Packaging as Commodity Bundling and Inter-type Competition in Retailing

by

Roger R. Betancourt
D. of Economics
U. of Maryland
College Pk., MD 20742

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Introduction

There is a substantial literature on commodity bundling. A seminal point of departure for the modern literature is the work of Adams and Yellen (1976).[1] It eliminates what one may consider two fundamental explanations for bundling: preferences (complementarity of demand) and technology (economies of scope). Instead, it focuses on commodity bundling as a mechanism for price discrimination between heterogeneous consumers. It defines three possible strategies for a monopolist selling two package sizes of the same items. Offering just the large size, which is called pure commodity bundling; offering both sizes with the large one priced at a discount, which is called mixed commodity bundling; and, implicitly, offering the small size which would be simple monopoly pricing or the pure components strategy in their terminology.

Subsequent work proceeds by relaxing the assumptions made by Adams and Yellen (1976) but, by and large, preserves the emphasis on commodity bundling as a form of price discrimination. Lewbel (1985), for example, extends their results by showing that there can be a profit incentive to bundle in the presence of substitutes and a profit incentive not to bundle in the presence of complements. McAffee, McMillan and Whinston (1989) characterize mixed commodity bundling as an optimal strategy in very general terms, by deriving the results in terms of joint probability distributions for the reservation values of consumers rather than in terms of discrete consumers and by allowing for premia as well as discounts, and they extend the result to a duopoly. More recently, the literature stressing the price discrimination aspect of commodity bundling

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[1]This work also provides references to the earlier literature.

has moved to the incorporation of strategic interaction features, for example Carbajo, de Meza and Seidman (1990) and Matutes and Regibeau (1992).

Of special relevance to our present purposes are three other contributions. Two of them stress the so called fundamental reasons for commodity bundling. Chae (1992) assumes an extreme form of economies of scope in the distribution technology and demonstrates that pure commodity bundling can increase profits and consumer surplus relative to a pure components strategy. This analysis and its application to the subscription television market is described by the author as a case of natural bundling. Salinger (1995) shows that when pure commodity bundling lowers costs (economies of scope), it tends to be more profitable when demands are positively correlated (goods are complements) and stand alone production is expensive. Finally, Gerstner and Hess (1987) analyze mixed commodity bundling in a setting where consumer heterogeneity in storage and transaction costs is used to explain discounts, premia and package sizes.

Whenever one observes more than one package of the same item available, one enters the world of commodity bundling. Whenever one observes a retail enterprise, however, another type of bundling arises as a fundamental characteristic of retail markets: namely, the bundling of distribution services with the items or services explicitly sold at retail, Betancourt and Gautschi (1993). This second type of bundling provides a form of natural bundling in retail markets that must be incorporated in any analyses of packaging in retailing. For, this feature allows for a shifting of distribution costs between consumers and retailers that can modify any conclusions drawn from viewing packaging as merely a form of commodity bundling. The latter is treated as simply a price discrimination device even in the best modern textbooks, e.g., Pepall, Richards and Norman (1999). In the context of retailing, however, both types of bundling associated with packaging need to be considered in order to accommodate the role of inter-type competition in retailing.

In the next section a simple model of intra-type competition in retailing is presented. It provides the basis for the subsequent analysis. In Section 2 the natural bundling of a distribution service, assurance of product delivery in the desired form, with the items sold at retail, which is a fundamental characteristic of the technology of retail markets, is shown to lead to a pure commodity bundling equilibrium in retail markets when all consumers are identical and, thus, the price discrimination normally associated with commodity bundling is impossible. In Section 3 the existence of an additional distribution service, assortment, and its natural bundling with the previous one is shown to lead to mixed commodity bundling equilibria in retail markets when all consumers are identical. In Section 4 the implications of the previous results for the explanation of discounts, premia and package sizes are explicitly drawn. The previous three sections stress the shifting of distribution costs across the market boundary between consumers and retailers as fundamental determinants of the commodity bundling associated with packaging and the role of inter-type competition in determining the main stylized facts of commodity bundling. Section 5 concludes by discussing the main implications of the analysis and bringing out the role of consumer heterogeneity and the associated price discrimination in the context of a real world illustration, namely the packaging of potato chips by retailers in a specific market.

1. A Simple Model.

An adaptation of the model in Betancourt and Gautschi (1993) for empirical implementation, Betancourt and Malanoski (1999), provides our point of departure. It captures the potential for shifting distribution costs across market boundaries, the natural bundling between distribution services and the items explicitly sold that occurs in retail markets and Bliss (1988) concept of (intra-type) competition in retailing.

The essence of the model is that retailers choose prices and distribution services simultaneously given the demand functions for the retailer's products and the level of competition in the market. Formally, we write the constrained maximand for a store as

$$L = pQ - C(v, Q, D) - wQ + \mu N[E^{=} - E(p, p^{=}, D, Z^0)]$$

where p is a vector of store prices; Q is a vector of output levels for each type of item sold, which is determined by the aggregate demand for these items faced by the store. N is the number of transactions. We will assume that all repeated purchases are the same and that all consumers of any one supermarket are identical; hence, Q= qN, where q is the vector of demand functions per transaction of the representative consumer, and N will be normalized at unity. C is a neoclassical cost function describing the costs of supermarket activities as a function of input prices (v) and the two types of outputs of the retailing activity, explicit products or types of items (Q) and the implicit levels of distribution services (D) that stores bundle with these items . w is a vector of the prices of the items purchased from suppliers. E is the expenditure function of the representative consumer, which depends on the store=s prices (p), the distribution services offered by the store (D), other prices ($p^{=}$) faced by the consumer and the optimal level of the consumption activities, Z^0.[2] E= is the lowest cost to this 'representative consumer' of attaining her maximum level of utility at an alternative establishment. μ is a Lagrange multiplier.

