Slotting Allowances and Product Variety in Oligopoly Markets

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Abstract: Slotting fees are fixed charges paid by food manufacturers to retailers for access to the retail market. The role of the practice and its effects on market efficiency are highly controversial. While the literature to date has largely focused on the effect of the practice on retail prices, it is also clear that slotting allowances have the potential to alter product variety in the market equilibrium. Our analysis reveals that the strategic use of slotting allowances by oligopoly firms increases both equilibrium retail prices and equilibrium product variety in the market. Absent slotting allowances, variety is undersupplied relative to the socially optimal resource allocation. We isolate this variety distortion by considering a class of models in which heterogeneous consumers have unit demand for their most desired product variant and demonstrate that equilibrium slotting fees restore the socially optimal level of product variety in the market equilibrium.

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JEL Classifications: L13, L14, D43.

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Introduction

Slotting allowances, which are up-front tariffs paid by manufacturers to retailers for access to supermarket shelves, are a common practice in grocery retailing. Slotting allowances are exchanged in a large number of product categories and are especially common in frozen and refrigerated foods, dry grocery, beverages, snacks, candy, and microwaveable shelf-stable foods, with magnitudes that range between $75 and $300 per item per store in the U.S. (FTC 2001). The extent of the practice is significant: Total spending on slotting allowances in the U.S. is on the order of $16 billion per year (Desiraju 2001). The most common form of slotting allowances levied in supermarkets are the so-called "product introduction allowances", which are applied to new products, although the practice is also used for existing products through "pay-to-stay fees", which are annual recurring payments often linked to premium product placement, for instance in end caps, on eye-level shelves, and in special displays.

The economic effects of slotting allowances are highly controversial. Slotting allowances can enhance efficiency by allocating scarce shelf space according to market prices (Sullivan 1997), by better allocating the risk of new product failure between retailer and manufacturer (Bloom, Gundlach, and Cannon 2000), or by creating a signaling element for manufacturers to reveal private information about product success to retailers (Chu 1992; Lariviere and Padmanabham 1997). Slotting allowances also can have anti-competitive effects. Slotting allowances place upward pressure on wholesale prices, and the ability of retailers to commit to higher wholesale prices can facilitate the exercise of market power (Shaffer 1991). Slotting allowances can also reduce market access by foreclosing markets to *de novo* entrants (Marx and

Shaffer 2004, Shaffer 2005) and serve as an instrument for national brand manufacturers to control the retail prices of private labels (Innes and Hamilton 2006, 2009).

Our aim in this paper is to examine the link between the strategic use of slotting allowances in oligopoly markets and the equilibrium provision of product variety. The number of products sold at supermarkets has increased dramatically following the inception of slotting allowances as a grocery practice in 1984, for instance the median number of stock-keeping units (SKUs) among U.S. supermarkets increased 52 percent (from 16,500 to 25,153) over the period 1990-2004 (Progressive Grocer). Aligning with this stylized fact, we demonstrate that retailers' use of slotting allowances as a facilitating practice to raise retail prices leads to greater product variety in the market equilibrium. The reason is that slotting allowances that serve to increase equilibrium retail prices also raise the return to introducing new products, thereby stimulating retailers to provide longer product lines.

We base our observations on a symmetric multi-product retail oligopoly market in which retailers select prices and product variety under non-localized spatial competition. Our model represents a generalization of the spokes model of Chen and Riordan (2007) to accommodate joint retailer decisions on prices and the length of retail product lines. We focus our analysis on product variety effects by examining circumstances in which heterogeneous consumers have inelastic demand for their most desired variant ('brand') in the neighborhood of the equilibrium prices. In this setting, product variety decisions have market efficiency effects while retail prices do not, which clarifies the welfare implications of slotting allowances on product variety in the oligopoly equilibrium.

Absent slotting allowances, oligopoly retailers undersupply product variety relative to the socially optimal resource allocation. The reason is that increasing the number of brands in a

product line intensifies price competition among retailers. When a retailer increases the length of his product line, rival retailers respond by reducing their retail prices, and this forces the retailer to choose between the competing goals of acquiring store traffic by offering consumers greater brand choices and enjoying higher retail margins on fewer brands. Slotting allowances remedy this problem by inoculating retailers from aggressive price responses when adjusting their product lines.

Our central finding is that slotting fees restore the socially optimal level of product variety in the market equilibrium. This outcome occurs due to three effects of product variety decisions on the retail oligopoly equilibrium. First, expanding product lines generates a *consumer surplus effect*. Longer product lines create better matches between consumers and brands, and this increases consumer utility. Under inelastic demand conditions, retailers who coordinate on prices can fully appropriate consumer rents from increasing the length of their product lines, so that the consumer surplus effect combined with supply-side information aligns social and private incentives for product variety.

In non-coordinated oligopoly markets, product variety is undersupplied in equilibrium because of the *strategic effect* of product line decisions on retail prices. Retailers respond to longer product lines of rivals by discounting their retail prices, and this deters retailers from increasing product variety. Absent slotting allowances, the consumer surplus effect and strategic effect together lead retailers to provide too little product variety from the social perspective.

