Vertical Control, Retail Inventories & Product Variety

By Howard P. Marvel and James Peck

Abstract

This paper analyzes distribution of products to consumers who have preferences for a particular product variant, such as a shoe of a given size. We assume that such consumers will switch to substitute, though for them inferior, products if a sufficient discount is offered. When the cost of a retailer's inventory is increasing in the number of variants (sizes) carried, we show that a manufacturer who attempts to induce competitive retailers to carry a particular size distribution will often fail if restricted to setting a wholesale price for each unit. Retailers that offer a less diverse assortment will be able to undercut full-line rivals. Consumers who prefer the sizes that continue to be carried benefit from lower prices but other consumers end up with inferior products and the manufacturer loses profits. The manufacturer's response to the narrowing of the equilibrium size distribution will offset some of the benefits to customers for sizes still carried. The manufacturer can restore its preferred sized distribution either by absorbing the cost of retail inventories (through a policy of accepting returns of unsold goods or via vertical integration) or by preventing retailers offering only popular sizes from discounting to attract customers from other product variants that the customers would prefer if all prices were the same. We use our model to explain the narrowing of size assortments observed after the passage of the Consumer Goods Pricing Act of 1974. Our model also predicts that vertically integrated catalog merchandisers will offer larger assortments than store-based retailers. Finally, we analyze the attempt by Starter, a manufacturer of sports team apparel, to prevent sub-wholesaling of the company's product lines.

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More than three-quarters of women and about two-thirds of men complain that stores simply don't have their size in stock.[1]

1   Introduction

This paper was prompted by the observation of one of the authors (the odd-sized one) that it has become far more difficult to find apparel and footwear products that fit. Retailer assortments of such products appear to be growing in terms of the number of styles and colors available, but over the last quarter century, the standard assortment of sizes handled by retailers, and particularly by discount retailers, has shrunk. The inability to find particular sizes does not arise from stock-outs, but rather from the sizes in question not being stocked in the first place. Limited size assortments are a hallmark of discount stores. Deep discount stores such as warehouse clubs carry particularly small size assortments.[2] But the range of sizes offered at department stores also appears to be narrowing. Few department stores carry shoes in narrow or wide sizes, and men's shirts, formerly stocked in $1/2$" collar increments and 1" sleeve lengths, now typically can be found in only small, medium, large, and extra large sizes with, normally, only two sleeve lengths per size.[3] The phenomenon that concerns us is not

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[1] 1995 Kurt Salmon Associates Consumer Pulse Survey, reported in Friedman (May 29, 1996)

[2] A trade press report on deep discount stores provides the following characterization: "Size assortments and breadth of brands carried are narrow and limited, while depth of inventory on hand is deep. Limited assortment ranges keep operating costs lower since wider assortments boost receiving and warehousing costs, as well as data processing costs associated with more stock-keeping units (SKUs) and space costs for more display. Limiting assortments to a few brands and a few sizes boosts volumes sold per SKU and lowers purchase costs." (Magrath, 1993).

[3] The change is typified by a customer who "asked a clerk at Banana Republic to find him a shirt in size 16$1/2$, 35. The kid stared at him, baffled.

merely that unusual sizes are disappearing from mass market retailers, but also that assortments of products for consumers of common sizes are becoming more coarse.

Why has the range of sizes offered contracted so substantially? The change does not appear to derive from an increase in the cost of producing garments or shoes in a wide variety of sizes: inspection of the size assortments of catalog and on-line retailers show them to be as wide or wider than ever. Occasionally even apparel brands typically carried in limited sizes can be found in a fuller size range at a few retailers, suggesting again that production costs are not the governing factor.[4] The problem appears to be one of obtaining distribution for a wide array of sizes, not of producing that array.

This paper offers an explanation based for the narrow range of sizes currently offered based on the cost of holding inventories of multiple sizes and the willingness of consumers to accept apparel items and shoes that provide a less-than-perfect fit. We

'There are two generations who don't even know what that means,' Fairchild says. (His neck measures 16$\frac{1}{2}$ inches, and his sleeve length is 35 inches.)" See Mclaughlin (September 21, 1999).

A more extensive discussion (Fenton, August 22, 1999) reaches the same conclusion:

> It's true, shirts used to be widely available in exact sleeve lengths. Today, they are still available, but certainly not so widely. Many manufacturers, in an ongoing effort to cut down on inventory, no longer make shirts in five exact sleeve lengths: 32, 33, 34, 35 and 36. Instead they make two sizes, referred to as 32/33 (sometimes called short) and 34/35 (long).
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> The actual sleeve lengths on these shirts are 32$\frac{1}{2}$ for the shorter ones and 34$\frac{1}{2}$ for the longer. It's obvious these two sizes are not going to be a precise fit for a lot of men.
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> It is also obvious that this is a cost-cutting technique used in making less expensive shirts (usually less fine in other respects as well as shirt sleeve options) and, oddly, also in some super-expensive designer shirts as well. The top-of-the-line shirtmakers who resort to this strategy coyly claim it allows customers to have their sleeves custom-shortened to exact specifications. But it really just saves the manufacturers money and the retail stores both money and shelf space.
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> Shirts with exact sleeve lengths can still be found in up-scale department stores among their better shirts, in top-drawer men's specialty shops, such as the Shirt Store and in the finer catalogs, such as Lands' End.

A similar problem exists for shoes: "Thousands of American women with C- and D-width feet endure B-width shoes because that's the only size most stores sell." (Thompson, June 27, 1999). Men's shoes are also widely available only in one width, D.

[4]Fenton (August 22, 1999), referring to sleeve lengths, advises that "[y]ou can even find them in quality off-price clothing stores, such as Marshalls. They usually cost about $10 to $15 more than similar shirts without exact sleeve lengths, and they may be well worth the difference."

show that a manufacturer who attempts to induce retailers to hold its preferred size assortment when selling through a competitive retail sector is unlikely to be able to do so if the only instrument under the manufacturer's control is a constant wholesale price per unit of its product. Retailers that offer a less diverse assortment will be able to undercut full-line rivals. Customers who prefer the sizes that continue to be offered may benefit in the resulting equilibrium, but customers who prefer in-between or unusual sizes, as well as the manufacturer, are harmed. The manufacturer's response to the narrowing of the equilibrium size assortment—increased wholesale prices—will offset some of the benefits to customers for popular sizes.