Since this constrained maximand is unfamiliar to many economists, it is instructive to discuss what it captures explicitly. The first three terms are the standard definition of profits for a retail establishment, in which it is useful to separate sales (pQ) and two dimensions of costs: those due to the distribution activities of the retailer (C(v, Q, D)) and those due to the production activities of wholesalers or suppliers (wQ). The fourth term represents a constraint that captures the effects of competition on supermarket behavior in the following sense. If there is a lowering of the competitive standard that a store faces, for example by a 1 $ increase in the lowest cost per transaction to a 'representative consumer' of attaining her maximum level of utility at an alternative establishment, the Lagrange multiplier, μ, measures the marginal contribution to profits of such an experiment. μ ranges between zero and unity.[3] This constraint captures Bliss (1988) concept of retail competition as offering the consumer better value for her money

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[2] E is a restricted expenditure or cost function in that D plays the role of a fixed input in this function. It has the well known implication (Shephards Lemma) that $\partial E/\partial p = q(p, D, p^=, Z^0)$. This is the Hicksian demand function which upon substitution of the demand for the commodities, $Z^0 = g(p, p^=, D, Y)$, generates the Marshallian demand function. See Deaton and Muellbauer (1980, Chs. 2 and 10) for the general procedure or Betancourt and Gautschi (1992) for its application to retail demand. In particular the last reference shows that, if we assume that other prices faced by the representative consumer (p=) are constant, the Marshallian demand can be written as q(p, D, Y) and it will be decreasing in price (p), and increasing in distribution services (D) and the consumer=s full income (Y). Finally, just as any restricted cost or expenditure function, it has the property that $\partial E/\partial D < 0$. And, this property can be used to define the shadow price of distribution services, $r = -\partial E/\partial D$, or how much the consumer would be willing to pay for an additional unit of distribution services if it were available in the market at an explicit price.

[3] If in the above example μ equals zero, we have the case of a monopolist and there are no gains from meeting the competitive standard. If μ equals unity the supermarket gains all the business of the representative consumer. For values between zero and unity the supermarket gains a fraction of the business of the representative consumer. If μ exceeds unity second-order conditions are violated. Thus the maximum value of μ is unity.

than at the next best alternative store in terms of an expenditure function that allows for the existence of distribution services and makes explicit the assumption of identical transactions across consumers and repeat purchases.[4]

For simplicity, consider the single-type of item and single-type of distribution services case-- optimal choices of prices and services by a store must satisfy

Price: $(p - C_Q - w)(\partial Q/\partial p) + Q(1-\mu) = 0$ (1)

Distribution Services: $(p - C_Q - w)(\partial Q/\partial D) + \mu r - C_D = 0$ (2)

Constraint: $\bar{E} - E(p, \bar{p}, D, Z^0) = 0$ (3).

It is insightful to proceed by considering two special cases that this model generates, which can be seen through these conditions. Suppose we assume first that $\mu = 0$. The constraint becomes irrelevant and we have a generalization of the standard monopoly case in the literature. (1) and (2) simply imply that the retailer chooses prices and distribution services such that marginal revenues equal marginal costs in both cases.

Suppose we assume instead that $\mu = 1$. Condition (1) implies $p = C_Q + w$, or the retail price equals the marginal cost of retailing an additional unit of output plus the cost of purchasing this unit from suppliers; condition (2) implies that $r = C_D$, or the shadow price of an additional unit of distribution services to the representative consumer equals the marginal cost of providing this additional unit to the consumer. Thus, we have a generalization of standard competitive behavior in a model that incorporates distribution services as a variable. Notice that in this model the conjectural variation is zero. That is

[4]Incidentally μ captures intra-type competition from other stores. General competition for the consumer's dollar is captured in the price elasticity of demand. Unless otherwise stated competition will refer to the former and not the latter.

the store takes its rivals prices and distribution services as given.[5] Hence, this model has all the advantages and disadvantages of the Bertrand model as discussed, for example, in Tirole (1988, Ch. 5). In particular, the slightest departure from competitive behavior results in the supermarket losing all of its sales to the representative consumer. This helps interpret the more general model. Namely, when $0 < \mu < 1$, the store loses a fraction of its sales to the representative consumer when it fails to meet the competitive standard represented by the constraint.

2. Inter-type Competition and Storage Costs: Pure Commodity Bundling Equilibria.

In order to relate our analysis to the existing literature while highlighting the fundamental characteristics of retail markets identified here, we follow the assumptions and definitions in Adams and Yellen (1976) as much as possible. In particular the definitions of the available strategies to the decision makers are logical extensions to our case of these authors' definitions. That is, we identify an equilibrium as a pure components equilibrium if there exists one type of firm selling small packages in equilibrium. An equilibrium is a pure commodity bundling equilibrium if there are two specialist types of firms: one offering a small package and one offering a large package. Finally, we identify an equilibrium as a mixed commodity bundling equilibrium if there are at least two types of firms: a generalist offering a small and a large package and either one or both of two specialists: a firm offering a small package and/or one offering a large package.

