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Product Proliferation and the Determination of Slotting and Renewal Allowances

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Abstract

We examine the roles of slotting and renewal allowances in the allocation of scarce retail shelf space. Several contrasting features of the two shelf allocational mechanisms are shown.

With slotting allowances, manufacturers can signal the profitability of new products and retailers can screen out the least profitable products. With renewal allowances in a full information context, manufacturers can induce retailers to carry their less profitable products, illustrating a "push" approach to attaining shelf placement; manufacturers of product that enjoy strong consumer "pull" obtain shelf placement without paying renewal allowances. In both cases, product proliferation results in higher slotting and renewal allowances by raising the opportunity cost of shelf space. However, as countervailing leverage against retailers, manufacturers of successful product lines can use their successful products to help attain placement for their relatively weak products.

I. Introduction

Retailers often function as "gatekeepers" when allocating scarce shelf space among competing manufacturers' products. In this paper, we analyze strategic interactions among manufacturers and retailers that occur in this process. We examine two models of shelf space allocation based on slotting allowances and renewal allowances. Slotting allowances are one-time payments by manufacturers to retailers in exchange for "slots" for their new products. Renewal allowances are similar payments for continued shelf placement of existing products.

Due to accelerating competition for shelf space, this analysis is particularly relevant today. Between 1980 and 1990, annual new grocery product introductions grew from 2,689 to 13,244(*New Product News*, selected issues), more than a fourfold increase, while the average number of items carried by grocery stores increased from 14,145 to 30,000(*The Food Marketing Industry Speaks*, Food Marketing Institute 1990, pp.233-234), which is roughly double. The number of grocery products grew still further to 167,980 by 1992.

Coincident with this burst of new product introductions, trade promotions grew as a percentage of the total marketing budget from 34% in 1980 to 44% in 1990(Donnelley Marketing Annual Surveys of Promotional Practices, 1980-1990). Slotting allowances and renewal allwances also emerged as standard trade practices in the 1980s(Cannon and Bloom 1991, Toto 1990, Sullivan 1993, Gibson 1988, Blattberg and Neslin 1990).[1] Curtis-Burns, for example, paid retailers $1 million to introduce its new canned-pie filling to half the country (Cannon and Bloom 1991), and Old Capitol paid Shoprite Foods $86,000 to stock $172,000 worth of microwave popcorn(Gibson 1988). By 1987, slotting and renewal allowances accounted for 30% to 55% of the estimated $17 billion manufactures spent on promotional expenditures.[2] In

1) According to Cannon and Bloom(1991), although the practice of offering special deals(e.g., off-invoice discounts, billback, and free cases to convince retailers to carry new products is not new, slotting allowances differ from more traditional trade promotions in three ways: (1) they are usually negotiated, (2) payment is made "up-front" in the form of a lump sum, and (3) the magnitude of individual payments is large.

2) Sullivan 1993: *Advertising Age* 8/3/87 and 5/9/88. Slotting allowances are generally believed to account for the bulk of this expenditure(Cannon and Bloom 1991).

roughly the same time period, a shift in the relative "power" of manufacturers and retailers has been perceived to have occurred.[3] In this overall context, we are interested in examining whether these developments can be explained, in part, by the increasing competition for retail shelf space.

In both of our models, many manfacturers compete for the shelf space of a single retailer. The first model, concerning the determination of slotting allowances, assumes an environment in which retailers are ill-informed about the profitability of various available new products (manufacturers are assumed to know the profitability of their own products). Three cases, based on different informational assumptions and institutional arrangements, are considered: an open English(ascending-bid) auction, a sealed bid auction, and the retailer's issuance of a take-it-or-leave-it offer. In all cases, slotting allowances serve as a mechanism to screen for the most profitable products. This is because only manufacturers who are confident of generating enough subsequent profits to recover the up-front cost of slotting allowances will pay them. The manufacturers, by paying slotting allowances, are thus signalling that their products are profitable. We go on to show that product proliferation leads to growth in the level of slotting allowances. This is because product proliferation increases the demand for retail shelf space, which in turn pushes up the "price" of the slot.

The second model, which describes the determination of renewal allowances, assumes an environment of perfect information. As with the first model, the most profitable products end up being carried and product proliferation leads to higher renewal allowances and a transfer of profit from manufacturer to retailer. This model also illustrates the role of "push" and "pull" approaches to achieving shelf placement. Manufacturers of less profitable products must use a push approach to gain shelf placement by paying high renewal allowances. Manufacturers that enjoy strong consumer pull for their products gain shelf placement without the need to offer renewal allowances. Lastly, manufacturers of profitable lines of existing products are shown to be more able than single-product manufacturers to place less

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3) In a recent survey of manufacturing executives in the packaged goods industry, 74% responded that "power" has shifted towards retailers(*Progressive Grocer*, April 1992, 24-26)

profitable products. Shelf placement is thus seen to be a greater barrier to entry for single-product manufacturers.

