

Rivalry in Price and Variety Among Supermarket Retailers

Timothy J. Richards and Stephen F. Hamilton*

Paper Submitted to Food System Research Group

Second Biennial Research Conference

June 16 - 17, 2005

Concourse Hotel, Madison, WI

* Authors are Power Professor of Agribusiness in the Morrison School of Agribusiness, Arizona State University, 7001 E. Williams Field Rd. Bldg. 130, Mesa, AZ. and Associate Professor of Economics, The Orfalea College of Business, California Polytechnic State University, San Luis Obispo, CA. 94307. Contact author: Ph. 480-727-1488, FAX 480-727-1961, email: trichards@asu.edu.

Rivalry in Price and Variety Among Supermarket Retailers

Abstract:

Variety is a key competitive tool used by retailers to differentiate themselves from rivals. Theoretical models of price and variety competition suggest that both firm and product heterogeneity are key determinants of price and variety strategies, but none test this hypothesis in a rigorous way. This study provides the first empirical evidence on supermarket retailers' combined price and variety strategies using a nested CES modeling framework. Unlike other discrete-choice models of product differentiation, the NCES model is sufficiently general to admit both corner and interior solutions in both store and product choice. The model is estimated using chain-level scanner data for four major grocery chains in a large, urban West Coast market. The results show that retailers do indeed use both price and variety strategies to compete for market share. Retailers tend to follow relatively similar, moderately cooperative pricing strategies, but tend to diverge in the extent to which they follow cooperative strategies in variety.

Key words: game theory, nested CES, price competition, retailing, variety.

JEL Code: D43, L81, M31, Q13.

Price and Product-Line Rivalry Among Supermarket Retailers

Introduction

Many believe that retailers operate in an environment that is best described as local monopoly markets (Slade 1995; Besanko, Gupta and Jain 1998; Dhar, et al. 2003). There is some evidence that consumers base their store-selection decisions on attributes unrelated to market prices such as location, cleanliness, service, or variety (Walters and McKenzie 1998), and retailers may use these various forms of non-price competition to differentiate themselves into local monopoly markets. It is also the case that shoppers generally find it easier to compare prices across brands within a store than to compare prices of common brands across retail stores (Slade 1995), and this also tends to promote localized brand competition.

Nonetheless, an emerging body of evidence suggests that the local monopoly view of retailing is strictly not true (Chintagunta 2002; Chintagunta, Dube and Singh 2002; Richards and Patterson 2004a, 2004b). Indeed, a cursory examination of the recent financial performance of U.S. supermarket chains suggests precisely the opposite – the rate of turnover in grocery store ownership appears to better approximate what we might expect to see under perfect competition. It is well-known, moreover, that supermarket managers seek to maintain the competitiveness of their stores across entire categories of goods, and accordingly set prices in a manner that takes rival retail prices into account (McLaughlin, *et al.* 1999). This suggests that retailers are not impervious to competitive market forces.

This paper takes the view that retailers act both as local monopolies and as competitive firms. Consumers tend to make discrete, long-run decisions regarding where to shop (and periodically revise them) according to which retail store is perceived to provide a desired

collection of goods at the lowest cost. This tends to stimulate intense price and non-price competition among retail stores. In the short-run, however, store choice is fixed, so that retailers retain an element of local monopoly power. Put differently, consumers compare prices across brands within-store more frequently than they compare prices across stores within-brand. At the same time, retail price discrimination is generally not possible between consumers who are shopping for brands and those who are shopping for stores. Retail prices must forge a compromise between these two roles.

Non-price competition is also important for store selection decisions. Among these retail tools, this paper focuses on the use of product-line, or variety, decisions. Retailers typically offer a wide range of product variety, and doing so can serve to attract a larger number of customers, build market share, and gain market power through “portfolio effects” (Nevo 2001).

This paper presents a structural empirical model designed to test the nature of price and variety competition among multi-product retailers. Unlike previous empirical work that considers only retail competition in prices, the framework here considers retail competition that arises jointly through the selection of prices and product variety. The approach nests consumer demand at both the store and the product level in a single utility maximization problem that explicitly accounts for the endogeneity of price and variety strategies. The data used to test the model are comprised of weekly sales within the fresh fruit category in supermarkets in the greater Los Angeles area. Because consumer packaged good sales are influenced to a large extent by manufacturer incentives and category management programs, the use of an unbranded commodity like fresh produce provides an uncontaminated view on retail strategies.¹ This allows

¹ Studies by Choi (1991) and more recently, Sudhir (2001), formally model the nature of manufacturer-retailer interactions but assume a highly simplified retail market.

for a relatively straightforward empirical examination of whether grocery retailers compete in prices, variety, both prices and variety, or are insulated entirely from either form of competition.

Background

Dixit and Stiglitz (1977) and Spence (1976) were among the first to develop formal models of product variety and price. The models follow along traditional lines of monopolistic competition in the sense that product proliferation emerges as an equilibrium condition through tension between the cost of developing new products and the effect of new products on reducing demand for existing products. Each product is identified as an individual firm and firms enter the industry, proliferating products in the process, until demand for brands is no longer sufficient to recover entry costs. More recently, Raubitschek (1987) extends the constant elasticity of substitution (CES) model of Dixit and Stiglitz by replacing the equilibrium condition with a two-stage optimization process in which a centralized manager for each firm selects the number of brands to offer in the first stage, and then each brand is priced independently by individual brand-managers in the second stage. The outcome is that the number of products offered by a given firm in equilibrium is higher when the (exogenous) number of firms is larger.

Anderson and de Palma (1992) make the useful distinction that differentiation often results in the selection of only one store or product. They develop a model of price and variety competition in which consumers select among stores, and then products within stores, according to a nested-logit framework. In equilibrium, they argue, greater heterogeneity among stores leads to less variety, while heterogeneity among products within each store leads to greater variety. However, it is well understood that the nested logit model, while more general than a simple logit

in the sense that it allows for store and product heterogeneity through extreme-value scale parameters, leads to unrealistic substitution patterns among products within each nest. The nested logit approach also implies that a corner solution must exist at each choice level. de Palma *et al.* (1993) apply this framework to explain spatial competition among video store owners in prices and variety, but do not formally test the implications of the theory.² Watson (2004) formally tests a variety and price game of this form under circumstances of endogenous location choices and finds that variety is a concave function of the number of local competitors.

Strategic product proliferation is important in a non-spatial sense as well. Brander and Eaton (1984) develop a model of strategic preemption in which producers of substitutable products are likely to monopolize a particular market segment in order to deter entry. Hamilton (2003) synthesizes these two branches of the modeling literature by combining a discrete store-choice model with a model of within-store product choice. This model allows for heterogeneity across retailer stores as well as heterogeneity across brands. The outcome is that product variety decisions depend on both store heterogeneity and product heterogeneity, whereas pricing decisions are influenced only by product heterogeneity. The implications of the model for product variety decisions nonetheless accord reasonably well with those of Anderson and de Palma (1992): Greater heterogeneity among stores leads to a smaller provision of product variety, although greater heterogeneity among products sold within each store leads to ambiguous effects in Hamilton's model. The reason for this is that greater product heterogeneity increases retail margins, which lowers the value of new product introductions that (at least partially) cannibalize demand from incumbent brands. This study provides an empirical test of the

² The authors address a specific example, but do not formally test the hypotheses that follow from their model.

theoretical predictions of these models.