Discounting is the source of the manufacturer's problem in achieving adequate retail inventories of its preferred size assortment. But even if the manufacturer cannot prevent such discounting of its products, it can restore its preferred size assortment in a number of ways. Our analysis attributes the narrowing of the size assortment to the retailers' inventory holding costs. Manufacturers can absorb the cost of retail inventories through a policy of accepting returns of unsold goods or via vertical integration. Alternatively, the manufacturer can attempt to prevent retailers offering only popular sizes from discounting to attract customers from other product variants that the customers would prefer if all prices were the same, using a form of resale price maintenance. Finally, the manufacturer can force retailers to hold and pay for the manufacturer's full assortment, though, as we shall see below, this forcing solution will often require that dealers not be permitted to reallocate inventory among themselves.

We model consumers' desired sizes in a spatial setting, an approach that has been widely used in modeling vertical restraints (Winter, 1993; Mathewson and Winter, 1984). Our model, however, rests on a "locational" characteristic such as size or style, where different consumers would choose different products if all were offered the same price.

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In contrast, Winter (1993) and Mathewson and Winter (1984) model consumers as having heterogeneous preferences over price and quality of service, but service is vertically differentiated—all consumers agree that more service is better than less. Other authors employ spatial models of vertical restraints to consider strategic effects (Gal-or, 1991; Rey and Stiglitz, 1995; Bonanno and Vickers, 1988). Our approach has the surprising consequence that a manufacturer with monopoly power over its market niche and full ability to choose which product characteristics to offer may nonetheless settle for an inferior set of sizes. The reason is that retailers must be prevented from discounting and thereby inducing consumers to accept a less-than-perfect fit. Our results bear a resemblance to results from models of retail outlet density (Gallini and Winter, 1983; Gould and Preston, 1965; Reagan, 1986), but again, our manufacturer controls directly the density of products offered in location space.

Our analysis proceeds as follows. In Section 2, we provide a simple description of our assumptions and present an example that demonstrates the process we have in mind. Section 3 presents a model of assortment choice by retailers facing costly inventories. Section 4 discusses the types of product characteristics that are most difficult to support in a competitive retail sector, reconciling the decline the the size assortment with increases in variety measured in other dimensions. This section also applies the theory to understand the motivation of Starter, a manufacturer of sports team apparel, for preventing independent wholesaling for its products. Section 5 offers concluding results and suggestions for future research.

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2 Inventories and Sizes: An Example

This section introduces our analysis by providing a much-simplified example of a retail sector in which the size assortment offered to consumers collapses due to discounting. This example also illustrates the role that retail inventories play in governing the assortment that will be offered in equilibrium.

We begin by assuming that there is a single representative consumer whose ideal size is either small, medium, or large. The consumer has a willingness to pay $v = 1$ for one, and only one, unit of the good in his or her ideal size. The consumer is willing to move at most one size away from his or her preferred size, and places a valuation of $1 - \gamma$, $1 > \gamma > 0$, on a unit of the good one size different from that consumer's ideal size. We thus assume that the consumer has a "right" size and an equal loss from moving to an inferior size. In our formal model, we relax this assumption.

The manufacturer is assumed to be able to produce units of each size with marginal cost of zero. There are no fixed costs of production associated with adding a new size. The manufacturer offers units of each size to retailers at constant prices per unit of w_S, w_M, and w_L for small, medium and large, respectively. These prices are set prior to the market period and remain fixed throughout the period.

Retailers (at least two) observe the wholesale prices and choose their retail prices simultaneously. Retailers then choose inventories. The consumer is able to observe both retail prices and available inventories, and decides which unit to purchase. The consumer's size is his or her private information. From the perspective of the manufacturer and retailer, the consumer's size is equally likely to be small, medium, or large.

In equilibrium, retailing of the manufacturer's line is contestable—a retailer will

adopt the line as long as it is expected to yield non-negative profits. Competition among retailers forces profits to zero, and only one retailer stocks a particular size in equilibrium.

The manufacturer would prefer that the retailer stock a unit in each of the three sizes. The customer would then find his or her preferred size in stock, and would be willing to pay a retail price, p^r, equal to one. The retailer's revenue would then be one, so that it would earn zero profits if the manufacturer sets the wholesale price equal to $\frac{1}{3}$. The manufacturer makes profits of one and the consumer retains no surplus. Unfortunately for the manufacturer, however, this solution, which is first best for the manufacturer, is not consistent with equilibrium.

Given a wholesale price of $\frac{1}{3}$, the retailer would have an incentive to deviate. If the retailer chose to sell only size M, setting a retail price of $p^r = 1 - \gamma$, all consumer types would purchase from that retailer.[5] Choosing one unit of size M to hold in inventory, the retailer's profit would be $(1 - \gamma) - \frac{1}{3}$, which is positive whenever $\gamma < \frac{2}{3}$ holds. A customer whose ideal size is M would receives a surplus of γ, while a customer of size S or L would obtain no surplus.

Since the manufacturer cannot obtain the integrated solution in which all three sizes are ordered, it has two options. First, the manufacturer could raise the wholesale price to $1 - \gamma$, anticipating that only size M would be ordered. Size M would be offered at a retail price of $1 - \gamma$, all consumers would purchase, and the manufacturer's profit would be $1 - \gamma$. The manufacturer's second option is to induce sizes S and L to be ordered, but not size M. To do so most profitably, the manufacturer would set a wholesale price of $\frac{1}{3}$ for sizes S and L, and a prohibitively high wholesale price exceeding 1 for size M.[6] The retail prices for sizes S and L would be 1, so medium-sized consumers would

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[5]Lowering p^r slightly below $1 - \gamma$ would induce all consumer types to strictly prefer the retailer.
[6]Since this is a motivating example, and a general framework based on fixed inventory costs is

not purchase, and the manufacturer's profit would be $2/3$.

Comparing options 1 and 2 above, we see that option 1 will be chosen when we have $0 \leq \gamma < 1/3$, and option 2 will be chosen when we have $1/3 < \gamma < 2/3$. In both cases, the outcome is a limited assortment of sizes available. For example, suppose that $0 \leq \gamma < 1/3$ holds. Only size M is available, and total surplus falls from the vertically integrated solution. Consumer surplus is now $\gamma/3$. The decline in expected total surplus is a consequence of ill-fitting clothes for small and large consumers—these consumers could be fitted properly if the retail sector could be induced to carry all three sizes. The transfer to a medium consumer occurs because he or she obtains the benefit of the price cut to induce other consumer types to wear clothes that do not fit properly.