Relevant Literature

Slotting and renewal allowances are much discussed in the trade press(e. g., Felgner 1989, Therrien 1989, Davis 1989) and have merited some empirical analyses(Sullivan 1993, Toto 1989) and examination of related legal issues(Cannon and Bloom 1991, Kelly 1991, Partch 1992). But few formal models of slotting or renewal allowances, or more generally of the shelf allocation mechanism, have been proposed, exceptions being those of Chu(1992) and Shaffer(1991).

Our model of slotting allowances extends Chu's single-manufacturer / single-retailer analysis to the case of multiple manufacturers competing for the shelf space of a single retailer. We also examine a model of renewal allowances as a mechanism for shelf placement under perfect information. In the process, we suggest that different manufacturers offer the retailer differential renewal allowances, which illustrates push versus pull approaches to achieving shelf placement.

Our model of slotting allowances is more applicable to the US packaged goods industry than Schaffer's because it acknowledges the informational role of slotting allowances in screening out unprofitable products. Shaffer's model, by assuming that manufacturers are homogeneous and that retailers possess perfect information about product profitablity, ascribes to slotting allowances no informational role.

Finally, our model of renewal allowances suggests that manufacturers with product lines are better able than single-product manufacturers to achieve retail shelf placement of less profitable items. Neither Chu nor Shaffer considers this issue.

In the next section, we discuss the role of slotting allowances in allocating shelf space, and the relationship between product proliferation and slotting allowances. In Section 3, we discuss similar issues with regard to renewal allowances. We then conclude and suggest areas of further research in Section 4.

Ⅱ. Product Proliferation and Slotting Allowances

Notation and Model Structure

We consider N manufacturers, each with a new product, who compete for the shelf space of a single retailer. The retailer has space for F(strictly less than N) products. (The amount ot shelf space allocated to a single product is henceforth called facing).

We consider various mechanisms of allocating retail facings in which each manufacturer i that is carried by the retailer pays a slotting allowance s_i. After facings are allocated, each manufacturer whose product is carried sets its wholesale price and the retailer sets an associated retail price.

To keep our model general, we do not explicitly analyze this price-setting part of the game. Instead, we allow the resulting manufacturer and retailer profits, denoted Π_i and π_i, respectively, to take on various values, which incorporate most commonly considered forms of pricing as special cases, including (1) simultaneous determination of wholesale and retail prices, (2) leader-follower behavior, (3) Nash bargaining outcomes and (4) simple cost-plus pricing.

The only restriction we require for tractability is that the product which generates the ith most manufacturer profit also generates the ith most retail profits stated formally:

$$\Pi_1 > \Pi_2 > \cdots > \Pi_N \text{ and } \pi_1 > \pi_2 > \cdots > \pi_N.$$

Thus, product i is unambiguously the ith most profitable product.

We simplify our analysis by assuming that if the retailer carries i, then π_i and Π_i are unchanged regardless of which other products are carried. Namely, products are neither substitutes nor complements. We also assume that the maximum slotting allowance that manufacturer i can pay is Π_i(so that $s_i \in [0, \Pi_i]$). To further simplify the analysis, we assume that money is indivisible beyond ε, where ε is small. Our notation is summarized in Table 1.

We assume that manufacturers know the profitability of their own products(through market research, pre-tests, and test markets) but the retailer does not(because the products are new).

Table 1 MODEL NOTATION

	Number	Facings	Slotting Allowance	Profit form *i*th Product*
Manufacturer	N		s_i	Π_i
Retailer	1	F		π_i

* Exclusive of slotting allowances.

Allocational Mechanisms

We consider three different game formulations(i.e., open English auction, sealed-bid auction, and retailer take-it-or-leave-it offer), which give rise to nearly the same equilibrium. The outcome is thus shown to be robust to different informational and institutional assumptions-covering what we believe to be prototypical cases. In particular, similar equilibria arise regardless of whether the manufacturers and retailer are informed of the profitability of the products competing for shelf space and of who makes the initial slotting allowance offer.

Open English Auction Representation. The slotting allowance is raised in increments and manufacturers indicate to the retailer whether they would be willing to pay. The process continues until only F manufacturers remain, each of whom pays the prevailing slotting allowance.(This form of English or ascending-bid auction is specifically called an English clock auction.) In this auction, the bidding process reveals information to the retailer about the profitability of manufacturers' products. The retailer need not know the manufacturers' profits for the market to attain equilibrium, nor do manufacturers need to know each others' profits.

Sealed-bid Auction Representation. Each manufacturer i offers, simultaneously and in secret, a slotting allowance s_i. The retailer then decides which offers to accept. Manufacturers are assumed to know the distribution of product profitability(Π_i and π_i for i=1, ⋯,N) although not which manufacturers make which profits; they base their offers on this prior information. The retailer has the same prior information.

The interesting feature of slotting allowance offers in this context is that they provide clues to the retailer about the likely retail profit of different products. Although the retailer observes the slotting allowance offers with certainty, it does not know the associated profits form carrying the product; and the retailer is concerned with both. (Note that the retailer is not committed to accepting the top F slotting allowance offers.)

We denote the retailer's prior expected retail profit from sale of product i, before observing a slotting allowance offer, as μ_i, and the retailer's posterior expected retail profit form sale of product, i, after updating expectations based on the slotting allowance offers, as $\hat{\mu}_i$. Such posterior expectations are specified as part of the equilibruim belief structure. The relevant equilibrium concept is perfect Bayesian equilibrium. (See Appendix 1 for details.)