Few empirical studies have examined product variety decisions in retail markets. Indeed, virtually all previous empirical research on the competitive aspects of product variety is directed at the manufacturing level, where “product lines” are typically comprised of a small set of related brands and competitors are few (Bayus and Putsis 1999; Kadiyali, Vilcassim and Chintagunta, 1996, 1999; Dobson and Kalish 1988; Oren, Smith and Wilson 1984). Roberts and Samuelson (1988) design and estimate a repeated two-period non-cooperative oligopoly model among U.S. cigarette manufacturers in which the number of brands is a key determinant of demand, but this is not treated as a strategic choice variable. Models of product-line competition in the empirical literature are commonly specified at the level of individual brands using product-level conduct parameters, while the proliferation decision, itself, is either treated as exogenous (Kadiyali, Vilcassim and Chintagunta (KVC) 1996, 1999) or without any reference to a structural model of competition (Bayus and Putsis 1999). KVC demonstrate that yogurt producers are able to acquire market power through the “portfolio effect” of offering a greater array of products, as a larger range of products effectively reduces a measure of the elasticity of demand over their whole product line. Draganska and Jain (2003) recognize the strategic importance of product-line length and estimate a model in which the number of varieties offered per product line, as well as the price of the products, are endogenous determinants of retail demand. This model follows Berry (1994), Berry, Levinsohn and Pakes (1995), and Nevo (2000, 2001) in specifying a logit demand model in which product differentiation is reflected in discrete consumer choices. Although the decision to introduce new products is presumably to attract new customers (i.e., by creating better matches between consumers and brands), none of these studies explicitly

considers the effect of product differentiation on the nature of competition in a market.

Empirical Model of Variety Competition

The primary implication of Hamilton's (2003) model is that, although retailers choose both variety and price, pricing decisions reflect only product heterogeneity and acquisition cost and not the intensity of competition among firms. On the other hand, the number of different products offered by a firm – variety – depends not only on product differentiation, but differences among firms as well. In order to test the core hypothesis of this research, we develop an econometric model that includes structural equations for: (1) equilibrium prices, (2) equilibrium variety (number of products per firm), and (3) the market share of each firm. Rivalry in either price or variety will, in turn, be largely determined by the degree of differentiation between firms, the extent of product differentiation, differences in marginal cost (wholesale price), and differences in fixed retailing costs. Both the degree of product differentiation and firm differentiation are, however, unobserved to the econometrician. Therefore, the econometric procedure estimates both product and firm, or chain differentiation as unknown parameters.

In the majority of cases, this is due to the fact that the extent of differentiation is unobserved to the econometrician, or is a latent variable influencing both competition and demand. Berry (1994); Berry, Levinsohn and Pakes (1995); Akerberg and Rysman (2003), and Nevo (2000, 2001), among others, explicitly account for unobserved product differentiation within a discrete choice framework. By estimating structural supply and demand models with consumer utility a function of both observed and unobserved product characteristics, these studies are able to identify the extent of differentiation in imperfectly competitive markets. This

approach, however, focuses on differentiation inherent in the product itself – or that created by manufacturers – and necessarily assumes away any further differentiation created by other channel members. Dhar and Cotterill (2003), on the other hand, argue that products purchased in retail supermarkets are differentiated in two dimensions: (1) from other products in the same chain according to their embodied attributes, and (2) from similar products in other chains on the basis of chain characteristics. This implies that a two-stage model of chain and product choice is required to estimate the degree of substitutability both among chains and among products within chains.

There are several ways to represent the two-stage choice process, depending on whether each stage is regarded as discrete (one alternative is chosen) or continuous (several can be chosen). Hanemann (1984) develops an econometric framework based on Deaton and Muellbauer (1980, p. 262) that integrates the discrete choice among brands and the continuous choice of quantity in one maximum utility problem. Vaage (2000) applies this model to Norwegian appliance and power demand, while Chiang (1991), Chintagunta (1993), Richards (2000) and van Oest, Paap, and Franses (2003) consider discrete choices among brands and continuous quantity purchases. Although this approach accommodates discrete / continuous choices in a theoretically consistent way, substitution among brands is driven entirely by their market share and not by fundamental attributes of the choice itself (Nevo 2001) and the price-response parameter in the brand-choice model is constrained to -1.0. Hendel (1999), Kim, Allenby and Rossi (2002) and Dube (2004) develop more general models of discrete / continuous choice designed to address the problem of “multiple discreteness” – when consumers buy several flavors or varieties of the same basic product on each trip to the store. Although these models are

able to accommodate decisions that consist of a mixture of discrete and continuous outcomes, they are more appropriate for household-level data where true corners are observed.

A logical and intuitive alternative to the discrete / continuous approach followed by the studies cited above is a nested logit similar to Anderson and de Palma (1992), de Palma *et al.* (1993) and Dhar and Cotterill (2003). Although retail grocery shoppers do indeed make a discrete choice among chains, the subsequent choice among products, and the quantities of each, are more appropriately considered to be continuous. Consequently, we adopt an approach that offers both a more general treatment of substitutability among products, while retaining the nested-decision logic inherent in shoppers' decisions between quality differentiated chains and products within chains – the nested CES (NCES).

Morey *et al.* (2001) develop a model of fishing-trip demand based on the NCES of Sato (1967) and Brown and Heien (1972). The NCES model allows for general substitution relationships among alternatives, is parsimonious in parameter space, allows for complementarity, has the potential to be flexible and, finally, appears to perform well in empirical application.³ Although they develop models based on both expenditure-share and trip-occasion share, for retail food demand, clearly expenditure share is the appropriate specification. Focusing on the choice among grocery stores on a single shopping occasion, we assume that a household maximizes utility from the current shopping trip only. Further, we assume that the consumer first chooses among the products she wishes to buy, and then decides from which firm

³ Brown and Heien (1972) call their NCES model the S-branch utility tree. This specification was, however, later criticized by Blackorby, Boyce and Russell (1978) because it implies preferences are affine homothetic. They reject this attribute of the S-branch model by specifying a more general Gorman Polar Form model that nests the S-branch as a special case.

she wants to purchase the entire bundle, based on considerations of both cost and inherent quality of the firm's stores. Using a two-level NCES specification, the indirect utility function for this problem is written:

$$V(\mathbf{p}_{ij}, \mathbf{y}) = \left[\sum_{i=1}^N \left[\sum_{j=1}^{N_i} \hat{p}_{ij}^{1-\sigma_i} \right]^{(1-\sigma)/(1-\sigma_i)} \right]^{1/(1-\sigma)} \mathbf{y}, \quad (1)$$

where σ_i is the elasticity of substitution among j products in store i , and σ is the elasticity of substitution among stores (and the outside option) in a given market. Analogous to the nested logit model of price and variety competition of Anderson and de Palma (1992), σ_i represents the degree of heterogeneity among products within a given firm (*intrafirm* heterogeneity) and σ represents the degree of heterogeneity among firms (*interfirm* heterogeneity). As they discuss, and clarify in a footnote, for retailers who sell many highly substitutable products with little heterogeneity (a seller of submarine sandwiches, for example) σ_i is likely to be high relative to σ . However, for retailers who sell products meeting many different and diverse needs, like supermarkets, substitution among stores is likely to be greater than within stores. Anderson and de Palma (1992) and Hamilton (2003) argue that retail markets with a high degree of intrafirm heterogeneity are likely to have a few stores offering many different products, while Anderson and de Palma (1992) maintain a high degree of interfirm heterogeneity leads to more stores, each with limited offerings. Although the number of firms is not endogenous in our model to this point, we are able to test these hypotheses regarding the number of products offered within each retail outlet. Prices are adjusted for the inherent "quality" of each product and chain in a manner similar to that suggested by Deaton and Muellbauer (1980) and Hanemann (1984) so that corner