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[5] Incidentally, as Tirole (1988, p.244) notes this is the only consistent conjecture in a static model.

Inter-type competition is defined as a situation in which there exists at least two firms offering similar items and substantially different levels of at least one distribution service to consumers. An example of inter-type competition is that which occurs between retail florists and supermarkets that sell flowers. Intra-type competition implies firms that are similar in their offerings of items and distribution services, for example competition among supermarkets. In practice, of course, the boundary lines can get blurred and these distinctions must be drawn in the context of the particular analysis. In terms of the previous definitions, only intra-type competition is possible in a pure components equilibrium.

In contrast to Adams and Yellen, and all of the references cited in the introduction, we will assume homogeneous consumers through the device of a single representative consumer. This is not because we believe all consumers to be the same, but because it provides a mechanism that brings out as sharply as possible the importance of cost shifting in the packaging decision at the retail level. From this perspective, packaging can be viewed as an instrument for offering consumers higher levels of assurance of product delivery in the desired form (small packages), which reduces consumers' storage costs, at the expense of the retailer incurring a higher level of storage costs due to the provision of a higher level of this output. This view is captured in the model of intra-type competition presented in Section 1. An increase in a distribution service (D) increase the costs of the store, by virtue of its role as an output, and it decreases the consumer's expenditures to attain a given level of utility, by virtue of its role as a fixed input.

If we assume one distribution service to be variable, assurance of product delivery in the desired form, and all others to be constant at the same level for every firm, it immediately follows from this model that:

Proposition 1: Imperfect intra-type competition is a necessary condition for a pure commodity bundling equilibrium to exist.

With perfectly competitive behavior, profit maximization by the retailer implies $p = C_Q + w$ and $r = C_D$. Hence, the retail price equals the marginal costs of retailing plus the price paid to suppliers per item and the consumer's shadow price for the distribution service equals the marginal cost per transaction of producing this level by the retailer. Given an increasing marginal cost function for distribution services, a firm providing small packages will provide a higher level of distribution services at any given p than one providing large packages, since the main determinant of costs of providing this distribution service is the number of packages. That is, with the same total number of items it takes more space, materials and labor to provide small packages than large packages.

Perfect (intra-type) competition leads to a pure components equilibrium in retail markets. The firm providing the higher level of distribution services will lead the consumer to experience a lower shadow price of the distribution services[6] and, thus, a lower level of expenditures in attaining the same level of utility. Hence, with homogeneous consumers, only the firm that provides the highest level of distribution

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[6] The shadow price of distribution services, $-E_D$, is decreasing in the level of distribution services. Since D plays the role of a fixed input quantity in the expenditure function, $E_{DD} > 0$.

services will survive in the market and a pure commodity bundling equilibrium is not feasible. Another way of interpreting this result is that perfect intra-type competition eliminates the natural bundling that exists between distribution services and the items explicitly sold at retail, by leading to marginal cost pricing of items and distribution services. In so doing, it eliminates the fundamental reason for commodity bundling with homogeneous consumers.

By definition a pure commodity bundling equilibrium implies the existence of inter-type competition: that is a small package firm coexisting with a large package firm in the same market. Under what conditions can this happen? The next proposition summarizes our main result.

Proposition 2: Given imperfect intra-type competition, quantity discounts are necessary for a pure commodity bundling equilibrium to exist with homogeneous consumers.

For this equilibrium to exist the representative consumer must be indifferent between the two types of firms. This implies that the expenditures of the consumer at each type of firm must be the same, other things equal. That is,

$$E\,[p(A), D(A), D\_, p', Z] = E\,[p\,(B), D(B), D\_, p', Z] \qquad (4),$$

where A identifies the small package retailer and B the large package retailer. Thus, p(A) [p(B)] is the price per item of the small [large] package retailer and D(A) [D(B)] is the level of assurance of product delivery in the desired form for the small [large] package retailer. D_ is the level of other distribution services offered by both retailers, p' are the prices of other items purchased by the consumer outside this market and Z are the levels of the consumption activities; all three will be assumed constant at the same level while patronizing both types of firms. By definition D(A) >D(B), which implies that the left hand side of (4) is less than the right hand side if $p(A) \leq p(B)$. This follows from the fact that the expenditure function must be decreasing in D and increasing in p. Hence, quantity discounts, i.e., p(A) > p(B), are necessary for this equilibrium to be possible on the consumer side. Otherwise, the consumer could not be indifferent between these two types of firms.

The above argument establishes the necessity of quantity discounts for a short-run equilibrium to exist; but if one of the two types of firms is making more profits than the other, the less advantaged one has an incentive to change type and the equilibrium will not last. If the equilibrium is to last, both types of firms should be experiencing the same level of profits. On the cost side, we have that C [Q, D(A), D_] > C [Q, D(B), D_]. We are assuming, following Adams and Yellen, that both types provide the same number of items to the consumers, Q.[7] In this setting the inequality follows from the nature of assurance of product delivery in the desired form as an output of retail firms, since we know that D(A) > D(B). Finally, the same level of profits implies

(p(A) - p)Q - C [Q, D(A), D_] = (p(B) -p)Q - C [Q, D(B), D_] (5).

