha$) or ($\hat{\delta}_{\text{int}}\le\delta$ and $(3\delta-1)\le\alpha$), then

$$v_{1/2}^{\text{dspl}}=\frac{1+\alpha}{3\alpha},\quad v_{2/2}^{\text{dspl}}=1,\quad w_{1/2}^{\text{dspl}}=\delta-\tfrac{1}{9}\left(-5\alpha-\frac{2}{\alpha}+2\right),$$

$$w_{2/2}^{\text{dspl}}=\delta+\alpha,\quad \pi^{\text{dspl}}=\frac{(1-2\alpha)^3+27\delta\alpha(1-\alpha-\delta)}{54\alpha}.$$

Finally, if ($\hat{\delta}_{\text{int}} \le \delta$ and $\alpha_{\text{bffr}}^{\text{dspl}} \le \alpha \le (3\delta - 1)$), then

$$v_{1/2}^{\text{dspl}} = \frac{1+\alpha+\delta}{4\alpha}, \quad v_{2/2}^{\text{dspl}} = \frac{3(\alpha+\delta)-1}{4\alpha},$$

$$w_{1/2}^{\text{dspl}} = \frac{-(1-4\alpha)\delta - \alpha(1-2\alpha)+2\delta^2+1}{4\alpha},$$

$$w_{2/2}^{\text{dspl}} = \frac{(\alpha+\delta)(3(\alpha+\delta)-1)}{4\alpha},$$

$$\pi^{\text{dspl}} = \frac{(1-\alpha-\delta)(1+5\alpha^2-\delta(2-5\delta)-2\alpha(1-5\delta))}{32\alpha}.$$

The NBM prefers displacement to buffering if $\pi^{\text{bffr}} < \pi^{\text{dspl}}$. After some algebraic manipulation, this condition can be written as $P(\alpha,\delta) > 0$, where $P(\alpha,\delta) = -4 + 6\delta + (10 + 3\delta(119 + 45\delta(-14 + 15\delta)))\alpha + 6(-2 + 5\delta(13 + 23\delta))\alpha^2 + (-8 - 231\delta)\alpha^3 + 16\alpha^4$.

First, we show that for all $0 < \alpha < \frac{1}{6}$ and $0 < \delta \le \hat{\delta}_{\text{int}}$, there exists at most one number $\alpha(\delta)$, depending on δ, for which $P(\alpha,\delta) = 0$, which is sufficient to prove that $\alpha_{\text{bffr}}^{\text{dspl}}(\delta)$ exists and behaves exactly as shown in Figure 2(b).

Define the function $\text{Root}(f(\delta))$ as the exact root of the polynomial equation $f(\delta) = 0$, where $0 < \alpha < \frac{1}{6}$ and $0 < \delta \le \hat{\delta}_{\text{int}}$. Let

$$S_1 \equiv \Big\{(\delta,\alpha)\colon 0<\alpha<\tfrac{1}{6},\ 0<\delta<\text{Root}\Big(-\tfrac{218}{81}+\tfrac{5{,}419\delta}{72}-\tfrac{1{,}775\delta^2}{6}+\tfrac{675\delta^3}{2}\Big)\Big\},$$

$$S_2 \equiv \Big\{(\delta,\alpha)\colon 0<\alpha<\tfrac{1}{6}, \text{Root}\Big(-\tfrac{218}{81}+\tfrac{5{,}419\delta}{72}-\tfrac{1{,}775\delta^2}{6}+\tfrac{675\delta^3}{2}\Big) \le \delta \le \text{Root}(10+357\delta-1{,}890\delta^2+2{,}025\delta^3)\Big\},$$

$$S_3 \equiv \Big\{(\delta,\alpha)\colon 0<\alpha<\tfrac{1}{6},\ \text{Root}(10+357\delta-1{,}890\delta^2+2{,}025\delta^3) < \delta \le \hat{\delta}_{\text{int}}\Big\}.$$

None of the above sets is empty because $\text{Root}(-218/81 + 5{,}419\delta/72 - 1{,}775\delta^2/6 + 675\delta^3/2) = 17/400 \approx 0.0425$, and $\text{Root}(10+357\delta-1{,}890\delta^2+2{,}025\delta^3) = 192/625 \approx 0.3072$.