solutions result from a utility-maximizing decision. Specifically, we multiply observed prices by a strictly positive function:

$$\Psi_{ij} = (\exp(\beta_{1ij} + \beta_{2ij}z_{ij} + \beta_{3ij}zp_{ij} + \beta_{4ij}N_i + \beta_{5ij}m_1 + \beta_{6ij}m_2 + \beta_{7ij}m_3))^{\sigma_i/(1-\sigma_i)}, \quad (2)$$

where γ_{ij} is an idiosyncratic preference parameter, z_{ij} is a binary variable indicating whether or not the product was on a promotion during the week, zp_{ij} is an interaction term between the promotion dummy and shelf price, N_i is the number of products offered by store i , and m_k are seasonal dummy variables. Multiplying ψ by the price provides a quality adjusted price so that $\hat{p}_{ij} = \Psi_{ij}p_{ij}$ for each $j = 1, 2, 3, \dots N_i$ products per chain and $i = 1, 2, 3 \dots N$ stores. Concavity requires $\sigma_k \in [0, \infty)$ and, to allow for the possibility that the quantity of some products is zero, $\sigma > 1$. Applying Roy's Identity to (1) and simplifying provides the share equations for each choice of chain and product:

$$S_{ij} = \left(\frac{\hat{p}_{ij}^{1-\sigma_i}}{\sum_{j=1}^{N_i} \hat{p}_{ij}^{1-\sigma_i}} \right) \left(\frac{P_i^{1-\sigma}}{\sum_{i=1}^N P_i^{1-\sigma}} \right), \quad (3)$$

where $P_i = (\sum_{j=1}^{N_i} \hat{p}_{ij}^{1-\sigma_i})^{1/(1-\sigma_i)}$ is the price-aggregator function, or price index, for chain i and S_{ij}

represents the market share (measured by expenditure) of product j sold in chain i . In our application of the NCES to chain and product choice, we include an "outside option" to allow for the fact that shoppers can buy fresh fruit from places other than the major retail chains described

by our data. Consequently, share expansion can indeed represent category growth for any of the chains considered here. An estimable form of (3) is created by expressing each share in logs and adding an iid error term, μ_{1ij} :

$$\log(S_{ij}) - (1 - \sigma_i) \log(\hat{p}_{ij}) + \log\left(\sum_{j=1}^{N_i} \hat{p}_{ij}^{1-\sigma_i}\right) - (1 - \sigma) P_i + \log\left(\sum_{i=1}^N P_i^{1-\sigma}\right) = \mu_{1ij}, \quad (4)$$

for $i = 1, 2, \dots, 4$ and $j = 1, 2, \dots, 5$. In the estimation procedure, the set of equations in (4) are estimated with the log-market share as the dependent variable. Estimating (4) on its own, however, provides no information on how firms interact in prices and variety.

To gain insight as to how variety effects price competition, and *vice versa*, we follow the structural industrial organization literature by formally modeling the supply side of the retail sector. Because of the size of the demand block (20 equations in all), simultaneous estimation of demand and the first order conditions for retail profit maximization with respect to price and variety in a manner similar to Bresnahan (1989), Berry, Levinsohn and Pakes (1995), Besanko, Besanko, Gupta and Jain (1998), Nevo (2001) is not possible. Therefore, we estimate the entire model sequentially, first estimating the demand block and then imposing the cross-equation restrictions implied by the demand estimates on the second-stage price and variety response model. In this way, we estimate both price and variety-response elasticities for each retail chain in our sample data.

Prices and variety in the NCES retail model are also clearly endogenous. Even if neither are strategic variables for retailers, which they may indeed be, they are likely to be endogenous for the more subtle reasons cited by Villas-Boas and Winer (1999) and Villas-Boas (2004). Both

prices and the number of product-types offered for sale are set by retail managers who are able to observe many factors that can influence store-level demand, but are not observable to the researcher. Display alignment, shelf-space, in-store specials, supplier concerns and many other considerations are taken into account in making marketing decisions that may not be observable to an outside analyst and are most certainly not independent from price and variety outcomes. In order to address these endogeneity issues, the demand system in (4) is estimated using an instrumental variables approach that is described in greater detail below.

Because the first order conditions for the NCS system are highly non-linear, we follow Dhar, *et al.* (2003) in deriving general first order conditions in terms of elasticities only.⁴ Draganska and Jain (2003) also derive the supply side for firms that choose both price and product-line length in general notation, but assume Bertrand-Nash behavior with respect to both variables. The model used here differs from Draganska and Jain (2003) in that we allow for more general, Nash behavior and estimate behavior at the store, rather than the individual product level. Focusing on store-level strategies has both logical and practical appeal. First, managers in a given city do not compare prices with rivals' on an individual product level, but rather category by category (McLaughlin, *et al.* 1999). Second, variety is more meaningful on a store-level (number of produce SKUs) than with respect to individual product lines (number of different sizes of apple), particularly in the fresh produce data used in this study. Third, estimating the entire four-store and five-product model would create an unreasonably high number of parameters to estimate, particularly given that we include both price and variety

⁴ Dhar, *et al.* (2003) extend the general notation for the first-order conditions of a profit maximizing multi-product firm presented by Nevo (2001) by demonstrating that the estimation of conduct parameters requires only elasticities from the demand system, along with measures of cost and other supply shifters as required.

reactions. Therefore, the profit equation for firm i is written as:

$$\pi_i = M \sum_{j \in N_i} S_{ij} (p_{ij} - c_{ij}) - g_i(N_i) = MS_i(P_i - C_i) - g_i(N_i), \quad (5)$$

assuming non-jointness of production. In (5), M is total market size, and c_{ij} , the marginal cost of retailing, is separable between wholesaling and a Generalized Leontief retail unit-cost function so that total product costs are written:

$$c_{ij} = m_{ij} + \sum_k \tau_k v_k + \sum_k \sum_l \tau_{kl} (v_k v_l)^{1/2}, \quad (6)$$

where m_{ij} is the wholesale (FOB) price of product j , v_k is a vector of input prices that includes retail labor costs, marketing costs and FIRE (finance, insurance and real estate) costs. Firm profit also includes certain fixed costs of variety, which encompass the costs of either developing and marketing private labels, or introducing and shelving external brands. Draganska and Jain (2003) argue that these costs are convex as greater variety imposes higher costs on the firm. To capture this effect, we model variety costs in terms of a simple quadratic function:

$g_i(N_i) = \delta_{i1} N_i + 0.5 \delta_{i2} N_i^2$, which, of course, implies linear marginal costs of variety.