Slotting allowances introduce a third *incentive effect* on product variety decisions. Slotting allowances serve to raise equilibrium retail prices, and introducing new products is more valuable to retailers when retail margins are high than when retail margins are low. Consequently, retailers' use of slotting allowances jointly facilitates higher prices and longer

product lines in the oligopoly equilibrium. Moreover, we show that the incentive effect exactly counteracts the strategic effect of product variety decisions at the equilibrium level of slotting allowances; hence slotting allowances align the market equilibrium with the socially optimal resource allocation under inelastic demand conditions.

The remainder of the paper is structured as follows. In Section 2, we present a model that combines consumer preferences for product variety at each retail store with preferences over retail stores in the spokes model. In Section 3, we derive the socially optimal allocation of product variety and compare this outcome to the private market allocation in an oligopoly retail market in which both slotting allowances and product variety decisions have strategic implications for retail prices. In Section 4, we extend the model to consider variations of consumer preferences over stores in the spokes network and recast the store choice problem using the random preferences model of Innes (2006). In each case our central findings are robust. Section 5 provides a numerical example that results in closed-form expressions for product variety and prices and Section 6 concludes.

2. The Model

The model is comprised of $R \geq 2$ retailers and $N \geq R$ retail stores. Retailer $i \in \{1,2,...R\}$ has n_i stores and the total number of stores available to consumers is $N = \sum_{i=1}^{R} n_i$. Consumers have preferences over retail stores according to their proximity to each store and the relative prices and product variety available at each of the various retailers.

Consumers have unit demand for their most desired variant ('brand') in the product category, and, at equal prices, select the brand that matches most closely with their preferred product characteristics. Product variety, as measured by the characteristics supplied by each brand, is symmetric in the sense of Spence (1974) and Dixit and Stiglitz (1977), which implies

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that consumer utility depends only on the number of brands available at a given store. Stores that

collect a greater number of brands in their product lines offer superior matches to consumers.

Let θ denote consumer type. A type-θ consumer, upon arriving at a store j that stocks v_j

different brands, obtains the net benefit,

(1) $$B(v_j, \theta) - p_j,$$

where p_j is the unit price charged by retailer j for brands in the product category and $B(.)$ is an

increasing and concave function, $B_v > 0$ and $B_{vv} \leq 0$. Consumer preferences over products are

independent of consumer preferences over retail stores; that is, all retail stores face an identical

distribution of consumer types, which we denote by $F(\theta)$ with density $f(\theta)$ and support $[\underline{\theta}, \overline{\theta}]$.

Consumer preferences over the various retail stores in the market are characterized by the

spokes model of Chen and Riordan (2007). Consumers of all types are located with equal

frequency on $M > N$ spokes, each of which emanates from a common center with length ½.

Retail stores are each located at the end of a spoke, and no two retail stores are located on the

end of any one spoke.[1] Consumers of each type are uniformly distributed on the network of

spokes, and the total mass of consumers is normalized to unity.

Consumers must travel on the spokes to reach retail stores. Traveling in the spokes

network entails transportation costs of t per unit of distance, so that a consumer located on spoke

i prefers to shop at the store at the end of her spoke. Traveling to any other store requires

traversing the hub of the network to the end of another spoke. Since all other stores not located

on a consumer's spoke are equally distant, the second-preferred retail store for each consumer is

randomly selected from one of the other $(M-1)$ spokes in the network with equal probability.

For expedience, we assume for now that consumers place zero value on shopping at a retail store

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[1] Note that this is an equilibrium outcome in the spokes model, as no retailer would choose to locate a store on a
spoke that is already occupied by another retail store, given the availability of vacant spokes ($N < M$).

that is neither the first- nor the second-preferred store.[2] There are thus four types of consumers in the model: (*i*) consumers for which both the first-and second-preferred store operate; (*ii*) consumers for which the first-preferred store operates but the second-preferred store is not available; (*iii*) consumers for which the first-preferred store is not available but the second-preferred store operates; and (*iv*) consumers for which neither the first- nor the second-preferred store operate.

To clarify the implications of slotting allowances on the market allocation of product variety, we consider the case of inelastic demand. This allows us to abstract from the well-known distortionary effect of slotting allowances on prices and isolate the social welfare implications of retailers' product variety decisions. Specifically, we assume that all consumers who can shop at their first- or second-preferred store choose to do so; that is, in the neighborhood of the symmetric oligopoly equilibrium ($p_j = p_k = p, v_j = v_k = v$),

(2) $$B(v,\theta) - p - t > 0, \forall \theta \in [\underline{\theta}, \overline{\theta}].$$

Condition (2) ensures that consumers' valuations are sufficiently high that consumers are willing to travel the entire distance between any two stores in the spokes network (unit distance) to procure their desired brand. It follows that the first three types of consumers are served in the market equilibrium, while only type-(*iv*) consumers remain un-served by any store.

Store *j* derives demand from three types of customers. Let *j* and *k* denote the first- or second-preferred store of a consumer with conditional probability $\dfrac{1}{M-1}$ and let *y* denote the distance of a given consumer to retail store *j*.

For type-(*i*) consumers, the marginal consumer between stores *j* and *k* is located at the distance

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[2] In Section 4 we consider modifications of the model in which all consumers are served in the market.