But the cost inequality implies that quantity discounts, p(A) > p(B), are necessary for (5) to hold and, thus, for the equilibrium to last.

Are quantity discounts sufficient for a pure commodity bundling equilibrium to exist? The answer is yes under additional assumptions. With identical costs conditions

[7] This assumption implies that expenditures on these particular items will be greater for the consumer when patronizing the small package retailer. Total expenditures and utility can be the same at both retailers, however, because the savings in storage costs allow the consumer at the small package retailer to use additional inputs to produce the same Z vector.

ex-ante, we can rewrite the first-order conditions in Section 1 as follows:

$[p- C_Q - w]- (1/\varepsilon)(1-\mu) = 0$ (6);

$(1/\varepsilon)(1-\mu)(\partial q/\partial D) +[\mu r - C_D] = 0$ (7).

Assuming, in addition, that the level of intra-type competition is the same for both types of firms, in the sense that μ is the same for both, the existence of quantity discounts implies restrictions on (6) and (7), i.e., $dp/dD > 0$. Starting from a pure components equilibrium where the second-order conditions are satisfied for the small package firm, we can show that these restrictions merely assure that the second- order conditions will also be satisfied for the large package firm. Since the argument is intricate and uses standard techniques, we present it in an Appendix available on request.

The differential shifting of storage costs across market boundaries associated with inter-type competition in a pure commodity bundling equilibrium requires quantity discounts. This result provides insight into a very commonplace observation with respect to one particular form of inter-type competition in retail markets: namely, the offerings of items in large packages by warehouse stores are accompanied by substantial quantity discounts relative to the offerings of the same items in smaller packages by convenience stores or vending machines.

3. Inter-type Competition, Storage Costs and Shopping Costs: Mixed Commodity Bundling Equilibria.

In this section we have the objective of demonstrating that the natural bundling that occurs among distribution services, in particular between assurance of product delivery in the desired form (small packages) and assortment (low shopping costs), can lead to a mixed bundling equilibria in retail markets where a generalist can coexist with a specialist.

Our main result can be stated in terms of the following proposition.

Proposition 3: Given imperfect intra-type competition, the existence of more than one distribution service, each of which is valued by the consumer, is a necessary condition for mixed commodity bundling equilibria to exist in a retail market with homogeneous consumers.

For the equilibrium to exist the consumer must be indifferent between patronizing a specialist (A) selling small packages and a generalist (C) selling a mixed bundle of small and large packages. This requires

E [p(C), D(C), D_(C), p', Z] = E [p(A), D(A), D_(A), p', Z] (8),

D(A) > D(C), because the small package retailer provides a higher level of assurance of product delivery in the desired form; and D_(A) < D_(C), because the small package retailer provides a lower level of assortment. p(A) is the price per item of the small package retailer and p(C) is the price per item of the mixed bundle retailer. If we assume that the price per item offered by both retailers is the same, p(A) = p(C), and that the number of items desired by the consumer is the same, then equilibrium requires that the lowering of consumer expenditures from the higher level of assurance of product delivery at the specialist compensate the higher expenditures due to the lower level of assortment and viceversa for the generalist or mixed bundle retailer. These trade offs are consistent with the properties of the expenditure function, where each distribution service operates as a fixed input, as long as the consumer has a positive valuation for each of the distribution services. If the consumer does not value storage costs (D) or shopping costs (D_), these trade offs become impossible and the mixed bundling equilibria can not exist.

On the cost side equilibrium requires costs to be the same for both types, i.e., C[Q(A), D(A), D_(A)] = C[Q(C), D(C), D_(C)]. Thus, if Q(A) = Q(C), the higher costs of assurance by the specialist must be compensated by the lower costs of assortment and viceversa for the generalist. Once again these trade offs are consistent with the properties of the cost function where each distribution service operates as an output.

Sufficient conditions require additional assumptions. We will consider one special case that is of particular interest in the context of retailing. In detailed analyses of features of retail markets one often finds the following characterization of the consumer' transaction costs technology, which is derived from the classical inventory model, for example Whitin (1952) and Oi (1992).

$TC = s(q/P) + h(P/2)$ (9),

where s is the shopping cost per trip and h is the storage cost for the average number of items held per period, P is the number of items in a package. As P increases shopping costs go down and storage costs go up. With only one consumer, and given s, h and q, there is only one optimal package size trading off shopping and storage costs and mixed commodity bundling equilibria are not feasible. One way of allowing the mixed bundle producer to exist with this technology is by introducing consumer heterogeneity with respect to s, h, or q, for example Gertsner and Hess (1987), but we will not pursue this avenue here.

A sufficient condition for the mixed bundle equilibria to exist in the homogeneous consumer setting with this linear in prices (s, h) transactions technology is to introduce a carrying constraint on the consumer.[8] Select the large package size at the mixed bundle retailer such that the consumer makes only one trip. This generates a transaction cost for the consumer of $TC= s + h(q/2)$. Impose now a binding carrying constraint on the consumer so that, for example, only one package per trip is possible when two packages and two trips would have been optimal in the absence of the constraint, and require the transaction cost at the specialist to equal the transaction costs at the generalist. The optimal package size for the specialist becomes $P= q- 2s/h$. Note that $p(C) = (P/q)p(S) + [(q-P)/q]\ p(L) = p(A)$. Since P and q are constant, a sufficient but not necessary way of satisfying this constraint is uniform pricing by the mixed bundle retailer, i.e., $p(S) = p(L)$, or the price per item of the small and large package are the same. Since q is arbitrary, the optimal size of the large package $(q-P)$, and consequently the proportion of items in the large package $(1- \alpha)$, increases with q in this type of equilibria.