Retailer take-it-or-leave-it Represention. The retailer issues a single slotting allowance offer which each manufacturer can accept or reject. The retailer is assumed to know the distribution of profits $\prod_i$ and π_i, $i=1,\cdots,N$, although not which manufacturer make which profits. Such information is required to avoid the retailer setting slotting allowances which result in empty shelves. (If the retailer lacked such information, it would be better off using an open English auction.) We assume that the retailer will not intentionally choose a slotting allowance that would leave empty shelves.[4] We include this allocational mechanism as an alternative to the two auction representations and to facilitate a comparison of our model with that of Chu(1992).

Equilibrium

All three game formulations described above lead to essentially the same outcome.[5]

Proposition 1. The top F products attain shelf placement in equilibrium. Manufacturers of these products pay slotting allowances of $\prod_{F+1}+\varepsilon$ in the open English and sealed-bid aucitons, and $\prod_F$ in the retailer take-it-or-leave-it game.

4) Appendix 2 shows that, under plausible assumptions about the distribution of profits, it is suboptimal for the retailer to intentionally leave open shelf space, even if it is allowed.

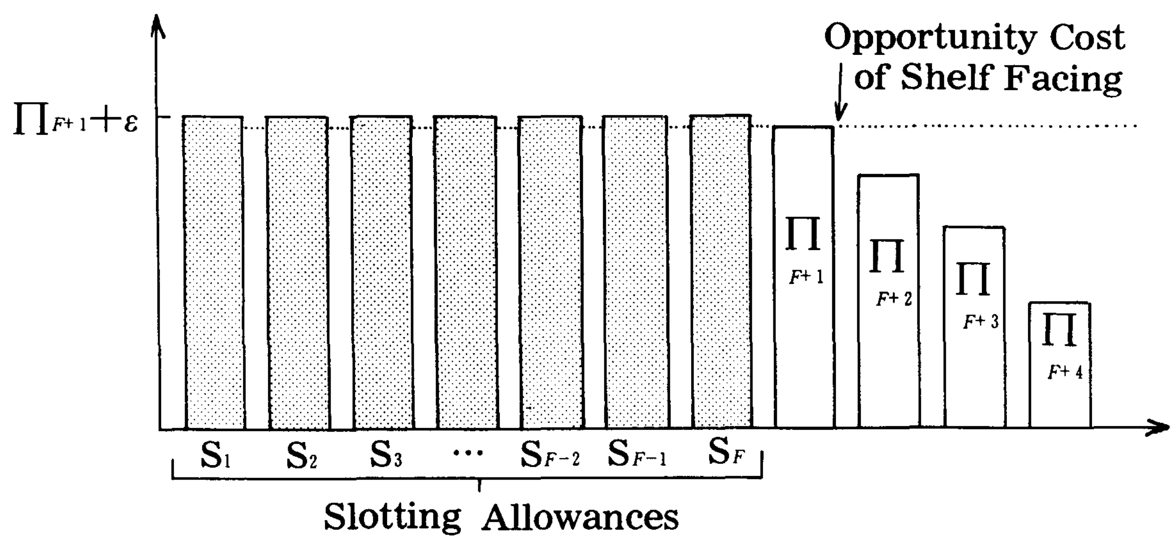
5) See Appendix 2 for proofs of this and all subsequent results.

The intuitive rationale for this result is that the N-F least profitable products are kept off the shelves because the equilibrium slotting allowance level exceeds what the manufacturers of these less profitable products could afford to pay. In the open English auction, the bidding mechanism reveals the slotting allowance that can play this role. In the sealed-bid auction, the top F manufacturers offer a slotting allowance level that can signal that their products are, indeed, the most profitable. In the retailer take-it-or-leave-it case, the retailer sets a slotting allowance that screens out the unprofitable manufacturers. In all cases, the profitabiity of the F+1st manufacturer, Π_{F+1}, constitutes the "opportunity cost" of a shelf facing (i.e., the value of the next best opportunity).

This opportunity cost determines the equilibrium slotting allowance, as illustrated in Figure 1 for the open English, and sealed-bid auctions. In the open English auction, equilibrium slotting allowances are ε above this opportunity cost because this is the smallest amount which eliminates the F+1st and all less profitable manufacturers from the bidding. In the sealed-bid auction, a bid of ε above Π_{F+1} is also the smallest amount which unambiguously signals to the retailer that the bid is from one of the top F manufacturers(and that the attendant retail profit form carrying the product

Figure 1

EQUILIBRIUM OF SLOTTING ALLOWANCE MODEL



Π_i = Manufacturer Profit for Product i

S_i = Slotting Allowance for Product i

is also one of the F highest). In the retailer take-it-or-leave-it case, the equilibrium slotting allowance level equals the profit of the product next in profitability above the F+1st products, $\prod_F$.