It is a straightforward algebraic exercise to verify the following: $\forall(\delta,\alpha)\in S_1$, $P(\alpha,\delta)<0$, implying that $P(\alpha,\delta)$ has no root on S_1; $\forall(\delta,\alpha)\in S_2$, $P(0,\delta)<0$, $P(\frac{1}{6},\delta)>0$, and $\partial P(\alpha,\delta)/\partial\alpha>0$, implying that on S_2, $P(\delta,\alpha)$ is negative at $\alpha=0$, positive at $\alpha=\frac{1}{6}$, and strictly increasing in α for all δ; and $\forall(\delta,\alpha)\in S_3$, $P(0,\delta)<0$, $P(\frac{1}{6},\delta)>0$, and $\partial^2 P(\alpha,\delta)/\partial\alpha^2>0$, implying that on S_3, $P(\delta,\alpha)$ is negative at $\alpha=0$, positive at $\alpha=\frac{1}{6}$, and strictly convex in α for all δ. Taken together, these properties imply that $P(\delta,\alpha)$ is strictly increasing in α on S_4, where we define S_4 to be

$$S_4 \equiv \Big\{(\delta,\alpha)\colon \arg\min_{\alpha} P(\alpha,\delta) < \alpha < \tfrac{1}{6},\ \text{Root}(10+357\delta-1{,}890\delta^2+2{,}025\delta^3) < \delta \le \hat{\delta}_{\text{int}}\Big\}.$$

Let l_{δ_2} and l_{δ_3} denote the vertical line segments in S_2 and S_3:

$$l_{\delta_2} \equiv \{(\delta,\alpha)\colon 0<\alpha_1\le\tfrac{1}{6}, \delta=\text{const}\} \subset S_2 \quad \text{and}$$

$$l_{\delta_3} \equiv \Big\{(\delta,\alpha)\colon \arg\min_{\alpha} P(\alpha,\delta) < \alpha < \tfrac{1}{6}, \delta=\text{const}\Big\} \subset S_4 \subset S_3.$$

On each vertical line segment l_{δ_i}, $i = 2, 3$, (1) P is negative at the bottommost point, (2) P is positive at the topmost point, and (3) P is strictly increasing in α. It follows that for each δ in S_2 and S_3, there exists a unique $\alpha = \alpha_{\text{bffr}}^{\text{dspl}}(\delta)$ above which $\pi^{\text{bffr}} < \pi^{\text{dspl}}$, and vice versa.

This establishes that for all $0<\alpha<\frac{1}{6}$ and $0<\delta\le\hat{\delta}_{\text{int}}$, there exists at most one number $\alpha(\delta)$, depending on δ, for which $P(\alpha,\delta)=0$. Next, we show that such $\alpha_{\text{bffr}}^{\text{dspl}}(\delta)$ also exist for all $0<\alpha<\frac{1}{6}$ and $\hat{\delta}_{\text{int}}<\delta\le\frac{3}{5}-\alpha$. For that purpose, define

$$S_5 \equiv \{(\delta,\alpha)\colon 0<\alpha<\tfrac{1}{6}, \hat{\delta}_{\text{int}}<\delta<\tfrac{15}{32}\} \quad \text{and}$$
$$S_6 \equiv \{(\delta,\alpha)\colon 0<\alpha<\tfrac{1}{6}, \tfrac{15}{32}\le\delta<\tfrac{3}{5}-\alpha\}.$$

A direct calculation reveals that on S_5, $\alpha_{\text{bffr}}^{\text{dspl}}(\delta) = (1/21)(13 + 155\delta - 4\sqrt{5}\sqrt{5+32\delta+320\delta^2})$, and on S_6, $\alpha_{\text{bffr}}^{\text{dspl}}(\delta) = 1 + 7\delta - 2\sqrt{1+16\delta^2}$.