Unlike Draganska and Jain (2003), however, we allow for price and variety behavior that is more general than Bertrand-Nash by introducing conduct parameters, or conjectural elasticities, with respect to both prices and varieties. Further, firms are assumed to form expectations of others' reactions to changes in both price and product line. In other words, we estimate cross-variable conduct parameters similar to Kadiyali, Vilcassim and Chintagunta (1999) so that we can test for whether firms respond to changes in price with changes in product

line and vice versa. In this way, the NCES model reflects an inherently “nested” problem in that each firm’s prices and product lines are determined by decisions made within other firms as well as for internal considerations. Taking this into account, the first-order condition with respect to the price index of retailer i becomes:

$$\frac{\partial \pi_i}{\partial P_i} = S_i M + \sum_k (P_i - C_i) \frac{\partial S_i}{\partial P_k} \frac{\partial P_k}{\partial P_i} M + \sum_k (P_i - C_i) \frac{\partial S_i}{\partial N_k} \frac{\partial N_k}{\partial P_i} M = 0, \quad k = 1, 2, 3, 4. \quad (7)$$

Similarly, the first order condition with respect to variety, or product-line length for retailer i is given by:

$$\frac{\partial \pi_i}{\partial N_i} = \sum_k (P_i - C_i) \frac{\partial S_i}{\partial N_k} \frac{\partial N_k}{\partial N_i} M + \sum_k (P_i - C_i) \frac{\partial S_i}{\partial P_k} \frac{\partial P_k}{\partial N_i} M - \delta_{1i} - \delta_{2i} N_i = 0, \quad k = 1, 2, 3, 4. \quad (8)$$

where P_i and C_i are retail and wholesale CES price indices, respectively, and the terms $\partial P_k / \partial P_i$, $\partial N_k / \partial P_i$, $\partial N_k / \partial N_i$, $\partial P_k / \partial N_i$, represent firm i ’s expectation of firm k ’s response to changes in its chain-wide “average” price and the variety of products on offer. These equations can be simplified by writing each in terms of demand and response elasticities, and measures of total category cost (e_i) and revenue (r_i), producing an estimable system of price:

$$r_i + \sum_k (r_i - e_i) \epsilon_{ik} \phi_{ik} + \sum_k (r_i - e_i) \eta_{ik} \lambda_{ik} = \mu_{2i}, \quad k = 1, 2, 3, 4, \quad (9)$$

and variety equations:

$$\delta_{1i}N_i - \delta_{2i}N_i^2 - (r_i - e_i)(\eta_{ii} + \sum_k \eta_{ik}\alpha_{ik} + \sum_k \epsilon_{ik}\gamma_{ik}) = \mu_{3i}, \quad k=1,2,3,4, \quad (10)$$

where ϵ_{ik} is the price elasticity of demand of product i with respect to the price of product k , η_{ik} is the “variety elasticity” of demand of product i with respect to the number of k products offered, ϕ_{ik} is the conjectural elasticity of firm k 's price with respect to a change in firm i 's price, λ_{ik} is the conjectural elasticity of firm k 's product-line length with respect to firm i 's price, α_{ik} is the elasticity of firm k 's variety response to an increase in offerings by firm i , while γ_{ik} is the conjectural elasticity of firm k 's price with respect to a change in firm i variety and μ_{2i} , and μ_{3i} are econometric error terms.

As a result, the entire system consists of three blocks of equations: (1) the demand block described in (4) that consists of 20 equations (four chains with five products each), (2) the price response block described in (9) that consists of four equations, and (3) the variety response block given in (10) that also comprises four equations. While estimation of the entire system together would be preferable, the size of this problem requires that each be estimated sequentially, while imposing the cross-equation restrictions implied by the previous stage. All parameter estimates are obtained by non-linear three-stage least squares (NL3SLS) within each independent block of equations.

Data and Estimation Methods

In order to provide a sample that is both of sufficient detail and depth to study the above problems yet is tractable in an econometric sense, the data for the proposed study consist of retail scanner data across multiple products within a single grocery category for four major

supermarket retailers located in a single metropolitan market. We use data from the fresh fruit category because retail sales of unbranded commodities represent the only opportunity to study competition that is not driven by manufacturer promotion programs, category management, or obligations created under slotting or pay-to-stay fee agreements. Retailer-specific data are required to identify competitive interactions among the four retail chains, while product-specific data provide the measure of heterogeneity among products within each chain. At the product-level, the data consist of price, quantity and total expenditures on a weekly basis from January 1998 through December 1999, for a total of 104 weekly observations. The data are gathered using checkout scanners and are aggregated over all stores for each of the four chains. Because there are a number of unique items per product definition, depending upon whether it is bagged or bulk, small or large, or a particular variety, we aggregate over individual price-look-up (PLU) codes to the product-level for red delicious apples, granny smith apples, fuji apples, bananas, and grapes. Our measure of variety consists of a simple PLU count for each aggregate product. All data were obtained from FreshLook Marketing, Inc. (FLM) of Chicago, IL.

Los Angeles represents an ideal case-study because there are a small number of retailers who dominate the retail market, each retailer follows a HI-LO as opposed to an EDLP strategy, and the Bureau of Labor Statistics reports wholesale product price data for major regional centers, so our wholesale price series is likely to represent true purchase costs.⁵ Moreover, Wal-Mart, who does not participate in any national scanner-data syndication services, does not sell

⁵ A HI-LO business model is one in which the retailer maintains a relatively high shelf price, but periodically offers significant discounts. Everyday-low-price (EDLP) retailers, on the other hand, maintain shelf prices that are as low as possible and rarely offer specials or discounts. Wal-Mart is an example of the latter, while Albertsons is an example of the former.

groceries in the Los Angeles market. Therefore, our data are more likely to be representative of the entire market. Issues of variety, price and firm-differentiation are best studied with single-category data due to the variety of factors consumers regard as important in choosing a store (Arnold, Oum and Tigert 1983; Supermarket News), the potential for heterogeneous price and product strategies across categories in a given store, and the necessity of pooling data over cross-sectional and time-series observations. Obtaining product SKU (stock-keeping unit) counts by product is important because different firms may emphasize one product over another. While one chain may stock many different varieties of apple, for example, the same chain may limit the number of available brands of peach in order to emphasize its higher margin offerings. Moreover, if the analysis were to consider other categories such as beverage, cereals or ice cream, the number of SKUs is often influenced by considerations such as manufacturer incentives, slotting fees, or promotional allowances (Chintagunta 2002). To identify a pure strategic variety choice, therefore, this analysis requires data from a single, important category for each chain.

Data for the other variables are from various secondary sources. Wholesale prices for the sample of fruits represented here are from the Economic Research Service of USDA (grapes), the Washington Growers' Clearing House (apples), or the Ecuador Minister of Agriculture (bananas) and represent shipping-point FOB prices. Retailing costs are measured by indices of wages in retail and wholesale trade, business services, advertising, finance, insurance and real estate (FIRE), transportation and utilities as well as a food store employment cost index, and an index of hourly wages among food store workers, all from the Bureau of Labor Statistics (BLS).

In order to capture retail competition at the chain-level, all prices represent per-product,

per-chain averages and all quantities are expressed on a per-chain basis. Therefore, each grocery chain is essentially regarded as one firm with multiple locations. Further, the “outside option” is calculated in a manner similar to Nevo (2001). Specifically, LA residents are assumed to consume each fresh fruit at the national average rate. US per capital fruit consumption values are then multiplied by the population of LA county (the market area of the sample chains) to obtain a total market consumption value for each fruit. The outside option is then the difference between total LA consumption and that represented by the sample chains. Any error can be due to differences between LA and national consumption rates, or to fruit purchased outside of the retail channel represented here. If these errors are random, then the parameter estimates remain valid.

Although estimating equations (4), (9) and (10) together is preferred on efficiency grounds, the size of the estimation problem required sequential estimation of the demand and supply blocks. Elasticity estimates from the system of equations described by (4), therefore, are included in equations (9) and (10) in order to recover the conjectural elasticity estimates. In both systems, however, prices and variety are clearly endogenous, so an instrumental variable procedure is used for each block of equations. For the demand system, the set of instruments includes the set of wholesale fresh fruit prices, the supermarket cost indices described above and lagged values of each product’s retail price and market share. Because of the large number of parameters in the demand system, however, this set of instruments is still not sufficient to obtain unique estimates of each. Consequently, we follow Villas-Boas (2004) and Draganska and Jain (2003) and interact these instruments with a set of product and chain binary indicator variables. The same set of instruments are also used to estimate the supply block. Both sets of equations are estimated using NL3SLS.