The main insight from the discussion in this section, thus far, is that the bundling of distribution services, each of which are valued by the consumer, is a natural source of commodity bundling in retail markets. The particular type of mixed commodity bundling equilibria analyzed here was selected to stress this point by keeping the price per item at both types of retailers constant and at the same level. In Section 2, we chose to keep the level of a distribution service constant and at the same level for both types and looked at the trade off between prices and the other distribution service.

We will conclude this section and connect it to the previous one as well as to

[8] Incidentally, Gerstner and Hess (1987) introduce a similar constraint in their analysis.

subsequent ones by analyzing the following case: the level of assortment will be assumed fixed at both types of stores but at a different level for each type. In particular the level of assortment at the specialist D_(A) will be fixed at a value (one package size) lower than the level of assortment at the generalist D_(C) (two package sizes). In this setting the imposition of a carrying constraint on the consumer, who therefore must make more trips at the specialist than at the generalist, allows for different trade offs between the two distribution services at the specialist and at the generalist. With homogeneous consumers this assumption suffices to generate a mixed commodity bundling equilibria with a specialist providing items in small package and a generalist providing them in small and large packages.

In equilibrium, the expenditure function of the consumer at the two types of retailers is given by (8) again. The differences are that no constraint is placed on the relation between p(A) and p(C) and that while D_(A) < D_(C), each of them is assumed constant. The constancy of assortment for each type of firm allows us to rely on equations (6) and (7) of Section 2 for the analysis of each type of firm. For (8) to be satisfied in this case, the consumer's trade off between price and assurance of product delivery in the desired form at the specialist must be such that it also compensates for the lower level of assortment at this type of retailer relative to the generalist.

In order to bring this out we will assume that the price per item of the small package is the same at both types of retailers, i.e., p(A) = p(S). In this setting a premia implies p(L) > p(A) and a discount implies p(L) < p(A). Thus, the price per item at the generalist is given by

$p(C) = \alpha\, p(A) + (1-\alpha)p(L)$ (10).

For any value of α, $0 < \alpha < 1$, it follows from (10) that a premium for the large package implies $p(C) > p(A)$ and a discount implies $p(C) < p(A)$. Can the consumer be indifferent between both retailers in both of these settings? The answer is yes. If there is a discount, the higher price per unit of the small package retailer (which increases E) is compensated by a higher level of assurance of product delivery in the desired form (which decreases E) and this must be valued highly enough by the consumer (the difference must be negative) to also compensate for the higher level of shopping costs. If there is a premium, the lower price of the small package retailer plus the higher level of assurance of product delivery in the desired form (both of which decrease E) must be sufficient to compensate for the higher level of shopping costs.

On the cost side equilibrium requires under these conditions that $C[Q, D(A), D\_(A)] > C[Q, D(C), D\_(C)]$ if a discount prevails, so that revenues for the small package retailer can exceed costs by the same amount than the smaller revenues for the mixed bundle retailer (with the lower price per item) exceed costs. Similarly, $C[Q, D(A), D\_(A)] < C[Q, D(C), D\_(C)]$ must hold for a premium to prevail in equilibrium. Both conditions are feasible, since they depend on the relative contributions to costs of providing a given combination of a level of assortment (through the availability of a different number of packages at each retailer on any one trip) and a level of assurance of product delivery in the desired form (through the total number of small packages) .

Hence, premia, discounts and, as we saw earlier, uniform prices are all feasible in mixed commodity bundling equilibria, because of the natural bundling among distribution services as well as between distribution services and the items sold at retail. Furthermore, the above discussion generates an empirical implication.

Proposition 4: Premia should be associated with high costs for the mixed bundle retailer and discounts should be associated with low costs for the mixed bundle retailer.

Interestingly, Agrawal, Grimm, and Srinivasan (1993) present evidence that provides partial support for this hypothesis. For a sample of 16 supermarkets, 600 brands and 62 products, they calculate the number of packages in a brand offered at a premium relative to the total number of packages and average this magnitude over all brands and stores for each product in their sample. This generates a dependent variable, Y, that measures the relative frequency of a premium in a product. In a logit regression, using Y/(1-Y) as a dependent variable , with a dummy variable that takes the value of 1 if the product must be refrigerated at the store and a value of zero otherwise as the indepndent variable, they obtain a positive coefficient which is statistically significant at the 10% level while controlling for other variables.[9] The costs of providing any combination of assurance and assortment are higher in the refrigerated environment.

4. Discounts, Premia and Package Sizes.

At this point we present two important stylized facts of packaging in retailing and discuss how the models developed earlier and their adaptation contribute to their explanation. Perhaps the most obvious stylized fact of packaging in retailing is that a large proportion of products sold in large size packages are sold at a discount.

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[9]This study will be discussed further in the next section.

Supermarkets are an example of a mixed bundle retailer and they provide most of the empirical evidence for this stylized fact.