Now, to analytically check the retailer's incentives to carry the premium NB, the defender, and the SB, use Lemma 1 with $N=3$, $(v_1,v_2,v_3) = (v_{1/2}^{\text{bffr}}, v_{2/2}^{\text{bffr}}, 1)$, and $(w_1,w_2,w_3) = (w_{1/2}^{\text{bffr}}, w_{2/2}^{\text{bffr}}, \alpha+\delta)$.

Similarly, to check the retailer's incentives to carry the premium NB, the defender, and to drop the SB, use Lemma 1 with $N=3$,

$$(v_1,v_2,v_3) = (v_{1/2}^{\text{dspl}}, v_{2/2}^{\text{dspl}}, 1) \quad \text{and}$$
$$(w_1,w_2,w_3) = (w_{1/2}^{\text{dspl}}, w_{2/2}^{\text{dspl}}, \alpha+\delta).$$

This completes the proof. □

Appendix C. Definitions of A_H and A_L

Let

$$\bar{\alpha} \equiv \inf\left\{x\colon -\alpha\le\delta\le\tfrac{3}{5}-\alpha,\ x\le\alpha\le\tfrac{1}{6}, \frac{\partial\alpha_{\text{bffr}}^{\text{dspl}}(\delta)}{\partial\delta}<0\right\}$$

and

$$\underline{\alpha} \equiv \sup\left\{x\colon -\alpha\le\delta\le\tfrac{3}{5}-\alpha, 0\le\alpha\le x, \frac{\partial\alpha_{\text{bffr}}^{\text{dspl}}(\delta)}{\partial\delta}<0\right\},$$

where $\alpha_{\text{bffr}}^{\text{dspl}}(\delta)$ is defined in the proof of Proposition 3. Then

$$A_H \equiv \{(\delta,\ \alpha)\colon -\alpha\le\delta\le\tfrac{3}{5}-\alpha,\ \bar{\alpha}\le\alpha\le\tfrac{1}{6}\} \quad \text{and}$$
$$A_L \equiv \{(\delta,\ \alpha)\colon -\alpha\le\delta\le\tfrac{3}{5}-\alpha,\ 0\le\alpha\le\underline{\alpha}\}.$$

References

Ailawadi KL, Harlam B (2004) An empirical analysis of the determinants of retail margins: The role of store brand share. *J. Marketing* 68(1):47–65.

Ailawadi KL, Pauwels K, Steenkamp JEM (2008) Store brands and store loyalty. *J. Marketing* 72(11):19–30.

Barsky R, Bergen M, Dutta S, Levy D (2002) What can the price gap between branded and private-label products tell us about markups? Feenstra RC, Shapiro MD, eds. *Scanner Data and Price Indexes*, 1st ed. (NBER Studies in Income and Wealth) (University of Chicago Press, Chicago), 165–228.

Bonfrer A, Chintagunta PK (2004) Store brands: Who buys them and what happens to retail prices when they are introduced? *Rev. Indust. Organ.* 24(3):195–218.

Brander JA, Eaton J (1984) Product line rivalry. *Amer. Econom. Rev.* 74(3):323–334.

Chen X, Narasimhan O, John G, Dhar T (2010) An empirical investigation of private label supply by national label producers. *Marketing Sci.* 29(4):738–755.

Choi CS, Coughlin AT (2006) Private label positioning: Quality versus feature differentiation from national brand. *J. Retailing* 82(2):79–93.

Chryssolouris G (2006) *Manufacturing Systems: Theory and Practice*, 2nd ed. (Springer, New York).

Corstjens M, Lal R (2000) Building store loyalty through store brands. *J. Marketing Res.* 37(3):281–291.

Dhar SK, Hoch SJ (1997) Why store brand penetration varies by retailer. *Marketing Sci.* 16(3):208–227.

Dick A, Jain A, Richardson P (1996) How consumers evaluate store brands. *J. Product Brand Management* 5(2):19–28.

Du R, Lee E, Staelin R (2005) Bridge, focus, attack, or stimulate: Retail category management strategies with a store brand. *Quant. Marketing Econom.* 3(4):393–418.

Dukes AJ, Geylani T, Srinivasan K (2009) Strategic assortment reduction by a dominant retailer. *Marketing Sci.* 28(2):309–319.