Results and Discussion

Although tests of the price and variety response hypotheses are conducted using the supply-side results, there is also considerable interest in the validity of the CES demand system and the insights it provides. If the elasticity of substitution among chains is equal to 1.0, then there is no need to consider a nested system as all chains are regarded as perfect substitutes. Similarly at the product level, an elasticity of substitution of 1.0 implies that all products are perfect substitutes. Based on the results in table 1, a Wald chi-square statistic for the hypothesis that $\sigma = 1.0$ is 17.50, while the critical value at one degree of freedom at a 5% level is 3.84. Therefore, we clearly reject the null hypothesis, which suggests that a two-level nested system is preferred. Among the product-level elasticities of substitution, we again reject the null hypothesis that $\sigma_i = 1.0$ in each case so different types of fruit are indeed imperfect substitutes for one another.⁶ In fact, Anderson and de Palma (1992) raise the issue of whether we should expect greater differentiation (less substitutability) within a particular chain or among different chains. In the supermarket example, consumers choose many types of goods to fill fundamentally differing needs, but each firm sells roughly similar types of products. Therefore, we expect greater differentiation within each chain than across chains. The results in table 1 support this expectation as the product-level substitution elasticities are significantly lower than the chain-level estimate. Interpreted as measures of heterogeneity, these estimates also mean that the degree of product-level heterogeneity is far greater than the level of heterogeneity among chains. Although four point-estimates of the product-level substitution elasticities do not permit a formal test of the

⁶ The test statistic for the null hypothesis that $\sigma_1 = 1.0$ is 303.689, for $\sigma_2 = 1.0$ is 147.053, for $\sigma_3 = 1.0$ is 219.775, and for $\sigma_4 = 1.0$ is 119.046. In each case, the test statistic is chi-square distributed with one degree of freedom.

hypothesis that greater product-heterogeneity leads to more variety, or longer product-lines, the estimates in table 1 provide some evidence contrary to this idea. Whereas chain 1 has a substitution elasticity of 0.040 and offers only 52.6 products on average, chain 4 offers 77.33 products and has a substitution elasticity among products of 0.202 – the highest of all our sample chains. Anderson’s argument maintains that if products are not readily substitutable for one another, a firm can introduce more brands without fear of cannibalizing existing sales. However, this must be weighed against the fact that retailers can span the characteristics space preferred by customers with fewer, more distinct products. In this case, the latter effect dominates.

The remaining parameters in the demand system comprise the product-level quality functions, ψ_{ij} . Whereas Morey *et al.* (2001) assume common quality parameters among each of their primary-level choices, this alternative was rejected in the LA retail data in favor of product- and chain-specific parameters. In each case, a positive parameter estimate suggests that the perceived “quality” or underlying demand for the product rises in the associated variable or, in the case of the intercept term, the inherent preference for the good in question is higher than average. In this respect, the results in table 1 indicate that consumers in three of the four chains express a preference for red delicious apples, while consumers in all chains tend to favor fuji apples. Perhaps surprising given the importance of bananas to fresh produce retailing, consumers in three of four chains tend to show a negative preference for bananas. Given the importance consumers place in the quality of a chain’s fresh produce, retailers are particularly interested in the effectiveness of price-promotion programs for fresh products. For virtually all products and chains, the promotion variable represents a strongly significant influence on demand. A positive value for the binary sales indicator means that demand increases during a sale, while a negative

interaction term means that demand also becomes less elastic. Both of these outcomes are desirable from the retailer's point of view. While it is not the primary objective of this paper, it would be possible to calculate the profit implications of a sale in each case with the CES demand estimates.

[table 1 in here]

With respect to the demand for variety, the β_{ik4} parameter shows the effect on the demand for product k in chain i of increasing the number of products offered within the fruit category. Consumers may value a variety of choices in fresh fruit if they are easily satiated in either the taste or nutritional attributes they desire when consuming fruit (McAlister and Pesemier 1982; Chintagunta 1998), they seek a hedge against future changes in taste (Walsh 1995) or desire more attributes than one item can provide (Farquhar and Rao 1976). Product variants in this case may mean different sizes of apple, package forms, or different colors of grape, for example. Although Draganska and Jain (2003) provide arguments for, and show empirical support for, a concave effect of variety on market share, here we maintain a linear relationship to keep the model as parsimonious as possible. In general, the results tend to be broadly positive, particularly in the case of fresh grapes, where many would argue that variety not only appeals to consumers' nutritional needs for diversity, but is also visually appealing as well. These results are similar to Draganska and Jain (2003) in yogurt or Bayus and Putsis (1999) in personal computers.

While it is a relatively simple matter to calculate price elasticities for individual products, because the focus of this paper is on chain-level strategies, table 2 presents estimates of "fresh fruit" price elasticities for each chain. Consistent with common notions of the competitiveness of the supermarket sector, the price elasticity of demand for each chain is near unity, except for

the fourth. As expected, the chains are substitutes for each other and, in general, strong substitutes both in an economic and statistical sense. With respect to variety elasticities, all of the own-elasticities are positive and significant, while the cross-elasticities are negative and significant. These elasticities provide some potentially valuable information. For example, the fact that the second and fourth chains both face price-inelastic demand, and relatively high variety elasticities suggests that these chains may benefit from higher prices and longer product lines among their fresh fruit. However, greater insight into the strategic value of these changes is provided by the supply-side estimates of each firm's price and variety response.

[table 2 in here]

These estimates are shown in table 3. As in Vilcassim, Kadiyali and Chintagunta (1999), each structural equation allows for firm-specific "multiple interactions" or expected price and variety responses by rivals to a change in variety, or to a change in price. Given that these responses are derived in a Nash equilibrium framework, all are assumed to be optimal given the choices made by other firms. By assuming general Nash behavior on the part of all firms, we offer a more comprehensive analysis of product-line decisions than Draganska and Jain (2003), who assume Bertrand-Nash (zero conduct parameters) in both prices and variety. With respect to price behavior, the conjectural elasticity estimates presented in the top panel show how rivals are anticipated to react to changes in the price of chain i . If the estimate is greater than zero, rival firms are expected to raise their prices in response to a rise in firm i 's price in a cooperative way. Clearly, the results in table 3 indicate that the retailers are far from competitive ($\phi_{ik} = 0$). Rather, the estimates in each case suggest a range from mildly cooperative (firm 2 with respect to firm 4) to strongly cooperative (firm 2 with respect to firm 3). These results also suggest that price and

variety are strategic complements as each firm expects its rivals to increase the number of products they offer in response to an increase in the firm's own price. When one firm raises its price, others' market shares will rise, thereby leaving them more consumer surplus to extract either directly through higher prices, or through a combination of even higher prices and longer product lines. Allowing for non-zero conjectural elasticities in this way provides perhaps greater insight into the variety choice problem than Anderson and de Palma (1992) as it recognizes that pricing decisions among rival firms also depend on product line decisions, and *vice versa*. Based on the pricing-equation estimates, therefore, retail supermarkets appear to behave cooperatively in their pricing decisions, both in response to rival price and product-line choices.