Thus the reason that the manufacturer is worse off is that when the retailer discounts its suggested list price, customers do not receive their most-preferred product variants, even though it costs the manufacturer nothing to produce for each of the three possible sizes of customer. The manufacturer does not pay for the units held as inventory for each of the sizes, but the retailer does, and therein lies the problem. It is a problem with a ready solution—so long as the manufacturer bears the cost of retailer inventories, as, for instance, when it accepts returns of unsold products for full credit, it can prevent discounting. The manufacturer could equivalently provide its products to dealers on consignment. Such arrangements became far less common a century ago, however, when retailing shifted from commission sales and manufacturer's representatives to mass distribution (Chandler, 1977). Retailers now typically take title to the goods they sell when they obtain those goods from the manufacturer, leading to the misalignment

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formally analyzed below, we omit the details. Basically, if the medium-sized consumer purchases, say, size S, then the wholesale price for size S must be less than the wholesale price for size L in order to be consistent with the equilibrium of the retail subgame. However, the wholesale price for size L can be at most $1/3$. Therefore, manufacturer profits cannot exceed $2/3$ when only sizes S and L are carried.

of incentives to hold inventories that is at the heart of our analysis.[7]

If the retailer does indeed take title to the goods it sells or holds in inventory and has no recourse to returns of unsold goods, the manufacturer can still obtain its preferred inventories by imposing vertical restraints. If the manufacturer can impose a price of one through resale price maintenance, the retailer will hold the desired stock. Resale price maintenance is, however, a per se violation of the Sherman Antitrust Act.[8] Another alternative is full line forcing. In more complex settings, this approach is limited by the retailer's ability to reorder the sizes it needs. A manufacturer can ship a full assortment, but if it cannot predict accurately which goods a particular retailer will sell, the manufacturer cannot ensure that the assortment will stay in stock. We will see below, in Section 4, that retailer transshipping can also defeat forcing if the distribution of preferred product characteristics differs across markets.

The example provides a simple illustration of the difficulty a manufacturer faces when selling a line of products. All that is required is that the retailer pay for inventories that it may not be able to sell, and that it be able to reduce those inventories by limiting the breadth of its line. We demonstrate these points more formally in the model that follows.

3   The Model

This section provides a formal treatment of the ideas introduced in the preceding example. The market we model consists of a single manufacturer and an infinite number

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[7]Note that another consequence of mass distribution is that retail establishments will often shift from brand to brand, suggesting that our characterization of retailing for a particular product as contestable is a reasonable assumption.

[8]For a more complete discussion, see Marvel (1994).

of potential entrants into the retail market.[9] The space of possible products is denoted by the real line, which could be interpreted as a product characteristic such as color or length, but which, for convenience, we will refer to as size. A point on the real line represents a particular size of the manufacturer's product. Consumers are distributed along the real line, where a consumer at location t is said to be size t. A consumer of size t who pays a price, p, to purchase a product of size τ receives utility given by:

$$u(t, \tau) = v - z \mid t - \tau \mid -p$$

where v represents a consumer's valuation of consuming his or her ideal size. We assume that consumers are evenly distributed across the real line, and we normalize the measure of consumers within any interval of length one to be one.

The manufacturer faces a fixed cost, F^m, for each size offered. We normalize marginal production costs to be zero. For each size carried by the retailer, the retailer also incurs a fixed cost, which accrues to the manufacturer. Our interpretation is that the retailer must have a certain number of units in stock at all times, F, and that these inventories go to waste after the market period is over.[10] We assume that returns policies, consignment, or other arrangements equivalent to vertical integration, are impossible. Each retailer seeks to maximize expected profits, and the manufacturer seeks to maximize profits per consumer.[11] To guarantee that a vertically integrated monopolist would

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[9]We assume that an infinite number of retailers are prepared to adopt one or more components of the manufacturer's line so long as the components in question are expected to yield nonnegative profits.

[10]As discussed in the example, we need the retailer to face a positive probability of unsold goods, which cannot be returned to the manufacturer. In order to support these inventories, which must be paid for by retailers in advance, the manufacturer will be forced to set a wholesale price below the ultimate retail price. Retailers might then have an incentive to cut their prices, carry a smaller line of products, and profitably induce consumers to switch away from their ideal size. Our fixed cost corresponds to the *certainty* that there are unsold goods, which is far simpler than the alternative where demand is random.

[11]We assume that consumers are evenly spread across the real line in order to have a symmetric

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wish to serve the market, we assume that $v \geq \sqrt{2F^m z}$ holds, which is necessary and sufficient for monopoly to be profitable.

The timing of the game is as follows. First, the manufacturer chooses a countable set of sizes to offer, $\{\ldots, \tau_{-2}, \tau_{-1}, \tau_0, \tau_1, \tau_2, \ldots\}$. We adopt the convention that size 0 is offered, $\tau_0 = 0$. The manufacturer specifies a wholesale price, p_i^w, for each size i that it chooses to offer. Next, a large number of potential retailers simultaneously announce a retail price, p_i^r, for each size that they are prepared to carry. Given the retail prices, consumers (who behave non-strategically) purchase one unit from the firm offering them the highest utility, if nonnegative, or choose not to purchase if all firms offer negative utility.[12] Retailers incur the fixed cost, $p_i^w F$, for each size that one of their customers demands.[13]

Our solution concept is subgame perfect Nash equilibrium.

Lemma 1 *In any equilibrium to the retail subgame, all retailers must receive zero profits.*

Proof. Suppose not, so some retailer receives positive profits. We know that there must be potential retailers who have not entered, because of the fixed cost. One of these retailers could instead enter the market, undercutting the profitable firm's retail price, by $\varepsilon > 0$, for each size the profitable firm carries. For sufficiently small ε, this deviation must be profitable. ∎

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outcome. To avoid boundary effects, we require an unbounded product space. Unfortunately, this also leads to unbounded total profits for the manufacturer. We are confident that our equilibrium spacing of sizes emerges in the limit, as we consider games with a bounded product space (where the manufacturer maximizes total profit).