Dunne D, Narasimhan C (1999) The new appeal of private labels. *Harvard Bus. Rev.* (May–June):3–8.

Gabszewicz JJ, Thisse J-F (1980) Entry (and exit) in a differentiated industry. *J. Econom. Theory* 22(2):327–338.

Gabszewicz JJ, Shaked A, Sutton J, Thisse J-F (1986) Segmenting the market: The monopolist's optimal product mix. *J. Econom. Theory* 39(2):273–289.

Gilbert RJ, Matutes C (1993) Product line rivalry with brand differentiation. *J. Indust. Econom.* 41(3):223–240.

Gruca TS, Sudharshan D, Ravi Kumar K (2001) Marketing mix response to entry in segmented markets. *Internat. J. Res. Marketing* 18(1–2):53–66.

Hauser JR, Shugan SM (1983) Defensive marketing strategies. *Marketing Sci.* 2(4):319–360.

Hayes RH, Wheelwright SC (1979) Link manufacturing process and product life cycles. *Harvard Bus. Rev.* (January):2–9.

Horowitz I (2000) An option-pricing look at the introduction of private labels. *J. Oper. Res. Soc.* 51(2):221–230.

Krajewski LJ, Ritzman LP (2004) *Operations Management: Processes and Value Chains*, 7th ed. (Pearson Prentice-Hall, Upper Saddle River, NJ).

Kumar N, Radhakrishnan S, Rao RC (2010) Private label vendor selection supply chain: Quality and clientele effects. *J. Retailing* 86(2):148–158.

Lal R (1990) Manufacturer trade deals and retail price promotions. *J. Marketing Res.* 27(4):428–444.

Liu Y, Cui TH (2010) The length of product line in distribution channels. *Marketing Sci.* 29(3):474–482.

Meza S, Sudhir K (2010) Do private labels increase retailer bargaining power? *Quant. Marketing Econom.* 8(3):333–363.

Mills DE (1995) Why retailers sell private labels. *J. Econom. Management Strategy* 4(3):509–528.

Narasimhan C, Wilcox RT (1998) Private labels and the channel relationship: A cross-category analysis. *J. Bus.* 71(4):573–600.

Pauwels K, Srinivasan S (2004) Who benefits from store brand entry? *Management Sci.* 23(3):364–390.

Pauwels K, Srinivasan S (2009) Pricing of national brands versus store brands: Market power components, findings and research opportunities. Rao VR, ed. *Handbook of Pricing Research in Marketing* (Edward Elgar Publishing, Cheltenham, UK), 258–282.

PLBuyer (2011) Suppliers guide. *PLBuyer* 25(2):60–72.

Private Label Manufacturers Association (2011) Private Label Manufacturers Association's (PLMA) 2011 private label yearbook. Technical report, Nielsen Company, New York.

Quelch JA, Harding D (1996) Brands versus private labels: Fighting to win. *Harvard Bus. Rev.* (January–February):99–109.

Raju JS, Sethuraman R, Dhar SK (1995) The introduction and performance of store brands. *Management Sci.* 41(6):957–978.

Ritson M (2009) Should you launch a fighter brand? *Harvard Bus. Rev.* (October):87–94.

Sayman S, Raju JS (2004) How category characteristics affect the number of store brands offered by the retailer. *J. Retailing* 80(4):279–287.

Sayman S, Hoch SJ, Raju JS (2002) Positioning of store brands. *Marketing Sci.* 21(4):378–397.

Scott-Morton F, Zettelmeyer F (2004) The strategic positioning of store brands in retailer–manufacturer negotiations. *Rev. Indust. Organ.* 24(2):161–194.

Sethuraman R (2009) Assessing the external validity of analytical results from national brand and store brand competition models. *Marketing Sci.* 28(4):759–781.

Sudhir K, Talukdar D (2004) Does store brand patronage improve store patronage? *Rev. Indust. Organ.* 24(2):143–160.

Villas-Boas JM (1998) Product line design for a distribution channel. *Marketing Sci.* 17(2):156–169.

Wernerfelt B (1986) Product line rivalry: Note. *Amer. Econom. Rev.* 76(4):842–844.