(3) $$y^*(\theta, p_j, v_j, p_k, v_k) = \frac{1}{2} + \frac{B(v_j, \theta) - B(v_k, \theta) + p_k - p_j}{2t}.$$

The corresponding number of type-(*i*) consumers served by firm *j* is

(4) $$\left(\frac{1}{M-1}\right)\left(\frac{2}{M}\right) \sum_{k \neq j, k \in \{1,\dots,N\}} \int_{\underline{\theta}}^{\bar{\theta}} y^*(\theta, p_j, v_j, p_k, v_k) f(\theta) d\theta$$

where the density of consumers at any point in the network is $2/M$.

Given consumption benefits in condition (2), all type-(*ii*) and type-(*iii*) consumers are served by store *j*. The number of type-(*ii*) consumers is

(5) $$\left(\frac{M-N}{M-1}\right)\left(\frac{2}{M}\right)\left(\frac{1}{2}\right),$$

where $\left(\frac{M-N}{M-1}\right)$ is the proportion of consumers on spoke *j* for whom the second-preferred store

is unavailable, 2/M is the density of consumers, and ½ is the length of spoke *j*. Similarly, the

number of type-(*iii*) consumers is the proportion of consumers whose first-preferred store is

unavailable $\left(\frac{M-N}{M}\right)$ multiplied by the conditional probability that store *j* is second-preferred,

which yields

(6) $$\left(\frac{M-N}{M}\right)\left(\frac{1}{M-1}\right).$$

Aggregating across type (*i*)-(*iii*) consumers in equations (4)-(6), demand facing store *j* is

(7) $$D_j = \alpha \left[\sum_{k \neq j, k \in \{1,\dots,N\}} \int_{\underline{\theta}}^{\bar{\theta}} y^*(\theta, p_j, v_j, p_k, v_k) f(\theta) d\theta \right] + \beta,$$

where $\alpha = \frac{2}{M(M-1)}$ and $\beta = \frac{2(M-N)}{M(M-1)}$. The spokes model reduces to the Hotelling model

when $M = N = 2$ under the restriction that $B(v_j, \theta) = B(v_k, \theta) = \bar{u}$ in equation (3). Models of

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multi-product retailers with localized retailer competition such as Hamilton (2009) take the form of (7) with $\alpha = 1$ and $\beta = 0$.

The number of type-(iv) customers, who remain un-served in the market, is the product of the proportion of customers whose first-preferred store does not operate $\left(\dfrac{M - N}{M} \right)$ and the conditional probability that their second-preferred store also does not operate $\left(1 - \dfrac{N}{M - 1} \right)$.

Letting Q_u denote the un-served customers in the spokes network, we have

$$(8) \qquad\qquad Q_u = \frac{(M - N)(M - N - 1)}{M(M - 1)}.$$

3. Product Variety

We make use of demand functions (7) to compare the market equilibrium to the socially optimal resource allocation. To focus attention on the role of slotting allowances on product variety provision, we suppress retailer entry and store choice decisions and treat retailers as being endowed with an exogenous and symmetric number of stores ($n_i = n = N/R$). Retailer costs of stocking v brands are fv and each brand has unit production cost given by c.[3]

A. Social Optimum

The socially optimal provision of product variety solves

$$\max_{v} \int_{\underline{\theta}}^{\bar{\theta}} B(v, \theta) f(\theta) d\theta (1 - Q_u) - fvN,$$

where the number of consumers served in the spokes network $(1 - Q_u)$ is defined in (8). The social optimum is completely characterized by the first-order necessary condition

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[3] Allowing for non-linear costs of v does not alter any of the results that follow.

(9)
$$\int_{\underline{\theta}}^{\overline{\theta}} B_v(v,\theta) f(\theta) d\theta (1 - Q_u) = fN.$$

Condition (9) states that the marginal return to product variety among customers served on the spokes network is equal to the marginal cost of stocking the brands at each of the N symmetric retail stores.

B. Market Equilibrium

Strategic interaction between retailers is modeled as a three-stage game. In the first stage, the contract stage, retailers simultaneously propose contracts with competitive brand manufacturers using a two-part tariff pricing structure comprised of a slotting allowance (s_i) and wholesale price (w_i) for each brand (v_i) the retailer decides to stock. In the second stage, brand manufacturers either accept or reject the retailers' contracts, and in the third and final stage, retailers compete in prices subject to market-clearing conditions on consumer demand (7).

To describe the symmetric market equilibrium, we consider three types of retailers in the third-stage pricing game: (*i*) retailer 1 with $(p,v,w,n) = (p_1, v_1, w_1, n_1)$; (*ii*) retailer 2 with $(p,v,w,n) = (p_2, v_0, w_0, n_0)$; and (*iii*) the (*R*-2) other retailers with $(p,v,w,n) = (p_0, v_0, w_0, n_0)$.

Let $\Delta B = \int_{\underline{\theta}}^{\overline{\theta}} \left(B(v_1,\theta) - B(v_0,\theta) \right) f(\theta) d\theta$ denote the relative consumer valuation of product variety available at retailer 1 compared to all remaining retailers in the symmetric equilibrium.