Gerstner and Hess (1987) found for a North Carolina supermarket that of 472 brands sold in two package sizes, 91.5% of the large packages were sold at a discount with 7.2 sold at a premium and 1.3 under uniform pricing. Agrawal, Grimm and Srinavasan (1993) summarize other supermarket studies and present some evidence of their own, which shows that 80 % of all packages were discounted while 18% sold at a premium and 2% under uniform pricing. The other studies generate similar results.[10]

A second less noticeable stylized fact is that products sold at a discount are usually sold in larger sizes than products sold at a premium. For instance, Gerstner and Hess (1987, Table 1) show that for the 91.5 % of the brands which were offered at discounts, the average size ratio was above two (2.26), i.e., $(1-\alpha)/\alpha = (q-P)/P > 2$. On the other hand, for the 7.2% of brands offering premia, the average size ratio was below two (1.78), i.e., $(1-\alpha)/\alpha = (q-P)/P < 2$.

Can the model of the previous section shed any light on these two stylized facts? The answer is yes. Inter-type competition leads to (8) holding. The mixed bundle retailer has to choose a price, p(C), and a level of assurance of product delivery, D(C), given his level of assortment D_(C). If in addition q (= K_1) is the same for both types of retailers, then with only two package sizes and P fixed at the specialist's level, the large package size (q-P) is fixed, so that the level of assurance of product delivery of the mixed bundle

[10] These other studies as well as Agrawal , Grimm and Srinivasan were not as meticulous as Gerstner and Hess in limiting their comparisons to brands offering just two package sizes.

retailer is also fixed. Hence, the only variable under the control of the mixed bundle retailer to select p(C) is the price of the large package, p(L), as can be seen from (10).

What happens if q increases to a new level, K_2? Given P (the package size of the specialist), p(A) goes down which decreases p(C) in (10), and (q-P) goes up thereby increasing (1-α) in (10), which lowers the level of assurance of product delivery in the desired form provided by the mixed bundle retailer. Finally, the mixed bundle retailer chooses p(L) so that the new p(C) allows (8) to hold at the higher level of q. Since assurance of product delivery in the desired form is now lower, however, this requires a lower p(C) (thus a lower p(L)) than in the absence of a change in the large package size in order to get the consumer to purchase the new level of q. So, the larger is q the lower are p(A), p(L), and p(C), and the higher is (q- P) and, thus, the size ratio as well as viceversa.[11] Therefore, we have

Proposition 5: Given intertype competition, the small package size of the specialist and the same level of output of items for both types, the higher is this level of output the more likely are discounts to arise and this will be associated with high size ratios; the lower the level of output the more likely are premia to arise and this will be associated with low size ratios.

Proposition 5 fully explains the second stylized fact and it provides insight into the explanation of the first one. To explain the first one fully one must also assume that products sold at discount are the ones with high levels of demand. Since most products

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[11] We are assuming that at the new equilibrium on the demand side, the equilibrium condition on the profit side also holds.

bought in large sizes are bought at discounts, some evidence in this regard is provided by the empirical evidence in Aggrawal, Grimm and Srinavasan (1993). They find that a high propensity to buy a product in large sizes, measured on a scale of 0 for don't buy to 5 for I usually buy the product in the largest size, is explained mainly by a high level of demand, measured as the mean response of the answers to the questions of " my household uses a lot of this product and my household can not do without this product" with the answers given on a five point scale from strongly disagree to strongly agree.

Gerstner and Hess (1987, Table 6) also show that the size of the discount is positively correlated with the size ratio and the size of the premia is also positively correlated with the size ratio. To explain this stylized fact with our model, note that our earlier analysis forced the mixed bundle retailer to produce the same level of output as the specialist, which in turn fixed the large package size for any given q. Hence, the mixed bundle retailer could only control p(L). Suppose instead that q(A) can differ from q(C). Equilibrium on the consumer side is affected as follows: the right hand side of (8) does not change as long as P is given, but the left hand side is different in that the mixed bundle retailer now controls two variables, p(L) and the size of the large package [(q(C) - P], that influence p(C) and one q(C) that influences D(C) directly. Equilibrium also requires looking at profits rather than just costs, i.e.,

[p(A) - w] Q(A) - C[Q(A), D(A), D_(A)] = [p(C)- w]Q(C) - C[Q(C), D(C), D_(C)] (11).

Consider first a situation in which a discount prevails, i.e., p(L) < p(A) and thus p(C) < p(A) for any α in (10), and (8) and (11) hold. Suppose we increase the size of the discount relative to the previous one so that in the new equilibrium the distance between p(A) and p(C) in (10) is longer than when q(A) = q(C). In contrast to the earlier situation, however, the mixed bundle retailer can reach this new lower price per item equilibrium by lowering p(L), which increases the size of the observed discount, or by increasing the size ratio at the original p(L), which increases the inter-type discount. In practice one would expect to observe both instruments used and thus the positive correlation.[12] Suppose instead that a premium prevails, i.e., p(L) > p(A) and thus p(C) > p(A) for any α in (10). If we increase the size of the inter-type premium in this setting so that the distance between p(C) and p(A) is longer, the mixed bundle retailer can attain this inter-type premium by increasing the observed premium [p(L)] or by increasing the size of the large package or any combination of both.[13]

More generally, we have

Proposition 6: When the mixed bundle retailer is not constrained to offer the same number of items as the specialist, the size ratio [(q- P)/P] and the price per item of the large size package [p(L)] act as complements in arriving at a given price per item of the bundle offered to the consumer [p(C)].