[table 3 in here]

On the other hand, the bottom panel shows that variety decisions are less uniform with respect to their implications for retailer strategy. First, the γ_{ik} parameters show the conjectural elasticity of firm k 's variety with respect to that offered by firm i . A positive elasticity, therefore, suggests that product lines are strategic complements – if one firm lengthens its product line, it will be able to raise its price, thus leaving more of the market for the other firms. As in the case of a simple price increase described above, with more market share the other firm can raise its price to extract more surplus (as suggested by the positive α_{ik} elasticities in table 3), or may either shrink their product lines to reduce cost, or lengthen them to build more pricing power. In table 3, firm 1 apparently makes product line decisions on the expectation that firm 2 will not follow, as is the case for firm two with respect to firms 1 and 4. Each firm, however, expects firm 3 to capitulate in any product line expansion (or contraction) in a relatively vigorous way. With respect to the expected price-response of rivals to changes in variety, firms 1 and 2 expect very

strong cooperation in nearly all cases, but firms 3 and 4 expect firm 2 to counter any changes they may make. This lack of uniformity may be due to the fact that changes in product line are not generally as transparent as prices. Supermarkets tend not to advertise many of the minor products they offer, but typically publish as many prices as possible on a weekly basis. Nonetheless, we can make a general conclusion that retailers, on average, tend to cooperate in both price and product-line decisions.

Further, because price elasticities in the CES model depend upon the elasticity of substitution among products, the results in table 3 can also be interpreted as indirect tests of the firm-heterogeneity hypothesis outlined in the introduction. In the lower block of results shown in table 3, a positive conjectural elasticity estimate (α_{ik}) suggests that firm i will offer more products for sale the higher the cross-price elasticity of demand, or the less heterogeneous it perceives the market to be. Unlike the product-heterogeneity case, this finding is consistent with the theoretical predictions of both Hamilton (2003) and Anderson and de Palma (1992). Anderson and de Palma (1992) explain this result in the following, indirect way: greater firm-heterogeneity, holding the number of firms fixed, allows each to raise its price, thus inducing entry and the range of products offered per store to fall. In our model, however, the effect is much more direct. Specifically, if chains are largely seen as homogeneous, then each will seek to differentiate themselves by offering a greater range of products. If doing so causes other firms to raise their prices in response to the overall increase in demand, then they each have further incentive to offer more variety. Clearly, this process is limited by the rising cost of variety (note the convexity of each of the variety cost functions in table 3), but can perhaps explain in part the rise of supercenters and other “big box” retailers in markets such as children’s toys, consumer

electronics and books.

Conclusions and Implications

This study provides some empirical evidence on the strategic interaction of pricing and product-line decisions by supermarket retailers. Theoretical models of price and variety competition suggest that *interfirm* heterogeneity reduces variety, or the length of a firm's product line, while *intrafirm* heterogeneity increases equilibrium variety. While other studies investigate this question using restrictive, nested-logit based models, this is the first to empirically test the variety / heterogeneity relationship using a flexible, nested CES model.

The data used in this study consists of two years of weekly scanner data for four major retail chains in the Los Angeles market. We use data from an unbranded, fresh product category in order to minimize the influence of manufacturer interference in retail sales decisions and to gain access to accurate and relevant wholesale price data. These data are used to estimate a fully structural system of fresh fruit demand and first-order conditions with respect to chain-level prices and product numbers. With this approach, the estimated conjectural elasticities represent retailers' response to firm heterogeneity in price and variety strategies.

Estimates of the demand system provide a number of interesting results. First, we find a lower elasticity of substitution among products within each chain than among chains, as expected given the similarity of product offerings among supermarkets. Second, we find considerable support for research among consumer product goods retailing (Chintagunta 2002) that finds price promotion to be highly effective in increasing product-level market share. Third, variety does indeed have a strongly positive impact on sales volume in a particular product line. Fourth, we

find that sales at the chain level are nearly approximately unit elastic with respect to price, and uniformly positively related to chain-level measures of variety.

Using the demand system estimates, we then estimate price and variety response equations that allow for that allow for multiple strategic interactions between rival firm's price and variety decisions. Of primary interest among these estimates, we find that each chain tends to follow a "cooperative" or complementary variety strategy with respect to certain of its rivals, but not all. Following different variety strategies with respect to some rivals is likely driven by perceived proximities in other respects, such as location, price levels or private label strategies. Further, we use these estimates to test Anderson and de Palma's (1992) hypothesis that greater firm-level heterogeneity is likely to lead to a smaller assortment of products offered per firm. We find support for this hypothesis, but not for their corollary that greater product-level heterogeneity leads to longer product lines. Moreover, the mechanism driving our result is fundamentally different as ours is strategic in nature while theirs derives from the type of equilibrium assumed.

While this research provides many implications for what we know about competitive interactions among supermarket retailers, perhaps the most important concerns the consequences for how the supermarket industry is likely to evolve. Driven by factors outside their immediate market niche, namely competition from other store formats, traditional supermarkets of the type we study here have been reducing retail prices in real terms in a number of categories. Consequently, if they follow cooperative pricing strategies, each will undercut the other until something nearly competitive arises. At the same time, however, variety is expected to respond in the same direction, leading to smaller product assortments and shorter product lines. In fact,

this is precisely what is occurring now. Through “efficient assortment” and category management programs, supermarkets are reducing SKU counts throughout the store in order to save inventory and handling costs as well as to allow the introduction of their own private-label brands.

References

- Ackerberg, D. and Rysman. Paper presented at the 5th Biennial Conference on Industrial Organization in the Food Industry. INRA-IDEI, Toulouse, France. June 2002.
- Anderson, S. P. and de Palma, A. "Multiproduct Firms: A Nested Logit Approach." *Journal of Industrial Economics* 40(September 1992): 261-275.
- Arnold, S., T. Oum, and D. Tigert. "Determinant Attributes in Retail Patronage: Seasonal, Temporal, Regional and International Comparisons." *Journal of Marketing Research* 20(1983): 149-157.
- Bayus, B. L. and W. P. Putsis, Jr. "Product Proliferation: An Empirical Analysis of Product Line Determinants and Market Outcomes." *Marketing Science* 18(1999): 137-153.
- Berry, S. "Estimating Discrete Choice Models of Product Differentiation." *RAND Journal of Economics* 1994
- Berry, S., J. Levinsohn, and A. Pakes. "Automobile Prices in Market Equilibrium." *Econometrica* 63(1995): 841-890.
- Blackorby, C., R. Boyce and R. Russell. "Estimation of Demand Systems Generated by the Gorman Polar Form: A Generalization of the S-Branch Utility Tree." *Econometrica* 46(1978): 345-363.
- Brander, J. A. and J. Eaton. "Product Line Rivalry." *American Economic Review* 74(1984): 323-334.
- Brown, M., and D. Heien. "The S-Branch Utility Tree: A Generalization of the Linear Expenditure System." *Econometrica* 40(1972): 737-47.
- Chiang, J. "A Simultaneous Approach to the Whether, What, and How Much to Buy Questions" *Marketing Science* 10(1991): 297-315.
- Chintagunta, P. K. "Investigating Purchase Incidence, Brand Choice and Purchase Quantity Decisions of Households." *Marketing Science* 12(1993): 184-208.
- Chintagunta, P. K. "Inertia and Variety Seeking in a Model of Brand-Purchase Timing." *Marketing Science* 17(1998): 253-270.
- Chintagunta, P. K. "Investigating Category Pricing Behavior at a Retail Chain." *Journal of Marketing Research* 39(2002): 141-154.