Given the range of product variety selected by retailers in the first stage of the game, retailer 1 selects a price level to maximize $\pi_1 = n_1 \left[\hat{\pi}_1 + (s_1 - f) v_1 \right]$, where

$$\hat{\pi}_1 = (p_1 - w_1) \left\{ \alpha \left[\left(\frac{n_1 - 1}{2} \right) + n_0 \left(\frac{1}{2} + \frac{\Delta B}{2t} + \frac{p_2 - p_1}{2t} \right) + n_0 (R - 2) \left(\frac{1}{2} + \frac{\Delta B}{2t} + \frac{p_0 - p_1}{2t} \right) \right] + \beta \right\}.$$

The expression in the square bracket of $\hat{\pi}_1$ is comprised of three sets of demand terms. The first

term reflects store demand for retailer 1 when competing with the (n_1-1) stores of retailer 1, each of which selects identical prices and product variety as the representative store. The second term is store demand for retailer 1 when competing with the $n_2 = n_0$ stores of retailer 2, and the third term is store demand for retailer 1 when competing with the n_0 stores of each of the remaining $(R-2)$ retailers. Making the substitution $n_0 = n_1 = n$ and $N = Rn$ into $\hat{\pi}_1$ and simplifying the resulting expression gives the profit of retailer 1 at the representative store, which is

$$(10) \qquad \frac{\pi_1}{n_1} = (p_1 - w_1)\left[k_1 + \frac{\alpha n}{2t}((p_2 - p_1) + (R-2)(p_0 - p_1))\right] + (s_1 - f)v_1,$$

where $k_1 = \left(\frac{\alpha}{2}\right)\left[N - 1 + (N-n)\frac{\Delta B}{t}\right] + \beta$. Differentiating this expression with respect to p_1 and then substituting for $p_2 = p_0$ in the symmetric equilibrium, the first-order necessary condition for a profit maximum for retailer 1 can be expressed as

$$(11) \qquad k_1 + \left(\frac{\alpha}{2t}\right)(N - n)(p_0 - 2p_1 + w_1) = 0.$$

Proceeding similarly for retailer 2, profit at the representative store of retailer 2 is

$$\frac{\pi_2}{n} = (p_2 - w_0)\left[k_0 + \frac{\alpha n}{2t}((p_1 - p_2) + (R-2)(p_0 - p_2))\right] + (s_2 - f)v_2,$$

where $k_0 = \left(\frac{\alpha}{2}\right)\left[N - 1 - n\frac{\Delta B}{t}\right] + \beta$. Differentiating this expression with respect to p_2 and then substituting for $p_2 = p_0$ in the symmetric equilibrium, the first-order necessary condition for a profit maximum for retailer 2 is

$$(12) \qquad k_0 + \left(\frac{\alpha}{2t}\right)(np_1 - Np_0 + w_0(N - n)) = 0.$$

The equilibrium in the pricing stage is characterized by the solution to equations (11) and (12). Solving these equations gives

(13) $\quad p_1^e = \left(\dfrac{N}{2N-n}\right)w_1 + \left(\dfrac{N-n}{2N-n}\right)w_0 + \left(\dfrac{2t}{\alpha}\right)\left[\left(\dfrac{N}{(N-n)(2N-n)}\right)k_1 + \left(\dfrac{1}{2N-n}\right)k_0\right],$

(14) $\quad p_0^e = \left(\dfrac{2(N-n)}{2N-n}\right)w_0 + \left(\dfrac{n}{2N-n}\right)w_1 + \left(\dfrac{2t}{\alpha}\right)\left[\left(\dfrac{n}{(N-n)(2N-n)}\right)k_1 + \left(\dfrac{2}{2N-n}\right)k_0\right].$

In the symmetric equilibrium ($w_0 = w_1 = w$, $v_0 = v_1 = v$), $k_0 = k_1 = k = \dfrac{\alpha(N-1)}{2} + \beta$ and the

equilibrium prices are $p_0^e = p_1^e = p^e = w + \dfrac{2kt}{\alpha(N-n)}$.

In the second stage of the game, each manufacturer is willing to accept the slotting

contract proposed by a retailer provided he receives a payment no less than his opportunity costs.

With a competitive manufacturing industry, these opportunity costs can be normalized to zero

without loss of generality. Accordingly, each manufacturer accepts the contract proposed by

retailer 1 whenever

(15) $\qquad\qquad\qquad n_1(w_1 - c)D_1 / v_1 - s_1 \geq 0$

where c is unit manufacturing cost. In equation (15), the manufacturer recompenses the retailer

for any departure of the contracted price from unit cost with the payment of a slotting allowance,

as in Shaffer (1991). The optimal terms in the retailer's contract specify that the manufacturer's

participation constraint be met with equality in (15).

In the contract stage, retailer 1 chooses the terms of the contract so as to maximize profits

in (10) subject to the (binding) participation constraint (15) and the pricing stage solutions in

(13) and (14). Substituting the pricing stage solutions into (10), the contracting problem is

$$\underset{v_1, w_1}{Max}\left\{(p_1^e - c)\left[k_1 + \dfrac{\alpha(N-n)}{2t}\left(p_0^e - p_1^e\right)\right] - fv_1\right\},$$

where $p_0^e - p_1^e = \dfrac{N-n}{2N-n}(w_0 - w_1) - \dfrac{N\Delta B}{2N-n}$. Differentiating profit per store with respect to v_1

and w_1 and then evaluating the resulting expressions at the symmetric equilibrium position

results in the first-order necessary conditions

(16)
$$k\frac{\partial p_1^e}{\partial v_1} + \left(w - c + \frac{2kt}{\alpha(N-n)}\right)\left[\frac{\partial k_1}{\partial v_1} + \frac{\alpha(N-n)}{2t}\left(\frac{\partial (p_0^e - p_1^e)}{\partial v_1}\right)\right] = f,$$

(17)
$$k\frac{\partial p_1^e}{\partial w_1} + \left(w - c + \frac{2kt}{\alpha(N-n)}\right)\frac{\alpha(N-n)}{2t}\left(\frac{\partial (p_0^e - p_1^e)}{\partial w_1}\right) = 0,$$

respectively, where we have made the substitution for $p^e - c = w - c + \dfrac{2kt}{\alpha(N-n)}$.