5. **Implications**.

One of our aims in the previous discussion was to explain as many aspects of the commodity bundling associated with packaging as possible without appealing to

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[12] This implies a larger q(C) and a lower D(C) for the representative consumer on the left hand side of (8), which is feasible. (11) can hold at the new values of the right hand side of (11) although revenues will increase, since the elasticity of demand has to be greater than unity. This increase permits supporting combinations of higher Q(C) and lower D(C) that entail higher costs for the mixed bundle retailer in the new equilibrium.

[13]This implies a smaller q(C) and a higher D(C) in (8), which is feasible. (11) can hold at the new values, although revenues decrease, provided the lower Q(C) and higher D(C) entail lower costs for the mixed bundle retailer in the new equilibrium.

consumer heterogeneity and the possibility of price discrimination. We have succeeded in this endeavor, perhaps too well, by explaining the main known facts about packaging without appealing to price discrimination. Is there any role for consumer heterogeneity? It follows straightforwardly from our approach that the main role of consumer heterogeneity is to generate the possibility of equilibria with greater variety in package sizes and types of firms. This variety includes, of course, a mixed bundle retailer that offers more than two package sizes in equilibrium. Instead of pursuing this reasoning in detail, which would be repetitious, we will look at the role of consumer heterogeneity by examining the packaging choices that one observes in a particular case and its implications.

Retailers make choices with respect to commodity bundling by choosing the set of packages they stock in their stores and, thus, offer their customers. We examine the choices made for one particular type of item, Utz no preservatives potato chips, by a variety of retail establishments in the Washington metropolitan area. That is, we have gathered data on package sizes and prices of this brand of potato chips at four different types of retail establishments in this area: a vending machine, a convenience store [14], two supermarkets from the same chain[15] and a warehouse store.

We present this information in Table 1. below, where we include the package price, the quantity in a package (q) and the price per item in a package, p(C),

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[14] A quick check of three other convenience stores belonging to the same chain in the area showed the same four package size and price offerings.

[15] On the other hand, a quick check of supermarkets from the same chain in the area revealed different offerings. The supermarket chosen in a higher income area offers larger package sizes than the one chosen in a lower income area.

Table 1. Typical Potato Chips Package Offerings in Washington Area.

	Package Price($)	p(C) price per item(¢)	q Package Quantity
Small Package Specialist (Vending Machine)			
Pack 1	0.55	2.75	20[1]
Pack 2	0.75	2.14	35
Generalist 1 (Convenience Store)			
Pack 1	0.69	1.97	35
Pack 2	0.99	1.23	80
Pack 3	1.49	1.24*	120
Pack 4	1.99	1.10	180
Generalist 2 (Supermarket A, moderate income neighborhood)			
Pack 1	0.99	1.23	80
Pack 2	1.49	1.24*	120
Pack 3	1.99	1.10	180
Pack 4	3.79	0.94	400
Generalist 2 (Supermarket B, middle income neighborhood)			
Pack 1	1.49	1.24*	120
Pack 2	1.99	1.10	180
Pack 3	2.99	1.06	280[2]
Pack 4	3.79	0.94	400
Large Package Specialist (Warehouse Club)			
Pack 1	4.49	0.80	560[2]
Pack 2	5.69	0.59	960
Pack 3	8.79	0.72*	1200[1]

* An asterisk indicates premia within or across types of stores in the following sense. Since we have ordered the packages by their sizes (number of items), the asterisk indicates that there is another package with a fewer number of total items and the same or lower price per item.

[1] The package size of the large scale specialist is obtained by putting together in a box 60 packages of the smallest size available at the small scale specialist.

[2] The package size of the large scale specialist is obtained by binding together two packages of the smaller size available at supermarket B.

experienced by a consumer when purchasing a particular package at an establishment type. The first thing that one observes is that in practice commodity bundling equilibria, if they exist, are mixed commodity bundling equilibria. That is, they usually involve at least one generalist. The one pure commodity bundling equilibria that potentially arises in this setting between the small package specialist and the large package specialist must accommodate enormous differences in shopping costs.

For instance, a consumer of the vending machine's smallest package for 60 days pays $24.21 more than a patron of the warehouse club for the same number of items over the 60 day period in the same daily package. The latter customer often must travel a fairly long distance to the warehouse for a purchase, store these packages at home over the sixty days, and remember to carry one of them every day to the consumption location. It is safe to assume that the representative customers of these two specialists are two very different types of consumers. Hence, pure commodity bundling equilibria are unlikely to exist in this case.

More generally, the variety of package sizes within and across types of establishments suggests a fair amount of consumer heterogeneity. Within the convenience store type, for example, the existence of four different package sizes suggests that their customers differ in at least three relevant dimensions of their demand for potato chips. These could be willingness to store, level of quantity demanded and either willingness to make purchase trips and/or consumption activities for which the commodity is demanded.[16] Not surprisingly, in view of this heterogeneity, we find some evidence of price discrimination.

With respect to the consumers of the 120 chips package, the evidence is incontrovertible.[17] All three generalists charge a higher price per item for this package than for the next smallest one, the 80 chips package, and one of them Supermarket B does not even offer the smaller package. The latter feature points out an important mechanism for price discrimination against consumers. We can think of a package or a commodity not offered at a store as available at this store at a price no one would be willing to pay, for example infinity, and this helps illustrate the benefits of inter-type competition to consumers.