The implications of Proposition 1 are as follow. First, slotting allowances serve as an optimal screening mechanism for the channel as a whole since the set of products that are ultimately carried maximizes total channel profit. In particular, only the F most profitable manufacturers are willing to pay slotting allowances of $\prod_{F+1}+\varepsilon$(or $\prod_F$) because they are the only manufacturers confident that subsequent sales and profits will recover this up-front fixed fee. This outcome substantiates the claim of some retailers that slotting allowances play a desirable economic role.[6]

Second, slotting allowances serve as somewhat imperfect signals of expected levels of retail profit. The signals are imperfect because the manufacturers of the F most profitable products, which are all placed, have no incentive to distinguish themselves from one another. Hence, all pay the minimum slotting allowance that sets them apart form the N-F least profitable products.

Third, the equilibrium result is robust in that it arises from both the open English and sealed-bid auctions, which have very different informational requirements and bidding structures. The open English auction does not require manufactures to have information on the distribution of manufacturer's profits whereas the sealed-bid auction does. The open English auction also involves successive bidding stages(which appers more realistic), whereas the sealed-bid auction involves only one bidding stage(which does have the desirable property of attaining equilibrium quickly).[7]

Another important implication of Proposition 1 is highlighted in our next result.

Proposition 2. Product proliferation (including at least one product with profit higher than $\prod_{F+1}$) leads to an increase in slotting allowances.

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6) Viewed from another perspective, the retailer gets the best of both worlds. For each product i that it carries, it gets a greater slotting allowance and a greater retailer profit π_i than would be obtainable from carrying any of the other products.

7) For further background in auction theory see Vickrey (1961), Riley(1989), and McAfee and McMillan(1987).

This arises as follows. If additional products become available with profit higher than the previous F+1st product, then there will be a new F+1st product such that $\prod_{F+1}^{New} > \prod_{F+1}$. Therefore, the equilibrium slotting allowance level will increase to be ε above this new opportunity cost of shelf space.

This result differs from that of Chu(1992). In particular, our model, with the retailer take-it-or-leave-it allocation mechanism, is most directly comparable to Chu's model. Both models assume one retailer that makes a take-it-or-leave-it offer, informed about the distribution of manufacturers' product profitability. Both models conclude that slotting allowances play a screening role. Our model, however, assumes multiple manufacturers and concludes that product proliferation can shift the division of channel profits toward the retailer by raising the level of slotting allowances. Furthermore, the equilibrium of our open English auction represenation shows that the optimal screening property of slotting allowances does not necessarily rely on the retailer's knowledge of the distribution of the manufacturers' product profitability.

Ⅲ. Product Proliferation and Renewal Allowances

We now consider competition for shelf space among manufacturers of established products. Although we reinterpret the variables to match the context of established products, this model has the same structure as the one described in Table 1 above. That is, a retailer has F facings available for estblished prodcuts; N manufacturers each produce an established product; and s_i describes the renewal allowance of the ith manufacturer.

Informational Assumptions, Auction Mechanism, and Equilibrium Concept

The distinguishing feature that makes our second model applicable to established products is the assumption that the retailer has complete information about each individual manufacturer's product profitability. As a result, different renewal allowance arrangements can be made with each manufacturer. To allow for this realistic possibility, we assume that each manufacturer i makes a renewal allowance offer and the retailer selects from the offers.[8] Because this is a perfect information model, the relevant equilibrium concept is a subgame perfection(consisting of properties 1 and 2 of the perfect Bayesian equilibrium described in Appendix 1)

Equilibrium

We can obtain the following equilibrium regarding renewal allowances. (For this equilibrium let n be the largest integer between 0 and F, inclusive, for which $\pi_n > \prod_{F+1} + \pi_{F+1}$.)

Proposition 3. The top F products attain shelf placement in equilibrium. Manufacturers of the n most profitable products pay no renewal allowances. The next F-n manufacturers pay renewal allowances in inverse relationship to profitability (in particular, manufacturer $i=n+1,\cdots,F$ pays renewal allowance of $\prod_{F+1}+\pi_{F+1}-\pi_i+\varepsilon$).

The intuitve rationale is again that the top F manufacturers keep the other manufacturers' products off the shelves by providing the retailer with more profit than the F+1st manufacturer could possibly provide. As in the slotting allowance model, the maximum renewal allowance that the F+1st manufacturer would be willing to pay is $\prod_{F+1}$; however, in this model, the retailer knows that it also gets retail profit of π_{F+1} from the F+1st manufacturer. Therefore, the opportunity cost of a shelf facing in this complete information context is $\prod_{F+1}+\pi_{F+1}$. To be assured of a slot, a manufacturer must thus provide a renewal allowance which when added to the associated retail profit π_i, is greater than or equal to $\prod_{F+1}+\pi_{F+1}+\varepsilon$.