[12]If two retailers tie for the lowest retail price for a give size, then all consumers purchasing that size are assumed to select the same retailer, for example, the retailer whose name comes first in alphabetical order. This assumption ensures that, in equilibrium, one firm serves the entire market for the size in question, but this retailer is still pressured to price at average cost. This is a standard assumption to guarantee contestability.

[13]The cost is fixed in that it does not depend on the quantity sold, but it depends on the wholesale price. This is in keeping with our interpretation of the cost as representing unsold inventories.

Lemma 2 *In any equilibrium to the full game, only one retailer can carry any particular size.*

Proof. Suppose not. If there were two retailers selling a particular size, and receiving nonnegative profits, then they must each pay the fixed cost. (It is inconsistent with equilibrium for the retailers to be earning negative profits in this size, because one of the retailers could increase its price on this size and avoid the fixed cost, without affecting revenues on any other size.) However, a potential retailer could slightly undercut the two retailers, thereby receiving (almost) the combined revenues of the two retailers, but at lower cost. ∎

We conclude that, in equilibrium, there is only one retailer carrying a given size, and all retailers receive zero profits.[14]

We will construct a symmetric equilibrium, in which there is a constant distance, d^*, between sizes offered by the manufacturer, all sizes are offered at the same wholesale price, all sizes offered are carried by retailers, and all retailers charge the same price. Consumers therefore purchase from the nearest retailer, so the retailer carrying size τ serves all consumers who purchase and are located between $\tau - d^*/2$ and $\tau + d^*/2$. Also, the consumer whose ideal size is exactly equidistant between the two nearest sizes offered (for example, size $d^*/2$) receives zero utility by purchasing in equilibrium.

Let $[t_i, t_i']$ denote the interval of customers served in equilibrium by the retailer selling size τ_i. Then, from Lemma 1, we have the contestable markets condition,

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[14]We are assuming that established retailers can choose whether or not to carry the manufacturer's line, and since the product has no scrap value, there are no mobility barriers for this market. While the retailer's inventory is sunk, there is no carry-over to the next period, so the retail market is contestable (Baumol, 1982). Our model does not require that a separate retailer sell each size—one retailer could be selling all of the sizes. As we will see below in Section 4, one solution to the manufacturer's problem is to engage in full line forcing—which means forcing a retailer to hold inventory in each size the manufacturer offers.

$$\pi_i^r = (p_i^r - p_i^w)(t_i' - t_i) - p_i^w F = 0. \tag{1}$$

Also, let $s_i z$ denote the equilibrium utility received by the consumer at location t_i from purchasing size τ_i, and let $s_i' z$ denote the equilibrium utility received by the consumer at location t_i' from purchasing size τ_i. Then the retail price must satisfy

$$p_i^r = v - (\tau_i - t_i)z - s_i z = v - (t_i' - \tau_i)z - s_i' z. \tag{2}$$

A necessary condition for equilibrium is that retailer i cannot profit by slightly undercutting p_i^r and expanding its customer base. The specification of this no-local-undercutting constraint depends on whether the expansion of the customer base encroaches on zero, one, or two neighboring retailers. We now derive the no-local-undercutting constraint for the case in which the retailer faces competition from both sides. (For the other two cases, the condition would be even stronger, since it is more tempting to undercut.)

If retailer i cuts its retail price to increase its customer base by δ on both sides, the consumer at location $t_i - \delta$ must be indifferent between purchasing from retailer i and retailer $i - 1$. It follows that retailer i must reduce its retail price by $2z\delta$, so profits can be expressed as

$$\hat{\pi}_i^r = (p_i^r - p_i^w - 2z\delta)(t_i' - t_i + 2\delta) - p_i^w F. \tag{3}$$

Using equation 1, and simplifying, we have

$$\hat{\pi}_i^r = 2\delta \left[\frac{p_i^w F}{t_i' - t_i} - (t_i' - t_i)z - 2z\delta \right]. \tag{4}$$

Since the right side of equation 4 must be nonpositive for all δ, the no-local-undercutting

constraint is

$$\frac{p_i^w F}{z} \le (t_i' - t_i)^2. \tag{5}$$

To construct the equilibrium, we first consider the problem in which the manufacturer chooses $\{\tau_i, p_i^w, p_i^r\}$ for each integer i, subject only to equations 1, 2, and the (weak) no-local-undercutting constraint, (5).[15]

Lemma 3 *If the manufacturer chooses $\{\tau_i, p_i^w, p_i^r\}$ for each integer i, to maximize profits (per consumer) subject only to equations (1), (2), and (5), then there is a solution that satisfies, for all i, $s_i = 0$, $s_i' = 0$, and*

$$\tau_i - \tau_{i+1} = d^* \equiv \max\left[\sqrt{\frac{9F^2}{16} + \frac{vF}{z}} - \frac{3F}{4}, \sqrt{\frac{2F^m}{z}}\right] \tag{6}$$

$$p_i^w = \frac{(v - \frac{d^* z}{2})d^*}{d^* + F}. \tag{7}$$

Proof. First we look at the configuration for a single market that maximizes the manufacturer's profits (per consumer). That is, for market i, suppose that the manufacturer could choose $(\tau_i, p_i^w, p_i^r, t_i, t_i', s_i, s_i')$ to maximize

$$p_i^w + \frac{p_i^w F}{t_i' - t_i} - \frac{F^m}{t_i' - t_i}, \tag{8}$$

where constraints 1, 2, and 5 only have to hold for market i. In equation 8, the first term represents revenues from output that the retailer sells to consumers, the second term represents revenues from output that is not subsequently sold to consumers (since

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[15]In particular, we do not impose the constraint that a retailer cannot profit from a large deviation that attracts all of the customers from neighboring markets.