- Chintagunta, P. K., Dube, J. P. and V. Singh. "Market Structure Across Stores: An Application of a Random Coefficients Logit Model with Store Level Data." *Econometric Models in Marketing* 16(2002): 191-221.
- Chintagunta, P. K. and D. C. Jain. "Empirical Analysis of a Dynamic Duopoly Model of Competition," *Journal of Economics and Management Strategy*, 4(1995): 109-131.
- Choi, S. C. "Price Competition in a Channel Structure with a Common Retailer." *Marketing Science* 10(Fall 1991): 271-296.
- Cotterill, R. W. "Market Power in the Retail Food Industry: Evidence from Vermont." *Review of Economics and Statistics* 68(1986): 379-386.
- Cotterill, R. W. and W. P. Putsis, Jr. "Market Share and Price Setting Behavior for Private Labels and National Brands," *Review of Industrial Organization*, 17(2000): 17-39.
- Deaton, A. and J. Muellbauer. *Economics and Consumer Behavior* Cambridge, U.K.: Cambridge University Press, 1980.
- de Palma, A., R. Lindsey, B. Von Hohenbalken, and D. S. West. "Spatial Price and Variety Competition in an Urban Retail Market: A Nested Logit Analysis." *International Journal of Industrial Organization* 12(1994): 331-357.
- Dhar, T. P., J. -P. Chavas, R. W. Cotterill, and B. W. Gould. "An Econometric Analysis of Brand Level Strategic Pricing Between Coca Cola and Pepsi Inc." Working paper. Food Systems Research Group, University of Wisconsin Madison. June 2003.
- Dhar, T. and R. W. Cotterill. "Oligopoly Pricing with Differentiated Products: The Boston Fluid Milk Market Channel," paper presented at AAFA annual meeting, Montreal, Canada. August. 2003.
- Dixit, A. K. and J. E. Stiglitz. "Monopolistic Competition and Optimum Product Diversity." *American Economic Review* 67(1977): 297-308.
- Dobson, G. and Kalish, S. "Positioning and Pricing a Product Line." *Marketing Science* 7(1988): 107-125.
- Draganska, M. and D. Jain. "Product-Line Length as a Competitive Tool." Working paper, Stanford University Graduate School of Business, October 2003.
- Dube, J. P. "Multiple Discreteness and the Demand for Carbonated Soft Drinks." *Management Science* forthcoming in 2004.

Ecuador Ministry of Agriculture. Agriculture Information System. (www.sica.gov.ec/ingles/cadenas/banano). June 2004.

Farquhar, P. and Rao, V. "A Balance Model for Evaluating Subsets of Multiattribute Items." *Management Science* 5(1976): 528-539.

Hamilton, S. "Variety Competition." Working paper, Department of Economics and Business, University of Central Florida, August 2003.

Hanemann, W. M. "Discrete/Continuous Models of Consumer Demand." *Econometrica* 52(1984): 541-561.

Hendel, I. "Estimating Multiple-Discrete Models: An Application to Computerization Returns." *Review of Economic Studies* 66(1999): 423-446.

Kadiyali, V., P. Chintagunta, and N. Vilcassim. "Empirical Analysis of Competitive Product Line Pricing Decisions: Lead, Follow, or Move Together." *Journal of Business* 69(1996): 459-487.

Kadiyali, V., P. Chintagunta, and N. Vilcassim. "Product Line Extensions and Competitive Market Interactions: An Empirical Analysis," *Journal of Econometrics*, 89(1999): 339-363.

Kim, J., G. M. Allenby, and P. E. Rossi. "Modeling Consumer Demand for Variety." *Marketing Science* 21(Summer 2002): 229-250.

Lancaster, K. *Variety, Equity, and Efficiency* New York: Columbia University Press. 1979.

Liang, J. N. "Price Reaction Functions and Conjectural Variations: An Application to the Breakfast Cereal Industry," *Review of Industrial Organization*, 4(1986): 31-58.

McAlister, L. and E. Pessemier. "A Dynamic Attribute-Satiation Model for Choices Made Across Time." *Journal of Consumer Research* 9(1982): 141-150.

McLaughlin, E. W., K. Park, D. J. Perosio, and G. M. Green. "FreshTracks 1999: The New Dynamics of Produce Buying and Selling." Department of Agricultural, Resource, and Managerial Economics, Cornell University, 1999.

Morey, E. R., W. S. Breffle, and P. A. Greene. "Two Nested Constant-Elasticity-of-Substitution Models of Recreational Participation and Site Choice: An "Alternatives" Model and an "Expenditures" Model." *American Journal of Agricultural Economics*, 83(2001): 414-27.

- Nevo, A. "A Practitioner's Guide to Estimation of Random-Coefficients Logit Models of Demand." *Journal of Economics and Management Strategy* 9(2000): 513-548.
- Nevo, A. "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica* 69(2001): 307-342.
- Oren, S., S. Smith, and R. Wilson. "Pricing a Product Line." *Journal of Business* 57(1984): S73-S100.
- Raubitschek, R. S. "A Model of Product Proliferation with Multiproduct Firms." *Journal of Industrial Economics* 35(March 1987): 269-279.
- Richards, T. J. "A Discrete/Continuous Model of Fruit Promotion, Advertising and Response Segmentation." *Agribusiness: An International Journal*. 16(2000): 179-196.
- Richards, T. J. and P. M. Patterson. "Sales Promotion and Cooperative Marketing Strategies among Grocery Retailers." forthcoming in the *Review of Industrial Organization*. 2004a.
- Richards, T. J. and P. M. Patterson. "Price Fixity as a Facilitating Mechanism." forthcoming in *American Journal of Agricultural Economics*. 2004b.
- Slade, M. E. "Product Rivalry with Multiple Strategic Weapons: An Analysis of Price and Advertising Competition," *Journal of Economics and Management Strategy*, 4(1995): 445-476.
- Spence, M. "Product Differentiation and Welfare," *American Economic Review*, 66(1976): 407-141.
- Sudhir, K. "Structural Analysis of Manufacturer Pricing in the Presence of a Strategic Retailer." *Marketing Science* 20(Summer 2001): 244-264.
- United States Department of Labor, Bureau of Labor Statistics. *Employment and Earnings: State and Area*. 2004. <http://stats.bls.gov:80/cgi-bin/dsrv?sa> (June 6, 2004).
- United States Department of Agriculture. Economic Research Service. *Fruit and Tree Nut Yearbook*. Washington, D.C. June 2004.
- Vilcassim, N. J., V. Kadiyali and P. K. Chintagunta. "Investigating Dynamic Multifirm Market Interactions in Price and Advertising." *Management Science* 45(1999): 499- 518.
- Villas-Boas, J. M. and R. S. Winer. "Endogeneity in Brand Choice Models." *Management Science* 445(October 1999): 1324-1338.

- Villas-Boas, J. M. "Consumer Learning, Brand Loyalty, and Competition." *Marketing Science* 23(Winter 2004): 134-145.
- von Haefen, R. H. and D. J. Phaneuf. "A Note on Estimating Nested Constant Elasticity of Substitution Preferences for Outdoor Recreation," *American Journal of Agricultural Economics* 85(2003): 406-413.
- Walsh, J. "Flexibility in Consumer Purchasing for Uncertain Future Tastes." *Marketing Science* 14(1995): 148-165.
- Walters, R. G. and S. B. McKenzie. "A Structural Equation Analysis of the Impact of Price Promotions on Store Performance." *Journal of Marketing Research* 25(1988): 51-63.
- Washington Growers Clearing House. *Annual Report*. Wenatchee, WA. 1998-1999.
- Watson, R. "Product Variety and Competition in the Retail Market for Eyeglasses." Working paper, Department of Economics, University of Texas at Austin, March 2004.
- Wilkinson, J. B., J. B. Mason and C. H. Paksoy. "Assessing the Impact of Short-Term Supermarket Strategy Variables." *Journal of Marketing Research* 19(1982): 72-86.