The situation is depicted in Figure 2. The opportunity cost of a shelf

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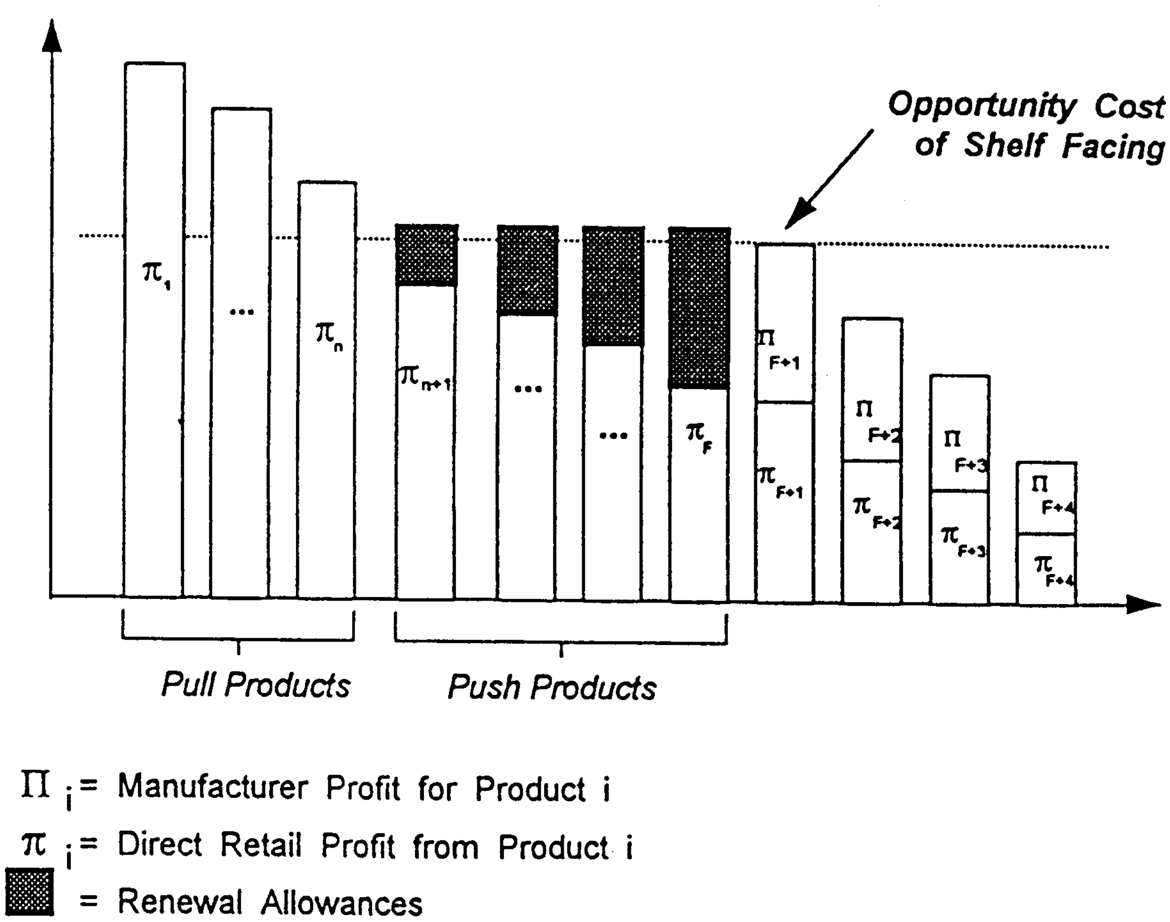
8) The open English auction and the single retail take-it-or-leave-it offer mechanism suffer from the drawback that they automatically result in the same renewal allowance for all manufacturers(in fact, the outcome is easily shown to be Proposition 1, which we have already considered). Another possible allocational mechanism is for the retailer to make a different take-it-or-leave-it offer to each manufacturer, which leads to the unrealistic outcome that the retailer extracts all of the channel profit. This mechanism ignores the fact that a profitable manufactuer may balk at such an offer by the retailer. Both the retailer and the profitable manufacturers control scarce resources (shelf space and profitable brands), and it appears inappropriate to apply an allocational mechanism that guarantees the retailer all of the surplus.

facing, $\Pi_{F+1}+\pi_{F+1}$, determines the equilibrium renewal allowances paid by the top F manufacturers. Products $i=1,\cdots,n$, if carried by the retailer, already generate retail profit in excess of this opportunity cost. Hence, manufacturers of these products do not need to offer renewal allowances to be slotted. Manufacturers $i = n+1,\cdots,F$, however, find themselves in a different position. Their products generate retail profit, π_i, less than the total profit $\Pi_{F+1}+\pi_{F+1}+\varepsilon$ required to keep the F+1st product off the the shelves. Such manufacturers must provide renewal allowance equal to the difference, $\Pi_{F+1}+\pi_{F+1}-\pi_i+\varepsilon$, in order to be assured of shelf placement.

Figure 2
EQUILIBRIUM OF RENEWAL ALLOWANCE MODEL



This model provides a formalization of the difference between push and pull approaches to achieving retail placement. To make their products sufficiently attractive to the retailer, less profitable manufacturers make concessions in the form of large renewal allowances, a push approach. Manufacturers whose products enjoy the greatest consumer pull, on the other hand, find it unnecessary to pay large, or even any, renewal allowances.

We now examine the effect of product proliferation on the determination of renewal allowances.

Proposition 4. Product proliferaton(including at least one product with total profit higher than $\prod_{F+1}+\pi_{F+1}$) leads to an increase in renewal allowances.