retailers' fixed costs accrue to the manufacturer), and the third term represents the manufacturer's fixed cost, since the number of sizes offered per unit interval of consumers is $1/(t_i' - t_i)$. Since only relative positions matter, we can think of the manufacturer as choosing $(t_i' - t_i)$ and $(\tau_i - t_i)$ rather than τ_i, t_i, and t_i'. Given $(t_i' - t_i)$ and p_i^w, equation 1 determines p_i^r. The choice of $(\tau_i - t_i)$ then determines s_i and s_i' from equation 2. Since $(\tau_i - t_i)$ only affects how total surplus is allocated across consumers, and whether surplus is nonnegative, we can impose $(\tau_i - t_i) = (t_i' - \tau_i)$, without loss of generality, which implies $s_i = s_i' \equiv s$. With some substitutions, and letting d stand for $(t_i' - t_i)$, we can write the problem that finds the optimal configuration for one market in isolation as

$$\max_{p^w, d, s \geq 0} p^w + \frac{p^w F}{d} - \frac{F^m}{d} \tag{9}$$

subject to

$$p^w = (v - \frac{dz}{2} - sz)\frac{d}{d + F} \tag{10}$$

$$\frac{p^w F}{z} \leq d^2 \tag{11}$$

If the parameters are such that the no-undercutting constraint, (11), does not bind, then the solution is $s = 0$, $d = \sqrt{\frac{2F^m}{z}}$, and p^w such that equation 10 is satisfied. If constraint 11 binds, substitute equation 11, which holds as an equality, into equation 10, which simplifies to

$$d^2 + \frac{3F}{2}d + sF - \frac{vF}{z} = 0. \tag{12}$$

Solving equation 12 for d as an implicit function of s, we have

$$d = \sqrt{\frac{9F^2}{16} + \frac{vF}{z} - sF} - \frac{3F}{4}. \tag{13}$$

Substituting the right side of (13) for d in the objective function, (9), it can be determined that manufacturer profits are decreasing in s, so the solution is $s = 0$, $d = \sqrt{\frac{9F^2}{16} + \frac{vF}{z}} - \frac{3F}{4}$, and p^w such that equation 10 is satisfied. Therefore, the optimal configuration of a single market is characterized by:

$$s^* = 0, d^* = \max\left[\sqrt{\frac{9F^2}{16} + \frac{vF}{z}} - \frac{3F}{4}, \sqrt{\frac{2F^m}{z}}\right] \tag{14}$$

Because this optimal configuration gives all marginal consumers zero surplus, $s_i = s'_i = 0$, the manufacturer can "stack" these markets together, with no gaps. Let us return to the problem in which the manufacturer chooses $\{\tau_i, p_i^w, p_i^r\}$ for each integer i, to maximize profits (per consumer) subject to equations 1, 2, and 5. Let $\tau_i = id^*$ hold, let p_i^w be determined by equation 7, and let p_i^r be determined by (1). It is easy to see that t_i is the midpoint between τ_{i-1} and τ_i, and that $s_i = 0$. In other words, equations (1), (2), and (5) are satisfied, and the manufacturer achieves the optimal configuration derived above. ∎

Proposition 4 *There is a symmetric equilibrium in which the distance between any two adjacent sizes is d^*, each wholesale price is $\frac{(v - \frac{d^*z}{2})d^*}{d^* + F}$, and each retail price is $(v - \frac{d^*z}{2})$.*

Proof. Given the sizes offered and the wholesale price, the zero retail profit condition requires that the retail price is bid down to $(v - \frac{d^*z}{2})$. Inequality 5 is satisfied, so there is no incentive for a retailer to lower its retail price to expand its customer base. To show that the retail subgame is in equilibrium when all retailers choose a retail price of $(v - \frac{d^*z}{2})$, we must show that large deviations, to capture entire neighboring markets, are not profitable.[16]

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[16]Equation 3 is not valid for large deviations. When the retailer offering size 0 chooses $\delta = \frac{d^*}{2}$, so the consumer at location d^* switches to size 0, all of the consumers in the interval $[d^*, \frac{3d^*}{2}]$ also switch

Without loss of generality, consider the case of a retailer offering size 0 at the price $\hat{p}^r$, such that, for $A = 3, 5, 7, \cdots$, consumers in the interval, $[-\frac{Ad^*}{2} - \delta, \frac{Ad^*}{2} + \delta]$, purchase size 0, for $0 \le \delta < \frac{d^*}{2}$ (see figure 1). The potential retailer's profit, denoted by $\hat{\pi}^r(A, \delta)$, is given by

$$\hat{\pi}^r(A, \delta) = \left[v - \frac{Ad^*z}{2} - 2z\delta \right] (Ad^* + 2\delta) - \frac{(v - \frac{d^*z}{2})d^*}{d^* + F} (Ad^* + 2\delta + F). \tag{15}$$

Substituting $t_i' - t_i = d^*$, $p_i^w = \frac{(v - \frac{d^*z}{2})d^*}{d^* + F}$, and $p_i^r = (v - \frac{d^*z}{2})$ into equation 3, we know that a retailer cannot profit from carrying size $\frac{(A-1)d^*}{2}$ and having the same marginal customer, at location $\frac{Ad^*}{2} + \delta$. From (3) and (15), we can derive the following:

$$\frac{\hat{\pi}_i^r - \hat{\pi}^r(A, \delta)}{d^*(A - 1)} = 3z\delta + \frac{(A + 1)zd^*}{2} - v + \frac{(v - \frac{d^*z}{2})d^*}{d^* + F} \tag{16}$$

The right side of (16) is increasing in both A and δ, so if we can show that the expression is nonnegative for $A = 3$ and $\delta = 0$, it must be nonnegative for all A and δ in the specified ranges. Since we have $\hat{\pi}_i^r \le 0$, the right side of (16) nonnegative would imply that $\hat{\pi}^r(A, \delta) \le 0$ holds as well. Substituting $A = 3$ and $\delta = 0$ into (16), we must show

$$2zd^* - v + \frac{(v - \frac{d^*z}{2})d^*}{d^* + F} \ge 0 \tag{17}$$

Inequality 17 can be reduced to $(d^*)^2 + \frac{4F}{3}d^* - \frac{2Fv}{3z} \ge 0$, which holds if we have

$$d^* \ge \sqrt{\frac{4F^2}{9} + \frac{2vF}{3z}} - \frac{2F}{3}. \tag{18}$$

to size 0. This follows from the linearity of the utility function.

Some straightforward calculations indicate that inequality 18 is implied by the definition of d^* in (6).

Finally, consider $\hat{p}^r$ such that, for $A = 3, 5, 7 \cdots$, consumers in the interval, $[-\frac{Ad^*}{2} - \delta, \frac{Ad^*}{2} + \delta]$, purchase size 0, for $\frac{d^*}{2} \leq \delta < d^*$. It follows that all consumers within the interval, $[-\frac{(A+2)d^*}{2}, \frac{(A+2)d^*}{2}]$, are willing to purchase size 0, so this case has already been considered (with $\delta = 0$).