To better understand the product line decisions of oligopoly retailers, it is helpful to

decompose the marginal return to product variety on left-hand side of (16) into three terms: (*i*)

the *consumer surplus effect*, $\left(\dfrac{2kt}{\alpha(N-n)}\right)\dfrac{\partial k_1}{\partial v_1}$, which is the direct effect of product variety on

consumers' valuations; (*ii*) the *strategic effect* of product variety on retail margins,

$k\dfrac{\partial p_1^e}{\partial v_1} + \dfrac{2kt}{\alpha(N-n)}\dfrac{\alpha(N-n)}{2t}\left(\dfrac{\partial (p_0^e - p_1^e)}{\partial v_1}\right)$; and (*iii*) the *incentive effect* of slotting allowances,

$(w-c)\left[\dfrac{\partial k_1}{\partial v_1} + \dfrac{\alpha(N-n)}{2t}\left(\dfrac{\partial (p_0^e - p_1^e)}{\partial v_1}\right)\right]$. The retailer invests in product variety until the marginal

return to variety (the sum of these three effects) equates with the marginal cost of introducing a

new brand, f.

Evaluating these terms in the symmetric equilibrium, the *consumer surplus effect* is

(18)
$$\left(\frac{2kt}{\alpha(N-n)}\right)\frac{\partial k_1}{\partial v_1} = kB_v^*,$$

where $B_v^* = \displaystyle\int_{\underline{\theta}}^{\overline{\theta}} B_v(v_1,\theta)f(\theta)d\theta$ and $k = \dfrac{\alpha(N-1)}{2} + \beta$. B_v^* is the marginal return to product

variety in consumer utility functions and k is the size of the market served by the representative

retailer, for instance $k = \frac{1}{2}$ in a Hotelling duopoly model ($N = 2$, $\alpha = 1$, $\beta = 0$). The *consumer surplus effect* represents the marginal benefit of an additional brand among consumers served by the retail store.

The *strategic effect* of variety on retail prices in the symmetric equilibrium is

(19)
$$k\frac{\partial p_1^e}{\partial v_1} + \frac{2kt}{\alpha(N-n)}\frac{\alpha(N-n)}{2t}\left(\frac{\partial(p_0^e - p_1^e)}{\partial v_1}\right) = k\frac{\partial p_0^e}{\partial v_1} = \frac{-nk}{(2N-n)}B_v^* < 0.$$

The strategic effect captures the price response of rival retailers to an increment in product variety by the contracting retailer. As in Anderson and de Palma (1992) and Hamilton and Richards (2009), an increase in product variety results in more aggressive price competition as rival retailers respond to a relatively unfavorable brand position by discounting prices in their product lines. The strategic effect deters retailers from providing greater product variety.

The remaining term, the *incentive effect* of slotting allowances, is

(20)
$$(w-c)\left[\frac{\partial k_1}{\partial v_1} + \frac{\alpha(N-n)}{2t}\left(\frac{\partial(p_0^e - p_1^e)}{\partial v_1}\right)\right] = (w-c)\left(\frac{\alpha}{2t}\right)\frac{(N-n)^2}{(2N-n)}B_v^*.$$

The *incentive effect* of slotting allowance depends on the equilibrium contract terms with brand manufacturers. When the slotting contract stipulates a positive slotting fee paid by each manufacturer to the retailer ($s_1 > 0$), the contract terms in (15) involve an elevated wholesale price above marginal cost for each brand ($w - c > 0$), which in turn implies that the incentive effect in (20) is positive. Stipulating an elevated wholesale price in the slotting contract with manufacturers results in higher equilibrium retail prices, and this increases the marginal return to introducing new brands in the product category.

Proposition 1. A retailer who considers only the consumer surplus effect of variety in equation (18) selects the socially optimal amount of product variety.

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Proof. By inspection of equations (9) and (18), the direct effect of variety on profits results in the socially optimal provision of product variety when $k = \dfrac{1-Q_u}{N}$. Making use of equation (8),

$\dfrac{1-Q_u}{N} = \dfrac{2M-N-1}{M(M-1)}$. Substitution of $\alpha = \dfrac{2}{M(M-1)}$ and $\beta = \dfrac{2(M-N)}{M(M-1)}$ into $k = \dfrac{\alpha(N-1)}{2} + \beta$

and simplifying the resulting expression completes the proof.   □

Conditional on store penetration (i.e., with $n_0 = n_1 = n$ fixed), retailers select variety optimally when ignoring the strategic effect and incentive effect of their contract choices. The intuition for this result is that the consumer surplus effect captures the marginal utility of brand introduction among consumers in the retailer's service territory. With inelastic demand among consumers, a coordinated group of retailers is able to fully appropriate the rents to product variety and therefore has incentives aligned with the social planner in providing all brands for which the marginal return to consumers exceeds the unit stocking cost, f. In non-coordinated oligopoly markets, however, retailers also take the effect of product variety on their rival's prices into account when selecting the length of their product lines. As a consequence, we arrive at

Proposition 2. Absent slotting allowances, retailers under-provide product variety in the symmetric market equilibrium relative to the socially optimal resource allocation.