As with Proposition 2, if additional products become available with total profit higher than the previous F+1st product, then there will be a new F+1st product such that $\prod_{F+1}^{New}+\pi_{F+1}^{New}>\prod_{F+1}+\pi_{F+1}$, and all equilibrium renewal allowances will increase to meet the new opportunity cost of shelf space. This again demonstrates how heightened competition for shelf space can drive manufacturers to make greater concessions to retailers, as has occurred in the consumer packaged goods industry.

Product Lines

For this model, we also show that a manufacturer with a profitable product line may have an advantage over a single-product manufacturer in achieving shelf placement for a less profitable item. Consider the manufacturer of a product line consisting of a profitable product i and an unprofitable product j. In particular, suppose that:

(1) $\pi_i>\prod_{F+1}+\pi_{F+1}+\varepsilon$ (i.e., product i is profitable)

(2) $\prod_j+\pi_j<\prod_{F+1}+\pi_{F+1}$ (i.e., product j is unprofitable), and

(3) $\pi_i+\prod_j+\pi_j>\prod_F+\pi_F+\prod_{F+1}+\pi_{F+1}+\varepsilon$. (i.e., product i and j together give greater profit to the retailer than the two next best opportunities of the retailer)

In other words, product i is such that it would pay zero renewal allowance in the equilibrium of Propostion 3. Prdocut j is less profitbale than product F+1, which represents the next best opportunity. Products i and j are(substantially) more profitable than products F and F+1.

We assume that the manufacturer of i and j may make either separate or joint offers for placement of products i and j. If the manufacturer makes a joint offer that is rejected by the retailer, neither product is placed and renegotiation is not allowed. Our key assumption is that negative renewal allowances are prohibited. The rest of the set-up being exactly as for Proposition 3, we arrive at the following conclusion.

Proposition 5. The manufacturer of the product line consisting of i and j achieves shelf placement for both products in equilibrium(even though product j would not have been placed if it had been manufactured by a single-product manufacturer).

The intuitive rationale for this result is that product i is sufficiently more profitable than the next best opportunity that the retailer is willing to carry a relatively unprofitable product, j, rather than lose product i. Of course antitrust restrictions on tie-in may limit the explicit exercise of such bargaining leverage to some degree.

This result has important implications for entry barriers. Products in the earliest phase of the life-cycle are typically less profitable than products in later phases. A single-product manufacturer introducing a new product thus faces a barrier to shelf placement that a manufacturer with a product line can avoid. This advantage, together with synergies in new product development, manufacturing, and consumer brand acceptance, may account for why so many new products on grocer's shelves are made by existing companies.

Ⅳ. Conclusion

Our findings regarding shelf space allocation, product proliferation, the division of channel profits, and the role of slotting and renewal allowances are as follows.

- For new products, manufacturers signal the potential profitability of their products by paying slotting allowances.
- Product proliferation leads to an increase in slotting allowances.
- For existing products, profitable manufacuters pay little or no renewal allowances(i.e., a pull approach to shelf placement), while less profitable manufacturers pay more renewal allowances(i.e., a push approach to shelf placement).
- Product proliferation leads to an increase in renewal allowances.
- Manufacturers with a profitable product line may be more likely to obtain shelf placement for a less profitable product than a single-product manufacturer, if the manufacturer of the product line can tie its less profitable product in with its profitable product line.

Some caveats regarding the application of our analysis to consumer packaged goods channels are in order. First, there are other important factors influencing channel power such as increased retailer access to scanner information, greater store size and retail concentration, and maturing of product markets(Messinger and Narasimhan, 1994). Second, we have assumed that the products are neither substitutes nor complements, and that there is only one retailer. It would be desirable to explore robustness when relaxing these assumptions.

Overall, we believe that the issues of product proliferation, slotting allowances, renewal allowances, push versus pull strategies, and countervailing leverage of manufacturers with product lines are of sufficient moment to the grocery and other similarly-evolving retail sectors to merit further study.

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Appendix 1

Perfect Bayesian and Subgame Perfect Equilibrium

We represent retailer acceptance of prodcut i by assigning to the choice function $C_1(s_1,\cdots s_N)$ the value of one and rejection of the ith offer by assigning to the choice function the value of zero. A perfect Bayesian equilibrium in the context of this model consists of a set of manufacturers' offers $s^*=(s^*_1,\cdots,s^*_N)$, a retailer choice function $C^*=(C^*_1,\cdots,C^*_N)$, and retailer posterior beliefs $\hat{\mu}^*_i$, $i=1,\cdots,N$, that possess the following properties.

1. *Optimality of Manufacturers' Strategies.* Each manufacturer i is made at least as well off by playing the equilibrium s^*_i as by deviating to s'_i. That is,

$$\text{(A1)} \qquad \text{Prob}(C^*_i(s^*)=1)\ (\textstyle\prod_i - s^*_i) \geq \text{Prob}(C^*_i\ (s'_i,\ s^*_{-i})=1)\ (\prod_i - s'_i)$$

for all $s'_i \in [0, \prod_1]$. where s_{-i} is the $N-1$ vector of slotting (or renewal) allowances of all manufacturers except the ith.