We have shown that the retail subgame is in equilibrium. Since conditions 1, 2, and 5 are necessary conditions for any equilibrium of any retail subgame, it follows from Lemma 3 that the manufacturer cannot improve on its objective, either. ∎

Because of the infinite commodity space, the manufacturer's objective is unaffected if, say, it leaves a finite amount of the commodity space unexploited. Thus, there may be other equilibria in which the manufacturer sets prices and the distance between sizes offered as characterized in Proposition 4, except for a finite section of the product space. We focus on the "natural" solution in which the efficient pattern holds everywhere, rather than almost everywhere. Also, Proposition 4 justifies restricting attention to the game where the manufacturer must choose a constant wholesale price and distance between sizes offered. That game would have a unique equilibrium (our characterization above), which remains an equilibrium if the manufacturer's strategy space is not restricted.

Corollary 5 *There exists $\overline{F}^m > 0$ such that, when $F^m \geq \overline{F}^m$ occurs, then the manufacturer offers the same set of sizes as a vertically integrated firm would offer. When $F^m < \overline{F}^m$ occurs, then the manufacturer offers fewer sizes (i.e., more distance between sizes) than an integrated firm would offer.*

Corollary 5 follows from Proposition 4 and equation 14 and the fact that the vertically

integrated firm chooses $s = 0$ and $d = d^*$ to maximize (9) subject only to constraint 10, exactly as the manufacturer does when the constraint given by (11) is not binding.

We now provide some comparative statics results.

Proposition 6   *i. If the equilibrium spacing is the same as the vertically integrated solution, so constraint 11 does not bind, then we have*

$$\frac{\partial d^*}{\partial F^m} > 0, \frac{\partial d^*}{\partial z} < 0, \frac{\partial d^*}{\partial F} = 0, \ and \ \frac{\partial d^*}{\partial v} = 0,$$

ii. If constraint 11 binds, so the equilibrium spacing is coarser than the vertically integrated solution, then we have

$$\frac{\partial d^*}{\partial F^m} = 0, \frac{\partial d^*}{\partial z} < 0, \frac{\partial d^*}{\partial F} > 0, \ and \ \frac{\partial d^*}{\partial v} > 0,$$

iii. The coarser spacing induces a higher wholesale price, so that solving equation 10 (with $s = 0$) for p^w as a function of d, we have

$$\frac{\partial p^w(d^*)}{\partial d} > 0.$$

Proof. Part (i) follows immediately from equation 14. For part (ii), $\partial d^*/\partial F^m = 0, \partial d^*/\partial z < 0$, and $\partial d^*/\partial v > 0$ follow immediately from (14). Also, d^* is of the form

$$d^* = \sqrt{a^2 F^2 + bF} - aF, \tag{19}$$

with positive parameters $a = {}^3/4$ and $b = {}^v/z$. From (19), one can show that $\partial^2 d^*/\partial F \partial b > 0$, which implies $\partial d^*/\partial F > \partial d^*/\partial F \mid_{v/z=0} = 0$.

For part (iii), from equation 10 (with $s = 0$), we calculate

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$$\frac{\partial p^w}{\partial d} = \frac{(d + F)(v - zd) - vd + \frac{zd^2}{2}}{(d + F)^2}. \tag{20}$$

Therefore, we have

$$\text{sign}(\frac{\partial p^w}{\partial d}) = \text{sign}(Fv - Fzd - \frac{zd^2}{2}). \tag{21}$$

Substituting $d = d^*$ into the right side of (21), the expression can be simplified to $\text{sign}(\frac{v}{2Fz} + \frac{3}{16} - \frac{1}{16}\sqrt{9 + \frac{16v}{Fz}})$. This expression can be treated as a function of the single positive variable, v/Fz, whose value is zero at $v/Fz = 0$, and whose derivative is positive. Therefore, $\partial p^w/\partial d > 0$ (when evaluated at d^*). ∎

Proposition 6 says that when the spacing of sizes in equilibrium is the same as in the vertically integrated solution, the assortment of sizes offered shrinks with increases in the manufacturer's fixed cost, or with decreases in consumers' "transportation cost," that is, their intensity of preference for a particular size. A retailer's inventory requirement is not relevant, since the wholesale price adjusts to ensure zero profits and achieve the vertically integrated outcome. The consumers' willingness to pay for an ideal size, v, affects the equilibrium retail price and manufacturer's profits, but does not affect the spacing between sizes offered in equilibrium.

When constraint 11 is binding, the manufacturer's fixed cost is irrelevant for the equilibrium spacing, which is instead determined by the need to prevent retailers from discounting and inducing consumers to switch sizes. Fewer sizes are offered when the retailers' fixed cost is greater, because there is a greater incentive to discount and expand one's customer base. Fewer sizes are offered when consumers' transportation cost is lower, because consumers are more tempted to switch sizes in response to discounting. Fewer sizes are offered when v is greater, because the manufacturer charges a higher

wholesale price to extract this additional surplus, which forces the manufacturer to offer fewer sizes (since $\partial p^w / \partial d > 0$ when evaluated at d^*).

4   When Does Variety Shrink? The *Starter* Case

A trip to a "category killer" store for any of the numbers of product classifications that have such stores will likely convince the reader that variety in assortments is often not lacking. We have remarked that footwear is a product for which the size assortment has become much more limited, but customers do not want for a plethora of styles of shoes. These contrasting observations suggest that if our theory is to be credited, it must apply only to some product characteristics. Consideration of our assumptions makes it clear that the customer must have a clear preference for one component before he or she visits a retailer in search of that component. When a consumer shops for styles, the sheer variety of styles offered at a particular location can be an attraction in and of itself if that consumer does not set off with a particular style in mind. In contrast, a consumer is likely to know which size he or she prefers, and will be willing to pay a premium for that particular size. Variety may be the spice of life, but it does little good for an extra large shopper to be offered a small size of apparel.

Our analysis is not limited to sizes, however. Consumers often form allegiances to sports teams, often, but not always the "home" team from the consumer's community. Such consumers may wish to display their attachment to a particular team by wearing apparel with the team's logo or symbol prominently displayed. Starter Sportswear[17] was a licensee of all of the major sports leagues, Major League Baseball, the National

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[17]The details of the Starter case are from the opinion in Trans Sport, Inc., v. Starter Sportswear, Inc., 964 F.2d 186 2nd Cir., 1992) (hereinafter *Starter*). The opinion in this case was written by then-retired Justice Thurgood Marshall.