Among the most important benefits of inter-type competition in retailing is that it prevents or ameliorates both explicit price discrimination and implicit price discrimination through nonavailability. Thus, a consumer who wants to avoid the premium associated with the 120 chips package at Supermarket B or the price discrimination through nonavailability of the 80 and 35 chips packages can accomplish both by patronizing a nearby convenience store and have access to the 80 and 35 chips packages. Intra-type competition, on the other hand, would force this consumer to travel substantially farther to another supermarket, for example A, and there one would only

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[16] Interestingly, our approach predicts for the mixed bundle retailer that the next to largest package is sold at a premium relative to the largest package and this prediction is confirmed for the three generalists in Table 1.

[17] One also expects some price discrimination to be associated with the pricing of Pack 3 at supermarket B. An increase of 60 chips in going from Pack 1 to Pack 2 leads to a drop in price per item of 0.14 cents. Hence, one would expect a similar or greater drop in price per item in going from Pack 2 to Pack 3, since the increase in the number of chips is 100 and the type of plastic bag use in the packaging is the same. Instead, we observe a drop in price per item of only 0.04 cents.

have access to the 80 chips package. Consumers who value accessibility of location highly are the ones who benefit the most from the inter-type competition provided by the convenience store.

Finally, the benefits of inter-type competition are intimately related to the distribution services that define the types of retail establishment. That is, the result in the previous paragraph is not an accident. Consider the consumer of Pack 3 at supermarket B. It is likely that there is price discrimination against this consumer. This is considerably mitigated by the existence of the large package specialist where the same package can be obtained at 0.26 cents less per item provided the consumer is willing to purchase, and thus store, two packages at a time. Since these warehouse clubs are less conveniently located than most supermarkets, consumers with low storage costs who can shop less frequently, and as a result value accessibility of location less, are the ones who benefit the most from inter-type competition in this case.

Our analysis brings out two important aspects of retail systems for the analysis of packaging. First, the natural bundling that exists among distribution services and between these services and the items sold at retail provides a fundamental rationale for the commodity bundling associated with packaging in retailing. Second, inter-type competition in retailing is exceedingly powerful and important from the point of view of welfare in the analysis of packaging. For it ameliorates, and in some cases it may eliminate the consequences of the use of commodity bundling through packaging as a form of price discrimination. This has been ignored in the prior literature cited in the introduction.

From this perspective, our analysis of packaging brings out important policy issues in retailing. Consider the frequent restrictions on retail space and retail hours that are imposed on retail systems through legislation all over the world, going back at least to the Middle Ages. These restrictions have the unfortunate consequence of preventing or eliminating inter-type competition. Space restrictions limit or eliminate warehouse and other large stores from certain areas; restrictions on hours eliminate or limit convenience stores. By preventing these types of retail forms from existing or limiting their viability, these restrictions make possible a greater variety of forms of price discrimination associated with commodity bundling in packaging and their welfare consequences.

Appendix. Quantity Discounts are Sufficient for a Pure Commodity Bundling Equilibria to Exist.

The second-order condition at the pure components equilibrium is simply the condition for a constrained maximum in the two variable case. The latter can be stated in terms of the second derivatives(F_{ij}) of the objective function, where F is the objective function presented in Section 1, and the derivatives of the constraint in that objective function (-q, -r). Namely.

(A1) $(C + D)qr - r^2 X - q^2 Y > 0$,

where $C = F_{12}$, $D = F_{21}$, $X = F_{11}$, and $Y = F_{22}$. Taking the total differential of the first-order conditions with respect to the endogenous variables we find

(A2) $Xdp^* + C\, dD = 0$

(A3) $Ddp^* + YdD = 0.$

Quantity discounts imply $dp^*/dD = - C/X = -Y/D > 0$. Hence if Y and X are less than zero, quantity discounts imply C and D are greater than zero which in turn implies the second-order condition (A1) is satisfied. Therefore, when the second-order condition is satisfied at the pure components equilibrium for the small package firm, quantity discounts are sufficient to ensure that they will be satisfied at the pure components equilibrium for the large package firm. Thus, they are sufficient for a pure commodity bundling equilibria to exist.

All we need to prove now is that X and Y, which are given below, are negative.

$X = [1- C_{QQ} (\partial q/\partial p^*)](\partial q/\partial p^*) + (p^*- C_Q -w)(\partial^2 q/\partial p^{*2}) + (1- \mu) (\partial q/\partial p^*)$, and

$Y= - C_{QD} (\partial q/\partial D) + (p^*- C_Q -w)(\partial^2 q/\partial D^2) - C_{DD} - \mu E_{DD.}$

If we have a monopoly situation $\mu = 0$ and the last term on the right hand side of Y vanishes, but the sum of the other three terms must be negative because they are just one of the second-order conditions for the two variable profit maximization case. The last term on the right hand side of Y must be negative because the expenditure function is convex in D, i.e., $E_{DD} > 0$. Hence, we have established that Y < 0 under both imperfect competition and monopoly. Furthermore, quantity discounts then imply that D > 0. Since D = C (by the continuity of the objective function) and ,thus, C >0, then quantity discounts imply that X < 0.

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