2. *Optimality of the Retailer's Strategy.* The retailer accepts F offers that it expects to yield at least as much total retail profit plus slotting (or renewal) allowances as any other set of F offers. That is, the retailer is made at least as well off by playing C^* as by deviating to C':

$$\text{(A2)} \qquad \sum_{i=1}^{N} C^*_i(s^*)(s^*_i+\hat{\mu}^*_i) \geq \sum_{i=1}^{N} C'_i(s^*)(s^*_i+\hat{\mu}^*_i).$$

3. *Bayes-Consistency of Beliefs.*[9] The posterior expected retail profit for any product i is equal to the *average* retail profit of the products of all manufacturers that offer s^*_i. (The intuitive rationale is that, in equilibrium, the retailer's posterior beliefs are correct on average over the group of manufacturers that offer the same slotting allowance.)

Formally, suppose $s^*_i \in \{s^1,\cdots,s^P\}$ for all $i=1,\cdots,N$, where $s^1,\cdots,s^P$ are mutually distinct. Then the posterior beliefs $\hat{\mu}^*_i$ are Bayes-consistent if

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9) We present a formulation of Bayesian-consistent beliefs that is easy to work within the context of our model. A more common formulation, in terms of prior and posterior probability distributions (instead of prior and posterior expectations), includes the present formulation as a special case.

$$\text{(A4)} \qquad \hat{\mu}_i^* = \sum_{j \in A^p} \pi_j / \# A^p \text{ when and only when } s_i = s^p,$$

for $p \in \{1, \cdots, P\}$, where $A^p = \{i : s_i^* = s^p\}$ and $\# A^p$ denotes the cardinality of A^p.

In the context of the model of renewal allowances, a subgame perfect equilibrium consists of properties 1 and 2 in a full information setting. The defining property of a subgame perfect equilibrium is that the equilibrium strategies of the multistage game are also equilibrium strategies of each subgame. Therefore, one can establish that an equilibrium is subgame perfect by working recursively backward from the last stage of the game, analyzing the equilibria of the successive subgames.

For background on these equilibrium concepts see Fudenberg and Tirole (1991, pp. 325-326).

Appendix 2
Condensed Proofs

An extended version of this appendix can be obtained from the authors on request.

Proposition 1

English Auction (*Proof*). Equilibrium is reached when the top F manufacturers bid $\prod_{F+1}+\varepsilon$. The last of the other $N-F$ manufacturers drop out of the bidding at that point.

This outcome arises because each manufacturer i has an incentive to stay in the bidding until the slotting allowance level is $\prod_i$ and to drop out thereafter. When the slotting allowance reaches $\prod_{F+1}$, the top F+1 manufacturers remain in the bidding. When the bidding reaches $\prod_{F+1}+\varepsilon$, the F+1st manufacturer drops out and equilibrium is attained. Q.E.D.

Sealed Bid Auction(*Sketch of proof*). We demonstrate below that the equilibrium consists of manufacturers $i=1,\cdots.F$ offering $\prod_{F+1}+\varepsilon$ and the other manufacturers $i=F+1,\cdots,N$ offering $\prod_i$. The retailer's equilibrium belief structure is such that if the slotting allowance exceeds $\prod_{F+1}$, than the posterior expected profit, $\hat{\mu}^*_1$, equals $\frac{1}{F}\sum_{i=1}^{F}\pi_i$ – the average of the top F products. Otherwise if $s_i\in(\prod_{K+1}, \prod_K]$, then $\hat{\mu}^*_i=\pi_k$, where $k=F+1,\cdots,N-1$.[10] The retailer chooses those products from which the sum of the slotting allowance and posterior expected retail profit, $s_i+\hat{\mu}^*_i$, is highest (if there is a tie, the retailer choose randomly among the tied products).

We sketch why there is no incentive for any player to deviate from these strategies. For one of the top F manufacturers, offering a slotting allowance lower than $\prod_{F+1}+\varepsilon$ leads to losing the certainty of shelf placement(because the F+1st manufacturer is offering $s_{F+1}=\prod_{F+1}$). Offering more is not necessary since $\prod_{F+1}+\varepsilon$ already signals that the product is among the F most profitable. Any other manufacturer $i\in\{F+1,\cdots,N\}$ does not attain shelf place-

10) If $s_i\in[0, \prod_N]$, $\hat{\mu}^*_i=\pi_N$.

ment in equilibrium, and hence gets zero profit, any other feasible slotting allowance for such a manufacturer leads to the same outcome and does not make the manufacturer any better off. The retailer's strategy of choosing those products with the highest slotting allowance and expected retailer profit is clearly optimal, provided that the retailer's beliefs are accurate.

Finally, it is easy to verify Bayes-consistency of the retailer's beliefs in this equilibrium(in this case $P=N-F+1$). In particular, the belief that, on average, those manufactures that offer slotting allowances of more than $\prod_{F+1}$ have products which generate retail profits of $\frac{1}{F}\sum_{i=1}^{F}\pi_i$ is fulfilled in equilibrium. Q.E.D.

Retailer take-it-or-leave-it Offer (Proof). The retailer will set the highest slotting allowance that fills all the shelves, which is $\prod_F$. Any higher amount would induce the Fth player to decline the shelf space and will not fill all the shelves.