Football League, the National Basketball Association, and the National Hockey League. Each league authorized Starter to produce "authentic" satin team sports jackets, that is, copies of those worn by the athletes and coaches in the respective league. Starter sold these jackets through retailers which included Trans Sport,[18] a retailer that sold through its own direct-mail catalogs as well as through a retail outlet of its own. But when Trans Sport began to resell Starter jackets to retailers nationwide, Starter refused to fill its orders and instituted a policy of banning transshipments or resale to unauthorized locations.

Starter had imposed a minimum order requirement on its retailers, but one that was tailored to the market in which each retailer operated. Starter described its policy as one "of selling only to retail outlets which carry a representative amount of the line as deemed appropriate by Starter in light of the type of retail outlet, the status of Starter's line or lines of merchandise, and marketing conditions." While Trans Sport tried to argue that this was an illegal tie designed to force Starter's customers to purchase other merchandise from Starter (caps, T-shirts, and so on) as a condition for receiving Starter jackets, it was unable to present any evidence to this effect, leading the court to conclude that this policy was designed to require dealers simply to carry a significant portion of its line of jackets.

Trans Sport found an apparently profitable business opportunity in ordering the full line from Starter in large quantities, but then reselling to retailers (for a $7 per jacket fee) in quantities that fell short of Starter's minimum order requirement. That is, retailers could pay a premium to obtain only the jackets that were most likely to have high inventory turnover in their areas.

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[18]Trans Sport was actually the sister company of Stickley, the retailer and direct-mail company that began transshipping to retailers. To avoid confustion, we will use "Trans Sport" to refer to both Stickley and Trans Sport.

Starter justified its refusal to deal with Trans Sport using standard economic arguments developed to explain resale price maintenance. As Justice Marshall noted: "Starter's intrabrand restrictions also help to convey to consumers a message of quality; consumers with little knowledge of league products may find a surrogate for information 'in the very fact that a dealer with a reputation for handling quality merchandise stocks a particular brand ...For some consumers, this is valuable information.' "[19]

While we are sympathetic to this interpretation,[20] it does not explain why Starter forced its full line on retailers, nor does it explain why discounters were willing to pay a premium for individual units when by doing so they could avoid purchasing the full assortment of jackets that Starter offered for their market. That is, Starter's concern with forcing retailers to carry its full assortment can be separated from its desire to keep its jackets out of discount outlets.[21] More importantly, Trans Sport's profit depended on its ability to purchase "large volumes of Starter team jackets,"[22] and to break these purchases into assortments that were more appealing to individual markets than Starter's own assortments, even as they commanded a $7 plus delivery fee premium over the Starter offerings.

Our explanation for the success of the Trans Sport transshipments and for Starter's objection to the Trans Sport's activities is that retail customers could lower their costs of inventory by ordering only the jackets most in demand in their communities, even though some customers in each community might prefer jackets for teams other than the local teams. The retailers that carried limited lines need to offer those lines at

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[19] *Starter,* at 190, quoting Areeda (1989, pages 184–185).

[20] Indeed, the Areeda treatment of dealer certification referenced by Justice Marshall (*Id.*) is in turn based upon Marvel and McCafferty (1984). See Areeda (1989), p. 184, fn. 12.

[21] Starter "preferred to deal with the 'Macy's of the licensed apparel industry, not the K-Marts of the world.'" Trans Sport v. Starter, 775 F. Supp. 536, at 543, quoting a plaintiff statement. Starter sold primarily to sports specialty stores, though its largest 16 customers included mass market retailers J.C. Penney and Sears.

[22] *Id.,* at 538.

prices lower than their full line competitors, but such discounts would be possible despite higher unit costs owing to lower inventory costs. The result for Starter would be a reduction in the number of retailers willing to hold the full jacket line, and less than complete satisfaction on the part of customers induced to buy jackets for the local team when in fact their preferences lay elsewhere. Just as will shrinking size assortments, retail competition for team jackets lower the variety of such jackets offered to consumers in a particular locality.[23]

5   Summary and Conclusions

Our analysis indicates that manufacturers will often find it difficult to maintain the variety of assortments of their products that they wish retailers to carry. They can increase the breadth of retailer assortments by imposing vertical restraints such as resale price maintenance or full-line forcing on retailers, but in doing so they face legal obstacles. Indeed, we believe that the narrowing of size assortments that took place soon after the Consumer Goods Pricing Act of 1975[24] removed from the Sherman Act, §1, two provisos granting anti-trust exemption to State fair trade laws. This change meant that resale price maintenance defaulted to its prior status as a per se violation of the antitrust laws. The law thus reduced the ability of manufacturers to protect their full assortment dealers from discounting.

Our analysis suggests that the consequences of this change in the law were predictable—

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[23]One may be concerned that Starter's policy could have been attempt to separate markets in order to practice price discrimination. The Starter opinion contain no suggestion that the wholesale price of a jacket varied across retailers, and, indeed, the price charged by Trans Sport for a jacket was substantially in excess of the per unit price charged by Starter to retailers directly. The court considered and dismissed price discrimination as a possibility: "Moreover, we see no traces of the burdensome effects generally associated with illicit monopolistic activity: price maintenance or discrimination or increased barriers to entry at the manufacturing level." *Starter,* page 191.

[24]Public Law 94-145.

size assortments should have fallen, as indeed they did. It is more difficult, however, to establish whether this change in retail behavior was undesirable. Consumers preferring common sizes may have benefited, while odd-size consumers were clearly harmed. It is even possible for social norms to adjust so that "fitted" garments are replaced by articles of clothing that previous generations would have considered unacceptably oversized.

Our discussion of *Starter* indicates that full-line forcing may in some cases aid a manufacturer in ensuring that its line is stocked in breadth sufficient to satisfy a variety of consumer preferences.[25] Notice, however, that our explanation for full-line forcing does not involve cross-subsidization. Each component of the manufacturer's line is individually profitable.[26]

Our paper adds one more coordination failure to the list of such failures that has been adduced to explain the use of vertical restraints (Deneckere et al., 1996, 1997; Marvel and McCafferty, 1984). In our case the coordination failure is based on our observation that a unit sold for inventory will not necessarily be resold by the dealer. It is thus revenue for the manufacturer, but a potential liability for its dealer. As with many other such coordination failures, this one can be solved by the manufacturer retaining control over unsold goods through either consignment or returns. Indeed Lariviere (1999) has argued that buy-back policies are an effective solution to a wide variety of problems arising from stochastic demand, and thus should be common in settings where retail inventories are substantial. We have previously (Marvel and Peck, 1995) offered some suggestions for why returns are not a panacea, but we believe that more work needs to be done to explain why returns policies are so far from ubiquitous.