Table 1. Nested CES Parameter Estimates: Los Angeles Retail Fresh Fruit, 1998-1999

Coeff.	Chain 1		Chain 2		Chain 3		Chain 4	
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
σ_i	0.040*	12.642	0.176*	31.381	0.123*	30.802	0.202*	29.866
β_{i11}	6.199*	6.060	3.620*	3.193	-0.948	-0.945	3.668*	3.593
β_{i12}	1.074	1.091	8.705*	8.910	9.082*	10.037	16.652*	17.320
β_{i13}	5.963*	5.922	-11.433*	-10.464	-6.524*	-6.397	-17.874*	-15.761
β_{i14}	0.096	0.367	0.298*	3.438	0.255*	2.159	0.532*	5.876
β_{i21}	-18.536*	-14.376	-0.533	-0.507	-2.050	-1.675	0.269	0.209
β_{i22}	-0.569	-0.592	9.526*	11.055	16.586*	13.850	4.580*	4.927
β_{i23}	2.351*	2.390	-10.341*	-10.079	-16.326*	-12.913	-4.375*	-4.263
β_{i24}	0.209	0.842	0.298*	3.489	0.229	1.941	0.532*	5.602
β_{i31}	23.458*	16.186	6.678*	5.656	15.514*	12.002	10.814*	8.076
β_{i32}	-0.807	-0.828	2.114*	1.985	0.926	1.042	5.891*	6.780
β_{i33}	4.151*	4.108	1.730	1.714	1.959*	2.002	-9.490*	-9.016
β_{i34}	0.499	1.956	0.378*	4.272	0.285*	2.493	0.519*	5.365
β_{i41}	-2.297*	-2.030	7.908*	7.397	-7.616*	-6.571	-4.535*	-3.662
β_{i42}	10.730*	10.377	22.073*	15.463	17.275*	15.751	10.838*	11.076
β_{i43}	-4.073*	-4.048	-23.600*	-16.468	-9.853*	-10.052	-9.316*	-9.627
β_{i44}	-0.353	-1.253	0.109	1.120	0.272*	2.339	0.557*	6.306
β_{i51}	1.541	1.538	-4.797*	-4.247	-2.413*	-2.332	11.474*	8.376
β_{i52}	15.491*	12.844	2.623*	2.572	3.772*	3.468	5.451*	5.855
β_{i53}	-5.175*	-5.885	-0.985	-1.524	-1.535*	-2.643	-2.470*	-4.789
β_{i54}	0.962*	4.081	0.512*	5.235	0.368*	2.882	0.571*	5.663
σ	0.870*	117.400						
LLF	-468.571							
χ^2	1,1214.79*							
N_i	52.606		73.663		70.529		77.328	

^a In this table, parameter β_{ijk} refers to the demand-parameter estimate for chain i , product j , variable k , where $j = 1$ is red delicious apples, $j = 2$ is granny smith apples, $j = 3$ is fuji apples, $j = 4$ is bananas, $j = 5$ is grapes, $k = 1$ is the product-chain specific preference parameter, $k = 2$ is the direct promotion effect, $k = 3$ is the price*promotion interaction effect, and $k = 4$ is the variety effect. N_i is the average number of products offered per chain over the sample period. A single asterisk indicates significance at a 5% level. The σ_i are elasticities of substitution among products within chain i , while σ is the elasticity of substitution among chains. Seasonal indicator variables are suppressed to conserve space, but are all significantly different from zero. The χ^2 test statistic compares the estimated model to the “null model” with constant terms only. At 5% and 141 degrees of freedom, the critical chi-square value is 169.711.

Table 2. Chain Price and Variety Elasticities

With respect to: ^a	Elasticity of:							
	Q ₁		Q ₂		Q ₃		Q ₄	
	ϵ_{1k}	t-ratio	ϵ_{2k}	t-ratio	ϵ_{3k}	t-ratio	ϵ_{4k}	t-ratio
P ₁	-1.151	-106.326	0.146	13.485	0.146	13.485	0.224	8.157
P ₂	0.321	6.632	-0.976	-20.157	0.321	6.632	0.353	8.631
P ₃	0.207	10.098	0.207	10.098	-1.090	-53.037	0.176	8.244
P ₄	0.624	8.657	0.623	8.631	0.623	8.644	-0.674	-9.527
	η_{1k}	t-ratio	η_{2k}	t-ratio	η_{3k}	t-ratio	η_{4k}	t-ratio
N ₁	0.179	6.795	-0.022	-6.089	-0.022	-6.089	-0.022	-6.089
N ₂	-0.022	-5.437	0.685	10.905	-0.226	-5.437	-0.226	-5.437
N ₃	-0.071	-4.990	-0.071	-4.990	0.369	7.617	-0.071	-4.990
N ₄	-0.032	-5.711	-0.129	-5.711	-0.063	-5.711	0.675	9.791

^a In this table, all subscripts refer to chain i , so Q_i is the volume of sales from chain i , P_i is the price index for chain i , and N_i is the number of products offered for sale by chain i . All elasticities are calculated at sample means. A single asterisk indicates significance at a 5% level.

Table 3. LA Supermarket Price and Variety Response Elasticities, 1998-1999

	Firm 1		Firm 2		Firm 3		Firm 4	
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
ϕ_{i1}	1.000	N.A.	0.403	17.777	0.455	13.463	0.232	45.481
ϕ_{i2}	0.458	22.897	1.000	N.A.	0.158	7.914	0.136	33.371
ϕ_{i3}	0.565	24.189	0.678	27.730	1.000	N.A.	0.127	29.757
ϕ_{i4}	0.326	22.351	0.072	4.388	0.239	13.671	1.000	N.A.
λ_{i1}	1.000	N.A.	0.126	50.124	1.210	24.750	0.211	39.071
λ_{i2}	0.425	17.735	1.000	N.A.	0.186	5.802	0.221	39.146
λ_{i3}	0.149	45.385	0.683	30.627	1.000	N.A.	0.053	1.297
λ_{i4}	0.134	11.933	0.030	2.240	0.139	11.526	1.000	N.A.
τ_{i1}	0.104	2.092	1.969	20.031	0.608	22.929	0.458	15.886
τ_{i3}	-0.407	-7.878	1.347	26.163	0.824	18.652	-0.102	-3.221
τ_{i13}	0.010	2.668	0.424	9.867	0.142	14.031	0.081	7.315
δ_{i1}	-2.826	-20.570	-1.540	-8.332	0.077	2.395	2.428	81.428
δ_{i2}	0.371	26.105	0.859	16.218	10.999	299.700	10.909	280.460
γ_{i1}	1.000	N.A.	-0.149	-1.856	0.082	8.854	0.052	4.717
γ_{i2}	-0.210	-3.798	1.000	N.A.	-0.058	-7.545	-0.043	-6.719
γ_{i3}	0.412	77.248	1.118	14.912	1.000	N.A.	0.017	2.476
γ_{i4}	0.160	2.866	-0.566	-7.456	-0.001	-0.538	1.000	N.A.
α_{i1}	1.000	N.A.	1.155	15.887	0.013	0.730	0.015	1.071
α_{i2}	0.146	25.191	1.000	N.A.	-0.035	-3.065	-0.018	-2.016
α_{i3}	1.058	148.070	1.306	17.642	1.000	N.A.	0.009	0.991
α_{i4}	0.380	8.288	-0.309	-5.647	0.002	-0.151	1.000	N.A.
LLF	4,094.223							

^a In this table, ϕ_{ik} is the conjectural elasticity of firm k 's price with respect to price changes by firm i , λ_{ik} is the conjectural elasticity of firm k 's variety with respect to price changes by firm i , α_{ik} is the conjectural elasticity of firm k 's variety with respect to the number of products offered by firm i , γ_{ik} is the conjectural elasticity of firm k 's price with respect to the number of products offered by firm ii , and τ_{ii} and δ_{im} are parameters of the retailing and variety cost functions, respectively. A single asterisk indicates significance at