Proof. Setting $w = c$ in equation (20), the market provision of product variety is given by equating terms in (18) and (19) to the cost of product introduction, f. The strategic effect of variety on prices in equation (19) is negative, and it follows immediately from Proposition 1 that retailers provide a smaller range of product variety in the symmetric market equilibrium relative to the social optimum. □

The reason for this outcome is that a providing a longer product line attracts customers to the retailer's store, and this imposes a negative externality on the rival retailers. Rival retailers, who seek to dampen the loss of market share from offering a relatively narrow selection of brands, respond by reducing retail prices. Given this effect of product variety on intensifying price competition, retailers are deterred from introducing new products, and this leads to narrower product lines in the market equilibrium than in the socially optimal resource allocation.

Now consider the role of slotting allowances. Slotting allowances provide the retailer with the ability to contract for a higher wholesale price in exchange for a tariff received from the manufacturer. Because the retail prices set by rivals depend jointly on wholesale prices and product variety of the contracting retailer, a slotting contract effectively grants the retailer an independent instrument to control the retail prices of rivals. Setting an elevated wholesale price in the contract stage signals rival retailers the intent to set correspondingly higher retail prices in the pricing stage, thereby allowing the retailer to extend the length of his product line without triggering an aggressive price response by rivals.

Proposition 3. In the symmetric market equilibrium, slotting allowances lead to the socially optimal allocation of product variety.

Proof. By Proposition 1, retailers provide optimal product variety when the sum of terms in equations (19) and (20) is zero. Collecting terms, this implies

(21) $$(w^* - c) = \frac{2nt}{\alpha(N-n)^2} k \, .$$

Now consider the optimal choice of w in the market equilibrium. Factoring terms in (17) gives

$$k \frac{\partial p_0^e}{\partial w_1} + (w^e - c) \frac{\alpha(N-n)}{2t} \left(\frac{\partial (p_0^e - p_1^e)}{\partial w_1} \right) = 0$$

Evaluating terms using (13) and (14), we have $\frac{\partial p_0^e}{\partial w_1} = \frac{n}{2N-n}$ and $\frac{\partial (p_0^e - p_1^e)}{\partial w_1} = \frac{-(N-n)}{2N-n}$, and

substitution gives the equilibrium contract choice, $(w^e - c) = \frac{2nt}{\alpha(N-n)^2} k$. Comparison with the

wholesale price level that achieves optimal variety in (21) implies $w^e = w^*$. □

The intuition for this result is straightforward. Absent slotting allowances, providing longer product lines has a strategic disadvantage. When a retailer increases the length of his product line, rival retailers respond by reducing retail prices, and anticipating this effect deters the retailer from extending his product line.

A slotting allowance resolves this problem. The optimal slotting allowance supports an elevated wholesale price in equation (21), which facilitates a commensurate retail price increase by rival stores. The ability to control the price response of rival retailers with a slotting allowance eliminates the strategic disadvantage of extending product lines, thereby allowing retailers to fully extract variety rents from consumers in the market.

4. Model Extensions

In this Section we consider two extensions of the model. First, we consider a variant of the spokes model in which all consumers are served. Second, we consider the 'random preferences' form of retailer competition considered by Innes (2006).

The spokes model can be extended to the case in which all customers shop at a retailer by adding higher order retailer preferences that are strictly inferior as the order rises. Specifically, the consumer benefit function can be written $B(v, \theta, \delta)$, where $\delta \in \{1, 2, ..., M-N+1\}$ is a rank

ordering of store preference. Provided that store preferences are sufficiently strong in the

neighborhood of the symmetric equilibrium prices and product lines that consumers prefer

higher-ranked stores to lesser ranked stores, but not so strong that they vitiate consumer demand

altogether at the lowest-ranked store (i.e., $B(v^*, \theta, M - n + 1) - p^* - t > 0, \forall \theta$), it follows that all

consumers are served in the market equilibrium. This modifies the analysis above in that each

store now expects to receive (1/N) of the additional 'captive customers' who lack a first- or

second-preferred store and would otherwise have gone un-served. Adding these captive

customers to the demand facing store j gives

$$\hat{D}_j = \hat{\alpha}\left[\sum_{k \neq j, k \in \{1,...,N\}} \int_{\underline{\theta}}^{\overline{\theta}} y^*(\theta, p_j, v_j, p_k, v_k) f(\theta) d\theta \right] + \hat{\beta},$$

where $\hat{\alpha} = \alpha = \dfrac{2}{M(M-1)}$ and $\hat{\beta} = \beta + \dfrac{Q_u}{N} = \dfrac{(M-N)(M+N-1)}{M(M-1)N}$.