Manufacturers $i=1,\cdots F$, will accept the slotting allowance offer of $\prod_F$ since the alternative is zero profits by not obtaining shelf space. Manufacturers $i=F+1,\cdots,N$ will decline the slotting allowance, since acceptance entails negative net profit. Q.E.D.

Note that even if we allow the retailer to intentionally leave shelves empty, it will choose to fill all the shelves if

$$\prod_{K+1}+\pi_{K+1}>K(\prod_K-\prod_{K+1}), \qquad \text{for all integers } K<F;$$

that is, if the additional total profits generated by adding the $K+1st$ product to the shelves exceeds the implied reduction in slotting allowances obtainable form the first K prodcuts (this assumes that if the first K products are carried, the slotting allowance is $\prod_K$). This condition will hold if $\prod_i$ does not drop rapidly as i is increased or if π_i is large relative to $\prod_i$.

Proposition 2 (Proof)

(For the English and sealed-bid auctions) Product proliferation involving introduction of at least one new product with manufacturer profit greater than $\prod_{F+1}$ will entail a reordering of products such that there is a new F+1st product and $\prod_{F+1}^{New} > \prod_{F+1}$. Therefore, according to Proposition 1, the slotting allowance will increase to $\prod_{F+1}^{New} + \varepsilon$.

The proof of the retailer take-it-or-leave-it case is essentially the same and is omitted. Q.E.D.

Proposition 3 (Sketch of proof)

Let $n \in \{0, \cdots, F\}$ be such that $\pi_n > \prod_{F+1} + \pi_{F+1}$ and $\pi_{n+1} \leqslant \prod_{F+1} + \pi_{F+1}$.[11] Then an equilibrium consists of the top n manufacturers offering zero renewal allowances; manufacturers $i = n+1, \cdots, F$ offering $\prod_{F+1} + \pi_{F+1} - \pi_i + \varepsilon$; and the remaining manufacterers $i = F+1, \cdots, N$ offering $\prod_i$. the retailer choose those manufacturers that offer the highest renewal allowances plus retail profit (if there is tie, the retailer chooses randomly among the tied products.) The outcome of this equilibrium is that the top F products are placed.

We sketch why there is no incentive for any player to deviate from these strategies. The top n manufacturers attain shelf placement without paying renewal allowances. For manufacturers $i = n+1, \cdots, F$, offering less than $\prod_{F+1} + \pi_{F+1} - \pi_i + \varepsilon$ leads to losing the certainty of shelf placement; in particular, offering $\prod_{F+1} + \pi_{F+1} - \pi_i$ gives the retailer renewal allowance plus retail profit of $\prod_{F+1} + \pi_{F+1}$, just equal to what the $F+1st$ manufacturer provides. These manufacturers also have no reason to offer more than $\prod_{F+1} + \pi_{F+1} - \pi_i + \varepsilon$ because this amout is sufficient to guarantee shelf placement. Manufacturers $i = F+1, \cdots, N$ do not attain shelf placement in equilibrium, and hence get zero profits; any other feasible renewal allowance offers lead to the same outcome and do not make these manufacturers any better off. In this full information context, the retailer's strategy is clearly optimal. Q.E.D.

Proposition 4 (Proof)

Product proliferation involving introduction of at least one new product with total manufacturer and retailer profit greater than $\prod_{F+1} + \pi_{F+1}$ will entail a new F+1st product in the ordering of products, and

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11) We define π_0 to be larger than $\prod_{F+1} + \pi_{F+1}$.

$$\prod_{F+1}^{New}+\pi_{F+1}^{New}+>\prod_{F+1}+\pi_{F+1}$$

Therefore, according to Proposition 3, any firm i previously paying renewal allowances of $\prod_{F+1}+\pi_{F+1}-\pi_i+\varepsilon$ will now pay increased renewal allowances of $\prod_{F+1}^{New}+\pi_{F+1}^{New}-\pi_i+\varepsilon$.

Proposition 5 (Brief sketch of proof)

Given the equilibrium strategies of the players (which are analogous to those of Proposition 3) it turns out that if the retailer accepts the joint offer of the manufacturer of products i and j, the retailer will carry products $\{1,2,\cdots,F-1, j\}$, while if it rejects the manufacturer's offer, it wil carry $\{1,2,\cdots,F, F+1\}-\{i\}$. The manufacturer that produces i and j will bundle the two products and offer a combined renewal allowance that will give the retailer at least ε more than products F and $F+1$ could maximally provide in renewal allowances plus retail profit: $\prod_F+\pi_F+\prod_{F+1}+\pi_{F+1}$. The equilibrium renewal allowance of the manufacturer of products i and j is accordingly $\prod_F+\pi_F+\prod_{F+1}+\pi_{F+1}-\pi_i-\pi_j+\varepsilon$.[12] Except for this feature the proof of equilibrium proceeds in the same way as for Proposition 3.

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12) This assumes that $\pi_i+\pi_j \leq \prod_F+\pi_F+\prod_{F+1}+\pi_{F+1}$. Otherwise the manufacturer of products i and j will pay zero renewal allowance in equilibrium and attain shelf placement.