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[25]Full-line forcing, however, presents its own set of antitrust problems. The *Starter* opinion suggests that had Starter's policy been less "vague," it might have been interpreted as tying, a per se violation of the antitrust laws.

[26]Our theory is different from metering or other discrimination schemes that have been proposed to explain forcing. See Burstein (1960).

References

Areeda, Phillip E. *Antitrust Law: An Analysis of Antitrust Principles and their Application.* Boston: Little, Brown (1989).

Baumol, William J. "Contestable Markets: An Uprising in the Theory of Industry Structure." *American Economic Review* 72 (March 1982): 1–15.

Bonanno, Giacomo and John Vickers. "Vertical Separation." *Journal of Industrial Economics* 36, no. 3 (March 1988): 257–65.

Burstein, M. L. "A Theory of Full-Line Forcing." *Northwestern University Law Review* 55 (February 1960): 62–95.

Chandler, Alfred D, Jr. *The Visible Hand: The Managerial Revioution in American Business.* Cambridge, Mass.: Belknap Press (1977).

Deneckere, Raymond; Howard P. Marvel; and James Peck. "Demand Uncertainty, Inventories, and Resale Price Maintenance." *Quarterly Journal of Economics* 111, no. 3 (August 1996): 885–913.

———. "Demand Uncertainty and Price Maintenance: Markdowns as Destructive Competition." *American Economic Review* 84, no. 4 (September 1997): 619–641.

Fenton, Lois. "Look Harder for Sleeve Lengths." *St. Petersburg Times* (August 22, 1999): 8F.

Friedman, Arthur. "Survey Says Shoppers Aren't Satisfied." *Daily News Record* 26, no. 103 (May 29, 1996): S14.

Gal-or, Esther. "Duopolistic Vertical Restraints." *European Economic Review* 35, no. 6 (August 1991): 1237–53.

Gallini, Nancy T. and Ralph A. Winter. "On Vertical Control in Monopolistic Competition." *International Journal of Industria -Organization* 1, no. 3 (September 1983): 275–86.

Gould, J.R. and Lee Preston. "Resale Price Maintenance and Retail Outlets." *Economica* N.S., 32, no. 127 (August 1965): 302–312),.

Lariviere, Martin A. "Supply Chain Contracting and Coordination with Stochastic Demand." In *Quantitative Models for Supply Chain Management*, edited by Sridhar Tayur; Ram Ganeshan; and Michael Magazine. Boston: Kluwer Academic Publishers (1999), pp. 233–268.

Magrath, Allan J. "Lessons from the Cost Cutters; Warehouse Clubs." *Sales & Marketing Management* 145, no. 14 (November 1993): 44.

Marvel, Howard P. "The Resale Price Maintenance Controversy: Beyond the Conventional Wisdom." *Antitrust Law Journal* 63, no. 1 (Fall 1994): 59–92.

Marvel, Howard P. and Stephen McCafferty. "Resale Price Maintenance and Quality Certification." *Rand Journal of Economics* 15, no. 3 (Autumn 1984): 346–359.

Mathewson, G. Frank and Ralph A Winter. "An Economic Theory of Vertical Restraints." *Rand Journal of Economics* 15 (Autumn 1984): 27–38.

Mclaughlin, Patricia. "Back in Vogue; Pattern Companies Are Reissuing Fitted Styles from the Early Part of the Century." *The Fresno Bee* (September 21, 1999): E3.

Reagan, Patricia B. "Resale Price Maintenance: A Re-examination of the Outlets Hypothesis." In *Research in Law and Economics*, edited by Richard O. Zerbe, Jr., volume 9. Greenwich, Conn.: JAI Press (1986), pp. 1–12.

Rey, Patrick and Joseph Stiglitz. "The Role of Exclusive Territories in Producers' Competition." *Rand Journal of Economics* 26, no. 3 (Autumn 1995): 431–51.

Thompson, Susan H. "Comfort or Fashion?" *Tampa Tribune* (June 27, 1999): Baylife Section, 1.

Winter, Ralph A. "Vertical Control and Price Versus Nonprice Competition." *Quarterly Journal of Economics* 108, no. 1 (February 1993): 61–76.

Trans Sport Inc., v. Starter Sportswear, Inc., 775 F. Supp. 536 (1991).

Trans Sport, Inc. v. Starter Sportswear, Inc., 964 F. 2d 186 (2nd Cir., 1992).

Figure 1: Discounting to Attract Customers from Nearby Sizes
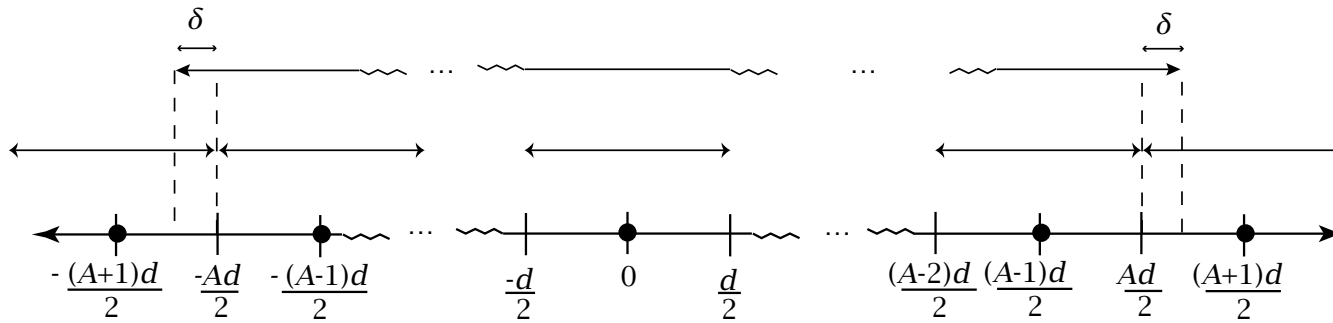
Top row: Customer base for size 0 in response to a deviation

Middle row: Equilibrium customer base

Bottom row: Sizes offered in equilibrium, each represented by ●.