Noting that this equation has the same form as demand equation (7), and that $Q_u = 0$ in

the socially optimal resource allocation, it follows that the variety effect is sufficient to obtain the

social optimum whenever $\hat{k} = \dfrac{1}{N}$, where $\hat{k} = \dfrac{\hat{\alpha}(N-1)}{2} + \hat{\beta}$. Substitution of $\hat{\alpha}$ and $\hat{\beta}$ into $\hat{k}$

and factoring terms demonstrates this is so. Hence, Proposition 1 continues to hold. Moreover,

since Propositions 2 and 3 depend only on the outcome of Proposition 1, and not on particular

values of α and β, these results continue to hold. Slotting allowances lead to the socially optimal

allocation of product variety in the market equilibrium under this demand structure as well.

Our results also extend to models of the form considered by Innes (2006). Innes (2006)

considers a variant of the Salop circle model in which N retail stores are equally-spaced on the

circumference of a circle of unit length. Consumers are uniformly distributed on the circle and

face transportation costs of t per unit of distance. Any possible ordering of the N stores among

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the N locations occurs with equal frequency, so that the relative frequency with which store j has store k as a neighbor is $2/(N\text{-}1)$. With full market coverage, demand on the arc between stores j and k in the event they are neighbors is

$$d_{jk}^{\;*} = \frac{1}{2N} + \int_{\underline{\theta}}^{\overline{\theta}} \frac{B(v_j,\theta) - B(v_k,\theta) + p_k - p_j}{2t} f(\theta)d\theta \; .$$

Total demand for store j is therefore

$$D_j = \sum_{k \neq j, k \in \{1,\dots,N\}} \left(\frac{2}{N-1}\right) d_{jk}^{\;*} = \tilde{\alpha} \left[\sum_{k \neq j, k \in \{1,\dots,N\}} \int_{\underline{\theta}}^{\overline{\theta}} y^*(\theta, p_j, v_j, p_k, v_k) f(\theta)d\theta \right] + \tilde{\beta},$$

with $\tilde{\alpha} = \dfrac{2}{N-1}$ and $\tilde{\beta} = \dfrac{-(N-1)}{N}$. Substitution of these terms into $\tilde{k} = \dfrac{\tilde{\alpha}(N-1)}{2} + \tilde{\beta}$ and

factoring yields $\tilde{k} = \dfrac{1}{N}$. Propositions 1-3 hold under this specification of store preferences as well as in the spokes model.

Slotting allowances lead to an optimal provision of product variety in a generalized class of oligopoly models with inelastic demand. The reason is that slotting fees provide retailers with an independent instrument to control the price responses of rivals. Use of this mechanism allows firms to counteract the strategic disincentive of product variety on retail prices by offsetting brand introduction with commensurate increases in wholesale prices on existing brands.

5. Example

Consider a Hotelling (1929) duopoly model with retailers spatially located at the ends of a unit line segment. Each retailer carries an endogenous number of brands, which are arrayed around a unit circle representing the characteristic space. Consumers visiting a given retailer incur a "matching cost" of θ per unit of distance in characteristic space between the location of their most preferred product and the product characteristics available in the nearest brand.

Prior to their arrival at retail stores, consumers' preferences are unknown to the retailers, who know only the distribution of consumer tastes in the population. Given a uniform distribution of consumer preferences for product characteristics, retailers optimally locate product variants at equidistant positions along the circumference of the circle. Measuring product characteristics continuously, this implies that the expected consumer matching cost when shopping at a retailer with v symmetric variants is

$$(22) \qquad 2\theta v \int_0^{1/2v} x\,dx = \frac{\theta}{4v}.$$

Letting $\bar{u}$ denote the gross value each consumer receives from consuming her most preferred product variant, expected consumer utility from shopping at retailer j is

$$(23) \qquad B(v_j,\theta) = \bar{u} - \frac{\theta}{4v_j}.$$

with $B_v = \dfrac{\theta}{4v^2}$ and $B_{vv} = \dfrac{-\theta}{2v^3}$. The introduction of brands on the unit circle improves the quality of the match between consumers and products, so that offering longer product lines serves to attract customers into the store.

Given the menu of products and prices available at each of the two retailers, the location of the critical consumer is given by

$$(24) \qquad y^*(p_1,v_1,p_2,v_2) = \frac{1}{2} + \frac{p_2 + \theta/4v_2 - p_1 - \theta/4v_1}{2t},$$

where retailer 1 is located at the origin of the unit line segment. Equation (24) gives the market demand for retailer 1, which takes the form in equation (7) with $\alpha = 1$ and $\beta = 0$ in the case of constant marginal density $f(\theta) = 1$.

The socially optimal allocation maximizes consumption value net of production costs,

$$W = \bar{u} - \theta/4v - c - 2fv - t/4.$$

Differentiating this expression with respect to v and solving the resulting first-order condition

gives the socially optimal allocation of product variety, $v^* = \sqrt{\theta/8f}$.

Now consider the market equilibrium. Given the range of product variety selected by the

retailers, retailer 1 selects a price level to maximize

$$\pi_1 = (p_1 - w_1)\left[k_1 + \frac{1}{2t}(p_2 - p_1)\right] + (s_1 - f)v_1$$

where $k_1 = \left(\frac{1}{2}\right)\left[1 + \frac{\theta(v_1 - v_2)}{8v_1v_2t}\right]$.

Substituting demand (24) into profit and differentiating the resulting expression with

respect to price, the first-order necessary condition for a maximum is

(25) $$k_1 + \frac{1}{2t}(p_2 - 2p_1 + w_1) = 0$$

for retailer 1. Proceeding similarly for retailer 2, the first-order condition is

(26) $$k_2 + \frac{1}{2t}(p_1 - 2p_2 + w_2) = 0$$

for retailer 2, where $k_2 = \left(\frac{1}{2}\right)\left[1 - \frac{\theta(v_1 - v_2)}{8v_1v_2t}\right]$.

Let $p_1^e(v_1, w_1, v_2, w_2)$ and $p_2^e(v_1, w_1, v_2, w_2)$ denote the simultaneous solution to equations

(25) and (26). The solution is

(27) $$p_1^e = \frac{1}{3}\left[2w_1 + w_2 + 2t(2k_1 + k_2)\right],$$

(28) $$p_2^e = \frac{1}{3}\left[w_1 + 2w_2 + 2t(k_1 + 2k_2)\right].$$

Notice that each retailer's equilibrium price is increasing in his own provision of product variety and decreasing in his rival's provision of product variety; specifically, $\dfrac{\partial p_1^e}{\partial v_1} = \dfrac{\theta}{12v_1^2} > 0$ and

$\dfrac{\partial p_2^e}{\partial v_1} = \dfrac{-\theta}{12v_1^2} < 0$. As a retailer lengthens his product line, consumers are attracted to the store, allowing prices (and margins) to rise within the category for the retailer. The rival retailer compensates for what is now a relatively narrow product line by discounting his prices to preserve market share. The effect of product variety on prices contrasts with the well-known effect of wholesale prices on retail prices, where a rise in wholesale prices by one retailer raises the retail prices of both retailers (Shaffer, 1991).

In the contract stage, retailer 1 chooses the terms of the contract so as to maximize profits subject to the participation constraint and the pricing stage solutions. Substituting the pricing stage solutions into profit, the contracting problem is

$$\underset{v_1, w_1}{Max}\left\{(p_1^e - c)\left[k_1 + \frac{1}{2t}\left(p_2^e - p_1^e\right)\right] - fv_1\right\},$$

where $p_2^e - p_1^e = \dfrac{1}{3}\left[w_2 - w_1 + \dfrac{\theta}{2}\dfrac{(v_2 - v_1)}{v_1 v_2}\right].$

The first-order necessary conditions for a profit maximum for retailer 1 are

(29) $$\frac{\theta}{24tv_1^2}\left[p_1 - c + 2k_1 t\right] = f,$$

(30) $$p_1 - c = 2t.$$

In the symmetric equilibrium ($w_1 = w_2 = w$, $v_1 = v_2 = v$), $k_1 = k_2 = k = 1/2$ and the equilibrium prices from the pricing stage are $p_1^e = p_2^e = p^e = w + t$. Making these substitutions in (29) and (30) gives $w^e = c + t$ and $v^e = \sqrt{\theta/8f} = v^*$. Slotting allowances lead to the optimal provision of

variety in the market equilibrium.

Next contrast this outcome to the case in which slotting allowances are not allowed. In this case $w_1 = w_2 = c$ and the market equilibrium is determined by (29). In the symmetric equilibrium, $v_1 = v_2 = v$, the equilibrium prices are $p^{ns} = c + t$ and the equilibrium variety range is $v^{ns} = \sqrt{\theta/12f} < v^*$.

6. Discussion

Much attention has been focused on the strategic role of slotting allowances in facilitating higher retail prices. In this paper we have shown that slotting allowances that lead to higher retail prices also serve to increase the provision of retail product variety by raising retail margins in the category. Moreover, slotting allowances reconcile the market equilibrium with the socially optimal resource allocation under conditions in which consumers have inelastic demand for their desired brand in the product category.

Absent slotting allowances, longer product lines attract customers. For this reason, when a retailer extends his product line he imposes a negative externality on rival retailers, eliciting an adverse price response. Because providing longer product lines intensifies price competition, each retailer is deterred from developing new products in the market equilibrium, and variety is undersupplied relative to the social optimum.

Slotting allowances allow retailers an independent instrument to control the retail prices of rivals. Slotting contracts that serve to elevate wholesale prices signals rival retailers the intent to set correspondingly higher retail prices, and this allows a contracting retailer to counteract the price response of his rivals when lengthening his product line. Slotting allowances therefore serve to increase product variety in the oligopoly market equilibrium.

When demand is inelastic, slotting allowances fully align social and private incentives for product variety. The reason is that retailers who coordinate on retail prices can fully extract consumer rents from product variety under inelastic demand conditions. Slotting allowances allow retailers a degree of price coordination when extending their product lines, and the ability to manipulate retail prices with manufacturer contracts aligns social and private incentives for providing product variety.

To clarify the efficiency implications of slotting allowances on product variety, we have couched our analysis in a setting where prices have no effect on resource allocations. In settings with elastic demand, slotting allowances would introduce offsetting welfare effects by simultaneously increasing both retail prices and product variety. The efficiency implications of slotting allowances in this case would depend on the relative valuation of prices and product variety in consumer utility functions. Understanding the role of slotting allowances in jointly altering retail prices and product lines is important to properly characterize the welfare implications of the practice. The trade-off identified here between price and variety effects suggests the need for empirical analysis to examine the relative importance of each effect.

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